Research and Development Protocol for Integrating Trees with Arable Crops, Switzerland

Project name	AGFORWARD (613520)
Work-package	4: Agroforestry for arable farmers
Specific group	Integrating trees with arable crops, Switzerland
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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 the second objective. It contributes to the initial research and development protocols (Milestones 10 & 16) for the participative research and development network focused on agroforestry with high value trees and on the use of agroforestry for arable farmers. The report addresses both work-packages 3 and 4 because the focus of the stakeholder group is planting fruit trees on arable land.

2 Background

The traditional agroforestry system *Streuobst* (Herzog 1998) is still relatively widespread in Switzerland: standard fruit trees scattered on grassland, which is mown or pastured (or both). Since about 2000, pioneer farmers have started to experiment with combinations of (mostly fruit) trees with arable crops. They have heard about agroforestry through the press and the internet, mostly from neighbouring Germany and France. Sereke et al. (2014) inventoried innovative agroforestry systems and evaluated their potential productivity and profitability, applying the methods developed in the SAFE project (Graves et al. 2010a, 2010b).

In 2014, parallel to the start of the AGFORWARD project, the Swiss Ministry of Agriculture commissioned AGRIDEA, the Swiss national farm extension service, to elaborate extension material for Swiss agroforestry farmers and to establish a participatory research and development network with up to 25 farmers (www.agroforst.ch / www agroforesterie.ch). The AGRIDEA project is also supported by the Swiss Landscape Foundation, which provides planting grants. The participatory research and development work (work-packages 3 and 4) of AGFORWARD is conducted together with the AGRIDEA project. The overall objectives are:

- To establish a network of farmers with agroforestry demonstration sites;
- To provide agroforestry extension material (website, leaflets, training);
- To record over the years the evolution of pioneer agroforestry sites, both in terms of biophysical growth as in terms of farmer expectations and satisfaction.

The last activity already started in 2011 (Kuster et al. 2012) and is pursued in the context of the AGFORWARD and AGRIDEA projects.

3 Objective of trial

The aim of the trial is to record the fate of farmer-led agroforestry experiments in terms of bio-physical development, ecosystem services and farmer perception. Key questions include:

- How do the trees develop?
- How do the trees affect crop yield?
- What are the major constraints perceived by the farmers and how does this perception change as the agroforestry plot evolves?
- What are the major advantages perceived by the farmers and how does this perception change as the agroforestry plot evolves?

In addition, we will record key tree and crop parameters which should allow, in the long run, the parameterisation of the Yield-SAFE model for the plots investigated. This will involve some tree species (fruit trees) and possibly new crops (e.g. horticulture – if not too complex to be modelled).

4 System description

Already in the first year of the establishment of the agroforestry network, eleven farmers were recruited (six more than originally planned). Table 1 summarises the characteristics of the agroforestry systems.

Figure 1. Agroforestry plot of the Stadel farm with mobile chicken shelters on the sown grassland component of the crop rotation between the trees.

Table 1. Agroforestry plots participating in the Swiss stakeholder group (work-packages 4 and 3) in 2015.

