System Report: Agroforestry for Ruminants in France

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Work-package	5: Agroforestry for Livestock farmers
Specific group	Agroforestry for ruminants in France
Deliverable	Contribution to Deliverable 5.13 (5.1): Detailed system description of a case study system
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Contents

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1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to Objective 2, Deliverable 5.13: "Detailed system description of case study agroforestry systems". The detailed system description includes the key inputs, flows, and outputs of the key ecosystem services of the studied system. It covers the agroecology of the site (climate, soil), the components (tree species, crop system, livestock, management system) and key ecosystem services (provisioning, regulating and cultural) and the associated economic values. The data included in this report will also inform the modelling activities which help to address Objective 3.

2 Background

Integration of trees with crops and/or livestock production (agroforestry) has been identified as a sustainable way to increase the productivity of land and to provide a number of ecosystem services and environmental benefits compared to disaggregated agricultural and woodland systems (Jose, 2009). In cattle production systems agroforestry may also improve animal welfare and provide additional fodder from trees and shrubs leaves (Broom et al. 2013). Trees could also impact the seasonality and spatial distribution of the understorey production, by buffering microclimate (Ryan et al. 2010) and by generating an uneven spatial distribution of nutrient deposition.

At present, agroforestry systems constitute only a minor part of the French ruminant husbandry. For their development, farmers need more information, especially on the way to establish a profitable agroforestry system, as they expressed during two stakeholders meetings held in France as part of the AGFORWARD project (Pottier and Novak, 2014). To answer these demands, a demonstration plot was designed in December 2014 together with 10 stakeholders willing to test options relative to 1) diversification of tree uses, 2) spatial organization of trees, and 3) protection of trees against livestock (Novak et al. 2015). This demonstration plot is described here.

3 Update on field measurements

Pasture productivity, cattle behaviour and tree damage were assessed during the eight grazing periods that occurred between April and November 2015.

4 Description of system

Table 1 provides a general description of French agroforestry systems for ruminants. A description of the specific case study system is provided in Table 2. Missing data will continue to be sourced during 2016.

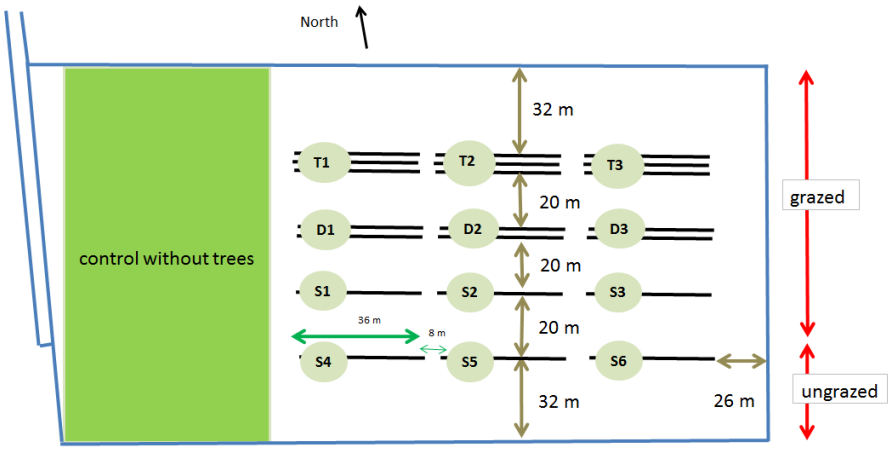
Table 1. General description of French agroforestry systems for ruminants

