

# System report: Grazed Orchards in Northern Ireland

Project name	AGFORWARD (613520)			
Work-package	3: Agroforestry for High Value Trees			
Specific group	Grazed orchards in Northern Ireland, UK			
Milestone	Contribution to Deliverable 3.7 (3.1): Detailed system description of a case			
	study system			
Date of report	30 November 2015			
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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 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

The initial stakeholder report (McAdam, 2014) and the research and development protocol (McAdam 2015) provide background data on grazed orchards in Northern Ireland. The practice of grazing orchards is very rare in the commercial orchards of Northern Ireland. The production of blemish free apples requires an intensive agrochemical programme. Lavery et al. (2014) estimated that there were 219 growers, managing 1,519 hectares of top fruit orchards in Northern Ireland in 2014. They reported that 1,519 hectares was equivalent to 40,936 spray hectares receiving an estimated 36.5 tonnes of active ingredient. Lavery et al. estimated that, 97% of all top fruit crops were grown in County Armagh, with Bramley apple orchards accounting for 99% of the total top fruit grown in Northern Ireland. There were an estimated 38,235 tonnes of Bramley apples harvested in 2014.

A typical orchard spray programme includes 10 to 12 fungicide applications from May to end of July to prevent the main disease apple scab (*Venturia inaequalis*), two herbicide applications to control weeds in the understory of the trees, and one insecticide application.

Farmers have proposed that control of apple scab and a reduction in pesticide inputs/costs might be achieved by grazing sheep in the orchards. The logic is that sheep will eat apple leaves immediately as they fall to the ground, and help to decompose old leaves by trampling, thus reducing the refuge for the organism responsible (McAdam 2014).

Commercial orchards are mown approximately eight times per year, an activity involving labour and machinery costs. The introduction of livestock to the orchard can minimise the need for such mowing and at the same time it can provide animal feed for sheep production. However the livestock can also incur costs, and bring additional complexity and administrative burdens to top fruit production (Burgess 2014; Corroyer 2014; Durrant and Durrant 2009).

# 3 Update on field measurements

Field measurements for the spring/summer trial described in the research and development protocol (McAdam 2015) began in early April 2015, and continued until mid-June when the sheep were removed. The autumn/winter trial is scheduled to commence late November after harvest is completed. Data from the site is to be collated and statistically analysed during December 2015.

# 4 Description of system

Table 1 provides a general description of the grazed orchard agroforestry system. A description of a specific case study system is provided in Table 2.

General description	on of system					
Name of group	Grazed orchards in Northern Ireland					
Contact	Jim McAdam					
Work-package	3: High value trees					
Associated WP	Work-package 2 and Work-package 5 (Use of livestock)					
Geographical	Grazed cider orchards are found in England, Wales, Northern Ireland and					
extent	northern France.					
Estimated area	In 2014 the total area of apple orchards in Northern Ireland was 1519 ha. 99%					
	of the apples grown in Northern Ireland are of the culinary variety "Bramley					
	Seedling" the other 1% is made up of cider and dessert varieties (Lavery et al.					
<b>T</b> - 1 - 1 - 1 - 1	2014). Typical field sizes are between 1.5 and 4 ha.					
Typical soil types	Cambisols					
Description	Tree specing varies with react tack used M0 dwarfing react tacks are widely.					
	used with spacing of 4 m between rows 1 5 m between trees. A berbicide strin					
	approximately 2 m wide is maintained in the tree rows while the grass string					
	between tree rows is mowed regularly. Field boundaries planted with					
	windbreaks or hedgerows of mixed woody species. Area below windbreaks					
	generally left unmown, producing a dense under storey.					
Pesticide inputs	Northern Ireland top fruit sector is made up of 99% Bramley apple and 1% other					
	top fruit crops to which 36.5 tonnes pesticides applied per year (Lavery et al.					
	2014). Pesticide inputs are mainly fungicides to prevent the main disease apple					
	scab (Venturia inaequalis)					
Tree species	Apple ( <i>Malus domestica</i> )					
Tree products	The top fruit industry annually produces about 30-45,000 t product per year of					
	which 12-15% goes to fresh market valued €8.64 million, 60-70% to the added					
	value market (value £7-8 million) and 25-30% to juice and cider production.					
Understory Crop	Grasses such as perennial ryegrass					
Crop products	Typically grass in orchards is not grazed or cut but maintained by mowing.					
Animal species	Traditionally none					
Animal products	The grass can be used to fatten lambs or to maintain the weight of ewes					
Other services	Eventually apple tree wood can be used as fuelwood.					
Regulating	Trees can provide shade for the sheep in summer and shelter in winter. The					
services	sheep can promote nutrient cycling and by eating fallen leaves, can remove a					
	refuge for fungi. Above-ground, the trees will increase carbon storage.					
Cultural services	Grazed orchards may change labour requirements for an orchard					

