System Report: Chestnut Agroforestry in Spain

Project name	AGFORWARD (613520)
Work-package	3: Agroforestry for High Value Trees
Specific group	Chestnut agroforestry in Spain
Deliverable	Contribution to Deliverable 3.7 (3.1): Detailed system description of a case study system
Date of report	13 January 2016
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Approved	Anastasia Pantera (11 April 2016) Paul Burgess (12 April 2016)

Contents

AGFORWARD (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

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 3.7: "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

Agroforestry with chestnut (*Castanaea sativa* Miller) is a traditional land use system in the eastern part of the Lugo province in Galicia, in North West Spain. Although chestnut groves are rarely intercropped (due to the low understorey production) or grazed (due to the fear of tree damage), the groves create a fine-grained mosaic of land uses including cropland and forests. However pig grazing does occur in some areas during the autumn and winter, where high slopes make chestnut harvesting unprofitable. Chestnut woodlands are also one of the best habitats for the commercial production of edible mushrooms.

From the initial stakeholder meeting in Galicia (Mosquera Losada et al. 2014) three innovations were identified. These were a) the evaluation of different types of tree protection at different tree ages to allow the safe introduction of pigs on a farm, b) improved mushroom production, and c) the production and testing of grafted and self-rooted plants of selected varieties of chestnut. These are considered in this report in turn.

3 Tree protection

3.1 Background

Large sections of the adult chestnut area belongs to the Natura 2000 network, are priority areas for birds, and are included in the recovery plan for grizzly bear populations in Galicia. These legal protection measures highlight the high natural and cultural value of the area. Moreover, the chestnuts produced in this region are recognized under the label of Protected Geographical Indication (PGI), and are mainly exported to selective markets in Europe.

3.2 Update on field measurements

Field measurements described in the research and development protocol (Fernández Lorenzo et al. 2015) began in 2015 and will continue until the end of 2017. All measurements have been and will be conducted by researchers from the University of Santiago de Compostela.

3.3 Description of system

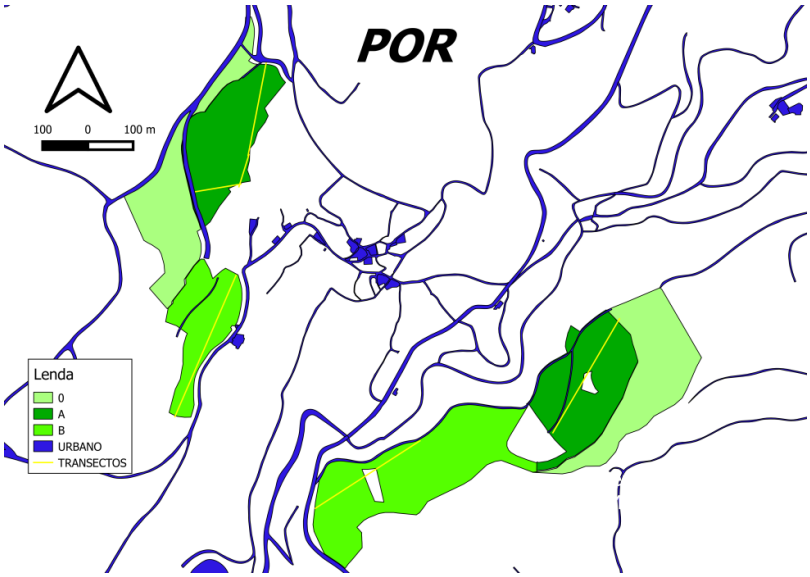
Table 1 provides a general description of the system and a description of a specific case study system is provided in Table 2.

