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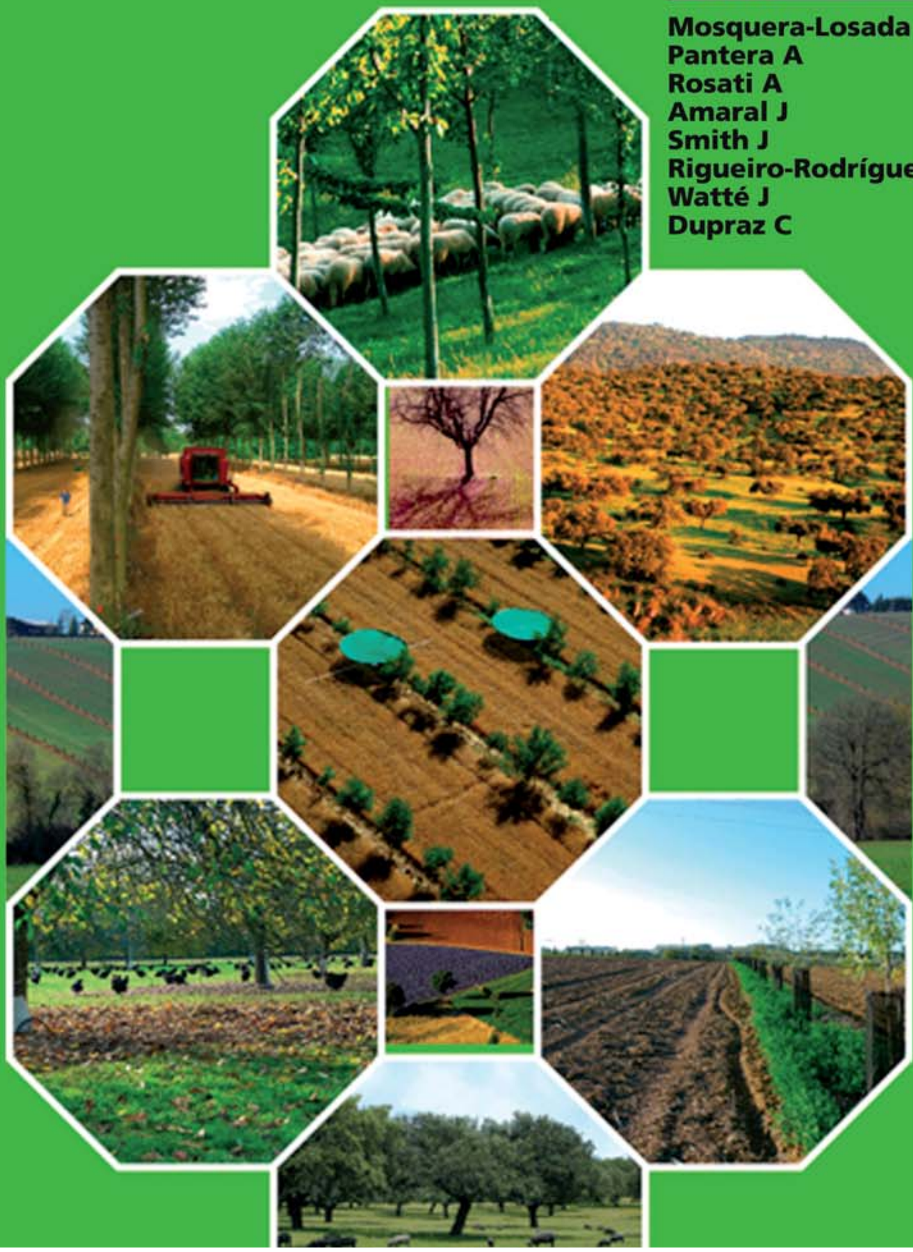

WHAT PRIORITIES FOR EUROPEAN AGROFORESTRY?

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Session 1: Innovative avenues for agroforestry in Europe in the next decade: research, development and policy

Session 2: Hot spots, What´s going on in Europe for agroforestry?

Parallel Session 3a Agroforestry: "Trees for a Sustainable European Agriculture" Meeting with European stakeholders ((at the European Parliament MEPs, Commission Officers, lobbyists)

Parallel Session 3b Trees for a Sustainable European Agriculture

Poster presentations

Session 1

Innovative avenues for agroforestry in Europe in the next decade: research, development and policy

Keynotes

Evidences and explanations for the unexpected high productivity of improved temperate agroforestry systems

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Concerns about the long-term sustainability of intensive monoculture systems have raised interest in more complex systems such as agroforestry (AF) systems. Improved agroforestry systems in temperate areas show promise (Eichhorn et al. 2006) and start to be adopted in Europe (Liagre and Colomb 2010). Such mixed systems may increase profitability and combine a high productivity with environmental services such as carbon-neutral energy production (Palma et al. 2007; Wise and Cacho 2005). Preliminary results also indicate that such systems may be more resilient to climate change than monocultures. Temperate AF systems have been evaluated by both field monitoring of long term experiments and by simulation with numerical models. The Land Equivalent Ratio (LER) (Mead and Willey 1980) is used as an indicator of the efficiency of the mixture. Any LER value above 1 indicates a benefit. LERs of perennial AF systems are tricky to measure or predict. LER measurements require sole production control plots that are often missing or biased in experimental designs (Dupraz 1998). This explains why almost no measured LERs of AF were ever published so far (Malézieux et al. 2008). An integrated AF model was used to predict the long-term productivity of AF systems. The model allows decomposing the production predictions into various multiplicative effects. Measured and simulated LERs for AF systems were surprisingly high: 1.2 to 1.6. It should be emphasised that a 1.4 LER means that a 100 ha AF farm produces as much as a 140 ha conventional farm where the productions are separated. The use of the simulation models allowed to explore various designs of AF systems, and suggested some crucial features to maximise the productivity of the system. North-South tree lines, 50 to 100 trees ha^{-1} densities, a dynamic pruning scheme of the trees and the use of winter crops are recommended for temperate AF systems. According to the model, several factors appeared to be essential for obtaining efficient AF systems: phenology lags between tree and crop components, plasticity of the root systems of the tree in response to the competition by the crop, and the availability of a deep resource of water that is within reach of the rooting system of the trees.

References

Dupraz C (1998) Adequate design of control treatments in long term agroforestry experiments with multiple objectives. Agroforestry Systems 43(1/3): 35-48.

Eichhorn MP, Paris P, Herzog F, Incoll LD, Liagre F, Mantzanas K, Mayus M, Moreno G, Papanastasis VP, Pilbeam DJ, Pisanelli A, Dupraz C (2006) Silvoarable systems in Europe: past, present and future prospects. Agroforestry Systems 67:29-50

Liagre F, Colomb V 2010 Une nouvelle étape importante pour l'agroforesterie. Agroforesteries 3 :7-13

Malezieux E, Crozat Y, Dupraz C, Laurans M., Makowski D, Ozier-Lafontaine H, Rapidel B, de Tourdonnet S, Valantin-Morison M (2009) Mixing plant species in cropping systems: concepts, tools and models. A review. Agronomy Sustainable Development 29:43-62

Mead R, Willey RW 1980 The concept of a "Land Equivalent Ratio" and advantages in yields from intercropping. Experimental Agriculture 16:217-228.

Palma JHN, Graves AR, Burgess PJ, Keesman KJ, van Keulen H, Mayus M, Reisner Y, Herzog F (2007) Methodological approach for the assessment of environment effects of agroforestry at the landscape scale. Ecological Engineering 29: 450-462.

Wise R, Cacho O 2005 Tree–crop interactions and their environmental and economic implications in the presence of carbon-sequestration payments. Environmental Modelling & Software 20(9): 1139-1148

Agroforestry systems: A land use option to enhance productive, environment and social benefits in forestlands

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The Iberian Peninsula has a large number of different agroforestry systems, but the silvopasture is the most extensively used. There is also a large variety of silvopastoral systems trying to cope temporal animal needs with the land productivity. The most extensive silvopastoral system is included in the Mediterranean area and called "dehesa" in Spain and "montados" in Portugal. This system allows reducing external inputs for animal feeding as branches, leaves temporally and fruits annually are used to overcome pasture production shortage. Trees also promote pasture production in some environments and usually at the end of the growing season. Atlantic silvopastoral systems include forest and shrubland grazing and mainly aim at reducing forest fire risk, produce high quality animal products and timber. In more arid regions of Sourthern silvopastoral systems are mostly based in the combination of shrubs and ephemeral herbaceous pasture. The role of palatable shrubs is essential during most limiting seasons. Mediterranean and Atlantic silvopastoral systems are combined through transhumance pathways also aiming at feeding animals with farm resources (fallows and stubbles) in short (from lowlands to nearby woodlands and highlands in the same region) and large corridors (transhumance from the Central-South Spain to the North Spain). The latter practices unfortunately have experienced a strong decrease in the last decades. Dominant tree and shrubs species in both environments varies broadly and depends on edaphoclimatic conditions. As results, mosaics of interrelated systems are found at different scales, from the plot to the landscape. Similar mosaics of silvopastoral systems and landscape are found across Mediterranean Basin Countries. Many studies have been carried out in all these systems and most of them conclude that they had advantages such as promoting biodiversity, increasing carbon cycling sustainability and enhancing soil and light resources use. Carbon cycling sustainability is promoted because organic carbon reaches deeper soil layers and trees storage carbon, but also because fires risk is reduced. Biodiversity is promoted at different scales, firstly because the tree (shading) and the animal (trampling, plant selection….) generates spatial heterogeneity at a plot level, secondly because different management needs (arable lands to produce forage crops and grazing lands) generates heterogeneity at a farm level. The mixture of the same type of farms in different environments (soil, climate) and combined with shrublands and grasslands also promotes heterogeneity and biodiversity at a landscape level. All these types of heterogeneity promote habitat, species and genetic diversity. All these findings justify a more appropriate consideration of these complex systems and landscapes in the European- and National-level policies. Specifically we ask for a wide definition of permanent pastures in the new CAP, where the positive role of trees and shrubs should be taken into account.

Extant vs. new agroforestry systems: A policy perspective

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Agroforestry has gained momentum throughout Europe over the last decade with several research groups, extension organizations and countries becoming increasingly involved in its promotion. The general objective of European agroforestry is to establish sustainable land use systems that involve trees and crops or animals and ensure a large variety of ecosystem services including provisional, regulating, supporting and cultural ones (Mosquera-Losada et al. 2005). This objective is generally thought to be met by new systems which are established by planting high quality timber trees in agricultural land already cropped or grazed by livestock in an organized way so that agricultural machinery is also used. As a result, European policies are pursued to adopt and financially support mainly such systems. Advantages of the new systems include compatibility with modern agricultural practices and the use of tree species with high potential growth and market value. However, such systems are suitable for countries with high agricultural land productivity and large ownership as it is the case in central and northern Europe. This is because farmers can allocate only part of their large farms to agroforestry. In countries with low productivity land and especially, with small ownership, on the contrary, it is very likely that farmers will not be motivated to allocate part of their farms to plant timber trees, even with financial support (Papanastasis 2005). This is the case in several Mediterranean countries including Greece (Papanastasis et al. 2008). On the other hand, these latter countries have a high number of extant agroforestry systems, either in function or abandoned (Eichhorn et al. 2006). In this paper, we discuss a policy change towards giving emphasis in restoring and maintaining the extant agroforestry systems in these countries rather than establishing new ones. This is because the traditional systems can ensure the same ecosystem services with the new ones with the only possible exception the production of high quality timber. Other factors though, such as costs, may be less for maintaining extant systems than establishing new ones.

References

Eichhorn MP, Paris P, Herzog F, Incoll LD, Liagre F, Mantzanas K, Mayus M, Moreno G, Papanastasis VP, Pilbeam DJ, Pisanelli A, Dupraz C 2006 Silvoarable systems in Europe – past, present and future prospects. Agroforest Syst 67:29–50

Mosquera-Losada MR, Rigueiro-Rodriguez A, McAdam J (eds) 2005 Silvopastoralism and sustainable land management. CABI Publishing, UK

Papanastasis VP 2005 Silvoarable systems and the European research project SAFE. In: Mantzanas K, Papanastasis VP (eds) Silvoarable systems in Greece: Technical and policy considerations. Laboratory of Rangeland Ecology, Aristotlte University, Thessaloniki, Greece, February 2005 (in Greek with English summary)

Papanastasis VP, Mantzanas K, Dini-Papanastasi O, Ispikoudis I 2008 Traditional agroforestry systems and their evolution in Greece, pp 89-109. In: Agroforestry in Europe: Current Status and Future Prospects (Rigueiro-Rodríguez A, McAdam A, Mosquera-Losada MR). Springer

Integration of Agroforestry in agriculture and landscape reclamation

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On the regional scale in Germany several research projects have been started that are embedded in the governmental funding R&D priorities based on the national program "Integrated Energy and Climate Programme" of the German Cabinet (2007). Embedded in the framework program "Research for sustainability" (FONA) the German Federal Ministry for Education and Research (BMBF) defines several funding priorities connected with land use adaptation strategies to Climate Change. One of these projects is the "Innovative Network of Climate Adaptation in the Region Brandenburg Berlin (INKA BB)" focusing on the alleviation of the impact of serious droughts. In agriculture, an upcoming idea is the implementation of agroforestry systems such as alley cropping where the integration of tree hedgerows on arable land improves the microclimate resulting in more stable or increased yields of crops. The hedgerow components of alley cropping are usually utilized for the production of biomass for material or energetic use. Recently, research has been started in the field of bioeconomy in agriculture. One example is the project "Economic and Ecological Assessment of Agroforestry Systems in Agricultural Practice (AgroForstEnergie). Changes in land use imply modifications and recalculations of bioeconomic assessments of the overall system discriminating between short and long term impacts. Demonstration sites have been established in Lusatia in cooperation with farm companies aiming on the production of food, feed and bioenergy under practical conditions. Based on additional collaborative projects an extended network has been established to study the impact of agroforestry on ecological aspects of land use (soil formation, water and nutrient use efficiency) and on the economical output. The investigations are be completed by defining ecological targets and the final calculation of economic benefits. In 2002 the National Nature Conservation Act was enforced, which requires that any intervention causing impacts to nature have to be compensated. The research project "ELKE" aims on the development of extensive land use systems where agroforestry systems are addressed as reliable compensation measures on agricultural land. The post-mining landscape (100.000 ha) in Lusatia is not comparable with the original landscape because of the altered landscape functionality, composition, and structure. Nevertheless, that implies the chance to develop new forms of land use. One challenge during soil reclamation is the rebuild of organic matter over time. Adopted agroforestry systems have emerged as best management practice supporting the target of carbon sequestration. Future research activities will be focused on "old" agroforestry systems. The Spreewald region in Lower Sorbian (100 km south-east of Berlin) is a sensitive area and was designated a biosphere reserve by UNESCO in 1991. It is known for its traditional water channel system of 1,300 km length and covers 484 km^2. Traditional agroforestry systems (shelterbelts like) with organic farmland and grassland are quite common but over the decades a sensitive restoration of the tree component is required. Important issues are the management of organic soils, water regime and the biodiversity.

State of Agroforestry in North America

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Trees, crops, and livestock have been grown together for many 100s of years in North America, however the roots of agroforestry (AGF) in modern times can be traced back to the windbreaks that were established during the 1930s ("Dust Bowl years") to reduce soil erosion in the Great Plains of Canada and the United States. More widespread interest in AGF in the US began in the mid-1980s leading to federal legislation in 1990 that established the USDA National AGF Center, which is jointly sponsored by two federal agencies, the Forest Service and the Natural Resources Conservation Service. The Center's mission is to accelerate the application of AGF through a national network of partners. The Department of Agriculture and Agri-Food Canada (AAFC) AGF Development Centre has a similar mission that provides AGF research, technology transfer, networking and AGF programming. The Association for Temperate AGF was established in 1991 as a member organization of AGF professionals and practitioners in North America. In addition, there are many universities offer AGF programs and courses. Agencies in the U.S. and Canada provide assistance to landowners to help them establish AGF practices; however, adoption of AGF is generally low with the exception of windbreaks and riparian forest buffers. Despite the recognized economic and environmental benefits of AGF, a key question is why is AGF not more widely adopted and practiced? To answer this question, a survey of AGF extent and success was carried out. Survey results showed that programs were more widespread in Canada, as the U.S. had only about one-third of the states reporting AGF programs. The types of practices differed across countries in terms of popularity. Most respondents felt the programs were only somewhat successful, but Canada had a higher percentage saying fairly to very successful. In both countries the most effective programs were ones that met environmental objectives such as biodiversity conservation, water quality and soil productivity. Topping the list of obstacles to successful programs were economic-related issues such as poorly developed markets for AGF products, lack of profit potential, additional expenses, and lack of financial assistance. In addition lack of familiarity, complexity, the time-consuming nature of many AGF technologies, and lack of outreach, training, and demonstrations of AGF in action were also significant responses. Four areas were emphasized in terms of factors that would help make programs more successful: (1) more educational and training opportunities (2) more financial support in policies and incentives and encourage adoption (3) markets for AGF products and (4) better collaboration and support among organizations. These results provide numerous lessons that can be learned from past or current programs to facilitate promotion and adoption of AGF in North America. Today, there are some promising developments, including 1) a growing body of science and technology to support AGF (e.g., *North American AGF: An Integrated Science and Practice*); 2) the release of the *USDA AGF Strategic Framework, Fiscal Year 2011–2016*, which provides a roadmap to advancing science, practice, and adoption of AGF across the US; and 3) a recent Memorandum of Understanding between Canada and the US, which commits AAFC and USDA to advancE the application of temperate AGF systems. A major focus of the new agreement is AGF as a tool for climate change mitigation and adaptation, in support of the goals of the Global Research Alliance on Agricultural Greenhouse Gases, of which both countries are members.