Table 1. General description of the grazed orchard system

Specific description of site						
Area (ha)	0.93 ha					
Co-ordinates	54°24'43.2000''N; 6°34'55.5528''W (54.412000; -6.582098)					
Site contact	Jim Mc Adam					
Site contact	jimmcadam@afbini.gov.uk					
Site photograph						
Overview of the AFBI trial	<image/>					
A trial plot area						

# Table 2. Description of the specific case study system



	from Loughgall to Armagh City and Navan						
Soil characteristics	Refer to Table 4. Available P is adequate in the Ap horizon, but K and						
	Mg are low. pH is extremely high in B and C horizons, reflecting the						
	high Calcium values and high total of exchangeable bases. The CEC is						
	hase saturated. The high loss of ignition value is due to the presence						
	base saturated. The high loss of ignition value is due to the presence						
	of carbonates. The strong red colour of the soil is not reflected in total						
	iron values. Soil textures are clay loam and clay (clay is 43.2 per cent)						
	in the B horizon. The soil may be classed as a Pelosol.						
Tree characteristics							
Species and variety	Apple (Malus domestica) dessert variety Jonagold and Cider Variety-						
	Coet-de-linge						
Date of planting	1998						
Inter-row spacing	Jonagold 4 m Coet-de-linge 5 m						
Inter-tree spacing	Jonagold 1.5 m Coet-de-linge 2 m						
Trees per ha	Jonagold 1485 Coet-de-ling 900						
Rootstock	Jonagold M9 Coet-de-linge MM106						
Tree protection	Trees are supported with a stake to prevent uprooting by wind.						
	A wire mesh is placed around the tree trunk to protect from hare						
	grazing "Hare guard"						
Typical apple yield	Typical apple yield are presented in Table 3. Vylupek (2010) quotes a						
	mean apple yield (fresh weight) from UK orchards of 15.7 t ha <sup>-1</sup> .						
	Centre for Alternative Land Use $(2007)$ quotes a yield of 12 t ha to 20						
	t ha <sup>+</sup> . Fairs (2010), quoted by Vylupek (2010) quotes a mature (10						
	years) yield of about 50 t ha . Yields can vary substantially between						
	vears que lo piennial pearing.						
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Stocking density	18 ewe lambs, rotated on through plots of 0.47 ha
Animal welfare	Sheep need to be checked daily to ensure health and welfare
Supplementary feed	Sheep may need access to mineral blocks

Table 3. Mean yields for apple varieties Coet-de-linge (cider) and Jonagold (dessert) on this site from planting in 1998 to 2015

Year	Fresh weight yield (t ha <sup>-1</sup> )		Yield Dry weight	yield (t ha⁻¹)
	Coet-de-linge	Jonagold	Coet-de-linge	Jonagold
1999	0.02	0.46	0.003	0.059
2000	1.38	1.79	0.179	0.232
2001	20.73	22.43	2.694	2.916
2002	4.25	21.49	0.552	2.794
2003	0.44	24.30	0.057	3.160
2004	30.21	40.83	3.927	5.307
2005	18.90	37.11	2.457	4.825
2006	42.50	44.34	5.525	5.764
2007	35.40	21.34	4.602	2.775
2008	36.85	55.15	4.791	7.169
2009	3.85	14.66	0.501	1.906
2010	47.67	46.13	6.197	5.997
2011	37.95	38.12	4.934	4.955
2012	*	*	*	*
2013	21.09	36.08	2.741	4.690
2014	20.85	27.52	2.710	3.577
2015 grazed	35.40	23.53	4.600	3.060
2015 mowed	47.56	47.26	6.180	6.140

Dry matter content calculated at 13% of fresh weight yield (Vylupek, 2010)

Table 4. Nutrient analysis for the three soil horizons of the brown earth soil on carboniferous limestone red till at Loughgall, Co. Armagh

Horizon	Р	К	Mg	Mg	Ca	Na	К	Dithio	Total P
	(mg	(mg	(mg	(mg	(mg	(mg	(mg	Fe	(mg
	kg⁻¹)	kg⁻¹)	kg⁻¹)	100 g⁻¹)	100 g⁻¹)	100 g⁻¹)	100 g⁻¹)	(mg kg <sup>-1</sup> )	kg⁻¹)
Ар	64	102	85	0.80	15.12	0.09	0.31	16,500	770
Bw	3	99	94	0.89	15.08	0.06	0.30	15,200	841
С	3	91	78	0.64	16.96	0.06	0.22	16,800	1009