General description of system	
Name of group	Agroforestry for ruminants in France
Contact	Sandra Novak
Work-package	5: Agroforestry for livestock farmers
Geographical extent	Silvopastoral systems in France are mainly represented by traditional systems such as “pré-vergers” where fruit trees are grown on permanent productive grasslands. Pré-vergers are mainly found in Lower Normandy (40% of the output of cider apples, involving over 13 000 farmers) and in Lorraine (mirabella plum production involving 200 farmers) (Bélouard and Coulon, 2002). Other traditional silvopastoral systems are found in upland areas (Jura, Pyrenees, Massif Central) or in the Mediterranean region. In these extensive systems, trees or shrubs from forests or rangelands can play a role as a forage resource (Balandier et al. 2002). In general agroforestry systems where trees are planted to play a role for ruminants are rare in France.
Estimated area	Pré-vergers represent 151,000 ha (Ducros et al. 2005) No data for agroforestry in productive ruminant systems
Typical soil types	Varied
Description	Ruminant systems range from systems where dairy cattle are only fed conserved forage to grassland-based systems. The role that trees can play in these systems depend on the role of grazing. As the integration of trees in ruminant systems is new, there are few data on productive ruminant systems where trees or shrubs are used as a fodder resource, fuelwood, or as source of litter or soil amendment.
Tree species	The tree species used in some trials include: ash, white mulberry, walnut, wild cherry.
Tree products	Tree fodder; woodchip for firewood, litter, soil amendment; timber
Crop species	Depending on the ruminant system considered, crops may be annual forage crops such as maize or sorghum, cash crops such as wheat or colza, or temporary or permanent grasslands.
Crop products	The cropping system may produce grass or forage crops that can be grazed directly by livestock or cut to provide animal feed (silage or hay), or grains for concentrated or as cash crops, and straw for litter.
Animal species	We will only study cattle but similar agroforestry systems may be developed for sheep and goats.
Animal products	Milk, meat
Regulating services	The trees can provide shade for livestock in summer, and shelter from wind and rain in the winter. They can also promote nutrient recycling, and increase carbon storage. They could also play a role in soil fertility thanks to mycorrhizae or the presence of nitrogen-fixing trees.
Habitat services and biodiversity	The tree rows may provide habitat and food sources for pest-controlling insects and pollinators, and may act as corridors and nesting site for wildlife.
Cultural services	Introducing trees into a livestock system will diversify the landscape.

Table 2. Description of the specific case study system

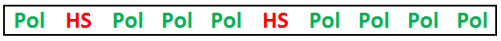
Specific description of site	
Area	3.0 ha
Co-ordinates	46°25’12,91”N; 0°07’29,35”E
Site contact	Sandra Novak
Site contact email	sandra.novak@lusignan.inra.fr
Example photograph	 Figure. 1. Cattle in the silvopastoral system June 2015
Map of system	 Figure 2. Aerial view of the fields involved in the OasYs system experiment hosting the silvopastoral demonstration “G14” paddock, which was designed with stakeholders in the frame of the AGFORWARD project (Novak et al. 2015). In green, the other agroforestry fields of the OasYs system experiment (M2, M3 and V12).

Figure 3. Aerial view of the silvopastoral “G14” paddock (source: Google satellite).



S=single row set ; D = double row set ; T = triple row set

Schematic representation of one 36 m unit



Pollard
High stem tree

Figure 4. Silvopastoral system design of the “G14” paddock, INRA Ferlus, La Gralière, Lusignan, France (not to scale)

The detailed experimental design is given in Annex A.

Possible modelling scenarios	
Comparison	It would be interesting to model the foliar biomass production of different tree fodder species (mulberry, alder, willow, elm, locust) depending on their management (pollarded or coppiced).