Session 1

Innovative avenues for agroforestry in Europe in the next decade: research, development and policy

Oral presentations

Future Wood Pasture: Integrating trees into evolving grazing systems in Northern England

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This presentation will focus on the effects of livestock grazing management on grazed woodlands and wood pasture in the North of England. Problems with simplistic grazing remedies are identified and novel approaches to tree regeneration to bring sites into favourable condition are discussed. The first case examines a site designated as a Site of Special Scientific Interest (SSSI) for its population of ancient juniper. The lack of juniper regeneration was identified in the past as a concern and changes to grazing management were made to address the problem. Removal of livestock grazing did not result in juniper regeneration and created additional problems with bracken infestation. The details of a modified grazing regime to stimulate regeneration are discussed. The second case examines the various approaches to encouraging natural regeneration in wood pastures. The use of Genguard exclosures, natural gorse thickets and livestock removal are examined. Results indicate that gorse thickets can protect new tree establishment provided rabbit populations are low. Genguards are effective at promoting tree regeneration on heathland but their effectiveness in grass dominant systems are limited. Livestock removal can be effective, but bracken control and supplemental tree planting may be necessary. Results indicate that management of livestock in grazed woodlands and wood pastures is essential to maintain new tree recruitment. The restoration of short duration, high intensity stocking may be necessary to promote regeneration and control bracken and may also bring additional benefits.

Short Rotation Coppices within agroforestry – options and limitations

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According to the EU Renewable Energy Directive (RED), all Member States should strive to a 20% share of renewable energy by 2020. To achieve this goal, approximately 17.5 million ha of land will have to be dedicated to the production of energy crops by 2020. Thus, an additional pressure on farmland biodiversity as well as on soil and water resources can be expected in biofuel production regions in the EU. In comparison with conventional crops for bioenergy production (e.g., canola, maize), Short Rotation Coppices (SRC) with fast growing trees like poplar and willow may even increase ecological services on the field as well as on the landscape level, as they may act as physical barriers against soil erosion, need significantly less fertilizers and pesticides or can functioning as riparian buffer strips to protect against water contamination (Dimitriou et al. 2009). However, SRC may also come along with some negative effects as the groundwater recharge quantities will be generally reduced though enhanced transpiration rates of trees or through nitrification pulses, which may occur after soil preparation measures before planting or after harvesting activities. Within this context, results from a case study in a lowland drinking water catchment area near Hannover, Germany are presented. Here, much effort was spend through extensification and set aside activities to reduce nitrate leaching but also SRC were established on fallow grounds to additionally produce bioenergy. Compared to the catchment level (9.5 mg NO_3-N L^{-1}) the nitrate leaching on the fallow ground but also under a 15 year old poplar plantation was significantly reduced (<1 – 2mg NO_3-N L^{-1}). Nevertheless, nitrate leaching increased temporarily after site preparation measures for planting (deep ploughing; >15 mg NO_3-N L^{-1}) and was permanently enhanced when a willow plantation was not early enough harvested (10 mg NO_3-N L^{-1}). At 655 mm of annual rainfall, ground water recharge (GWR) was reduced by 40 % (to 180 mm a^{-1}) through a five year old willow plantation, compared to the fallow ground reference plot (300 mm a^{-1}). However, transpiration was limited by low soil water storage capacities, which in turn led to a moderate impact and transpiration losses. It is concluded that well-managed SRC on sensitive areas (e.g., drinking water catchments) can prevent nitrate leaching, while impacts on GWR may be mitigated by management options (Schmidt-Walter and Lamersdorf 2012). To increase the added value of SRC with respect to ecological services (biodiversity, nutrient leaching, erosion protection etc.) the implementation of SRC should be highly adapted to the local background conditions (sizes of SRC plots, harvesting cycles, site preparation measures, species etc.). It is hypothesized, that if the application of SRC would be better linked or even embedded in the general requirements of the agroforestry approach - i.e. for instance, reducing their installations as large scale monocultures to a minimum - the ecological added value but also the general acceptance of SRC would significantly increase.

References

Dimitriou I, Busch G, Jacobs S, Schmidt-Walter P, Lamersdorf N (2009) A review of the impacts of short rotation coppice cultivation on water issues. vTIAgric For Res 3:197–206

Schmidt-Walter P, Lamersdorf NP (2012) Biomass production with Willow and Poplar short rotation coppices on sensitive areas—the impact on nitrate leaching and groundwater recharge in a drinking water catchment near Hanover, Germany. DOI 10.1007/s12155-012-9237-8

Valuing the carbon sequestration potential of European agroforestry

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The potential of agroforestry and other agricultural measures in sequestering carbon is a a clear option for climate change mitigation. The related value for society is estimated. The technical potential of the agricultural measures to sequester carbon is based on a literature review. The future value per ton of Carbon sequestered is estimated by applying the "avoided cost" approach. This approach considers the cost savings due to carbon sequestration by agroforestry, when the climate change policy objective has to be met that global temperature rise is to be kept below two degrees Celsius. Agricultural practices like agroforestry, introducing hedges, low and no tillage and cover crops have an important potential to increase carbon sequestration. The total technical potential in the EU-27 is estimated to be 1566 million tons CO2-equivalent per year. This corresponds to 37% of all CO_2-equivalent emissions in the EU in 2007. The introduction of agroforestry is the measure with the highest potential, i.e. 90% of the total potential of the measures studied, resulting in a potential of about 1400 million tons CO2-equivalent per year. Taking account only of the value for climate change mitigation, the introduction of agroforestry is estimated to have a value of 282 euro/ha in 2012 that will gradually increase to 1007 euro ha^{-1} in 2030. Our results imply that there is a huge potential which represents an important value for society in general and for the agricultural sector in specific. At the European level, only in the last few years policy makers have recognised the important benefits of agroforestry. In their rural development programs some European countries now support farmers to introduce agroforestry. But still the current level of support is only a small fraction of the societal value of agroforestry. If this value would be fully recognised by internalising the positive externality, we expect that agroforestry will be introduced to a very large extent in the next decades, in Europe and the rest of the world, and this will importantly change the rural landscapes.

Scotland' Woodland Expansion target – Can Agroforestry play a part?

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The Scottish Government has set an ambitious but historically achievable target of 10,000 hectares of new planting every year for the next 10 years. This published target has caused concern amongst Farmers who feel that their livelihood and that of food production will be put under threat. This is not the desire of the Scottish Government and as a result a consultation process with industry representatives and land managers took place, and a report on the findings produced and published (www.forestry.gov.uk/weag). Selected comments from Farmers and Land Managers recorded at consultation meetings: a) There should be a 10% limit (of the gross holding area) imposed for tree planting b) Riparian sections should become priority tree establishment areas c) Farmers generally do not have woodland management skills, and are more focused on looking after animals and their crops d) There should be better integration of forestry and farming e) Many felt that Agroforestry would be a land management approach that they would consider as there was recognition of the benefits (primarily shelter) f) Farming and Forestry policies need to be fully integrated g) Grazing of existing woodlands could help to reduce the burden of grazing pressure on non-wooded land h) If farm woodlands were to be managed, could they count as part of the proposed 7% Ecological Focus Area?. The report came up with 24 recommendations to be considered to meet Woodland Expansion Targets set by Government. 2 of these recommendations relate to Agroforestry systems were: Number 3: 3a) *'The focus of woodland expansion should be away from prime agricultural land, but it should be recognised that there may be important opportunities for small scale tree planting, for example on field margins……'* (Scotland does not have a large area of prime agricultural land – class 1,2 and 3.1 – therefore there should be a presumption against creation of medium to large sized woodlands on this type of land) 3b) *'Grazing land has significant potential …this should be achieved in ways that seek to avoid adverse impacts on local patterns of agriculture and that aim to complement and enhance the agricultural and environmental value of the remaining unplanted land'* Number 10: * *'Making use of Agroforestry measures in the Rural Development Regulation'* * *'Supporting woodland creation models which combine grazing and shelter'* * *'There is scope for creating woodlands where grazing is planned as a management objective'* We concluded that there are 2.69 million hectares of land in Scotland suitable for woodland expansion. Total cattle numbers have reduced from 2.4 million (1982) to 1.8 million (2001); sheep numbers have dropped from 8.5 million to 6.5 million over the same period. Taking 100,000 hectares of land out of livestock production could reduce overall livestock numbers by 0.2%. However, livestock grazing currently averages only 0.5 LSU/ha. There is therefore the capacity to maintain current levels of livestock numbers but to achieve this we need to consider a combination of strategically placed shelterbelts, new areas of silvopasture and also the conversion of woodlands to silvopasture. These are all currently being considered.

Food systems under population pressure and running out of fossil fuels: any options left?

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Agroforestry is being promoted as an example of ecological intensification, but confusion persists as to what this actually means. Intensifying is about raising productivity (or the efficiency of production) by increasing inputs. Let's recall that efficiency is an output/input ratio. Intensification happens if increasing input(s) leads to a more than proportionate output response, thereby improving efficiency. However, which output is being measured against which input, on which time-scale and in which units? There are many ways to get output/input ratios, and typically there are trades-offs: improving one ratio happens at the expense of another one. Collectively, we tend to communicate with peers about the ones that seem to matter most to most people in a given context, ignoring the trade-offs. But contexts change and at one point trade-offs cannot be ignored any longer. Output can increase even though output/input ratios decrease. Conversely, to achieve a better efficiency, one can work to keep output constant all the while lowering input levels, which is called… extensification! Food for confusing thought indeed. So the question of the meaning of ecological intensification can be rephrased as: which output/input ratio matters most in the long run? Our premise is that energy efficiency (or productivity) matters most, yet it has never got the attention it deserves. When considering energy fluxes through food systems, it is helpful to distinguish ecological energy (derived from the sun and intercepted through photosynthesis) and various types of cultural energy (spent by humans to optimise biomass production and transfers). To simplify, cultural energy can be split into two main sub-types: biological (renewable) and industrial (non-renewable) cultural energy. *Pre-industrial* intensification was about raising the productivity of the land by inputting more labour, at the expense of labour efficiency. *Industrial* intensification is about raising labour efficiency by huge inputs of industrial energy, at the expense of (industrial) energy efficiency. The one trade-off we collectively ignore today is energy efficiency. When running out of industrial energy, the only options left are to make better use of the remaining types of energy, the ones that are truly renewable. That's how we define ecological intensification. In an increasingly *post-industrial* context, agroforestry is not without its drawbacks, but it is definitely about making better use of the abundant solar energy at our disposal.

CAP and agroforestry: a new approach by habitat efficacy

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For a long time the CAP was unfavorable to field trees and hedgerows: land covered by trees was not eligible for CAP premium leading to clearances. More recently trees have been barely tolerated, until they found support with the measure in favor of agroforestry. The future CAP must consider trees as an asset for agriculture. The first pillar of the CAP could benefit existing trees (preservation) and the second pillar could enable each farmer to add to his or her resources. *What is the situation?* Rural trees have been declining but are not absent; segregation increases between afforestation and agriculture (Figure 1). Evolution of populations of cultivated areas birds is particularly revealing of this ecological degradation since birds are at the top of food chains.

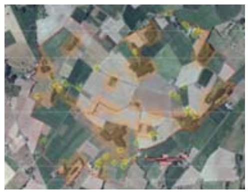

Figure 1. Land use changes in France: Red: afforestation and hedges

Figure 2: HPA scheme

Which of the CAP's mechanisms can respond serious environmental problems arising from the increasingly rapid development of intensive farming? Four key challenges for the CAP have been identified by AFAHC: - Easy to use and control; - Meet the requirements of quality food production and preservation or restoration of the environment; - Breaking segregation between agricultural production parcels and environmental conservation areas - Involve the whole utilised agricultural area (UAA) while ensuring freedom farming to management and initiative. *Habitat Ratio (HPA in French)*: Landscape ecology experts have shown that the beneficial insects for crops, which pollinate them and/or are predators of their pests, need shelter. From such refuges, their potential colonization territory in fields is an area less than 60 m wide along a hedge, wood edge or watercourse, or around a pool (high-diversity continuous elements) and less than 30 m from an isolated tree, agroforestry tree, alignment, meadow orchard or dry stone wall (low-diversity continuous elements). Starting from this observation, CartoPAC aerial photographs can be used to calculate the "Habitat Ratio" area. This is the area that can potentially be colonized by beneficial insects. The BIH/UAA ratio gives a good idea of the distribution of trees and fixed landscape elements useful in an agroecological approach. The ratio could be progressive (increase from 20% to 50% over the five years *This method is:*- straightforward to teach and understand; gives freedom to the farmer for his agroforestry organization; ensures an even distribution over the whole agricultural surface (UAA); simplified control by CartoPAC; and applies to all agricultural production systems and farmers can also tailor their projects to their ambitions by EU cursors and by natural region (Figure 2).

Reference

AFAHC 2011 Field trees in the future CAP. http://www.afahc.fr/fichiers%20pdf/PAC/Fields_Trees_in_CAP2013_02.pdf

Session 2

Hot spots, What´s going on in Europe for agroforestry?

Oral presentations

Quercus ithaburensis silvopastoral systems in Greece

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Quercus ithaburensis with its subspecies is an east-Mediterranean species forming distinctive silvopastoral system in Greece. *Q. ithaburensis* was used in the past for its wood, acorns as well as for tannery but nowadays in Greece is mainly used for grazing, especially by sheep and is declining due to overgrazing and abandonment. The impressive shape of the tree as well as the strength of its wood, have greatly influenced the economy, artistries and civilization of the areas where it existed throughout the years supporting the local economies. During the 20th century, activities such as conversion of forest to agricultural lands, overgrazing, illegal lumbering, and forest fires have confined *Q. ithaburensis* to small-forest clusters or isolated individual trees in many areas of continental and insular Greece. The use of cheap, chemical dyes has eliminated the most important use of its acorns in tannery and confined it to their nutritive and ecological value. The understory of such systems is composed mainly of holm oak, almonds, olives, carobs, mulberries, several bushes or dwarf shrubs, providing fodder for sheep, goats, and hogs. Nowadays farmers are converting them to olive groves and/or agricultural fields. However, in Turkey there is still a great interest for *Q. ithaburensis* used for organic tannery derived products such as leather goods, tapestry etc. providing a use full example for the economic re-use of the species. Based on the preliminary results of a research program (ARCHIMEDES III), undergoing presently on these systems, they are of great nutritional value for grazing livestock enhancing plant biodiversity. The regeneration of the species appears to be locally affected by overgrazing. These systems are of great economic and ecological value to the local communities providing numerous products such as dairy products, meat, herbs and firewood. Grazing animals represent a cash income to the farmer through meat and milk, nutrient transfer from forage to soil through their faeces, a successful way for seedling removal, and they contribute to soil organic matter turnover. An important contribution of grazing animals is that of reducing understory biomass and, subsequently reducing forest fire risk. This raises a very important issue, especially after the devastating forest fires of 2007, and needs to be further investigated. Black truffles have been discovered recently in *Q. ithaburensis* forests providing a valuable reason for the preservation of these systems. Based on these preliminary results and by the use of a dendrochronological approach, valonia oak silvopastoral systems are composed of old trees, of over 300 years old, that were always developed as open forests intensively used and affected by man. To conclude, valonia oak systems are traditional silvopastoral systems of great economic, social and environmental value and need to be preserved and further developed by public awareness, by farmers' incentives and by preservation measures taken by local authorities.