Canton	Municipality	Agroforestry system
Vaud	Arnex sur Orbe	Arable row crops in combination with walnut (*Juglans sp*), wild cherry (*Prunus avium*), wild pear (*Pyrus communis*), linden tree (*Tilia sp*), checker tree (*Sorbus torminalis*), sorb trees (*Sorbus domestica*). Planted in 2011, integrated production system.
	Romanel sur Morges	Planned agroforestry system with pollarded willow trees and fruit trees in combination with arable crops. Will be planted in 2015, organic farming system.
Lucerne	Grosswangen	Walnut and plum trees (*Prunus domestica*) in combination with an arable rotation which comprises sown grassland. The grassland is pastured with chicken (fattening). Tree planting started in 2013, still ongoing. Organic farming system.
	Malters	Permaculture project with various fruit trees (mostly quince *Cydonia oblonga*), wild fruit trees, berries. Organic farming system.
	Sursee*	Apple trees (*Malus domestica*) in combination with potatoes, strawberries and sown flower strips. Established in 2009, integrated production system.
Geneva	Meinier	Planned agroforestry system with standard fruit trees and hedgerows in combination with an arable rotation. Will be planted in 2015. Organic farming (recently converted)
Zurich	Stadel	Planned agroforestry system with standard apple trees (*Malus domestica*) and special crops (berries). Organic farming system (Figure 1).
Neuchatel	Cressier	Apple (*Malus domestica*), wild cherry (*Prunus avium*) pear (*Pyrus communis*) in combination with an arable rotation. Planted in 2014 in cooperation with Frigemo SA (landowner). Integrated production system.
Aargau	Möhlin*	Sour cherry (*Prunus cerasus*), apple (*Malus domestica*), various wild fruit trees and shrubs (berries) in the tree line, in combination with horticulture and ecological focus areas. Trees were planted in 2009 and 2010. Organic farming system (Figure 2).
	Niederwil	Sweet chestnut (*Castanea sativa*) in combination with an arable rotation. Organic farming system (Figure 3).
Basel-Landschaft	Buus*	Poplar (*Populus tremula*) in combination with an arable rotation. Tree planting started in 2011, still ongoing. Trees not for short coppice but to grow up. Integrated farming system.

The sites marked with an "*" have been selected for long-term monitoring with data recording starting in 2011 (Kuster et al. 2012)

Figure 2. Sown field margin as ecological focus area in combination with cherries, wild fruit trees, shrubs and berries and with horticultural crops (Möhlin farm)

Figure 3. Sweet chestnut in an agroforestry setting. The tree row will be progressively thinned and the eliminated smaller trees will be sold as planting material (Niederwil farm)

5 Trial design

The plots listed in Table 1 have been established by farmers themselves and lack a proper experimental set-up (e.g. no control, no replication, no planned experimentation but ad-hoc adaptation of management to external conditions, possibly changing requirements and learning experiences). We have no control over the management of the plots. Farmers form a network and gather regularly in the context of training sessions in order to learn from experts (e.g. training course on tree pruning for agroforestry in winter 2014/15) and from each other. Therefore, instead of a biophysical design, we have a "social" design of shared learning, facilitated by classical extension methods and inputs from research through the AGFORWARD project. This type of approach has been recently evaluated as very successful in stimulating farmers to adopt new technologies (Waters-Bayer 2015).

All farmers have agreed to allow for measurements, to participate in interviews, and to share their recordings and experience. Three plots have been selected for continuous monitoring (Sursee, Möhlin and Buus farms) which started in 2011 and will be pursued beyond the duration of AGFORWARD. On the other farms, a basic set of data will also be recorded and interviews will be carried our regularly.

6 Measurements

The measurements carried out on the agroforestry plots are summarized in Table 2 and detailed below.

Table 2. Agroforestry plot features and parameters recorded on agroforestry plots of the Swiss participatory research and development network

Feature or parameter	All agroforestry plots	Buus, Möhlin and Sursee plots
Characteristics of the agroforestry system, including digital map and tree co-ordinates	At tree planting	At tree planting
Soil characteristics	Soil core and spade probing, stability of soil aggregate (at time of tree planting)	Soil profile and lab analysis in 2011
Plot management and yields	Annual	Annual
Farmer motivation and perception	Annual interviews	Annual interviews
Biodiversity	Overall evaluation	Overall evaluation
Tree measurements	No	Every three years, starting in 2011
Machinery and labour input	Annual, based on farmer's records	Annual, based on farmer's records and on additional interviews

As trees have only recently been planted (e.g. 2009 at the Möhlin system) and because the trees are comparatively slow growing, the full effects of the trees on the crop system will take time to develop.

6.1 Measurements which are carried out on all agroforestry plots

The agroforestry plots of all farms which participate in the network are characterized with respect to spatial layout, soil conditions, plot management, farmer motivation, and perception.

System description and spatial layout

The components of the agroforestry system are recorded at the moment of establishment by means of a datasheet. Tree locations are measured with a GPS and plotted in a GIS. The resulting maps are made available to the farmers.