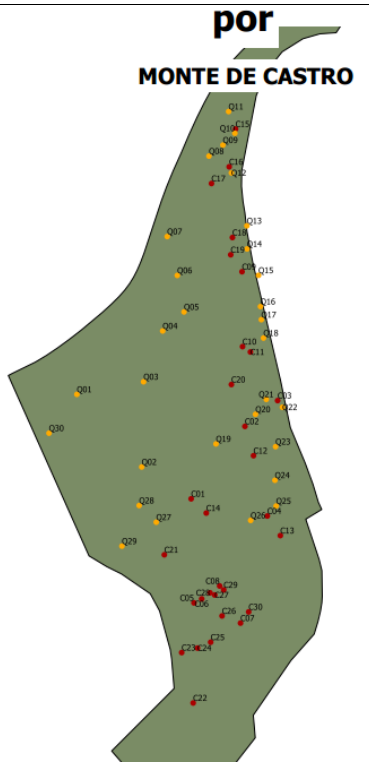
Table 1. General description of the system

General description of system	
Name of group	Chestnut agroforestry in Spain
Contact	Maria Rosa Mosquera Losada
Work-package	3: Agroforestry for High Value Trees
Associated WP	none
Geographical extent	Agroforestry with chestnut (*Castanaea sativa* Miller) is a traditional land use system in the eastern part of the Lugo province (Galicia, North West Spain)
Estimated area	16.6 ha
Typical soil types	Cambisol
Description	Although chestnut groves are rarely intercropped (due to the low understorey production) or grazed (due to the fear of tree damage), the groves create a fine-grained mosaic of land uses including cropland and forests. However pig grazing does occur in some areas during the autumn and winter, where high slopes make chestnut harvesting unprofitable.
Tree species	Chestnut (*Castanea sativa* L.)
Tree products	Chestnuts production
Crop species	None
Crop products	None
Animal species	Celtic pig
Animal products	Pork
Other provisioning services	Possibility of using tree pruning as firewood.
Regulating services	Trees can provide a microclimate with reduced temperature fluctuations. Trees can promote nutrient cycling and increase carbon sequestration.
Habitat services and biodiversity	Trees and animals can modify the biodiversity due to the formation of microhabitats (unshaded and shaded areas and effect of the animals' faeces).
Cultural services	This type of system can increase the rural employment.
Key references	See end of report

Table 2. Description of the specific case study system

Specific description of site	
Area	16.6 ha
Co-ordinates	43°01'57.26"N, 7°55'26.53"W
Site contact	University of Santiago de Compostela: María Rosa Mosquera Losada

Site contact email	mrosa.mosquera.losada@usc.es
Example photograph	 Figure 1. Example photographs of chestnut trees
Map of system	 Figure 2. Location of the chestnut agroforestry sites

	 Figure 3. Layout of one of the chestnut agroforestry sites
Possible modelling scenarios	
Comparison	Technical and economic analysis of silvopastoral systems vs exclusively agricultural and forest systems
Climate characteristics	
Mean monthly temperature	9.8 ºC
Mean annual precipitation	1232 mm
Details of weather station (and data)	"Corno do Boi" weather station (http://www2.meteogalicia.es/galego/observacion/estacions/estacionsHistorico.asp?Nest=10101&prov=Lugo&red=102&tiporede=automaticas&idprov=1-#)
Soil type	
Soil type	Cambisol
Soil depth	50 cm
Soil texture	To be defined
Additional soil characteristics	Water soil pH: 5.3
Aspect	Umbra (opposite to light orientation -when the slope is north)
Tree characteristics	
Species and variety	Chestnut (*Castanea sativa* L.)
Date of planting	The experiment will be carried out in two stands of 50 and over 100 years old
Intra-row spacing	The stand comes from natural regeneration so there is not regular plantation

	pattern
Inter-row spacing	The stand comes from natural regeneration so there is not regular plantation pattern
Tree protection	The use and the lack of protection will be tested in the treatments
Typical increase in tree biomass	12 m^3 ha^{-1} $year^{-1}$
Crop/understorey characteristics	
Species	*Ulex* sp.*, Pteridium* sp. *and Rubus* spp.
Management	None
Typical crop yield	
Fertiliser, pesticide, machinery and labour management	
Fertiliser	None
Pesticides	None
Machinery	None
Manure handling	None
Labour	Four people to establish the experiment, two people to visit the experiment all weeks and two people to carry out the field samplings
Fencing	Not required
Livestock management	
Species and breed	Celtic pig
Description of livestock system	Free range
Date of entry to site	Pigs usually start grazing in April in the 50 years old stand and in October in the old stands.
Date of departure from site	Pig cease grazing usually in September in the 50 years old stand and in December in the old stands.
Stocking density	1.5 livestock units per ha
Animal health and welfare issues	Pigs need to be regularly checked to ensure health and welfare
Annual mortality rate	0
Requirement for supplementary feed	Yes, during the previous period of pig fattening. They are fed with a mean amount of concentrate consumption of 2.5 kg pig^{-1} day^{-1}
Typical level of pig production	Animals are usually killed when their weight reaches 100 kg
Financial and economic characteristics	
Costs	Unknown