Olive agroforestry: an inverse approach to agroforestry

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Most often, new agroforestry (AF) sites are obtained by planting trees in arable land (alley cropping) to provide several benefits (profit, environmental, biodiversity, etc.). However, they may be achieved when AF is implemented in existing trees/orchards that might otherwise be abandoned or removed for lack of profit, such as millions of hectares of olive orchards in Europe. In fact, due to the high harvesting cost, traditional olive cultivation is rapidly becoming uneconomical in developed countries. Converting such a landscape to an olive-based AF system, intercropping olives with other economically-viable crops/animals, can provide economic sustainability, allowing maintenance of a traditional agricultural landscape, which is also functional to tourism activities. An AF system including the cultivation of a wild asparagus species (*Asparagus acutifolius*) as an understory crop together with raising meat chicken in the olive orchard was studied during two years. Asparagus plants were transplanted in the orchard resulting in 5000 plants ha^{-1}. Two meat-chicken cycles (100-110 days) per year with 1000 animals ha^{-1} each, were carried out in spring and fall, avoiding hot summers and cold winters. The chickens grew as expected for outdoor animals and had no measurable negative effects on either the asparagus plants (they are prickly and the birds do not eat or damage them) or the olive trees. The annual load due to manure was about 170 kg N ha^{-1} and 220 kg P_2O_5 ha^{-1}. N fertilization is abundant and P in excess if repeated every year. Weed control was good, but the distribution of the animal housing was important to avoid overgrazing and soil compaction in the areas surrounding the housing. Chickens appeared to be able to destroy olive suckers, further reducing costs, in addition to the weeding and fertilizing activities. The asparagus yield was not measured due to full yield is reached after 2-3 years of transplanting. However, preliminary observations in the orchard suggests that the asparagus yield is very similar to that reported in pure stands, which may be explained because olive orchards intercept relatively little light compared to other orchards and produce the highest oil yield when intercepting only 55% of available PAR. Wild asparagus produces relative little biomass compared to other crops, needing relatively little resources, including light: this species naturally occurs in moderate shade. However, the asparagus was planted only along tree rows to allow easy access to farm equipment for soil management and harvesting, therefore the asparagus plant density was about one sixth compared to pure stands and the yield can be estimated to amount to a similar fraction. Increasing the asparagus density (and yield) in the olive orchard to similar values as in pure stands appears possible as long as plant spacing is designed to allow the necessary traffic for the olive harvest. The olive yield was not affected by the cultivation of the asparagus underneath the tree canopy. Overall, the system appears capable of producing similar olive and asparagus yields as in pure stands, thus greatly increasing the total yield per area of land. In addition this polyculture may also host one or two meat chicken cycles/year, decreasing the overall environmental impact due to the synergisms among crops and animals. More details can be viewed in a video available online (http://www.youtube.com/watch?v=ALw73WwUr2o&feature=plcp).

Role of Macaronesian Forest in hydrology and rural development in the islands

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Macaronesian consists of a group of several islands, volcanic in origin, scattered in the North-East Atlantic off the coast of Africa, The archipelagos and islands are (from North to the South; Azores, Madeira, Canarias and Cape Verde). The total inhabitants are more than two millions. Three of them belong to countries in the European Union: Azores and Madeira to Portugal and the Canary Islands to Spain and Cape Verde is an independent country. Agriculture and tourism are the main stay of Macaronesian's economy and development. Other important fact on this region is the Macaronesian forest that is the subtropical cloud forests endemic to the Atlantic islands. In these volcanic islands, the rainfall regime and its torrential nature, together with the steep slopes and the soil types present are considered to be some of the main factors affecting forest hydrology and soil conservation. In the case of Canary and in Azores archipelago, another important factor to understand the water resources regulation in the islands is the fog precipitation. In the Canary Islands this effect occurs from the 600 meters, powered by vegetation adapted to this type of precipitation. Finally, in the region of Macaronesian, forests also has a role in the promotion of sustainable tourism, people are looking for experiences related to the environment, so that in addition to traditional forest use, this tourism could develop rural sites associated with forest. In this document, it will be studied the fundamental aspects that affected by forest, insular hydrology and rural development, mainly related with water erosion control, the use of water and forests and finally the precipitation of fog.

Plantations of High Value Timber – Agroforestry Systems in Modern Production; 14 years of experience in the Federal State of Baden-Württemberg / Germany

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Agroforestry has attracted growing interest, at least in the scientific community. Various research projects on national and federal level have been conducted in recent years. Three important points have to be made about these systems: one aspect is the historical and cultural importance. Secondly their ecological significance as outstanding and unique habitats has to be highlighted. Thirdly there is interest in the remaining, traditional systems from a conceptual perspective as possible options for low intensity agricultural systems in less favoured areas. In Central Europe traditional wild orchards still cover vast areas but are steadily declining. One of the most important aspects is the economy of agroforestrial systems, which in general is very poor compared to modern and intensive systems of forestry and agriculture. In this context the plantation of different fruit tree species in order to produce veneer wood is an interesting and new interpretation of the traditional wild orchard system. In the district 'Ostalbkreis' in the Federal State of Baden-Württemberg such fruit tree plantations have been implemented since 1997. At seven sites with together ca. 10 hectares plantations with mainly fruit trees have been established. Table 1 gives an overview about the species and related agricultural uses of the undergrowth.

L	Size (ha)	Species	Age	Agricultural use
A	1	*Juglans regia* L.; *J. nigra* L.; Hybrids (*J. nigra x J. regia and J. major x J. regia*); *Prunus avium* L.	15	grazing with cattle; mowing
B	1.3	*P. avium*; *J. regia*; *Pyrus domestica* Med.; *Sorbus domestica* L.	14	grazing; mowing; mulching, bee-keeping
C	1	*P. avium*; *J. regia*; *Pyrus domestica**; *S.domestica*; *S. tormenalis* L.	12	mulching
D	1	*P. avium*; *J. nigra*	12	mowing
E	0.2	*Malus silvestris* Mill.; *Pyrus communis* ; *S. domestica*	12	grazing with sheep
F	0.8	*M. silvestris*; *P. domestica*; *Pyrus communis*; *J regia*; *P. avium*	7	mulching, bee-keeping
G	4 a	*J. regia*; *J. nigra* Hybrids (*J. nigra x J. regia and J. major x J. regia*); *Pyrus domestica*; *P. avium*; *P. domestica*; *Castanea sativa* Mill.	6	mowing

Table 1: Overview of plantations in the Ostalb-District in the Federal State of Baden-Württemberg / Germany in 7 localities. * 4 varieties; ** 10 varieties

Main results are that the quality of the planted trees and careful and intense treatment during the first years are important factors for achieving satisfying growth and potential high timber quality. Economic factors only allow that the undergrowth can be managed as grassland. Up to the age of 10 years of the plantations mowing will be the only option. Markets observations show that demand and supply are extremely volatile. Good prices for high value timber depend on limited availability and being able to match with the market trends. Later once is subject of continuous and unpredictable development. Advice is given that the production of high value timber from fruit trees grown in agroforestry like cultures is economically only successful if production stays small-scale, if a great variety of tree species can be presented and if plantations cover a wide range of age classes.

Integration of trees in the agricultural landscape of Switzerland – a linkage between traditional and modern agroforestry

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Trees on arable land were widely common in the traditionally cultivated landscapes of Switzerland. However, intensification of agriculture and governmental incentives for uprooting standard fruit trees (1960s) reduced the number of traditional standard fruit trees by 80 % since 1950. The traditional orchards, like the streuobst meadows or the selvas in Tessin, the woody pastures in the mountain regions and the hedgerows can be seen as classical agroforestry (AF) systems in Switzerland. The modern systems tie in with these traditional ones and adapt them to the present-day agriculture. Pioneer farmers combine standard fruit trees with arable crops. There is no financial support for AF but farmers can apply for subsidies available for traditional orchards as long as fruit trees are planted. Timber production in AF is hardly practiced. Between 2006 and 2010 the research project "Baumgärten" (tree gardens) was conducted by the Swiss research station Agroscope Reckenholz-Tänikon (ART), which investigated the perspectives of AF in the landscape of Switzerland, with its economical, social and ecological impacts. One outcome was the foundation of the lobby group "IG Agroforst" in 2011, with members out of the sectors research, consultancy, practice and NGOs under the leadership of ART and AGRIDEA, the Swiss federal farm consultancy organisation. The elaborations of political framework requirements, the development of AF-systems in the field and climate certifications are the main activities of IG Agroforst. Furthermore it took position regarding revision of the Swiss agricultural policy. The national annual convention of IG Agroforst took place in April 2012, with international speakers, workshops and excursions. An intended exchange with the timber industry this year will examine the production of high quality timber on AF areas. Special challenges for the future are the ongoing shortage of cultivated land due to rising population density and spreading forest on marginal land. For this reason various stakeholders associate the introduction of trees in cultivated areas with yield reduction and rising labour requirement. Reliable data concerning AF in Switzerland are lacking and evaluations in the "Baumgärten" project were solely based on modelling (Kaeser et al. 2010a). Therefore a follow-up research and demonstration project will intend to establish trial lots on existing farms, collecting and comparing these data. Increased capacity building and the development of consultancy tools should also be part of the follow-up project. The greatest potential for AF in Switzerland exists at sites which are endangered by erosion and at water protecting areas. At those locations and in context of the discussion about sustainable and climate friendly food production, with its rising importance for the costumer, lie further great potentials of AF in Switzerland (Kaeser et al. 2010b; Kaeser et al. 2011).

References

Kaeser A, Palma J, Sereke F, Herzog F 2010b Umweltleistungen von Agroforstwirtschaft / Prestations environnementales de l'agroforesterie. ART-Bericht / Rapport ART 736

Kaeser A, Sereke F, Dux D, Herzog F 2010a Moderne Agroforstwirtschaft in der Schweiz. Zürich, ART-Bericht 725.

Kaeser A, Sereke F, Dux D, Herzog F 2011 Agroforstwirtschaft in der Schweiz / Agroforesterie en Suisse. Agrarforschung Schweiz / Recherche Agronomique Suisse 2(3), 128 – 133

www.agroforst.ch / www.agroforesterie.ch

Is basal tree area a useful indicator for predicting tree-crop interactions in Silvoarable systems? Long-term observations in a walnut (*Juglans* spp.) experimental site

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Novel silvoarable systems, with the intercropping of valuable hardwoods with arable crops, are promising land use systems for Europe, combining food security with timber production and environmental safeguard. The profitability of silvoarable systems is strictly connected with the duration of the period of intercropping, with possible decreasing intercrop yield with increasing tree age. Therefore, it is of primary importance to predict crop yield in relation to increasing tree size, according to simple tree parameters, such as tree basal area (G), as a function of stem diameter and tree density. This hypothesis was tested in experimental plots of walnut trees (*Juglans regia* L. and hybrid NG23xRA, CW and HW, respectively) in central Italy. Trees, established in 1992, were intercropped firstly with wheat (*Triticum aestivum*), then with clover (*Trifolium incarnatum* L) and finally with a natural meadow, comparing intercrop yield to the sole crop as crop reference yield (CRY=[(sole crop yield-intercrop yield)/sole crop yield]x 100). Tree observations were carried on the stem diameter (DBH) and height, leaf phenology, crown diameter (CD). Percentage of photosynthetic active radiation (% PAR) underneath tree canopy was estimated with digital hemispherical photos. Hybrid walnut showed better growth rates in comparison to common walnut, as well as a lower competiveness towards intercrops for a late leaf development in spring. CD was linearly correlated with DBH; G and % PAR were negatively correlated among them. Regression equations between the CRY and G are presented in Table 1: significant negative correlations were found for wheat and the meadow, not for clover in the observed G intervals. Several silvoarable models can be simulated, using G and CRY, in relation to chosen tree densities. These data can be used for minimizing competitive interactions towards the intercrops up to the harvesting age of the timber trees. For example, with 50 tree ha^{-1} the CRY for wheat decreases to less than 80% at a plantation age of ca. 23 years, representing two thirds of the harvesting cycle for hybrid walnut. With a density of 83 trees ha^{-1} the wheat yield should start declining to less than 80% of the sole crop at a plantation age of 17 years.

Obs. Year	Inter crop	Tree species	Regression Equation	r	G interval
2003	Wheat	HW	CRY= -6.21G+100	-0.78***	0-5
		CW	CRY= -8.71G+100	-0.73**	0-6
2004	Clover	HW	CRY= -0.04G+100	-0.07ns	0-6
		CW	CRY= -1.54G+100	0.2ns	0-6
2010	Natural meadow	HW	CRY= -3.9G+100	-0.58*	0-14
		CW	CRY= -4.6G+100	-0.61*	0-10

Table 1. Relationship between plantation basal area (G, m^2 ha^{-1}) and intercrop yield variation in comparison to the sole crop, as Crop Reference Yield (CRY, %), for a walnut silvoarable system in central Italy. *CW and HW=hybrid and common walnut, respectively.*

Session 3b

Trees for a Sustainable European Agriculture

Poster presentations

Triennal production of wheat and barley in association with young pecan in the northeast of Tunisia

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Triennial production of three agroforestry associations was studied in the region of Mateur in the northeast of Tunisia (subhumid bioclimate) from 2008 to 2011. These are crops of durum wheat, barley and faba bean in association with young pecan aged 8 to 11 years for their unproductive phase (0-10 years), to promote this culture in the region, occupying the soil and improving rural incomes interested in it. Pecans were planted at a density of 5 m x 5 m; wheat and barley were sown on the fly (± 200 plants / m²) in the bands between the rows of pecan (EA), near the pecan (SA) and in a control field (TE) with the same soil and climatic conditions while the bean is sown directly in soil. Culture of the faba bean is used as green manure in a classic rotation bean-wheat-barley. Yields of wheat, barley and faba bean planted between rows of pecan (EA) did not differ significantly with those of the control. By contrast, a sharp decline in bond yields was observed for the crops grown near the pecan (SA).The competition of surface roots of trees, and shading trunks and branches are the main causes of declining performance under the canopy (SA). Integration of the bean in the rotation has played a very important role in restoring the nitrogen fixed by its nodes. The pecan cohabits easily with winter annuals because of phenological shift. This system is productive, sustainable and advisable during the unproductive pecan phase.

Trees in the agricultural area: a stable ecosystem decreasing the sensitivity of crops to climatic variability

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For several years in Europe, water has become the limiting factor in agricultural productivity. Between short, intense and sometimes destructive rainy periods, and long dry periods, agriculture must still preserve its yields. Agroforestry (AGF) is an answer to these problems. Three major lessons can be extracted from the latest research on the impact of the rural tree. Contrary to popular belief, the tree does not compete with the crop on water needs. The drought soil peak in an AGF field is delayed for a month and its intensity is divided in half in comparison to the agricultural control test. AGF causes drying of deep soil layers. Because of their opportunistic nature, roots collect nutrients where they are available (depth below crops). The two others explanations are the creation of a cooler microclimate reducing water losses of crops, and the establishment of the hydraulic lift phenomenon. The tree brings back up water from depths by its root system to feed the rootlets of dry soil layers, moistening the soil surface and promoting the growth of mycorrhizae. Water sampling in different soil layers implies an increase of the water retention potential. Infiltration increases by 30% in the dry season and 95% in the wet season, thanks to the vertical structural transformation of the ground caused by an increase in the micro and macro porosity created by the trees roots system. This soil airing coupled with the constant supply of organic matter increase the usable water reserves. More than 200mm of water are stored below a black poplar aged only 12 years, which means more than 800 m^3 at an AGF plot with 50 trees ha^{-1} (SAFE 2012) and reduced runoff water, decreasing flooding risks and soil erosion. The runoff coefficient is divided by three. The tree also allows infiltration water quality by reducing nitrate losses by 36%. AGF system is more water-retaining and also more water-consuming; therefore it could be included as a way to optimize natural resources management. AGF also allows the creation of a stable ecosystem decreasing the sensitivity of crops to climatic variability and annual yields heterogeneity. For all these functions only related to water management, the tree provides services that are necessary to maintain an environmentally friendly and profitable farming system. Moreover, by reducing the violence of floods, AGF systems contribute to population security.

References

SAFE 2012 Silvoarable agroforestry for Europe. http://www1.montpellier.inra.fr/safe/english/results/final-report/SAFE%20Final%20Synthesis%20Report.pdf
Talbot 2011L'intégration spatiale et temporelle du partage des ressources dans un système agroforestier noyers-céréales : une clef pour en comprendre la productivité ? http://tel.archives-ouvertes.fr/docs/00/66/45/30/PDF/These_talbot.pdf

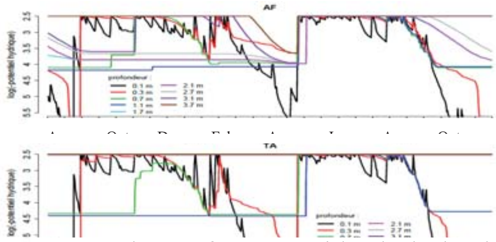

Figure 1: Changes of water potential as the depth and the month (Talbot 2011)

Field trees and hedges against climate change

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Which strategies of plantation in anticipation of climate change? One of the basic principles is to consider that local tree species are the best adapted to the environment. They have to be favored for local plantations. This principle is the adaptation results of hard genetic selections of species and regional provenance adapted to the local climate and soil. The corollary of this principle is that in different soils and climate, species and local provenance won't be adapted. If climate change will modify significantly local climate, it may challenge the principle of adaptation of species and provenances to a new local climate. Hence the dual legitimate questions: do we have to continue to plant native species? If not, which plant? What will be the future climate? The general context predicts a plausible warming of 3-6 degrees over the twentieth century, accompanied by an increase in water deficit, the speed of warming and precipitation changes, all variable according to regions. It is possible to define by regions amplitude limits of expected changes but not to confirm the dates of these changes and their real magnitude. This is a first uncertainty insurmountable today. How will species react to these changes? The importance of expected problems is such that we do not have any references in the past. Species transfer from one region to another in forestry and horticulture confirms that there are limits against climate tolerance, primarily related to cold winters and summer droughts. Climate change currently concerns the tolerance to summer droughts. The analysis of the past human transfer and the climatic limits of natural species area lead to various situations: some species already locally in limits of tolerance appear very vulnerable whereas others are probably able to withstand water deficits significantly stronger. Which plant to choose now? It is essential to define the climate vulnerability of local species for each homogeneous pedoclimatic region (size of French department).Those of which tolerance limits are over plausible climate changes may continue to be planted. For vulnerable species, the life expected for the planted species has to be analyzed. For them, it could be interesting to limit their place in the plants choice, but without their exclusion, because of the uncertainty of the climate evolution and species reactions. To reduce the risk of the decrease of species diversity in the future, we could advise the introduction of current tolerant species to climate variation. Plant species from South of Europe and Mediterranean area have in principle to be preferred. General suggestion: species and provenance transfers are in principle necessary from the South to the North that realizes the crucial implementation of local genetic resources conservation policies. Regional uncertainty on future climate and the likely high diversity of responses according to species need a strong effort of knowledge regionalization. This one is underway in forestry. Species used outside of forests are the same. So a strengthening of links with applied forest research is essential. A transnational approach (Europe and Mediterranean basin) for all work is necessary.