Figure 4. Agroforestry plot of the Niederwil farm (chestnut with arable rotation)

Soil characteristics

Soil conditions are recorded, preferably before tree planting, in order to advise the farmer on the species to use. Soils are then generally characterized, for example in terms of organic content and the soil profile.

Figure 5. Soil characterisation at the Cressier agroforestry plot

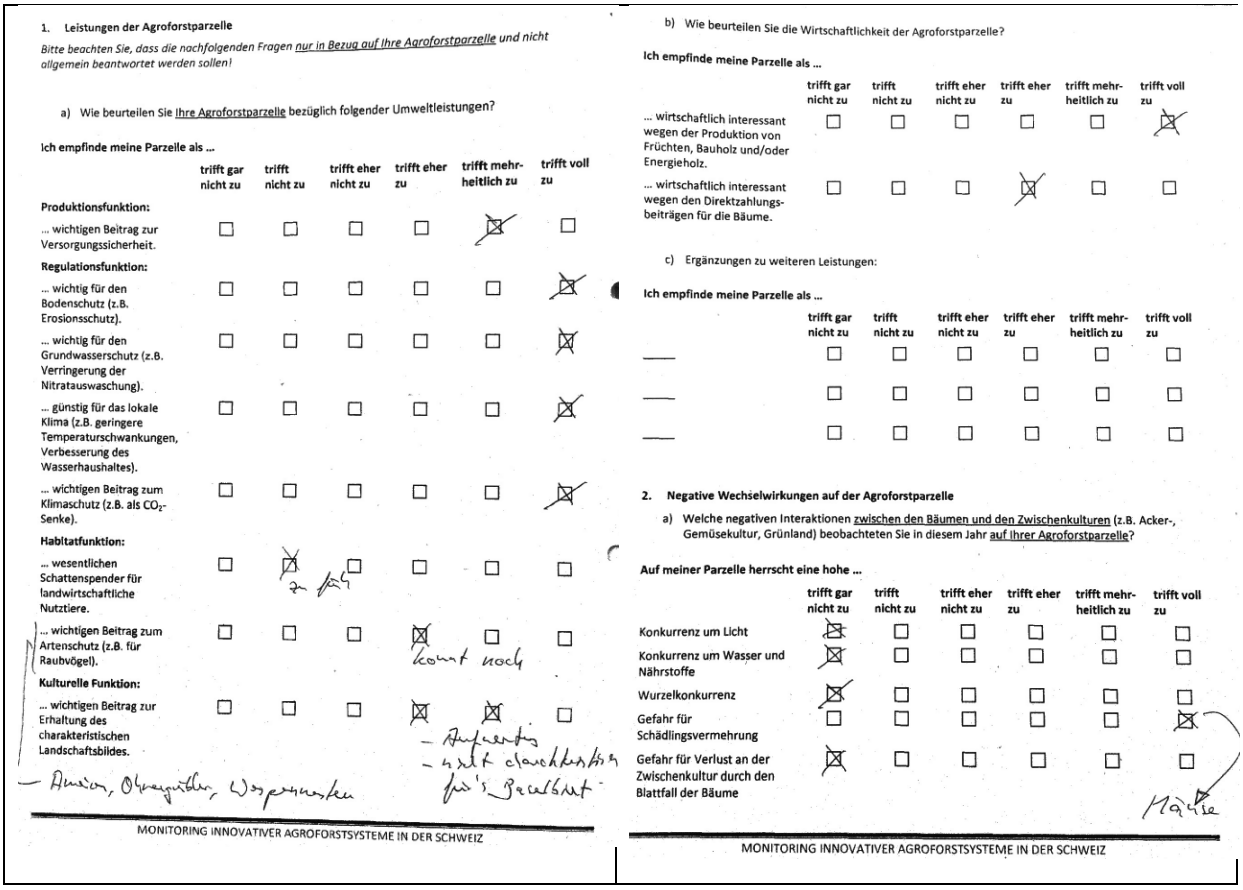
Plot management and yields

The management of the agroforestry plots is recorded based on the records, which farmers make for the agricultural administration (in the context of cross-compliance). Those records also comprise information about the yield of the agricultural component of the plot. Tree yields (fruit harvest) will also be recorded based on the farmers' records, once the trees bear fruit, which are harvested.