Soil horizon	CEC (mg 100 g <sup>-1</sup> )	рН	Nitrogen (%)	Carbon (%)	Loss of ignition (%)	Sand (%)	Silt (%)	Clay (%)
Ар	24.42	7.0	0.27	2.92	8.5	50.6	25.1	24.3
Bw	16.88	7.8	0.09	1.28	5.6	42.4	14.4	43.2
С	18.21	8.3	0.06	0.60	7.7	43.3	26.5	30.1

#### 5 Description of the tree component

#### 5.1 Variety

Apple trees are formed with a combination of a clonal rootstock to give the tree a particular growth habit, and a clonal scion which will determine harvest fruit variety. The majority of orchards in Northern Ireland are "bush" type systems grown on dwarfing rootstock M9. M9 trees require good soil conditions, the ground around the tree clear of weeds and grass, and permanent staking. M9 mature trees grow to 1.8-2.4 m high and have a 2.7 m crown spread (Keepers Nursery). The apple varieties used at this study site are cider "Coet-de-linge" and dessert "Jonagold". Both varieties are harvested at the end of October/November.

#### 5.2 Tree density and height

Both varieties in this orchard were planted in 1998, Jonagold at 1485 and Coet-de-linge at 900 trees per ha, while new commercial cider orchards in the UK tend to be planted at densities of about 600-700 trees per hectare (Vylupek, 2010). Durrant and Durrant (2009) suggested that the cider-maker Bulmers is establishing new orchards planted at a density of 650-750 trees per hectare. Despite this many older orchards are still in use for cider production, and are planted at densities as low as 300 trees per hectare.

The trees received early formative pruning to maintain a single dominant leader followed by regular pruning to thin the canopy. The maintained canopy enables light and air penetration through the tree and allows sprays applied with an air assisted sprayer and to penetrate into the heart of the canopy. Small tree forms (2-3 m high) allow harvesting by hand.

# 6 Trial results

Data generated from the 2015 trial is not due for processing through biometrics for statistical analysis until mid-December 2015 so only mean data is reported here. Several questions were posed, regarding sheep grazing in orchards, at the initial stakeholders meeting in Northern Ireland (McAdam, 2014). To obtain quantitative answers a replicated experimental of a split-plot design was carried out in 2015 in an existing orchard planted in 1998. Treatments included four replicates of three crops: dessert apples, cider apples, and a grass control, split into two grass management treatments: grazing or mowing.

Using mixed breed sheep, the initial stock rate was set at three sheep per plot but after eight days it was considered that five sheep per plot was a more appropriate stocking rate for the trial area. Plot sizes in the trial are 0.33, 0.04 and 0.042 hectares.

Grass in the orchard has been typically managed by mechanical mowing once per month from March to October. No damage to trees was recorded by this method of management. From 12 May to 17 June 2015, Coet-de-linge, Jonagold and grass plots had a mean of 50, 57 and 57 total sheep grazing days accumulated respectfully.

#### 6.1 Effect of orchard grazing on trees, yield and fruit quality

Northern Ireland fruit growers are generally very resistant to the concept of sheep grazing their orchards. Their main concerns are the damage to trees resulting in tree mortality and reduced yields.

Observations from a preliminary trial in 2014 highlighted the importance of careful monitoring of grass grazing levels to ensure that the sheep did not graze the trees. In 2014, with low levels of available grass, over one night the sheep removed large areas of bark from the tree trunk and lower larger limbs. In the 2015 trial, even with daily assessments of grass levels one plot (Jonagold) had 13% of the trees with bark damage. All trees in the grazed plots showed signs of lighter branches/twigs getting caught up and tangled in the sheep's wool, leaving strands of wool in the lower canopy (Figure 1). This did not always result in damage as they did not tend to eat this type of material. In all the grazed plots the sheep grazed and stripped the lower branches of leaves and flowers up to 1.14 m from ground level (Figure 1). On one occasion a sheep was observed leaping to catch leaves over 1.14 m.



Figure 1. On the left ungrazed plots show no damage to the lower canopy where on the right hand side is typical effect of sheep browsing in apple trees.

The reduction in cropping area from the trees lower canopy in grazed plots resulted in an overall loss of yield of 26% and 50% for the Coet-de-linge and Jonagold respectfully when compared to yields from mowed (Table 5).