Signs of quality for the conservation and local use of native plant species

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Genetic diversity is essential for the functioning of natural selection. Public action is justified for the conservation of native plants and genetic diversity of plant species. Encouraging initiatives and approaches guaranteed by certifications quickly create local economic development by creating vocational tracks for preserving plant genetic diversity. Many works of landscaping, public parks, wilderness restoration of environments, and preservation of flowers for bees, use seedlings and plants whose origin is not defined or known. These actions can lead to significant risks to biodiversity. In France, excluding forestry regulations covering about 50 tree species, other trees and shrubs, who are mostly found in rural plantations (hedges, rows of trees, agroforestry, riparian strips, compensatory plantations, renaturing, etc..) are not subject to regulation. In France, this concerns at least 250 species of trees and shrubs are concerned. The origin of trees and shrubs for sale is largely unknown, even for local species. These trees and shrubs are not necessarily adapted to local conditions. They often have low genetic diversity. If plantations are successful, the cross-pollinization of these plants with allochthonous strains spontaneous changes the local gene pool and influence the resilience and adaptability of local wild species to natural disturbances. Being long-lived woody plants, this genetic pollution is present for many years. Trees and shrubs are long-lived woody plants; this genetic pollution is exercised for many years. Trees are present in biodiversity corridors, greenways and linear parks. They are important genetic transmitters. Rural trees are leaders in the maintenance and strengthening of the adaptability of trees and shrubs to climate change. Finally, natural regeneration is no longer a guarantee of genetic diversity in some areas, due to a too low density of woody local plants or due to plantations, sometimes widely, conducted over the last 20 or 30 years from plant material of unknown origin or even cultivars. The stakes are four fold: create an eco-friendly economic sector local; preserve resource sites; a national database of wood from local and a national surveillance network of woody plants; and fight against pests. Creating a mark "trees and shrubs of local origin" is based on: areas of crops adapted to the territories of use; a harvest specification by species; a cultivation workbook for each species; a legal notebook tracking from seed to plant; and information carriers and communication.

Research on silvo-arable systems with valuable broadleaves in Catalonia (NE Spain)

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Modern agroforestry is still an incipient, underdeveloped land-use in Spain. In Catalonia region, North-East Spain, dominated by Mediterranean climate, the research on the use of valuable broadleaved species for forest restoration and high quality timber production under minimal management conditions started on 2001. The research conducted by CTFC (Forest Sciences Center of Catalonia) and CPF (Forest Ownership Center of Catalonia) led to promising productive results in the area. During following years, the various topics of research with valuable broadleaves included: a) Study of species and provenances adaptation: around 26 materials of walnut, cherry, ash, service tree, maple, pear tree, etc, were tested all around Catalonia. b) Development and evaluation of plantation techniques aiming at minimizing management: weeding techniques (innovation on biodegradable mulching materials in comparison to traditional techniques) and protection against browsing (individual shelters models) c) Innovation on plantation schemes: mixed plantations of various valuable broadleaved species, combination of broadleaves with short-rotation forestry (poplar, biomass crops, etc.) and with agricultural and pasture use. In this research, an important milestone has been the POCTEFA project "Valuable broadleaves for restoring and enhancing economic development of rural areas: innovation and technology transfer on sustainable plantation techniques" (PIRINOBLE – 2009-2012 - www.pirinoble.eu), developed in coordination with CTFC, CPF, IDF and CRPF Midi-Pyrénées (France). The silvoarable systems performed in the last years, with experimental and demonstrative aims, include:a) A 5 ha system with cereal (rotation of wheat and barley) intercropped by rows of hybrid walnut (*Juglans x intermedia* MJ-209xRa), ash (*Fraxinus angustifolia*) and service tree (*Sorbus domestica*), established in March 2010. This system aims at studying the growth of tree rows when cropped on 1 or 2 sides, and without crops, as well as the effect of trees on agricultural production. Annual measurements on trees include diameter and height growth, nutrient and water status. Annual measurements on crops include production at different distances from tree rows. Because of the young age of the plantation, our results show no interaction so far. b) A 1 ha system where sage (*Salvia officinalis*) is intercropped with hybrid walnut (*Juglans x intermedia* NG-23xRa), since November 2011. The objective of this experience is to study the crossed-interactions between both productions, compared with pure systems of walnut and sage. Experimental monitoring is similar to the previously mentioned silvo-arable system. The promising results of these experiences, although preliminary, are supposed to help spreading modern agroforestry systems in the country.

Olive tree and annual crops association's productivities under Moroccan conditions

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Agroforestry, which means association on the same land of trees and crops, is a traditional practice in Morocco. In some cases, man has eliminated forests to establish agriculture and in others man has associated many crops (annuals, perennial or both) to investigate narrow lands in his possession. In recent years, agroforestry is of high interest for the scientific community at international level because of the negative impacts of monoculture intensification. This TRADITIONNAL and also NATURAL field system has many advantages like preservation of biodiversity, diversification of productions, C sequestration, alternative solution for climatic change or soil erosion control, among others. In Morocco, such practices are used in mountainous and oasis regions where water and/or land resources are limited. In these locations, many crops are mixed and their monitoring is complicated. Unfortunately, few scientific studies were dedicated to such systems and some people might describe them as primitive, no productive and indicates that they must been changed. Also, technical advertising, when it is possible, concerns every crop solely and not the whole system. The aims of this work, based on diagnosis, are to a) determinate of the importance of olive tree and annual crops association b) to perform an agronomic diagnosis of the system, c) to evaluate of advantages and disadvantages of such practice according to farmers and scientists point of views. Methodology included an a) Agronomic diagnoses was mainly carried out in the region of Meknès Fès Sefrou and others regions, where experimentation was also implemented including description of crops between olive tree rows, olive tree density, distance left between olive tree and annual crops and different crop results b) Interviews of farmers, researchers, development agents to determine the importance, advantages and disadvantages of these practices and c). Exploration of date and study made after evaluating approximately 70 reports. Results showed that 75% of farmers growing olive trees are also producing annual crops between tree rows. Those crops included cereals, legumes, and vegetables. Cereals are dominant in 50% of land occupation. We estimated that for an average density of 100 tree ha^{-1}, annual crops may occupy 75% of the land, while olive tree may occupy the remaining part. Farmers indicated that technical interventions (ploughing, fertilizing) concerns mainly annual crops and then can promote olive tree production. Olive tree monoculture is described by plantation age, density or accessibility. According to farmer's estimations: legume crops like faba bean do not affect olive production, when compared with cereals like durum, soft wheat or barley. Olive production is reduced by about 39%, when cereals are intercropped between the rows. However, farmer produces an added value of cereals or legume of respectively 9 and 7 Mg ha^{-1}. We hypothesized that legume do not affect negatively olive production since those crops have short cycle and may provide nitrogen to plantation as a result of biologically fixation. We can conclude that the association of perennial and annual crops is a common practice by farmers and might be more important in future due to land scarcity. Scientific development to analyse such systems is necessary. Positive and negative interactions should be elucidating to choose more profitable combinations in adequate conditions. Association of perennial and annual crops might be an interesting option to face climatic change and climatic variation and, at the same time, it could enhance land profitability.

Inoculation of chestnut (*Castanea sativa* Mill.) saplings in a chestnut grove with *Amanita caesarea* (Scop.:Fr) Pers. mycelial inoculant and monitoring of its persistence in soil

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In the Natural Park of Sierra de Aracena y Picos de Aroche (Southwest of Spain) European chestnut (*Castanea sativa* Mill.) constitutes an agroforestry system that is one of the identifying traits of the Park,with a great social and landscape value but, nowadays, with clear symptoms of abandonment because of its low profitability. In this area, chestnut groves occupy near 5000 ha and many of them are potential areas for *Amanita caesarea* fruiting. *A. caesarea* is a fungal species with an important ecological function because it forms ectomycorrhizas with chestnut. In addition, its carpophore is widely appreciated as edible, which adds value to the chestnut groves. However, *A. caesarea* fruiting is scarce or absent in many of these chestnut groves and it is not detected in the rhizospheric soil. As an alternative to increase the profitability of these abandoned chestnut groves, the aim of this work was to achieve the fruiting of this prized fungal species. Several inoculation assays were carried out in a chestnut grove, where there were not *A. caesarea* mycelium in the soil and therefore no fruiting bodies have appeared in the recent years. *A. caesarea* mycelial pure cultures were obtained from sporocarps collected in a chestnut grove in the Park and mycelial inoculant was applied as alginate mycelial beads on chestnut saplings. Four months after inoculation *A. caesarea* has been detected in rhizospheric soil by PCR techniques using ITS rDNA fluorescently labeled primers. DNA extracted from *A. caesarea* mycelial pure culture was used as a reference. Successive soil samples should be taken and analyzed to confirm the survival of the fungus as a first step to achieve *A. caesarea* fruiting in these chestnut groves and contribute to the sustainability of this valuable agroforestry system.

Agroforestation and level of income in Italian rural areas: an analysis of multifuntionality in the rural development plan

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The second pillar of Common Agricultural Policy has defined some principles to improve rural development through multifunctionality; this implies the need for farmers to plan and put into practice different activities to protect the rural space both in environmental terms and also in economic terms. In particular, agroforestation, by different actions put into place since 2000 by the European Union, has produced positive impacts on the transition from an agrarian productivist model to a post-productivist one. Many Italian regions, giving subsides to farmers, have improved the level of agroforestation in different rural territories with plenty of positive socio-economic aspects, including improving the level of income of farms. The aim of this paper was to analyze, using a quantitative approach by a regression model, the main and foremost relationships among the dependent variable, in terms of income of farmers, and the independent variables such as amount of subsides paid by the European Union to improve the afforestation of rural areas, afforested surfaces, number of farms in activity, number of agro-touristic farms and number of rural districts, which are proxy variables of pluriactivity in the primary sector. During the time of observation, from 2000 to 2012, it was possible to observe an increase in dimension of cultivated surfaces by forest and a growth of farmer's income due to the development of different activities. To sum up, agroforestation was a positive tool to increase the pluriactivity in the primary sector and to protect rural space by multifunctionality reducing the supply of commodities in particular in some Italian regions located close to mountain areas.

The rural tree as a green network of agricultural landscapes

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The future of biodiversity of agricultural areas requires the strengthening of biological reserves and a connection between each of them. Indeed, for each species to ensure its durability, it needs appropriate feeding, growing and reproducing conditions. But that is not enough; a population also requires exchange with other neighboring populations to mix genes. Most animal and plant species use these "road links" called corridors. Currently, the amount of these elements in the majority of agricultural landscapes is decreasing (hedges, ponds, bank, dry stone walls ...) and now they have become insufficient to ensure the maintenance of biodiversity. Successive assessments are clear; biodiversity is always declining in these landscapes. The changeover from diversified family farming to a simplified and specialized agriculture based on the expansion of field sizes, production increases, on seed selection and on the huge use of chemical products is mostly (rajoute cela si ce n'est pas la seule cause, cela rend la chose moins radicale) responsible for these losses of habitat. This evolution leads to biological dysfunctions and, consequently, an enhanced and permanent presence of pests. Environments need to be more complicated to find balance again. *Why (do we have to) maintain a dynamic biodiversity in agricultural area?* A general principle for species conservation must guide man in space management. Although some species are out of interest for our current activities, it is wise to keep them alive, because needs and knowledge evolve. Then, the regulative principles and the balance within ecosystems can be used as production principles. For example, feeding intelligently the soil increases the presence of numerous fungi. Most of them have no effect on productions such as cereals. By the place they permanently occupy in soils, these neutral fungi will reduce the development and presence of fungal diseases specific to cereals. *How?* The idea is to increase the number of tanks and connections. So, by reconstructing new habitats in the center of agricultural islands, the roughness and the heterogeneity of the landscape will increase. The tree is a major tool to structure the landscape. By its multifunctionality, the tree also impacts positively on some agricultural aspects (soil fertility, water retention.....). It also brings an added value as carbon sequestration, biomass sector, green tourism, useful and profitable for the farm. Biodiversity is a common good; to give it a financial value can only be done though other products. We must continue to act on these agricultural areas to produce, but we must stop doing it to the detriment of vital causes such as water quality or biodiversity. It is therefore by directing the way of production to the fundamentals of agroecology that the future of biodiversity will be guaranteed.

Figure 2: Earwig on a branch

Agroforestry system – its implementation in research and forestry practise in Slovenia

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Agroforestry (AGF) combines a number of economic, ecological and social functions and represents a great potential for Slovenia. In Europe we recognize 6 basic types of AGF practices: silvopasture, forest farming, silvoarable AGF, riparian buffers, multipurpose trees and improved fallow. We present the first overview of potential uses of AGF systems, their products, services, and a legal basis for implementation in Slovenia. Most of the above mentioned AGF types are not explicitly regulated in Slovenia, but some of them have existed in the territory under different names or uses for centuries. The existing legislation doesn't directly deal with AGF although it relates to a number of legal bases. Silvopasture is one of the oldest and most recognizable types of AGF in Slovenia. At the end of the last century there was extensive interdisciplinary research on silvopasture, in particular on forage. Trees were considered primarily in terms of increasing biodiversity and additional fodder for livestock. In the Slovenian forest management system we apply several methods for stimulating the production of non-timber forest products in the forest. For example, Slovenia is preparing regular management plans for wild game. The methods for targeted cultivation of specific products, such as ectomycorrhizal fungi are under development and application. Still there is a lack of long-lasting and educational examples for growing mycorrhizal fungi in plantations or suitable natural habitats. Silvoarable AGF in Slovenia can be linked with trees growing on agriculture land such as hedges or windbreaks. This type of AGF is especially important in the areas where reclamation of the land and the absence of the trees is causing a number of environmental problems. Management of riparian forest in Slovenia is also provided in forest management plans. The Forest Act distinguishes between indigenous and non-indigenous riparian tree zones although the non-indigenous tree zones are not considered as forest. Riparian buffer strips are often considered in terms of biodiversity, wind protection and landscape enhancement. With development of intensive agriculture practices, orchards as an example of multipurpose tree AGF had lost their importance. With the project "Revival of orchards and fruit gardens in Slovenia" the importance of the orchard in terms of fruit production and biological diversity was discovered again. Improved fallow was a traditional type of land use where forest was slashed and burned for agricultural land. Today it is no longer in use. The current situation of AGF in Slovenia shows fragmentation, poor organization and lack of knowledge and experience. There is an absence of good practices which would encourage their use among land owners. New research built on existing knowledge and interdisciplinary approaches could provide us with the necessary knowhow on advantages that AGF can offer in Slovenia. At the same time we believe that more intensive research will improve the collaboration between forestry, agriculture and other sectors. This will ensure even more effective, profitable and nature friendly use of natural resources.

References

Vochl S, Premrl T, Grebenc T, Ferreira A (2012) Agroforestry system - its implementation in research and forestry practice in Slovenia. Les, 64(5): 142-150.

Trees outside forest, markers of the evolution of landscapes and farming practices in Europe

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As a component of very old agrarian systems, arboriculture has historically contributed to the plant or landscape diversity of the territories. Legacy of past rural systems who have used the tree as structuring element, landscapes of trees outside forest today are a threatened heritage and are little taken into account in the public policies. From the 1960s, these extremely diversified wooded systems are often fallen into disuse, were destroyed or replaced by an intensive and standardized arboriculture, which radically changed these landscapes. The longevity of the trees can hide a trend to abandonment but many traditional agroforestry systems have lost their usefulness and their features. Some trees outside forest's landscapes may thus be viewed as relics and one can even speak of critical situation for the survival of certain complex traditional agrosilvopastoral types, as for example those of wooded pastures or pastured-orchards. The poster will present results of a research conducted in France (Midi-Pyrenees), Spain (Andalusia) and Italy (Ligurian Apennines), on sites selected by being concerned with landscapes in a crisis or abandonment situation: their recent history and dynamics in course, operating modes and resource uses. They represent a scientific and policy issue not only because of the problems and challenges they pose, but also by the potential they represent. Indeed, by their frequency and spatial extension, they represent a heritage that should be recognized as an intergenerational resource for the future. Vectors of biodiversity, they represent one of the dimensions of the European cultural heritage that must be taken into account in the local, regional and national policies of sustainable development.