Figure 6. Farmer's field records on horticultural production at the Möhlin agroforestry plot

Farmer motivation and perception

Each year, the farmer is interviewed and interrogated about his / her perception of advantages / disadvantages / problems on the agroforestry plot. The questionnaires are adapted and improved, based on the feedback obtained.



1. Leistungen der Agroforstparzelle

Bitte beachten Sie, dass die nachfolgenden Fragen nur in Bezug auf Ihre Agroforstparzelle und nicht allgemein beantwortet werden sollen!

a) Wie beurteilen Sie Ihre Agroforstparzelle bezüglich folgender Umweltleistungen?

Ich empfinde meine Parzelle als ...

	trifft gar nicht zu	trifft nicht zu	trifft eher nicht zu	trifft eher zu	trifft mehrheitlich zu	trifft voll zu
Produktionsfunktion:						
... wichtigen Beitrag zur Versorgungssicherheit.	☐	☐	☐	☐	☒	☐
Regulationsfunktion:						
... wichtig für den Bodenschutz (z.B. Erosionsschutz).	☐	☐	☐	☐	☐	☒
... wichtig für den Grundwasserschutz (z.B. Verringerung der Nitratauswaschung).	☐	☐	☐	☐	☐	☒
... günstig für das lokale Klima (z.B. geringere Temperaturschwankungen, Verbesserung des Wasserhaushaltes).	☐	☐	☐	☐	☐	☒
... wichtigen Beitrag zum Klimaschutz (z.B. als CO_2-Senke).	☐	☐	☐	☐	☐	☒
Habitatfunktion:						
... wesentlichen Schattenspender für landwirtschaftliche Nutztiere.	☐	☒	☐	☐	☐	☐
... wichtigen Beitrag zum Artenschutz (z.B. für Raubvögel).	☐	☐	☐	☒	☐	☐
Kulturelle Funktion:						
... wichtigen Beitrag zur Erhaltung des charakteristischen Landschaftsbildes.	☐	☐	☐	☒	☒	☐

b) Wie beurteilen Sie die Wirtschaftlichkeit der Agroforstparzelle?

Ich empfinde meine Parzelle als ...

	trifft gar nicht zu	trifft nicht zu	trifft eher nicht zu	trifft eher zu	trifft mehrheitlich zu	trifft voll zu
... wirtschaftlich interessant wegen der Produktion von Früchten, Bauholz und/oder Energieholz.	☐	☐	☐	☐	☐	☒
... wirtschaftlich interessant wegen den Direktzahlungsbeiträgen für die Bäume.	☐	☐	☐	☒	☐	☐

c) Ergänzungen zu weiteren Leistungen:

Ich empfinde meine Parzelle als ...

	trifft gar nicht zu	trifft nicht zu	trifft eher nicht zu	trifft eher zu	trifft mehrheitlich zu	trifft voll zu
____	☐	☐	☐	☐	☐	☐
____	☐	☐	☐	☐	☐	☐
____	☐	☐	☐	☐	☐	☐

2. Negative Wechselwirkungen auf der Agroforstparzelle

a) Welche negativen Interaktionen zwischen den Bäumen und den Zwischenkulturen (z.B. Acker-, Gemüsekultur, Grünland) beobachteten Sie in diesem Jahr auf ihrer Agroforstparzelle?