Table 5. Yield expressed as a fresh weight (t ha<sup>-1</sup>) and dry weight (t ha<sup>-1</sup>) obtained from Coet-de-linge and Jonagold apple varieties in the mowed and grazed management treatments in 2015

Apple variety	Grass maintenance treatment	Fresh weight yield (t ha <sup>-1</sup> )	Dry weight yield (t ha⁻¹)
Coet-de Linge	Mow	47.56	6.18
Coet-de Linge	Graze	35.40	4.60
Jonagold	Mow	47.26	6.14
Jonagold	Graze	23.53	3.06

To allow the input of sheep into the orchard and to determine if the sheep had any effect on apple scab during the growing season, fungicide applications for the control of apple scab were only carried out over early flowering. Coet-de-linge shows a better resistance to leaf scab than Jonagold. In August Coet-de-ling had 9.5% leaf scab compared to 71.6% for Jonagold. Coet-de-linge grazed plots recorded a slightly lower percentage of leaf scab in August (8.8%) than the mowed plots (10.2%), whereas the opposite was true for the Jonagold where the leaf scab in the grazed plots reached 72.8% compared to 70.5% in the mowed plots.

From post-harvest assessments, grazing had no effect on fruit scab incidences for cider which both had a mean of 0.25% fruit Scab. Cider apples, such as Coet-de-linge, are grown solely to produce apples which are juiced to produce cider, so the appearance of the apple is not important. Cider Coet-de-linge fruit size increased with the presence of sheep with 10% more in the upper size band between of 60-80 mm compared to mowed plots (the level of significance is still to be determined).

Jonagold however is grown to supply duel markets, fresh fruit and juicing. For the fresh market, skin finish is very important since top quality Grade 1 fruit should be pest and disease free. Jonagold from mowed and grazed plots had similar levels of fruit scab 45.5% and 44.0% respectfully. However the percentage of unmarketable fruit scab differed with mowed plots having 6.25% and grazed plots 10.5% (the level of significance is still to be determined). Jonagold has typically a large fruit size of 70 mm and above. In this trial fruit size was generally smaller than normal with only 28.5% in mowed plots and 47.8% in grazed plots having a size greater than 70 mm. The apple packer/processor would consider levels of fruit scab and size grades of Jonagold apples when deciding which market route to follow. Considering the large levels of fruit scab and economics of sorting for the fresh market along with the low fruit size, all Jonagold produced in this trial would be likely to be sent to the juicing market resulting in a reduction in profit for the farmer.

Data from this trial confirms the need to maintain a full season pesticide spray programme especially for the control of apple scab with the Jonagold variety. This in turn would lead to greater labour input to manage the sheep during spray operations. To reduce this labour input data is required to ascertain if it is safe to leave the sheep in the orchard during spraying.

#### 6.1 Effect of grazing orchards on sheep

Of the 20 sheep used in the trial only five spent their total time in the grass plots, the other fifteen spent between 4 and 21 days on grass with the rest of their time shared over the grazed cider and Jonagold plots. No adverse health effects were recorded for the sheep. Those sheep that spent 100% of their time on grass had an overall mean weight loss of 1 kg from entry to the site 12 May to 17 June 2015, while for the same period the other sheep had a mean weight gain of 3.83 kg, suggesting that there is an advantage to sheep of grazing in orchards. During the trial period sheep were seen to rest under the trees rather than in the open grass strips (Figure 2).



Figure 2. Sheep resting under the apple trees

# 6.2 Financial and labour impacts of grazing orchards

During May to June 2015, when the sheep were active on the trial, the non-grazed plots were mowed on three occasions. The costs saving associated with managing sward heights with grazing is offset by additional labour costs required. Increased labour is required for daily management of the sheep, checking on numbers and health, checking grass levels and movement to fresh grass. Checking and movement of sheep within the orchard is more difficult and time consuming than in open pasture as they run through the trees. The presence of sheep in the orchard makes apple husbandry e.g. pesticide applications more difficult. Research will be required to determine if the sheep need to be removed from the orchard during such applications.

The trial data suggests that no serious bark stripping should occur as long as the grass levels in the orchard are maintained above a certain level, but failure to do so will result in major damage being caused in only a few hours. Financial losses can be expected through loss of production area (sheep stripped the lower branches of leaves and flowers up to a height of 1.14 m) and thus total yield harvested, from an orchard of dwarf or semi-dwarf apple trees where mixed-breed sheep are

allowed to graze. A more complete analysis of financial and labour impacts will be reported in the next cycle.

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