Root activity of some trees under agroforestry systems: can it be traced by soil chloride content?

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Agroforestry is an emerging strategy to reduce the detrimental effects of intensive agriculture while sustainably feeding an increasing number of people. Compared to tropical areas, much fewer studies have been conducted on the effect of agroforestry on soil quality in temperate areas. At least in Europe, the farmers are still quite hesitating to adopt this because of the uncertain impact on crop productivity through the competition for water and nutrients. Therefore, there are urgent requirements for researchers to provide further information on the interactions between trees and crops on the spatial distribution of their respective root systems. Due to their roots and canopy, trees can create a zone of influence for the nearby soil and crops. The intensity of the impact on soil varies along the influence-zone. How do the trees affect surrounding soil in 3-dimensions? Without this knowledge we cannot predict how trees compete with the crops. Here we propose that the chloride could be a feasible indicator to study the active zone of root and therefore the impact of trees on soil moisture. We found high chloride concentrations in the soil under oak hedgerows at the end of the growing season. By measuring tree transpiration, water pressure head at different depths in the soil and groundwater level, water balance was computed over the studied period. Then we modeled chloride under the hedgerow with well-recognized software HYDRUS-1D. We show that hedgerow transpiration was very high. Consequently, the high transpiration lead to the accumulation of chloride when chloride is excluded by tree roots during the uptake of water and nutrients. This research indicates how chloride could be used as an indicator of trees roots spatial distribution.

Trace metal availability under different land uses (forest and agriculture)

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Trace metal concentrations in soil solution represent the most available fraction of trace metals. Extraction by ultra pure water has shown to be a good indicator of soil solution concentration and trace metal availability. In the present study, soil solution concentration of toxic (Cd and Pb) and essential (Mn and Fe) metals were examined for differences between land uses (forest and agriculture). The study was conducted in Eastern Croatia. The results indicate a significant influence of land use on water extractability of all examined metals except Fe. In water extracts from forest sils, the concentrations were significantly higher compared to extracts from agricultural sols for Mn ($p<0.001$), Cd ($p<0.001$) and Pb ($p<0.01$) (Tale 1). Such behaviour of water extractable trace metals is most likely related to soil pH and DOC, since soil properties also showed significant difference among land uses (Table 1). Several authors showed that soluble concentrations of trace metals are controlled by soil properties mainly pH, SOC and DOC (McBride et al. 1997; Tipping et al. 2003). These findings, in context of agroforestry, can indicate beneficial effect of using trees on agricultural land for availability of essential elements such as Mn, however, together with essential elements toxic ones (Cd and Pb) will also become more mobilized and available for plants.

	Land use	n	Mean	StDev	Min	Max
Fe	Agri. field	53	20.13	29.29	0.36	125.3
$mgkg^{-1}$	Forest	21	20.17	15.37	0.61	69.4
	ALL	**74**	**20.14^{ns}**	**26.00**	**0.36**	**125.3**
Mn	Agri. field	53	0.9	2.9	0.004	20.89
$mgkg^{-1}$	Forest	21	4.3	4.1	0.096	18.15
	ALL	**74**	**1.86^{***}**	**3.6**	**0.004**	**20.89**
Cd	Agri. field	53	0.0006	0.001	0.00003	0.007
$mgkg^{-1}$	Forest	21	0.0019	0.0008	0.00086	0.004
	ALL	**74**	**0.0009^{***}**	**0.001**	**0.00003**	**0.007**
Pb	Agri. field	53	0.008	0.009	0.0004	0.042
$mgkg^{-1}$	Forest	21	0.015	0.010	0.0010	0.038
	ALL	**74**	**0.010^{**}**	**0.010**	**0.0004**	**0.042**
pH	Agri. field	53	6.8	1.003	4.3	8.02
	Forest	21	5.2	0.825	4.4	7.40
	ALL	**74**	**6.3*** **	**1.180**	**4.3**	**8.02**
SOC	Agri. field	53	1.5	0.7	0.46	4.4
%	Forest	21	2.3	0.8	0.94	5.1
	ALL	**74**	**1.7*** **	**0.8**	**0.46**	**5.1**
DOC	Agri. field	53	16.3	4.8	6.1	33.1
mgl^{-1}	Forest	21	50.5	12.9	23.8	73.0
	ALL	**74**	**26.0*** **	**17.4**	**6.1**	**73.0**

Table 1. Descriptive statistics for water extractable trace metalsand main soil properties under different land uses (n = 74). n – number of samples, Fe - Iron, Mn – Manganese, Cd – Cadmium, Pb– Lead, SOC – soil organic carbon, DOC – dissolved organic carbon; *, ** and *** indicate significant difference between land uses at $p<0.05$, $p<0.01$ and $p<0.001$ respectively, ns stands for not significant.

References

McBride M, Sauve S, Hendershot W 1997 Solubility control of Cu, Zn, Cd and Pb in contaminated soils. *European Journal of Soil Sciences* 48, 337–346

Tipping E, Rieuwerts J, Pan G, Ashmore MR, Lofts S, Hill MTR, Fargo ME, Thornton I 2003 The solid-solution partitioning of heavy metals (Cu, Zn, Cd, Pb) in upland soils of England and Wales. *Environmental Pollution,* 125, 213–225

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The field tree, a sustainable fixer of carbon

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The field tree has the advantage to fix carbon permanently in agricultural areas and to be less limited to enhance the storage further than the forest tree. Regions and rural territories have over the last few years undertaken a thorough review on energy and climate changes. As part of the establishment of Energy and Territories Climate Plans (the evaluation of potential carbon storage represented by hedgerows), the field tree appears essential. This assessment has led to the development of an innovative methodology of work on this problem. From the inventory data of hedges, a bibliographical synthesis, validations, adjustments, and typological classification are needed to better define the components of hedges identified in the territories. The determination of linear hedges and isolated trees, according to their developmental characteristics and their spatial densities, allows the assessment of the total length. Field surveys and scientific works of different regional and national programs are organized to establish the volume and biomass of aerial and root parts, but also of the soil by the presence of the trees elements. These data are used to estimate the carbon storage from the hedge and the individual trees. Thus the elements previously identified and quantified allow the assessment of the carbon stock of a hedged farmland. The evaluation of the annual growth of the hedges, current knowledge and observed practices helps assessment of the carbon influx according to different hedge types. These values are assessed yearly. This assessment helps to highlight a large variability depending on the type but also the topographical location of the hedges. Flows can range from 30 kg to 1.23 metric ton of $C0_2$ per 100m per year according to the type and location of the hedge notably against the slope. To cope with climate changes, do the different agroforestry forms offer margin of improvement? Two strategies are explored. The first one develops simple measures based on factors of increase and regeneration of hedge networks. The increase of carbon storage potential could be also done by the development of agroforestry and tree and hedge management, such as removal of strong pruning, exchange between less productive hedges by dynamic systems of hedges and different tree size. Finally, the development of hedge management plans is the first step to optimize wood production. The second point is about the establishment of a carbon market that could give a carbon value to hedgerows in addition to energy and timber wood. The establishment of such a market requires discussions with all the stakeholders already identified in the territories and perhaps some new ones as producer groups. There are now so many solutions that can be mobilized but they require a consideration that must be realized in consultation with all the stakeholders on fieldwork and must be well technically accompanied.

Analysis and evaluation of agroforestry systems using landscape indicators

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Agroforestry systems (AGF) are land uses that include the combined production and use of forest trees, agricultural crops and/or livestock, on the same land unit, either by spatial arrangement or in chronological sequence. AGF landscapes result from a complex agricultural and ecological history and constitute elements of cultural heritage. In northern Greece, traditional AGF are in danger of being abandoned or converted to intensive monocultures. This process could lead to subsequent loss of biodiversity, ecosystem stability and accumulated cultural knowledge. This could be avoided by preserving the active and functional AGF and restoring the abandoned ones, always taking into account the prevailing socioeconomic conditions. The purpose of this paper was to develop a methodology for the analysis and evaluation of AGF of Macedonia-Thrace (Greece), using tools and applications such as ArcGIS, Fragstats, PCA etc. in combination with traditional knowledge (interviews with local people, literature, etc.). To achieve this purpose, the following objectives were set: a) identification and inventory of AGF b) evaluation of abiotic, biotic factors and management actions that influenced and still are influencing their present status and c) evaluation and comparison of seven (7) AGF by using landscape indicators. In order to achieve these objectives the AGF were identified and mapped using satellite images and orthophotos. This was followed by A survey of environmental and socioeconomic factors. Finally, for the seven selected A.S., indicators of a) patch size, density and perimeter b) patch shape, c) patch isolation and proximity and d) landscape connectivity, were calculated using the program Fragstats. It was revealed that the A.S. of Macedonia-Thrace over 10 ha are 695 and occupy a significant proportion of land uses which is not apparent in the official state statistics, but it is incorporated and mentioned, in most cases, as agricultural land. Moreover, the principal component analysis showed that seven main factors affect and shape the AGF in Macedonia and Thrace. These factors contribute to the 64.72% of the total explained variance and, in order of importance, are the environmental conditions, the population potential, the social basis of management, the degree of use of the AGF, the potential for production movement, the adequacy of water and the isolation of the systems. From the analysis of landscape indicators for the seven selected areas it is concluded that they are a useful tool in interpreting the sociopolitical conditions that shape the landscape of the A.S. Specifically, landscape indicators NP, LPI, AREA, SHAPE, PAFRAC, GYRATE and CONNECT can serve as indicators to depict A.S.' abandonment. Landscape indicators ENN, CA, LPI, AREA, SHAPE, PAFRAC, PROX, GYRATE and CONNECT can depict landscape pattern in A.S. The measurement of landscape connectivity is possible by the use of indicators CONNECT and GYRATE. Depicting landscape pattern may serve as an interpretative tool to monitor A.S. abandonment. It is also demonstrated that agroforestry serves as means to improve landscape from an environmental, aesthetic and economic point of view. It is imperative to put into practice landscape and AGF policies promoted by the EU in order to maintain AGF landscapes of Greece, and also to provide significant growth potential to rural economies.

Establishment of new agroforestry systems in northern Greece

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Silvoarable agroforestry that comprises widely-spaced trees intercropped with arable crops is an old practice in Greece. In several areas, traditional silvoarable systems occur with different combinations of trees and crops depending on the ecological zone and the agricultural practices. They cover an area of about 1,000,000 ha and according to tree species, divided into traditional silvoarable systems with natural (800,000 ha) and cultivated trees (200,000 ha) (Papanastasis et al. 2008). The most important systems with cultivated trees are the intercrops of olive trees with annual crops (cereals, vegetables, grapes) (Eichhorn et al. 2006), fruit trees (apple, pear, peach, apricot, cherry) with annual crops (cereals, vegetables) and nut trees (almond, walnut, chestnut) with arable crops (cereals, vegetables, grapes) (Papanastasis et al. 2008). Although the trees were planted recently, they are managed with traditional practices in order to produce fruits, nuts or fodder. Only recently recognized is the role of these trees to produce high quality timber similar or better to timber imported from tropical areas. During the last decade, modern practices for the management of agroforestry systems have been introduced to farmers of northern Greece, and several conferences and seminars are organized in order to inform farmers of this new land use practice. Under the European research project SAFE, experimental plots were established at the Municipality of Askio (northwest Greece) (Mantzanas et al. 2005). Specifically, 3 plots covering an area of 2 ha were established in collaboration with local farmers. The tree species were hybrid walnut, cherry tree and the local species *Celtis australis*. Two of these plots were cultivated with cereals and the other with maize. As expected, trees at the maize plot had an amazing growth the first 2 years due to summer irrigation. After that period the farmer changed the crop and cultivated legumes without irrigation resulting in a constant growth for a period of 4 years. The last 3 years, an increase in height and diameter at breast height was observed. Trees did not affect the crops because of the young age and the specific shape formed by branch cutting in order to produce clear and good quality stems at a height more than 3 m. Regarding the cereal plots, there was a slow increase (height and diameter) in all tree species the first 6 years. A remarkable increase followed the last 3 years. This is, probably, the result of good tree establishment. Trees were not affected by the cereal crops and the cultivation activity all these years. On the other hand, trees did not affect the crops due to their age (9 years old). All tree species had similar growth in height and diameter. The experimental plots constitute a living advertisement of modern agroforestry systems and make farmers more aware of this new land use practice.

References

Eichhorn MP, Paris P, Herzog F, Incoll LD, Liagre F, Mantzanas K, Mayus M, Moreno G, Papanastasis VP, Pilbeam DJ, Pisanelli A, Dupraz C 2006 Silvoarable systems in Europe – past, present and future prospects. Agroforest Syst 67:29–50

Mantzanas K, Tsatsiadis E, Batianis E 2005 Traditional silvoarable systems in Greece: The case of Askio Municipality. In Mantzanas K., Papanastasis VP (eds) Silvoarable systems in Greece: Technical and policy considerations. Laboratory of Rangeland Ecology, Aristotlte University, Yhessaloniki, Greece, February 2005 (in Greek with English summary)

Papanastasis VP, Mantzanas K, Dini-Papanastasi O, Ispikoudis I 2008 Traditional agroforestry systems and their evolution in Greece, p. 89-109. In: Agroforestry in Europe: Current Status and Future Prospects (Rigueiro-Rodríguez A, McAdam J, Mosquera-Losada MR (eds). Springer Science

Towards the silvopastoral management of high quality timber plantation. The case of mature walnut in Mediterranean Spain.

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In the last decade, intensive hardwood plantations, based on high levels of energy consumption and chemical inputs, have substantially increased in many Spanish regions. However, periodical harrowing and the use of herbicides and mineral fertilizers are controversial management practices. Silvopastoral management could allow reducing the economic costs of these plantations and optimize their overall environmental services. Here we present preliminary results of the Spanish project SILVOMAD where we evaluate the response of intensive walnut plantations (3-4 harrowing per year of alleys, 2-3 herbicide application per year in the tree lines, and fertirrigation) to alternative methods to: Control the competing herbaceous understory (harrow, brushcutter, grazing). Substitute the mineral N fertilization by sown of leguminous pastures will also reinforce pastoral value. These treatments are combined with different doses of irrigation (W1 to W3, with 1 to 3 lines of drip irrigation), to respond to water shortage and competition among trees and understory in Mediterranean agroforestry systems. After 12 years of intensive management, the management change did not affected walnut water status or mean leaf water potential (Ψ=-1.5 ± 0.1 MPa). Only with the lower dose of irrigation, trees without control of understory herbs showed Ψ marginally lower. CO_2 assimilation rate (*A*) depended marginally of dose of irrigation, with lowest *A* values in W1. While in W1 the lowest mean value of *A* was recorded in grazed plots, increasing irrigation dose (R3), *A* trended to be higher in grazed plots than in other treatments (Table 1). Results of photochemical efficiency indicate that walnuts did not suffer important stresses, although slight but significant differences were detected (Table 1). Legume sown worsened slightly the state of walnut leaves, while with grazing walnuts maintained very high values of Fv/Fm. Although in this first year, the increment of the tree diameter (0.5 cm y^{-1}) was not affected by management practices, slight differences in the physiological parameters could indicate a potential slowing of the tree growth at the long term with the silvopastoral management here tested, which could be prevented increasing the dose of irrigation.

Management and Watering treatments	CO_2 ASSIMILATION RATE µmol CO_2 m^{-2} s^{-1}				PHOTOCHEMICAL EFFICIENCY Fv/Fm		
	W1	W2	W3		W1	W2	W3
Control	7.0±1.0 abcd	7.3±1.1 ab	6.6±0.8 abcde		0.790±0.005 g	0.807±0.003 bcde	0.806±0.003 bcdef
N-Fertilized	5.2±0.9 de	7.6±1.0 a	5.3±0.9 cde		0.803±0.003 def	0.806±0.003 bcdef	0.814±0.004 abc
Legume	5.8±0.8 abcde	6.5±0.8 abcde	6.3±0.7 abcde		0.804±0.004 cdef	0.797±0.004 fg	0.799±0.005 efg
Harrow	5.6±0.6 bcde	6.3±0.8 abcde	5.3±0.7 cde		0.816±0.003 a	0.814±0.004 ab	0.811±0.003 abcd
Brushcutter	5.9±0.8 abcde	6.4±1.0 abcde	6.7±1.0 abcde		0.817±0.002 a	0.813±0.003 abc	0.807±0.005 bcde
Grazed	5.1±0.7 e	5.7±0.8 bcde	7.1±1.1 abc		0.810±0.004 abcd	0.807±0.007 bcde	0.810±0.005 abcd
	Manag	Wat	Manag x Wat		Manag	Wat	Manag x Wat
p-values	0.353	0.089	0.193		**0.003**	0.288	**<0.001**

Table 1. Mean values (±S.E.) of CO_2 assimilation rate and photochemical efficiency in walnuts with different management of soil and understory herbs. Different letters indicate significant differences (p=0.05).