Auf meiner Parzelle herrscht eine hohe ...

	trifft gar nicht zu	trifft nicht zu	trifft eher nicht zu	trifft eher zu	trifft mehrheitlich zu	trifft voll zu
Konkurrenz um Licht	☒	☐	☐	☐	☐	☐
Konkurrenz um Wasser und Nährstoffe	☒	☐	☐	☐	☐	☐
Wurzelkonkurrenz	☒	☐	☐	☐	☐	☐
Gefahr für Schädlingsvermehrung	☐	☐	☐	☐	☐	☒
Gefahr für Verlust an der Zwischenkultur durch den Blattfall der Bäume	☒	☐	☐	☐	☐	☐

MONITORING INNOVATIVER AGROFORSTSYSTEME IN DER SCHWEIZ

Figure 7. Example farmer perception questionnaire from one of the agroforestry plots

Biodiversity

The actual measurement of biodiversity indicators on agroforestry systems (i.e. species lists of plants and fauna groups) is laborious and requires control plots for comparison. Also, it makes sense only once the trees have reached a certain size. Therefore, we will apply a simple evaluation key, which has been developed for the evaluation of the potential of agroforestry to promote bird species (Kaeser et al. 2010).

Facteurs	Paramètres	Points
Mise en place du système agroforestier		
1. **Espèces d'arbres**	Espèces d'arbres indigènes, adaptées au site[1]	1
	Espèces d'arbres étrangères au site	0
2. **Disposition et densité** des arbres	Espacés[2] (≤ 50 arbres/ha)	1
	Serrés (> 50 arbres/ha)	0
	Orientation Est-Ouest[3] des rangées	1
	Orientation Nord-Sud des rangées	0
Exploitation du système agroforestier		
3. **Exploitation agricole** (de la surface située entre les arbres)	Herbages uniquement	2
	Terres assolées et herbages (les bandes sous les arbres ne comptent pas)	2
	Terres assolées uniquement[4] (avec/sans bandes sous les arbres)	0
	Pâturage/Herbe fauchée/Mulch[5]	1
	Surfaces herbagères coupées court/sol ouvert[6]	1
4. **Entretien des arbres**	Arbres en majorité non ébranchés très haut, pas de bois d'œuvre	0,5
	Arbres en majorité ébranchés très haut, bois d'œuvre[7]	0
	Les branches coupées restent en tas[8] sur le sol	0,5
Ne remplir que si les terres assolées sont majoritaires: 5. **Exploitations des bandes sous les arbres**	Bandes herbacée	1
	Aucune bande herbacée	0
	Arbustes sur les bandes sous les arbres	1
	Ourlet herbacé sur les bandes sous les arbres	1
	Larges bandes (≥ 3 m)[9]	1
	Bandes étroites (< 3 m)	0
Ne remplir que si les herbages sont majoritaires (Ne cocher qu'une possibilité):	Herbages avec beaucoup d'arbustes	4
	Herbages avec peu/pas d'arbustes	2
6. **Intensité d'exploitation**	Pas de fumure/fumure extensive et pas de pesticides	3
	Fumure intensive et/ou emploi de pesticides	0
	Pâturage extensif ou prairie/bandes sous les arbres avec 2 coupes par an au maximum	1
	Prairie/bandes sous les arbres avec plus de 2 coupes par an	0
7. **Protection de la nature** et autres **mesures d'entretien** (concernent aussi les éléments déjà en place et les surfaces voisines)	Nichoirs ou vieux arbres pour les oiseaux qui s'abritent dans les trous d'arbres	1
	Arbustes ou haies pour les oiseaux qui nichent dans les buissons	1
	Jachère florale ou herbages extensifs	1
	Végétation au sol, lacunaire ou rase	1
Somme		
Maximum de points atteignables pour la comparaison		20