Climate characteristics	
Mean monthly temperature	11.6 ± 0.5°C (1991-2010)
Mean annual precipitation	804 ± 148 mm (1991-2010)
Details of weather station (and data)	A weather station is located at the experimental INRA facility since April 1988.
Soil type	
Soil type	Dystric cambisol
Soil depth	90 cm
Soil texture	loamy (25.3 % sand, 57.8 % silt, 16.9 % clay)
Additional soil characteristics	developed from loamy parent material of unknown origin over red clay; characterized by vertical tongues
Aspect	Flat
Tree characteristics	
Species and variety	High stem trees: pear, honey locust, service tree Pollards: white mulberry, Italian alder Coppiced trees: goat willow, field elm, black locust, grey alder The following will also be planted in 2016: liana beside pollards, and various shrubs and perennial species to create a "fodder hedge"
Date of planting	17 February 2015
Tree row set (width)	single (2 m) , double (6 m) or triple (10 m)
Intra-row spacing	4 m between high stem trees or pollards 1.3 m when coppiced trees are considered
Inter-row spacing	20 m
Tree protection	Single or double line of electric fence, electric fencing tape, metal or plastic fences, olfactory repellents
Typical tree yield	No harvest to date
Typical increase in tree biomass	Not determined
Crop/understorey characteristics	
Species	This plot is included in a crop-grassland rotation. Grassland sown in April 2014 including lucerne (15 kg ha^{-1}), tall fescue (5 kg ha^{-1}), cocksfoot (5 kg ha^{-1}), perennial rye-grass (5 kg ha^{-1}), spring barley (20 kg ha^{-1}), white clover (2.6 kg ha^{-1}), birdsfoot trefoil (2.5 kg ha^{-1}), chicory (2 kg ha^{-1}), lentil (9.8 kg ha^{-1})
Management	The ungrazed part of the field was mown three times in 2015 and the other part was grazed eight times by dairy cows between April and November 2015.
Typical grass yield	Around 9300 kg DM ha^{-1} $year^{-1}$ on the ungrazed part of the field (3 cuts).
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Dung and urine during the grazing of dairy cows
Pesticides	None
Machinery	Tractor and mower, tedder, roundballer and trailer for the part being cut. Crusher for the refusals and roller chopper for the maintenance of tree rows Tree rows were subsoiled 10 February 2015. Trees were irrigated on 27 and 28 July 2015 using a water bowser.
Manure handling	Not necessary in the field

Labour	Animals checked daily when in field
Fencing	Field has hedge and barbed wire fence on two sides, and barbed wire fence on other two sides. Several fencings were erected along each tree row prior to cattle entering field (see above “tree protection”).
Livestock management	
Species and breed	Holstein dairy cows
Description of livestock system	The herd is part of an agroecological system experiment with rotational grazing on 14 paddocks.The dairy cattle graze from March to December depending on weather and soil conditions. When the grassland growth is low, the animals only graze half-time, *i.e.* they stay in the cowshed during the daytime in summer or during the night (after the last milking) in late autumn. When they are not grazing, the animals are fed at the cowshed with silages of maize, sorghum or cereal-legumes mixtures, and concentrates.
Date of entry to site	8 April 2015
Date of departure from site	The paddock was grazed eight times between 8 April and 19 November 2015, which represent a total of 16.5 days of grazing.
Stocking density	Between 24 and 38 cows ha^{-1} on the silvopastoral paddock
Animal health and welfare issues	None. Hedge could provide shelter from wind and shade in the summer, but the just planted trees will have no effects.
Requirement for supplementary feed	When the animals grazed half-time, they received silage (between 3.2 and 6.4 kg DM cow^{-1} d^{-1}) and concentrates (between 0.4 and 0.8 kg cow^{-1} d^{-1}) at the cowshed.
Technical data, livestock	
Production volume	In 2014, the milk production was 6744 l per cow for the entire herd being part of the OasYs system experiment.
Herd performance	See above
Feed consumption	Not determined. The grassland biomass available for grazing is estimated to be around 8000 kg DM ha^{-1} on the entire period of grazing and permitted to feed a total of 1028 cows x days of grazing.
N-balance	At the scale of the entire OasYs system experiment, the N-balance (including N fixation by legumes) was estimated at 14 kg N ha^{-1} in 2014.
Financial and economic characteristics	
Costs	At the scale of the entire OasYs system experiment, the production costs have been assessed in 2014 at 406 euros per 1000 l milk, compared to an average of 444 euros per 1000 l milk for dairy farms of Poitou-Charentes, which represent a cost price of 326 compared to an average of 348 euros per 1000 l milk.

5 Pasture productivity and flora composition of the grazed pasture

Results of the 2015 biomass productivity and flora composition of the grazed grassland and of the ungrazed part are given respectively in Tables 3 and 4.