Cu dynamics in *Quercus rubra* L. agroforestry systems after sewage sludge inputs

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Many studies have shown that the use of sewage sludge as fertilizer in Galician silvopastoral systems increase tree growth and pasture production. However, the application of sewage sludge to soil can pose a threat to the environment, with the major concern arising from the fact that sewage sludge contains a relatively higher concentration of heavy metals (mainly Zn and Cu) than that normally found in soils, which is regulated in Spain by the R.D. 1310/1990 and by the European Directive 86/278/EEC. When sewage sludge is used as fertilizer it is important to apply adequate dose of this residue. The agronomic rate that can be safely applied depends both on the heavy metal concentrations in the sludge and on the N concentration and the proportion of the N that can readily be mineralised within the first year after application to the soil. A sewage sludge application rate exceeding crop needs could result in leaching losses of Cu and N to ground and surface waters, thus affecting drinking water quality. The objective of the present study was to evaluate the effects of different dose of sewage sludge (100, 200 and 400 kg total N ha^{-1}) compared to control treatment (no fertilization) on the total and available Cu concentration in soil and the Cu levels of pasture in a silvopastoral system under *Quercus rubra* L. The results showed that all values of total Cu in the soil of this experiment were very low compared to the Spanish regulation limits (50 mg kg^{-1}) (RD1310/1990). This may be explained by the fact that sewage sludge is produced in an area without nearby pollution sources and that the soil had initial low levels of this element (11.6 mg kg^{-1}). Moreover, the concentration of soil total and available Cu was higher in the last years of the study than when the experiment was established, probably due to the slow incorporation of sewage sludge to the soil over time. Regarding to the effect of treatments, in general, high doses of sewage sludge increased more the concentration of soil total and available Cu than the other treatments, because Cu was present in the sewage sludge in greater amounts than the background values in the receiving soil and the amount of Cu applied to the soil with the high doses of sewage sludge was higher than with the low and medium doses. Finally, an increment of soil total and available Cu increased the Cu concentration in pasture but not exceeding the range between 20 and 100 mg kg^{-1}, which are considered excessive and toxic, respectively, for plants.

Fertilization effect on pasture production and tree growth after 10 years establishment

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The combination of tree and pasture production has been recently promoted by the EU. Pasture production under trees produces annual farm outputs which promote long term rural population stabilisation compared with exclusively forest systems. At the same time, the presence of a tree increases the long term value of the land. The objective of this study was to evaluate the effect of two different tree densities and species, and fertilization on annual meadow production after 10 years of a silvopastoral system establishment. The tree species were birch (*Betula alba* L.) and pine (*Pinus radiata* D.Don) established with two different fertilisation management: no fertilisation (management traditional option for forestlands) and mineral fertilisation (management traditional option for agronomic lands). Initial sown species included perennial ryegrass (*Lolium perenne*) together with white and red clover (*Trifolium repens* and *T. pratense*). The results showed a significant effect of fertilization, and tree species type and density on meadow production. Meadow production was not reduced over time in spite of tree canopy development under birch, but indeed it was diminished under both *Pinus radiata* densities very soon, which makes birch more suitable for combining tree and meadow production when compared with pine. Fertilization had a major effect at the start of the experiment in terms of modifying annual meadow production. However, by the end of the experiment fertilization effect was modified by tree density as can be seen in Figure 1.

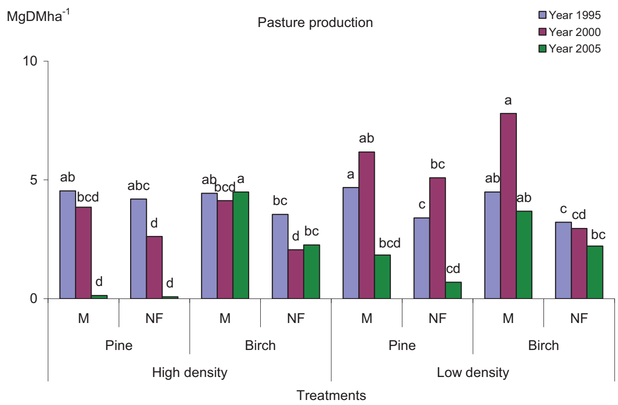

Figure 1. Pasture production (Mg DM ha^{-1}) in the systems for two planting densities (High density: 2,500 trees ha^{-1}; Low density: 833 trees ha^{-1}), two types of tree canopy (*Pinus radiata*: Pine, and *Betula alba*: Birch) and two different fertilisation management (M: mineral fertilisation, NF: no fertilisation). Different letters indicate significant differences between treatments in the same year ($p<0.01$).

Pasture production on dense stands and fire risk

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Spain, together with Greece, Italy and part of France has to manage forest for wood and environment services production, but taking into account the high fire risk that forest has in these areas. Galicia has one of the highest forest fired rate of Europe due to the high land productivity of the region caused by high precipitations and warm temperatures during the spring followed by an usually dry summer, when understory and forest are burnt. Foresters use to recommend high stand densities, over 1667 trees ha^{-1}, because then, good phenotype trees are ensured (improved genetic trees are usually lacked). They expect that fire risk is reduced due to shading created by the tree canopy development that limits understory growth. However, this fact depends on tree type and the age of the stand. *Pinus pinaster* Atlantic sub-species and *P. radiata* are the most important conifers planted in Galicia and they use to be planted at a high density. In the first years after planting, they have a free canopy growth until tree cover is over 100%. This causes a high reduction on understory pasture production, but also a tree leaf fall due to the lack of light for the inner parts of the trees. Pinewood and senescent material in soil could be as high as 7 Mg ha^{-1} year^{-1} after 10 years of planting 2500 trees ha^{-1} after 8 years in high dense stands. A similar result is obtained with 1667 ha^{-1} after 15 years of tree planting with the traditional lack of management of these stands, explained by the high costs. Both, the amount of pinewood in the understory and dead branches of trees connected through the stand make difficult to stop fires once they start. As the time pass through, lower branches are broken if not pruned and light start to go through the canopy reaching the soil. This originates a reduction in the pinewood layer which is incorporated into the soil (due to better temperatures and humidity) allowing the development of a shrubby understory, which competes better for the resources than the herbaceous understory with trees (Mosquera-Losada et al. 2011) and therefore reduces tree production. Therefore, understory composition varies due to the development of tree in dense stands causing a reduction on high quality timber productivity and increasing fire risk. On the contrary, the use of broadleaves at high stands like birch, allows herbaceous production up to 4 Mg ha^{-1} year^{-1} after 15 years due to better incorporation of leaves in the soil which also allows a high amount of light reaching the understory. However, tree growth is strongly reduced at 2500 trees ha^{-1} probably due to the higher intraspecific tree competition. Both biodiversity and C soil storage is also significantly improved by using birch instead of *Pinus* (Rigueiro-Rodríguez et al. 2010). In any case, from a tree and understory point of view, low densities should be promoted to reach more sustainable systems and allow obtaining better intermediate pasture production and final tree production.

References

Mosquera-Losada MR, Cuiña-Cotarelo R, Rigueiro-Rodríguez A (2011) Effect of understory vegetation management through liming and sewage sludge fertilisation on soil fertility and Pinus radiata D. Don growth after reforestation. European Journal of Forest Research 130(6):997-1008

Rigueiro-Rodríguez A, Mosquera-Losada MR, Fernández-Núñez E (2010) Afforestation of agricultural land with Pinus radiata D. Don and Betula alba L. in NW Spain: effects on soil pH, understorey production and floristic diversity eleven years after establishment. Land degradation and environment 21:1-15

Soil density and carbon sequestration changes in *Prunus* silvopastoral systems

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Silvopastoral systems have been considered a good tool for carbon sequestration by taking up atmospheric carbon dioxide and storing it in the tree, understory and soil. The effect of animal presence on carbon sequestration in silvopastoral systems has to be evaluated as they could increase or depress carbon sequestration depending on stocking rates and the effect on soil organic matter mineralisation mainly caused by faeces. Also soil fractions have been known to influence carbon storage. This study was undertaken to demonstrate the effects of livestock grazing at two different stocking rates [Light stocking rate (LS; 4 sheep ha^{-1}) and heavy stocking rate (HS; 8 sheep ha^{-1})] compared silvopastures with no grazing (NG) on the amount of carbon stored in the whole soil and three differently sized soil fractions (250–2000 µm, 53–250 µm, < 53 µm) at four soil depths (0–25, 25–50, 50–75, and 75–100 cm) and tree growth. The presence of animals in silvopastoral systems plays an important role in carbon sequestration by direct or indirect modifications of pH, soil bulk density, and soil fraction proportions. LS promoted carbon sequestration linked to macroaggregates in the upper soil layers compared with HS and NG. However, in deep horizons NG enhanced SOC storage more than grazing treatments and this carbon was linked to microaggregates, increasing the soil density. Better carbon concentration was found when 1 m soil depth was evaluated in LS treatment, but no differences in the carbon storage per hectare were found due to the high soil bulk density in NG treatment. The presence of trees plays an important role in soil carbon sequestration which could be modified by the presence of livestock by direct or indirect chemical (pH) and physical (soil bulk density and soil fractions) modifications of soils. The major soil carbon sequestered was found in the first 50 cm of soil and it was linked with macroaggregates and occurred in LS treatment due to the greater presence of root biomass and OM addition by animal excreta than in NG and higher soil pH than in HS. In the deeper soil layers, the major soil carbon sequestered was related to microaggregates and was enhanced by NG treatment due to higher soil bulk density and the indirect effect of the greater presence of roots in LS treatment than in NG. However, it is relevant to bear in mind that this high presence of tree roots in LS treatment opens up biopores and adds SOM at larger depths, increasing soil organic carbon over time, which would lead to a soil carbon pool that would be stable over the long term. Further studies should be carried out to evaluate the global C storage per hectare as a result of increased soil C concentration in the larger soil size fraction in grazed systems.

Vegetation dynamics under *Castanea sativa* stand grazed with Celtic pigs

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In this study we evaluated the evolution of vegetation in a mountain of Lugo managed by the cooperative pig Porco do Incio Celta. The plot has an area of 16.59 ha, is fenced and maintained with a stocking density of 1.5 livestock units ha^{-1}. In this plot it could be distinguished an area dominated by *Castanea* and other by shrubs. The ground cover was measured in May 2010, before the entrance of animals, and a year later. An increase in the percentage of bare ground was found in both areas, being the effect more important in the wooded area. The dominant vegetation in each area was different, with species such as fern under the *Castanea* stand and in leafy bush and gorse in the treeless area. Especially important was the control of fern species under the *Castanea* canopy of low forage value, and costly eradication (Figure 1). The damage on the trees were measured seven months after the entry of cattle, which allowed us to observe that pigs had affected more young trees of oak than chestnut saplings.

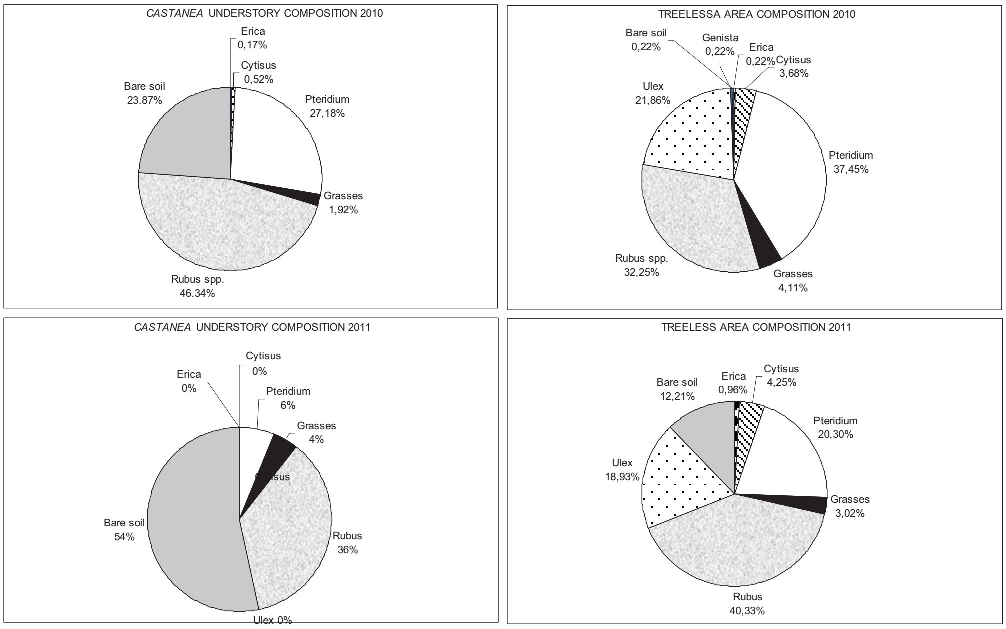

Figure 1. Understory and treeless area composition after one year of a establishment of a silvopastoral system with the celtic pig autochthonous breed.

AMF and water retention in roots of four different agroforestry trees intercropped with maize

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A randomized block design with four replicates and five treatments consisting of *Melia volkensii, Senna spectabilis, Gliricidia sepium, Leucaena leucocephala* and control (treeless plots) was established to study arbuscular mycorrhizal fungi (AMF) and water retention in roots of different agroforestry trees intercropped with maize in a semi-arid location. Spore extraction and fungal identification were carried out in every plot. From each treatment, tree roots were collected and assessed for mycorrhizal infection and root water content. The results obtained indicated that the trees under study associated with five different genera of AMF; these five genera were *Acaulaspora, Glomus, Gigaspora, Scuttelospora* and *Entrophospora* of which the latter were not numerous. In comparison with other tree species and with treeless plots, *Melia volkensii* plots had a significantly higher ($P<0.05$) number of AMF spores in each genus. The percentages of root infection were also significantly higher ($P<0.05$) in *Melia volkensii* as compared to *Leucaena leucocephala, Gliricidia sepium* and *Senna spectabilis*. A significant correlation existed between AMF root infection % and the number of AMF spores in the soil ($R=0.7$, $P<0.05$). The root water content was significantly higher ($P<0.05$) in *Melia volkensii* as compared to the other trees and a statistically significant correlation ($R=0.9$, $P<0.05$) between the percentage of AMF root infection and the water retention in the roots was also found for this agroforestry tree intercropped with maize.

Exploring the Possibilities to Run Agroforestry Business in Greece

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Over the last years the pressure for maximization of the net profit from agricultural activities is growing extremely high. Moreover, forestry is facing the challenges for fulfilling the increasingly high human needs for goods and services (high water quality, soil retention, wildlife habitat conservation, etc). Both activities are developed in an increasingly demanded economic environment were humans have to wisely balance welfare and economic and environmental sustainability. Agroforestry (AGF) introduces an integrated approach for using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy, and sustainable land-use systems. Such combinations may be of bilateral (silvoarable, silvopastoral), or trilateral (agrosilvopastoral) form, but all having in common the simultaneous exploitation of the same parcel of land. AGF is an activity exercised rather intensively over last centuries up to the intense mechanization of agriculture. There are evidences in the Mediterranean that various forms of AGF were developed in France, Spain, and Portugal. In Greece, Sidiropoulou (2011) has recorded remnants of 695 such AGF systems in Macedonia and Thrace that are evidences of the use of these systems in the past. Given the various benefits provided by AGF, recent national agricultural policies have developed to promote the establishment of such activities. EU (AGRI/2254/2003, and 1698/2005 directives) offers incentives to farmers for the introduction of trees (density lower than 50 trees ha^{-1}) into agricultural lands. Moreover, the new CAP is expected to promote AGF. Given the new perspectives for the increase of agricultural income, the pressing needs for *greening* economies, and the general appreciation of primary production as leverage for further national development, it is expected that a new field for innovative actions towards AGF is generating for Greece and a new type of agro-market rises. In this new agro-economic landscape, a firm making AGF business is expected to flourish. The potentialities of such AGF business in Greece are the subject of a proposed M.Sc. study. The objectives will be to (a) outline the organizational structure of an (hypothesized) AGF firm for Greece, (b) outline the basic operations of the firm, (c) search for the resources (assets) needed to run the firm, (d) study its relative position for agro-market and to foreseen the market share of the new entry, and (e) investigate the level of willingness of land professionals (foresters, agronomists, animal production specialists) to join the new firm. To achieve the objectives the following methods will be used: literature review relevant to the organizational structure and the basic operations of agro-business, interviews with academic specialists on AGF, interviews with those who run agro-business construction of a Bass-like model (and define its critical parameters) and intention exploration by questionnaires addressed to technical University students.