Faktoren	Parameter	Punkte
Anlage des Agroforstsystems		
1. **Baumarten**	Einheimische, standortgerechte Baumarten[1]	1
	Standortfremde Baumarten	0
2. **Anordnung** der Bäume und **Baumdichte**	Locker[2] bepflanzt (≤ 50 Bäume/ha)	1
	Dichter bepflanzt (> 50 Bäume/ha)	0
	Ost-West[3]-Ausrichtung der Reihen	1
	Nord-Süd-Ausrichtung der Reihen	0
Nutzung des Agroforstsystems		
3. **Landwirtschaftliche Nutzung** (der Fläche zwischen den Bäumen)	Nur Grünland	2
	Acker und Grünland (Baumstreifen zählen nicht dazu)	2
	Nur Acker[4] (mit/ohne Baumstreifen)	0
	Beweidung/Mahd/Mulchen[5]	1
	Kurzrasige Grünlandflächen/offener Boden[6]	1
4. **Baumpflege**	Mehrheitlich nicht hoch geastete Bäume, kein Wertholz	0,5
	Mehrheitlich hoch geastete Bäume, Wertholz[7]	0
	Geschnittene Äste bleiben als Haufen[8] liegen	0,5
Nur ausfüllen, wenn mehrheitlich Ackerland: 5. **Baumstreifennutzung**	Gras-/Krautstreifen	1
	Keine Gras-/Krautstreifen	0
	Sträucher auf den Baumstreifen	1
	Krautsäume auf den Baumstreifen	1
	Breite Streifen (≥ 3 m)[9]	1
	Schmale Streifen (< 3 m)	0
Nur ausfüllen, wenn mehrheitlich Grünland (nur eine Möglichkeit ankreuzen):	Grünland mit vielen Sträuchern	4
	Grünland mit wenigen/ohne Sträucher	2
6. **Nutzungsintensität**	Keine/extensive Düngung und keine Pestizide	3
	Intensive Düngung und/oder Pestizideinsatz	0
	Extensiv genutzte Weide oder Wiese/Baumstreifen mit 2 oder weniger Schnitten/Jahr	1
	Wiese/Baumstreifen mit mehr als 2 Schnitten/Jahr	0
7. **Naturschutz-** und weitere **Pflegemassnahmen** (auch bereits vorhandene Elemente und auf benachbarten Flächen)	Nistkästen oder alte Bäume für Höhlenbrüter	1
	Sträucher oder Hecken für Strauchbrüter	1
	Buntbrache oder extensiv genutztes Grünland	1
	Lückige oder kurzrasige Bodenvegetation	1
Summe		
Maximal erreichbare Punktzahl zum Vergleich		20

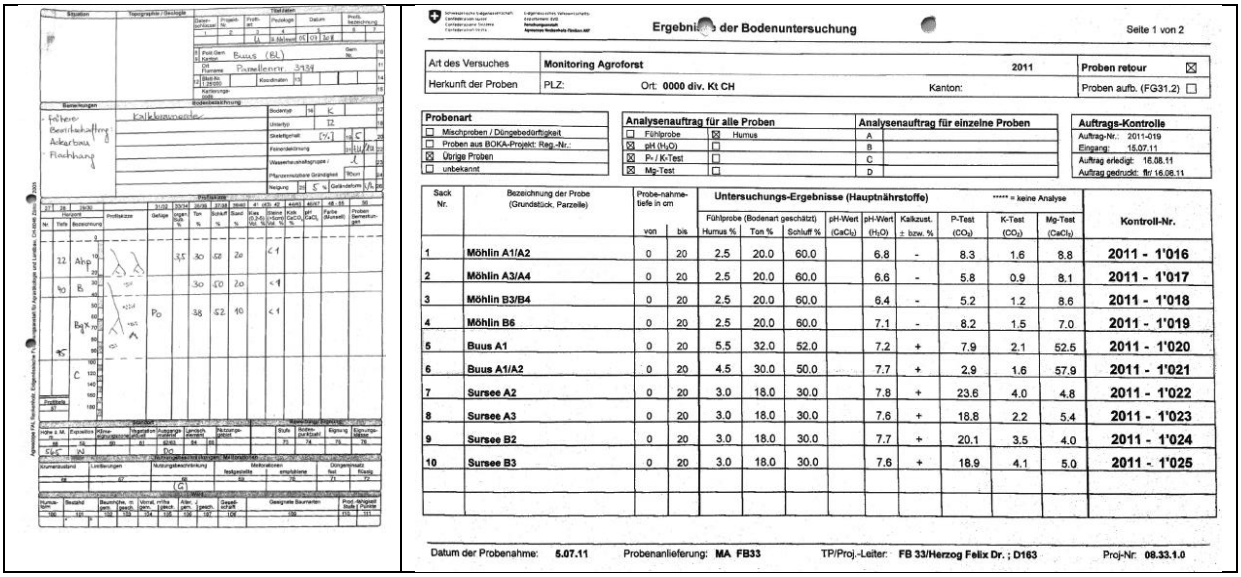
Figure 8. Checklist for the layout of agroforestry systems with respect to their potential to promote bird species (in French and German, based on Kaeser et al. 2010). An agroforestry plot can obtain up to 20 points. Multiple selections are possible.