Table 3. Pasture production and composition in the grazed agroforestry paddock

Grazing period	Date of entry into the paddock	Grazing duration (day)	Cattle numbers	Stocking = cattle numbers x grazing duration	Grass land DM yield (t DM ha^{-1})	Legume (%)	Grass (%)	Chicory (%)
P1	8 April 2015	2.5	70	175	0.71	34	16	51
P2	5 May 2015	2.5	73	181	2.00	43	26	29
P3	4 June 2015	2.5	72	180	2.17	46	19	35
P4	30 June 2015	2.0	63	126	0.97	40	15	44
P5	3 August 2015	1.5	58	87	0.40	13	10	80
P6	14 Sept 2015	2.5	46	115	0.99			
P7	12 Oct 2015	2.0	52	103	0.58	11	24	66
P8	18 Nov 2015	1.0	61	61	0.16			
	Total	**16.5**	**494**	**1028**	**7.96**			

Figure 5. Cattle grazing the G14 paddock

Table 4. Pasture production and composition in the ungrazed part of the agroforestry paddock

Date of cut	Cut number	Grassland DM yield (t DM ha^{-1})	Legume (%)	Grass (%)	Chicory (%)
19 May 2015	C1	3.71			
9 July 2015	C2	3.68	48	10	43
16 October 2015	C3	1.96	6	13	18
	Total	9.35			

The biomass productivity of the grazed grassland on the entire grazing period (from 8 April to 19 November 2015) was estimated at 7962 kg DM ha^{-1} whereas the three cuts of the ungrazed part represented a biomass of 9346 kg DM ha^{-1}. The grazed grassland was mainly composed by chicory in summer and autumn. Clover and lucerne were the main legumes, and grass species were tall fescue, perennial rye-grass and cocksfoot.

Figure 6. The ungrazed part of the G14 paddock

6 Efficacy of the tree protections

To restrict the browsing of the newly established trees, five types of tree protections were tested, i.e. single or double line of electric fence, electric fencing tape, metal or plastic fences, and olfactory repellents. Another option included excluding the paddock from grazing and to mow the grassland during the first years of the establishment phase.

An objective during the first year was to evaluate cows' behaviour and tree damage for the different protection methods and within each grazing period.
Results:

- electric fence, electric fencing tape and metal fence were very efficient in protecting trees from cow damage during all the current grazing period (up to 19 November 2015).
- the plastic fence was damaged by cows on a corner from the first day of grazing and it was tattered at two places from the 4th grazing period (1 July 2015). It was mended with a piece of string at each grazing permitted to prevent cows from entering into the tree rows up to the 6th period of grazing which occurred mi-September 2015. At the 7th grazing period (12 to 14 October 2015), two cows went under the tattered fence and they broke two tree stakes and browsed the top of two trees (one white mulberry and one alder). Before the 8th grazing period, the tattered areas where strengthened with a strip and the cattle did not any more go into the tree rows.

Figure 7. Cattle browsing on mulberry

Figure 8. Cattle browsing on the plastic fence

- The four olfactory repellents tested were garlic essence, spirit vinegar, a repellent for deer used by hunters (which is a mixture of spices and NPK fertilizer) and fresh cow dung. They turned out to be ineffective from the first day of grazing, either when they were sprayed directly on the trees (at the first grazing) or on the wood chips around trees (at the second grazing period). Observations showed that cattle were overall attracted by the stakes used as rubbing posts, and they also played with the mesh tree guards. As a result, 77% of trees were damaged at the end of the second grazing period. The removal of stakes and mesh tree guards on this tree line, and the installation of two poles with brushes to be used as rubbing posts and of barrier tape along the tree line were efficient to prevent cows from damaging

the trees from the third grazing period (at the beginning of June 2015) and until the last grazing.

Figure 9. Cattle scratching against a brush fixed on a pole near the tree row initially protected with olfactory repellents

Figure 10. Cattle grazing near the tree row initially protected with olfactory repellents and then equipped with a barrier tape

7 Acknowledgements

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Annex A. detailed experimental design