References

Sidiropoulou A 2011 *Analysis and Evaluation of Agroforestry Systems Using Landscape Indicators,* Ph.D. Thesis, Aristotle University, Thessaloniki, Greece (in Greek)

Training advisors in agroforestry(ies)

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Whatever its forms, agroforestry needs theoretical and practical knowledge. If this knowledge is not passed on, it will disappear. Today, it doesn't exist in any degree course that put trees or hedges in the heart of their program, even though many things are done in the field. Goal / method: The French national association AFAHC ("Rural Trees and Hedges" – French Organisation) wants to point out that a specific job exists, which consists of giving advice on agroforestry, in France and in Europe. In this way, the AFAHC used its partner network in the French territory: an inquiry has been sent to them in order to inventory all the actions that are implemented concerning pastoral trees or hedges. In the short term, the aim is to describe in a brochure all the training or degree courses that are available in France. This brochure is in progress and the first copy will be released in September 2012. Results: 106 partners answered to the inquiry, representing 54 local territories in France (Figure 1). Each partner described 3 or 4 training sessions, which represent approximately 350 training session related to agroforestry. The themes covered are mainly biodiversity protection (84%), agronomic interests (78%) and landscapes (78%). Conclusion: In the medium term, it is essential to professionalize this job by writing a convention, creating a « job label », organizing the training offers, even developing a real school career to prepare « advisors in agroforestry ». In this way a national company could offer themselves to manage the national training, as a coordinator and/or guarantor of the job labelling. The issue would be that a national structure would manage the national training, and act as a coordinator and/or a guarantor of the job label.

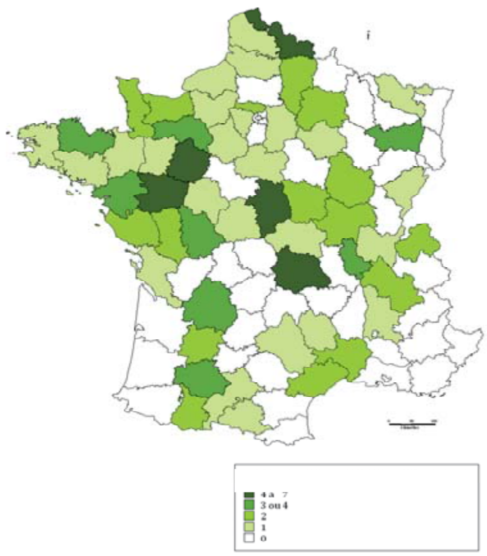

Figure 1. Number of enquires answered per province in France

***Paulownia* tree-planting in Sardinia (Italy) and its evaluation for agroforestry systems and sustainable land use**

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It is known that agroforestry is the integration of trees, crops and livestock on the same area of land and can be applied to all agricultural systems by planting trees on agricultural land or introducing agriculture in existing woodland. Sardinia (Italy) has a traditional heritage of agroforestry systems and a high potential value for innovative modern agroforestry systems that include environmental strategies and sustainable land use too. For example, planting *Paulownia* trees could be a beneficial system leading to a low carbon and high biomass productive agriculture in short time, with other specific ecosystems services included flood mitigation, reduction of diffuse pollution and soil erosion, protection of crops and livestock against climatic hazards due to climate change, integrated habitat network, and landscape amenities. For these main objectives it appears an essential prerequisite to identify good practices operating in different situations from specific cases. So this work reports about the establishment and the development after two years of a *Paulownia* tree plantation in a large and homogeneous agricultural area, a representative site of the Oristano province (Central Sardinia, Italy). The case study concerns a man-made plantation of *Paulownia tomentosa* (Thunb.) Steud., in Campulongu locality, in the countryside of Oristano, in Central Sardinia (Italy), established in the autumn of 2009 on agricultural lands, partially covered before by bushes of Mediterranean vegetation (*Cistus* spp.) and by Mediterranean crops, over 2 hectares. The observations have been focused on an identified plot, greater than 1 hectare, on the survival and growth of trees after two years, trying to explain the role of density (1333 trees ha^{-1}) and of species used compared with data trends found in the literature. The case study reported significant results for survival and growth of the *Paulownia* trees. The mortality was 22.35%, the average value of basal diameter was 4,34 cm and the average height was 2.09 m. These first results showed that the role assigned to *Paulownia* trees can be a beneficial system leading to a low carbon and high biomass productive agriculture in short time including other specific ecosystems services as flood mitigation, reduction of diffuse pollution and soil erosion, protection of crops and livestock against climatic hazards due to climate change, integrated habitat network and landscape amenities. Data collection of recurrent monitoring will be basic to confirm this role also in the future.

Agroforestry management plans

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The management of agroforestry systems consists of the implementation in a directional manner of very different kinds of technical management procedures to effectively guide the evolutionary process. The many management methods, what ever their degree of complexity, remain adaptable. In recent times, the interventions associated with the commonly used term of sustainable management, concerning the multifunctionality of systems and the concept of intergeneration al solidarity, are acclaimed. The management plan aims to rationally define and organize the operations to be performed within a management unit for a given period. This real operational intervention program results from creating a forward study based principally on the technical analysis of the state of the agroforestry system and its evolution, with consideration of the long term objectives to be reached, in view of goods or services expected, and the assessment of these objectives applicability through the study of human, material and financial resources as well as technical procedures. This concept of planning, traditionally attributed to foresters, can be introduced in a modern way in other environments. The intention to implement the concept of sustainable management has led many public and private organizations to apply it to diverse territorial sectors, including agroforestry systems, whether traditional or innovative. This tool, which is undeniably pragmatic whilst realizing a strategic approach, being both conceptually and substantially elaborate, offers many advantages. It enhances the knowledge of the manager for whom it is a practical and simple, whilst being a flexible, technical guide. The management plan, thanks to the inclusion of objectives, is also one of the keys, essential to continuity of action, inherent in a rational management and an efficient transmission of agroforestry estates. Despite the steps taken being ambitious and based on experience, the dissimilarities between the various management plans which have been made are however regrettable. Their diverse and occasionally contradictory content leads to concerns about the management policy. Without explicit and recognized definition of management that only the public authorities and interprofessional groupings can legitimately draw up, each structure deals individually with issues, sometimes without any real notion of sustainable management. This leads to, and continues to breed, alack of coherence of management to an upper geographic scale and a partial consideration of research and development work, however rich in the implication of management practices. Due to the increasing use of agroforestry management plans and their practical implementation, it appears essential to supervise their elaboration and potentially to follow their application, either by regulations or an eco-certification process.

Agroforestry in Flanders: range, opportunities and barriers

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Agroforestry offers many opportunities to enhance farm resilience and to respond to future challenges in Flemish (and West European) agriculture. Some examples of this are diversification in production and supplying a wide range of ecosystem services. Economically speaking, the expected increase in demand for biomass and high-quality wood products may make agroforestry a shock-proof investment for farmers. Agroforestry potentially meets the social demand for eco-efficient agro-ecological production methods while being economically profitable. Though far less than a few decades ago, trees bordering agricultural parcels may still be found quite regularly in some regions. However, agroforestry systems in which (rows of) trees are actually planted inside crop parcels, with the genuine intention to combine both crop and woody biomass production, are sparse. As such, experience with agroforestry in Flanders is very limited. The few agroforestry pioneers up to date mainly focus on the growth of common walnut (Juglans regia), poplar (Populus spp.), wild cherry (Prunus avium), common ash (Fraxinus excelsior), black locust (Robinia pseudoacacia), oak (Quercus spp.), chestnut (Castanea sativa), lime (Tilia spp.) or different species of fruit trees, combined with grassland or crops such as winter wheat, maize or potatoes. Combinations with vegetables are generally considered difficult, mainly for reasons of heterogeneous growth and/or contamination with twigs or leaves. Very often farmers shift towards (temporary) grassland on these agroforestry parcels after five up to ten years (depending on the specific combination), when competition between crop and tree increases. To further promote the implementation of feasible and profitable agroforestry systems in Flanders, the Flemish government has recently started subsidizing the instalment of agroforestry parcels. For parcels of at least 0.5 ha with an agricultural crop production and between 30 to 200 trees per ha, up to 70 % of the plantation costs may be recovered through this subsidy. However, the response to the subsidy program remains relatively low so far. In addition to stumbling blocks regarding legal and administration issues, many technical, organizational and economical questions remain unanswered. What is needed in the short term, is (1) an increased knowledge of ecological interactions, ecosystem services and technical impact, but even more of economic opportunities for agroforestry systems relevant to the Flemish agricultural context; and (2) an increased understanding of intention, attitude, norms, perception and social identity of those involved, to overcome the psychological and social barriers to agroforestry adoption.

Phosphor sorption kinetics in short rotation coppices of *Robinia pseudoacacia* L. on marginal post-mining areas in northeast Germany

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Recently, the short rotation coppice (SRC) with black locust tree (*Robinia pseudoacacia* L.) is widely used in recultivation of post mining sites. The R. pseudoacacia as a fast growing tree species can be used for biomass and bioenergy production and at the same time can improve soil quality being an alternative to agriculture crops on marginal sites. The objectives of our studies were to evaluate the influence of different in ages SRC on the P sorption capacities in post lignite mining soils, and as well compare the total soil organic P (P_{org}) and plant available P (P_{ava}) content and it contribution to enhance the soil quality under different development stages of *R. pseudoacacia*. In the presented sorption experiment, artificial P solutions were reacting with the soil for a specific period after which the concentration in the solution was measured and the amount of P sorption was calculated. The post lignite mining soils with sandy overburden substrate were sampled at three different depths: 0-3, 3-10 and 10-30 cm from different rotation stages of *R. pseudoacacia*: 2-, 3-, 4-, and 14-years old plantation (R2, R3, R4, and R14, respectively). The results showed that the highest sorption capacity was found under the oldest site - R14, removing ca. 80 mg P kg^{-1} and the lowest sorption was found for the youngest sites: R2 and R3 (ca. 25 mg P kg^{-1}). There was not found any significant difference between the sites R2 and R3 in time sorption distribution. However, at each depth the P sorption under the oldest R14 site showed significant difference when compared to other younger *R. pseudoacacia* sites. Moreover, maximum P sorbed was found to be linearly related to the sum of oxalate-extractable Fe and Al in all soil layers, thus the results confirm that Fe and Al oxides mainly influence the soil P sorption capacities. The amount of P_{org} in the soil increased with increasing age of *R. pseudoacacia* (P<0.01) ranged in the topsoil layer from 17.7 to 85.5 mg kg^{-1} at R2 and R14, respectively. The increasing age promoted an increase in the P_{ava}, where the largest fraction was found in the oldest site - R14 (8.03 mg kg^{-1}). However, the amounts of P_{ava} were very low compared to the recommended amounts in soils for normal plant growth. The results suggest that 14 years of *R. pseudoacacia* cultivation on post mining sites have a positive influence on the P dynamics in the nutrient poor soils. Nevertheless more research is needed on the long-term effects of SRC.

Assessment of ecosystem services provided by alley cropping systems for biomass production in Germany

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Alley cropping systems which integrate strips of short rotation coppices into conventional agricultural sites (ACS) have recently gained increasing interest in Germany. These ACS can be used for the simultaneous production of crops and woody biomass which enables farmers to diversify the provision of market goods. Integrating trees into the agricultural landscape can create additional benefits for the farmer and society also known as ecosystem services (ES). The scientific literature suggests that ACS are able to provide additional benefits as compared to conventional agriculture. Among the important ES provided by ACS are carbon sequestration, soil fertility, water quality, groundwater recharge, and biodiversity. However, assessment methods are required which are easy to use and provide reliable information regarding change in ES with change of the land use practice. In this context, our aim was to develop a methodology to assess selected ES provided by ACS in Germany. For this purpose an indicator set was selected from the literature and linked with the relevant ES previously identified. Furthermore, a model was developed to facilitate the calculation of the indicators. The results showed that ACS established at agricultural sites have higher capacity to provide ES as compared to single-crop agriculture. The capacity of ACS with 50% trees is higher than the capacity of ACS with 30% trees which suggests that the capacity of the system to provide ES increases with increased proportion of trees. The methodology seems to be a promising tool to facilitate the assessment of ES provided by the land management practices considered. In the long term this measurement approach can be broadened to include monetary evaluation of ES. This will enable rewarding farmers for providing environmental benefits therefore, accurately compensating them for the outputs supplied.

Attitude of Flemish farmers towards agroforestry as a farming system

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Various types of silvo-arable and silvopastoral systems have a long history in Europe. However, in many parts like the region of Flanders, most of these age-old systems have been abandoned as they do no longer agree with today's economy and intensive farming practices. At the same time, a modernized agroforestry system could respond to several challenges in West European agriculture, by creating product diversification and the supply of a variety of ecosystem services. The Flemish government recognizes these opportunities and subsidizes the instalment of agroforestry parcels. The possible psychological and social barriers to agroforestry adoption can be revealed by studying the intention, attitudes and perceptions of those involved. Do farmers know about the principles of agroforestry? What is their attitude towards agroforestry as a potential farming system, particularly for their region or even their own farm? What would motivate them to get involved and what are the perceived obstacles? After interviews with pioneer farmers, a questionnaire was created and sent to 500 randomly selected Flemish farmers, together with basic information about agroforestry. With 86 useful replies (17% of all distributed questionnaires), the questionnaire pointed out that a majority (55%) of the farmers had never heard of agroforestry or its principles. After being informed about agroforestry, silvopastoral systems seemed most promising for Flanders, with 53% answered neutral to positive. The intention amongst farmers to engage in agroforestry now or in the future was rather low (16%). The main disadvantages reported were: lower crop production (mainly because of shade), lack of (large) farming parcels and difficulties with mechanization. Moreover, agroforestry was perceived to be difficult, with low economic profit, and a possible disadvantage when selling or renting the parcel. On the other hand, several advantages were recognized, mainly on socioecological aspects like improvement of the landscape, biodiversity and erosion. Future research, demonstration and education about agroforestry should clarify whether the perceived (dis)advantages for the implementation of agroforestry are realistic, with a focus on technical and economical aspects. This will make it possible to identify what types of agroforestry may be appropriate to introduce into agriculture in Flanders.

Delivering multiple ecosystem services in UK agriculture – can agroforestry do it all?

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Agricultural production will need to double by 2050 to feed the predicted global population of 9 billion. A key challenge is therefore to increase productivity in a sustainable way so that environmental impacts are minimised. We investigated whether agroforestry, an intensive but sustainable system, could reconcile potentially conflicting demands for food production, biodiversity and provision of other ecosystem services in UK farmland. To quantify multiple ecosystem service provision and assess potential trade-offs between them we measured four services - productivity, biodiversity, pollination services and above- and below-ground carbon stocks - in six organic agroforestry systems paired with equivalent organic monoculture systems (controls) across southern UK. Responses differed both between agroforestry and control systems, and amongst agroforestry systems: initial results indicate higher productivity in silvopasture systems, but greater pollinator species diversity in silvoarable systems. Trade-offs are therefore expected to vary depending on the type of land use. Biodiversity is higher in both types of agroforestry system being studied. Pollination services appeared strongly influenced by land use. In arable land, agroforestry treatments have on average more than double the abundance of hoverflies than monoculture treatments, whereas in pasture land there was little difference between treatments (interaction between treatment and land use χ^2_1=40.225, P <0.001). The same pattern was observed with bumblebee species richness: in arable land, agroforestry treatments have almost three times the number of bumblebee species than monoculture treatments whereas in pasture land there was no difference between treatments (interaction between treatment and land use χ^2_1=7.6144, P =0.00579). Biodiversity, using butterfly species richness as a proxy, was significantly higher in agroforestry compared to monoculture regardless of the type of land use (χ^2_1=6.144, P =0.01319). Mean butterfly diversity using Margalef's diversity index was 2.64 in agroforestry systems and 1.56 in control systems. Further work will clarify service provision and trade-offs, however initial results suggest the potential for such systems to deliver a combination of more regulatory and more provisioning ecosystem services. Early data analysis implies that in agroforestry systems the trade-offs appear to depend on system design, age and management practice. We conclude that agroforestry in the UK shows potential to enhance environmental quality through multiple ecosystem service provision without overall loss in productivity. Further work is planned to look at the economic implications of these findings.