6.2 Measurements carried out at the Buus, Möhlin and Sursee agroforestry plots

The agroforestry plots in Buus, Möhlin and Sursee have been monitored since 2011. In addition to the information recorded on all plots (see Section 6.1), a detailed soil analysis has been made (soil profile, laboratory analysis), and tree growth, utilisation of farm machinery, and labour input are recorded in more detail (Kuster et al. 2012).

Soil analysis

A soil profile (90 cm) was characterised and for the top soil (0 – 20 cm) a laboratory analysis was conducted on physical soil properties, pH, P, K and Mg contents. The original soil samples are still available and are stored at Agroscope.



Ergebnisse der Bodenuntersuchung — Seite 1 von 2

Art des Versuches	Monitoring Agroforst	2011	Proben retour ☒
Herkunft der Proben	PLZ: Ort: 0000 div. Kt CH	Kanton:	Proben aufb. (FG31.2) ☐

Probenart: ☐ Mischproben / Düngebedürftigkeit; ☐ Proben aus BOKA-Projekt: Reg.-Nr.:; ☒ Übrige Proben; ☐ unbekannt

Analysenauftrag für alle Proben: ☐ Fühlprobe; ☒ Humus; ☒ pH (H_2O); ☐ P- / K-Test; ☒ Mg-Test; ☐

Analysenauftrag für einzelne Proben: A; B; C; D

Auftrags-Kontrolle: Auftrag-Nr.: 2011-019; Eingang: 15.07.11; Auftrag erledigt: 18.08.11; Auftrag gedruckt: fir 16.08.11

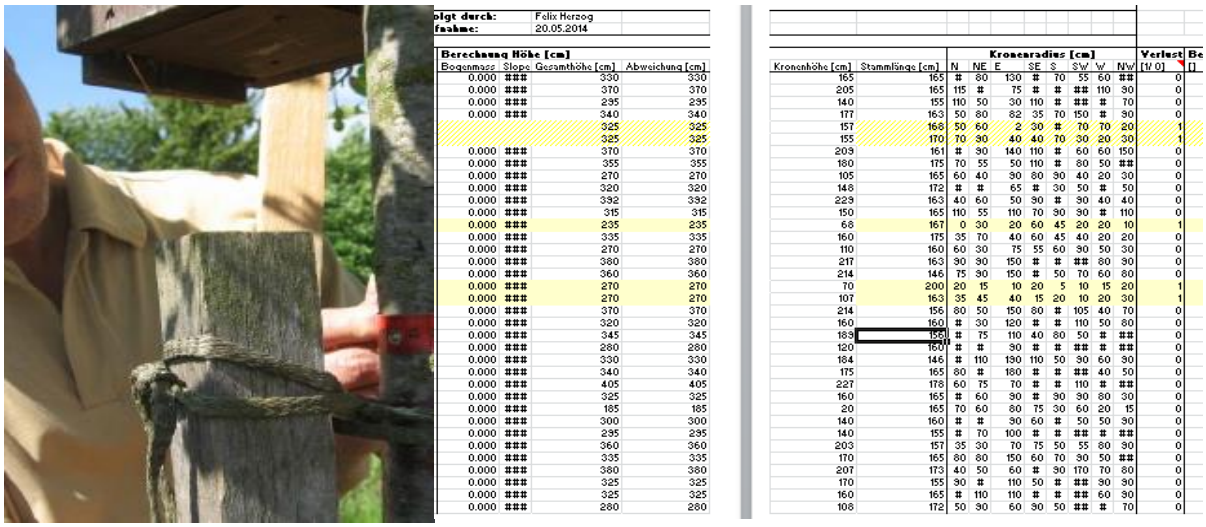
Sack Nr.	Bezeichnung der Probe (Grundstück, Parzelle)	Probe-nahme-tiefe in cm von	bis	Untersuchungs-Ergebnisse (Hauptnährstoffe) ***** = keine Analyse: Fühlprobe (Bodenart geschätzt) Humus %	Ton %	Schluff %	pH-Wert ($CaCl_2$)	pH-Wert (H_2O)	Kalkzust. ± bzw. %	P-Test (CO_2)	K-Test (CO_2)	Mg-Test ($CaCl_2$)	Kontroll-Nr.
1	Möhlin A1/A2	0	20	2.5	20.0	60.0		6.8	-	8.3	1.6	8.8	2011 - 1'016
2	Möhlin A3/A4	0	20	2.5	20.0	60.0		6.6	-	5.8	0.9	8.1	2011 - 1'017
3	Möhlin B3/B4	0	20	2.5	20.0	60.0		6.4	-	5.2	1.2	8.6	2011 - 1'018
4	Möhlin B6	0	20	2.5	20.0	60.0		7.1	-	8.2	1.5	7.0	2011 - 1'019
5	Buus A1	0	20	5.5	32.0	52.0		7.2	+	7.9	2.1	52.5	2011 - 1'020
6	Buus A1/A2	0	20	4.5	30.0	50.0		7.7	+	2.9	1.6	57.9	2011 - 1'021
7	Sursee A2	0	20	3.0	18.0	30.0		7.8	+	23.6	4.0	4.8	2011 - 1'022
8	Sursee A3	0	20	3.0	18.0	30.0		7.6	+	18.8	2.2	5.4	2011 - 1'023
9	Sursee B2	0	20	3.0	18.0	30.0		7.7	+	20.1	3.5	4.0	2011 - 1'024
10	Sursee B3	0	20	3.0	18.0	30.0		7.6	+	18.9	4.1	5.0	2011 - 1'025