3.4 Plans for 2016

In 2016, the use or lack of protection will be tested in chestnut stands. As it was done in 2015, the effect of the protection will be measured using qualitative indicators (1: undisturbed; 2: bark affected; 3: bark destroyed and 4: root affected).

4 Improved mushroom production

4.1 Update on field measurements

Field measurements described in the research and development protocol (Fernández Lorenzo et al. 2015) will begin in March 2016 and will continue until the end of 2017. All measurements will be conducted by researchers from the University of Santiago de Compostela.

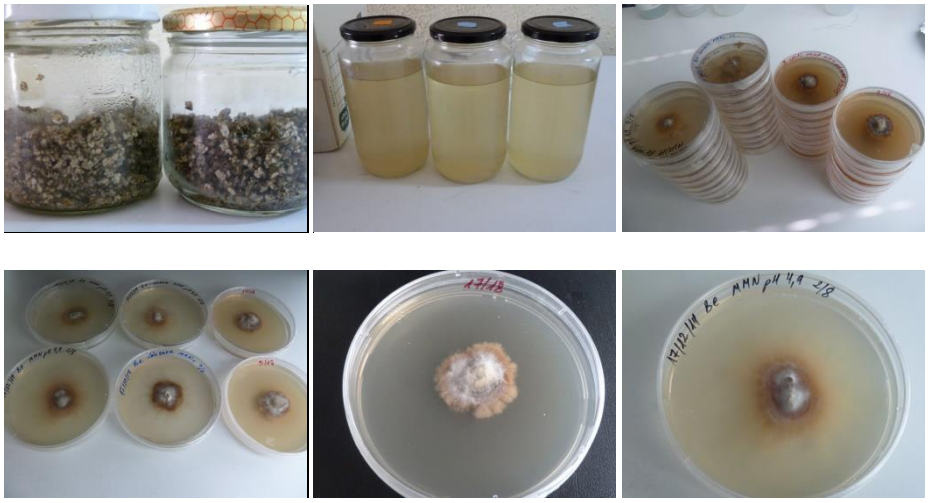
4.2 Description of system

Table 3 provides a general description of the system. A description of a specific case study system is provided in Table 2. Missing data will continue to be sourced during 2015.

Table 3. General description of the system

General description of system	
Name of group	Chestnut agroforestry in Spain
Contact	Maria Rosa Mosquera Losada
Work-package	3: Agroforestry for High Value Trees
Associated WP	None
Geographical extent	Agroforestry with chestnut (*Castanaea sativa* Miller) is a traditional land use system in the eastern part of the Lugo province (Galicia, North West Spain)
Estimated area	To be defined
Typical soil types	To be defined
Description	Although chestnut groves are rarely intercropped (due to the low understorey production) or grazed (due to the fear of tree damage), the groves create a fine-grained mosaic of land uses including cropland and forests. Chestnut woodlands are also one of the best habitats for the commercial production of edible mushrooms.
Tree species	Chestnut (*Castanea sativa* L.)
Tree products	Chestnuts production
Crop species	Typical natural understory which is consumed by animals
Crop products	None
Animal species	None
Animal products	None
Other provisioning services	Possibility of using tree pruning as firewood.
Regulating services	Trees can provide a microclimate with reduced temperature fluctuations. Trees can promote nutrient cycling and increase carbon sequestration.
Habitat services and biodiversity	Trees can modify the biodiversity due to the generation of microhabitats (unshaded and shaded areas).
Cultural services	This type of systems can increase rural employment.
Key references	See end of report