Economic development of the rural tree biomass

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The rural tree is the linear forest for areas devoid of forest massif. Usually a hectare of forest is equivalent to about one kilometre of hedge farmland. In this way we may consider that a department with 3200 km of hedged farmland possesses 3200 ha of forest on top of the basic forest resources. Because of the cheap price of fossils fuel over the last 50 years the rural tree has been mostly forgotten as a source of fire wood. Log wood fuel is the primary renewable energy used in France: 45 million m² of wood is burnt every year. This raw material is almost entirely used by private individuals as the main way of heating or as additional heating. But the log doesn't use the entire rural tree (maximum 50 to 60% of it). Based on this observation and because log boilers are not automated enough, the idea of crushing the entire tree had been explored. It enables the use of the entire tree and produces a smoother fuel that is more appropriate for automatic boilers. This kind of boiler (with a small capacity) was first developed on small farms because farmers have a high availability of this resource on their farms (wood, hedges). Collective boiler rooms made for public infrastructure are turning to power wood made with woodchip and more and more woodchip boilers are created in France. Even if they are automatically fed, they also need more technical installations and daily maintenance. These additional costs create local activity and may help the economy. The price of wood isn't rising like other materials. Indeed the rise of fuel prices forms 90% of the global working bill for a fuel oil boiler. This difference offsets the additional costs. New kinds of cooperatives named Special Interest Cooperative Society (SCIC in French), based on the wood power field, are being created everywhere in France. As a distinctive feature, they can include upon 20% of social contributions from local institutions. Because of their special feature the SCIC incorporate client and salaried employee. Both are making up two compulsory colleges. A SCIC must work both on economic efficiency and a social aspect. Setting up a SCIC is often linked to a multi-professional societal request. Local institutions are often strongly involved in it because they are asking for a wood boiler for their public infrastructures. It is not easy to compare rural tree resources with the forest tree resources because of the diversity, the statute and the lack of technical reference for the rural tree. However, according to the ONCFS (French national office for hunting and wildlife), there is still 730000 km of rural tree lines in France. This represents 730000 ha of forest, 100'000 more than the French forest in Les Landes which is the biggest forest in the EU. The rural tree is therefore an economic, social and environmental resource. It is a resource that cannot be ignored by local and national economies in our current context of fossil fuel depletion.

Session 4

Fresh progress, novel evidence. What's going on in Europe for agroforestry?

Oral presentations

Tree fine roots dynamics and carbon sequestration potential in a Mediterranean agroforestry system

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According to the FAO (2012), agriculture is responsible for 14 percent of global greenhouse gas emissions. Agriculture suffers the impacts of climate change, but "agriculture has the potential to be an important part of the solution, through mitigation" as recognizes IPCC. Agroforestry (AGF) systems are known to sequester C into aerial biomass, but also play an important role by enhancing C inputs into deep soil horizons. AGF trees have often a deep rooting system, due to the competition with the annual crop (Mulia and Dupraz 2006). C inputs from roots (turnover and exudates) may constitute an important part of SOC as they are easily stabilized through different processes (Oelbermann et al. 2004; Rasse et al. 2005; Peichl et al. 2006). ECOSFIX project aims at studying ecosystem services of shallow and deep roots such as hydraulic redistribution, C sequestration and soil fixation in different ecosystem structures and climates (Costa Rica, Laos, France). This work focusses on the experimental device that was implemented in an intercropping system at Restinclières, France in 1995 (durum wheat and walnut (13x8m)). A huge pit (5m long, 4m deep) was dug into the soil, perpendicularly to a tree row. Fine root impacts (< 2mm diameter) were counted on each trench walls, cubes of soil (1 dm^3) were sampled at different depth and a model of root length density (RLD) from root intercept counts was established (Maurice et al. 2010). It well fitted (R^2=0.59). This method allowed estimating root density through the profile, which was surprisingly homogeneous, down to a depth of 4 m and across the cropped alley. Soil cylinders were collected to measure C content, bulk density, penetrometry and soil C fractionation. Roots were sampled at different depths to be chemically analysed and study root traits. 16 minirhizotrons and Tª sensors were implemented in the pit at different depths and distances from the trees, to estimate fine root turnover of walnut trees. Images are collected every three weeks. 3 other 1.5 m deep pits were dug (in AGF, agriculture control and forestry control), and litterbags containing fine roots were installed at different depths before the pits were filled up. Chemical composition changes and mass loss will be analyzed after one year to determine the decomposition rate. Root C input into the soil was also modeled with the Hi-sAFe model.

References

Maurice J, Laclau JP, Scorzoni RD, de Moraes Gonçalves JL, Nouvellon Y, Bouillet JP, Stape JL, Ranger J, Behling M, Chopart, JL, 2010 Fine root isotropy in Eucalyptus grandis plantations. Towards the prediction of root length densities from root counts on trench walls. Plant Soil, 334: 261-275.

Mulia R, Dupraz, C. 2006. Unusual Fine Root Distributions of Two Deciduous Tree Species in Southern France: What Consequences for Modelling of Tree Root Dynamics? Plant and Soil 281: 71–85

Oelbermann M, Voroney RP, Gordon AM 2004 C sequestration in tropical and temperate agroforestry systems: a review with examples from Costa Rica and southern Canada . Agriculture, Ecosystems and Environment 104: 359-377.

Peichl M, Thevathasan NV, Gordon AM, Huss J, Abohassan RA 2006 C sequestration potentials in temperate tree-based intercropping systems, southern Ontario, Canada. Agroforestry Systems 66: 243-257.

Rasse DP, Rumpel C, Dignac MF 2005 Is soil carbon mostly root carbon? Mechanisms for a specific stabilization. Plant and Soil:269(1-2):341–356.

Agroforestry brings free range chickens back to their natural habitat

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In the Netherlands about 20% of the farms with laying hens have a so-called free range area. However, on many farms only a minority of the animals is seen outside. As part of a larger study on laying hen welfare we collected data about the free range area. We investigated how many animals actually used the provided area and the relation with feather pecking, the presence of which in laying hens is a measure for animal welfare. In our poster we present the results of that study, which together with other aspects of the range areas give rise to our present work on agro-forestry in poultry free range areas. We visited 63 flocks of organic laying hens on 26 farms. All flocks were 50 weeks or older. Plumage damage scoring was done on a sample of 40 hens. The farmers were asked to estimate the maximum percentage of their hens that was seen outside simultaneously under ‘perfect’ conditions. We estimated the percentage of shelter in the outdoor run. Shelter was defined as ‘vegetation or artificial cover of at least 1 meter high’. Multiple linear regressions were used. The first model showed that severe feather pecking did not occur when at least 66% of the hens made use of the outdoor run. The second model showed that the percentage of hens outside was higher in case of smaller flock size, a younger age of purchase of the hens, more cockerels between the hens and in case of a higher percentage of cover in the run. Since this study was done, the number of free range farms increased. At present the amount of shelter to ‘lure’ hens outside, the peak mineral load on the soil, the costs of an effective, well managed range and poor biodiversity have gained attention from several stakeholders. With agro-forestry several of these troubles can be tackled. Animal welfare increases as chickens are kept in a systems that resembles their natural habitat. Moreover, trees distributed over the whole outdoor run surface make more hens use it more evenly distributed, which spreads the mineral load. Minerals will be used by the growing trees. Trees provide a variation of microhabitats for other animal and plant life, which increases the biodiversity. Depending on the type of trees, fruits, branches or roots can be harvested and used. Subject of our research among others is the profitability of the system. In the Netherlands we have examples of tree-nurseries, grapes and other fruits in chicken outdoor runs. In a participatory network with poultry farmers called ‘trees for chickens’ we will further develop silvopastoral systems.

References

Bestman MWP, Wagenaar J 2003 Farm level factors associated with feather pecking in organic laying hens. Livestock Production Science 80:133-140

Farmer's Network for Fodder trees and Multifunctional Land Use

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This knowledge sharing network for farmers, advisors and researchers was set up in the Netherlands in 2011 to promote the multifunctional use of trees and shrubs in modern dairy farming systems. In these silvopastoral systems we want to combine pasture production with the benefits from trees as fodder, energy, nutrient cycling, carbon storage, biodiversity and landscape. Our aim is to create a third crop on dairy farms next to grass and maize. In this network we exchange and generate information from literature and field research on the value of trees for fodder (e.g. harvest, production, feeding value, phytotherapeutic value), energy (e.g. harvest, production, storage, market, woodstoves), nutrient cycling, carbon storage (e.g. deep roots), biodiversity (e.g. soil biota and insects) and landscape. In the first year of the project trees were established in combination with grass-clover at three dairy farms (goats and cows). On each farm a plantation plan was designed using a participatory approach. Stakeholders were involved (e.g. farmer, landscape organisation, advisors) during the designing phase of the project. On one farm the main focus is on willow (*Salix alba*) along ditches, while on another farm robinia (*Robinia pseudoacacia*) was combined with willow (*Salix alba),* hazel-tree (*Corylus avellana*)and black alder (*Alnus glutinosa*) as a kind of forest at the entrance from the stable to the pasture. From willow four different clones were selected on basis of production, disease resistance and palatability for animals. The clones used are Sven, Klara, Gudrun, Tora. In the first year of the project, cuttings of willow were planted in April 2011. In this first year the total dry matter production of wood and leaves varied between 1139 and 5597 kg DM ha-1 with 18 to 33% of leaves. Sven was most productive and Gudrun had the biggest leaves. The cuttings and trees were planted in a rotavated and ploughed grass-clover sward. To reduce weeding in 2012 the trees were undersown with pure white clover. On one farm an undersowing of a small leaved white clover variety Pirouette is compared with a broad leaved variety Alice. In September 2011, June 2012 and September 2012 leaves of the different trees were sampled for feedings value and mineral content on sandy and clayey soil. In terms of crude protein and mineral content the different trees have potential but the in-vitro digestibility is in general lower than 65%. Possibly the results of the *in-vitro* digestibility are negatively affected by the content of tannins or other secondary metabolites in the leaves, while in-vivo this would be less of a problem. This is under investigation now. In January 2012 a desk study has been carried out on the phytotherapeutic value of tree leaves. In September 2012 leaves of willow were baled for silage, and first and second year growth of willow were grazed by goats. In our presentation the different results from the project are discussed.

Agroforestry systems: field and modeling approach

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Nitrogen is one of the main limiting factors for long term crop production, as it is exported by biomass harvest. The use of nitrogen fertilizers to manage this loss has led to environmental disorders such as water-tables and rivers pollution, mainly because of an inefficient use of these inputs. Trees have shown their ability to reduce nitrogen leaching and improve soil fertility, by establishing a safety net under the crop root zone, and recycling deep extracted nutrients through litter-fall (Cadisch et al. 2004). While agroforestry systems may enhance the nitrogen balance as compared to monocultures, it is obvious that nitrogen will remain a limiting factor for crop and tree growth. The research program INTENS&FIX aims at studying plant associations involving nitrogen fixing species. Improve N supply by biological N2 fixation should limit the use of fertilizers. This project addresses forest plantations and agroforestry systems over different sites (Brazil, Congo, and France). In France, the Restinclières agroforestry research site includes walnut plantations for producing timber. The mixtures with alfalfa, a perennial legume crop, or Alnus cordata, an N2-fixing tree are under study. Improving the nitrogen status of the walnut trees relies mainly on two processes: (i) nitrogen fixing rate and (ii) nitrogen transfer rate from the fixing species to the walnut. The efficiency of these two processes is under the control of numerous factors, including the type of association regarding the biological cycle lags and the effects of light, water and nitrogen competition (Sanginga et al. 1995; Pelzer et al. 2012). Our approach consists in measuring N fluxes in the system. The nitrogen balance approach allows constructing nitrogen use efficiency indexes for the different systems, including controls without fixing species. Stable isotope analyses are carried out to assess the nitrogen fixation rate, and a 15N-NO3 phloem injection was applied to alders to estimate the nitrogen direct transfer rate from the fixing species to the walnut and to the different system components (roots, leaves, trunk, bark and soil), following the method described by Horwath et al. (1992). Mineralization rates are measured in situ as well to evaluate the speed of indirect transfer by litter-fall degradation. These experiments were conducted in 2012 on a forest plantation mixing alders and walnuts, and will be adapted to the walnut-alfalfa association in 2013. Besides, an agroforestry simulation model developed by INRA (Hi-sAFe) is used to simulate the response of tree growth on a long term virtual experiment (40 years) to the introduction of a nitrogen fixing crop, either as annual or perennial crop.

References:

Cadisch G, Rowe E, Suprayogo D, van Noordwijk M 2004. Safety-nets and filter functions of tropical agroforestry systems. Controlling Nitrogen Flows and Losses. 406-414

Horwath WR, Paul EA, Pregitzer KS 1992 Injection of N-15 into trees to study nitrogen cycling in soil. Soil Science Society of America Journal 56:316-319

Pelzer E, Bazot M, Makowski D, Corre-Hellou G, Naudin C, Al Rifai M, Baranger E, Bedoussac L, Biarnes V, Boucheny P, Carrouee B, Dorvillez D, Foissy D, Gaillard B, Guichard L, Mansard MC, Omon B, Prieur L, Yvergniaux 2012 Pea-wheat intercrops in low-input conditions combine high economic performances and low environmental impacts. European Journal of Agronomy 40:39-53

Sanginga N, Vanlauwe B, Danso SKA 1995 Management of biological N2 fixation in alley cropping systems: Estimation and contribution to N balance. Plant and Soil, 174(1-2):119-141.

The role of woody components on productivity and persistence of extensive silvopastoral systems. The case of Iberian dehesas

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Extensive pastoralism has frequently caused the progressive elimination of trees and shrubs through multiple mechanisms, both direct (e.g., browsing and trampling) and indirect (e.g., soil compaction, soil fertilization that favor grasses). Moreover, these woody elements have been removed by humans (fire, periodical plowing, cutting …) in many cases in the belief woody plants reduce forage availability. The intense rural abandonment experienced in last century or decades by most European regions is enabling a rapid wood encroachment of many of those previously deforested landscapes. Overall, both fine and coarse habitat and landscape mosaics are currently commons in European pastoral regions, noteworthy (but not exclusively) in Mediterranean countries. Here we summarize the results of the Spanish project MODE (Assessment of the ecological and productive effects of dehesa encroachment, as a tool for its sustainable management) where we evaluate the forage offer (indicator of productivity; Table 1) and tree regeneration (indicator of sustainability; Table 2) under different system structures resulted of the combination of pasture, trees (*Quercus ilex*) and shrubs (either *Cistus ladanifer* or *Retama sphaerocarpa*).

Structure	Components	Pasture	Tree Browse	Acorns	Shrub Browse	ME[5]
Mono-layered	Pasture	1920	0	0	0	16896
	Cistus[1]	760	0	0	1313	15341
	Retama[1]	2300	0	0	153	21831
Two-layered	Tree[2]+Pasture	1820	250	435	0	21952
	Cistus[3] +Pasture	1150	0	0	704	14759
	Retama[4]+Pasture	2150	0	0	58	19523
Three- layered	Tree[2]+Cistus[3] +Pasture	1103	339	184	704	18214
	Tree[2]+Retama[4] +Pasture	2048	205	468	58	24639

Table 1. Forage offer (kg ha^{-1} y^{-1}) under different structures of vegetation in Iberian dehesas. [1]Shrub cover =100% ; [2]Tree cover = 25% ; [3]Cistus cover = 54% ; [4]Retama cover = 38% ; [5] Metabolic values (ME ; in MJ ha^{-1}). Estimated assuming 10.3, 5.82, 6.59, 10.4 and 8.8 MJ kg^{-1} MS for acorns, *Q. ilex* leaves, *C. ladanifer* sprouts, *R. sphaerocarpa* fruits and pasture, respectively.

Although pasture yield is reduced slightly beneath tree canopy, the presence of trees (holm oaks) increases importantly the availability of forage resources at plot level, because trees contribute with acorns and leaves as additional forage resources. Also, the presence of certain shrubs species, as the leguminous *Retama*, increases notably the forage offer, because the facilitation of pasture growth. This shrub species also favors oak seedling and sapling recruitment. Even pioneer competitive shrub species (*Cistus*) that reduce the forage offer of the system, could play a positive role for the regeneration of the tree layer, assuring thus the long term persistence of the silvopastoral system, what is not guaranteed in the two-layered ones. Understanding the role of tree and shrubs in pastoral systems is of major interest for the productivity and persistence of pastoral systems, and for the implementation of specific policy.

	Dehesa Farms with *Cistus* shrubs				Dehesa Farms with *Retama* shrubs			
	Emerged Seedlings	Survived Seedling	Small Saplings	Large Saplings	Emerged Seedlings	Survived Seedling	Small Saplings	Large Saplings
Open	0.2 ± 0.1c	0.1 ± 0.1c	0.1 ± 0.1c	0.6 ± 0.2c	0.2 ± 0.1c	0.1 ± 0.1b	0.1 ± 0.1c	1.0 ± 0.2c
Shrub	0.6 ± 0.3b	0.3 ± 0.2b	0.4 ± 0.1b	1.3 ± 0.8b	0.3 ± 0.1c	0.1 ± 0.1b	0.7 ± 0.2a	5.1 ± 0.9a
Tree	2.7 ± 0.6a	0.8 ± 0.2b	0.6 ± 0.1b	1.3 ± 0.2b	1.6 ± 0.9b	1.0 ± 0.6a	0.2 ± 0.1b	0.8 ± 0.2bc
Tree-shrub	6.5 ± 1.8a	3.5 ± 1.1a	3.5 ± 0.8a	2.2 ± 0.3a	4.4 ± 1.5a	1.9 ± 0.9a	1.2 ± 0.4a	2.8 ± 0.4b

Table 2. Density of new holm oak plants (Num/100m^2) under different dehesa structures.

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