Table 4. Description of the specific case study system

Specific description of site	
Area	To be defined
Co-ordinates	To be defined
Site contact	University of Santiago de Compostela: María Rosa Mosquera Losada
Site contact email	mrosa.mosquera.losada@usc.es
Example photograph	 Figure 4. Mycelia produced in the laboratory of the University of Santiago de Compostela
Map of system	To be defined
Possible modelling scenarios	
Comparison	Chestnuts production combined with mushrooms production vs chestnuts production without mushrooms production.
Climate characteristics	
Mean monthly temperature	9.8°C
Mean annual precipitation	1232 mm
Details of weather station (and data)	"Corno do Boi" weather station (http://www2.meteogalicia.es/galego/observacion/estacions/estacionsHistorico.asp?Nest=10101&prov=Lugo&red=102&tiporede=automaticas&idprov=1-#)
Soil type	
Soil type	To be defined
Soil depth	To be defined
Soil texture	To be defined
Additional soil characteristics	To be defined
Aspect	To be defined
Tree characteristics	
Species and variety	Chestnut (*Castanea sativa* L.)

Date of planting	To be defined
Intra-row spacing	To be defined
Inter-row spacing	To be defined
Tree protection	To be defined
Typical increase in tree biomass	
Crop/understorey characteristics	
Species	Cleared understorey
Management	Inoculation with *Boletus edulis*
Typical crop yield	200 kg of boletus ha^{-1} $year^{-1}$
Fertiliser, pesticide, machinery and labour management	
Fertiliser	None
Pesticides	None
Machinery	None
Manure handling	None
Labour	Four people to establish the experiment, two people to visit the experimental site all weeks and two people to carry out the field samplings.
Fencing	Not required
Livestock management	
Species and breed	None
Financial and economic characteristics	
Costs	Unknown

4.3 Plans for 2016

The mycelia are being produced in the laboratory of the University of Santiago de Compostela. The inoculum was harvested at the end of 2014. In spring 2016, the tree superficial roots of different chestnut trees of two different diameters (below and above 50 cm) will be cleaned of soil, and the inoculum will be applied with a brush.

Mushroom production in both inoculated and not inoculated trees of different diameter will be evaluated during the autumn 2016 and 2017 every week. All carpophores of the plot will be harvested, weighed in humid and dry and identification of the place of harvesting will be noted.

5 Field tests of grafted and self-rooted chestnut of high fruit quality

5.1 Background

Chestnut trees are autochthonous in Galicia. Grafted chestnuts that were able to produce high quality fruits were expanded by monks during the Middle Ages. Chestnuts occupied most of this region until the nineteenth century and were a key source of carbohydrate for human beings. However the ink disease (*Phytophthora cambivora* or *Phytophthora cinnamomi*) destroyed most of the trees in the lower latitudes of Galicia. In the recent years, the high value of the product and the environmental benefits of chestnut trees have increased the demand for new plantations in low latitudes. The profitability of these new plantations could benefit from understorey management and grazing animals.

In this region, the use of grafted plants of selected varieties of chestnut could increase the quality and the production of chestnuts. Moreover, the farmers' chestnut association and industrial chestnut processors have already provided their preferences from an economic perspective. Some of the selected varieties have created interest among farmers, but it is still unknown which varieties are most suitable for which areas. The technique of micrografting (both in vivo and in vitro) could permit the production of a great number of grafted plants in short time periods. On the other hand, the use of self-rooted plants of varieties with a good rooting ability could help rapid establishment and carbon sequestration in ink disease-free areas. This innovation is in line with measure 222 of the Rural Development Programme dealing with the establishment of agroforestry systems.

Hence the objective of the third set of experiments is to produce and test grafted and self-rooted plants of Galician chestnut varieties that have been selected for fruit quality.

5.2 Update on field measurements

Field measurements described in the research and development protocol (Fernández Lorenzo et al. 2015) will begin in 2016 and will continue until the end of 2017. All measurements will be conducted by researchers from the University of Santiago de Compostela.

5.3 Description of system

Table 5 provides a general description of the system. A description of a specific case study system is provided in Table 6.

Table 5. General description of the systems

General description of system	
Name of group	Chestnut agroforestry in Spain
Contact	Maria Rosa Mosquera Losada
Work-package	3: Agroforestry for High Value Trees
Associated WP	None
Geographical extent	Agroforestry with chestnut (*Castanaea sativa* Miller) is a traditional land use system in the eastern part of the Lugo province (Galicia, North West Spain)
Estimated area	The total area of the research site is about 2.5 ha
Typical soil types	To be defined
Description	Chestnut trees are autochthonous in Galicia. In this region, the use of grafted plants of selected varieties of chestnut could increase the quality and the production of chestnuts. The technique of micrografting (both in vivo and in vitro) could permit the production of a great number of grafted plants in short time periods
Tree species	Chestnut (*Castanea sativa* L.)
Tree products	Chestnuts production
Crop species	None
Crop products	None
Animal species	None
Animal products	None
Other provisioning	Possibility of using tree pruning as firewood.

services	
Regulating services	Trees can provide a microclimate with reduced temperature fluctuations. Trees can promote nutrient cycling and increase carbon sequestration.
Habitat services and biodiversity	Trees can modify the biodiversity due to the generation of microhabitats (unshaded and shaded areas).
Cultural services	This type of systems can increase the rural employment.
Key references	See end of report

Table 6. Description of the specific case study system

Specific description of site	
Area	The total area of the research site is about 2.5 ha
Co-ordinates	To be defined
Site contact	University of Santiago de Compostela: María Rosa Mosquera Losada
Site contact email	mrosa.mosquera.losada@usc.es
Example photograph	 Figure 5. Micrografted plants of Parede variety three months after micrografting, ready to be established in the field
Map of system	To be defined
Possible modelling scenarios	
Comparison	Chestnuts production of grafted trees vs chestnuts production of trees not grafted
Climate characteristics	
Mean monthly temperature	9.8°C
Mean annual precipitation	1232 mm
Details of weather station (and data)	"Corno do Boi" weather station (http://www2.meteogalicia.es/galego/observacion/estacions/estacionsHistori

	co.asp?Nest=10101&prov=Lugo&red=102&tiporede=automaticas&idprov=1-#)
Soil type	
Soil type	To be defined
Soil depth	To be defined
Soil texture	To be defined
Additional soil characteristics	To be defined
Aspect	To be defined
Tree characteristics	
Species and variety	The plant material used for this experience consists of explants (microscions/microcuttings) of five selected varieties of chestnut (*Castanea sativa*) trees: “famosa”,” inxerta”, “parede”,” negral”, “longal” and “loura”.
Date of planting	The planting will begin in 2016
Intra-row spacing	5 m
Inter-row spacing	5 m
Tree protection	If needed
Typical increase in tree biomass	
Crop/understorey characteristics	
Species	Cleared understorey
Management	None
Typical crop yield	
Fertiliser, pesticide, machinery and labour management	
Fertiliser	None
Pesticides	None
Machinery	None
Manure handling	None
Labour	Four people to establish the experiment, two people to visit the experimental site all weeks and two people to carry out the field samplings.
Fencing	Not required
Livestock management	
Species and breed	None
Financial and economic characteristics	
Costs	Unknown

5.4 Plans for 2016

In 2016, the micrografting of the 5 varieties on hybrids resistant to the ink disease will be prepared in the laboratory and established in the field. The data collection will be carried out from August 2016 to December 2017

5 Acknowledgements

The AGFORWARD project (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD,

Theme 2 - Biotechnologies, Agriculture & Food. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

7 References

Fernández Lorenzo JL, Rigueiro Rodríguez A, Ferreiro-Domínguez N, González-Hernández P, Burgess P, Mosquera-Losada MR (2015). Research and Development Protocol for Chestnut Agroforestry in Spain. 15 June 2015. 7 pp. Available online: http://www.agforward.eu/index.php/es/chestnut-agroforestry-in-galicia-spain-654.html

Fernández-López, J (2013). Variedades para os soutos novos. Ed. Xunta de Galicia. 38 pp.

Fernández-Lorenzo JL, Fernández-López MJ (2005). Reinvigoration of mature *Castanea sativa* by micrografting onto a juvenile clone. Acta Horticulturae 693: 293-298.

Fernández-Lorenzo JL, Crecente S (2010). In vivo serial micrografting of *Castanea sativa* in short cycles. Acta Horticulturae 866: 291-296.