Datum der Probenahme: 5.07.11 Probenanlieferung: MA FB33 TP/Proj.-Leiter: FB 33/Herzog Felix Dr. ; D163 Proj-Nr: 08.33.1.0

Figure 9. Soil profile and analysis of the Buus agroforestry plot (2011)

Tree growth

On each of the three plots, a selected number of trees (between 30 and 120) have been permanently marked and are measured every three years in terms of diameter at breast height, crown diameter (eight measurements), trunk height, and tree height. The first measurements were made in 2011, and they were repeated in 2014.



olgt durch: Felix Herzog
faahme: 20.05.2014

Berechnung Höhe [cm]				Kronenradius [cm]								Verlust	Be
Bogenmass	Slope	Gesamthöhe [cm]	Abweichung [cm]	Kronenhöhe [cm]	Stammlänge [cm]	N	NE	E	SE	S	SW	W	NW	[t/ 0]	[]
0.000	###	330	330	165	165	#	80	130	#	70	55	60	##	0	
0.000	###	370	370	205	165	115	#	75	#	#	##	110	90	0	
0.000	###	295	295	140	155	110	50	30	110	#	##	#	70	0	
0.000	###	340	340	177	163	50	80	82	35	70	150	#	90	0	
		325	325	157	168	50	60	2	30	#	70	70	20	1	
		325	325	155	170	70	30	40	40	70	30	20	30	1	
0.000	###	370	370	209	161	#	90	140	110	#	60	60	150	0	
0.000	###	355	355	180	175	70	55	50	110	#	80	50	##	0	
0.000	###	270	270	105	165	60	40	90	80	90	40	20	30	0	
0.000	###	320	320	148	172	#	#	65	#	30	50	#	50	0	
0.000	###	392	392	229	163	40	60	50	90	#	90	40	40	0	
0.000	###	315	315	150	165	110	55	110	70	90	90	#	110	0	
0.000	###	235	235	68	167	0	30	20	60	45	20	20	10	1	
0.000	###	335	335	160	175	35	70	40	60	45	40	20	20	0	
0.000	###	270	270	110	160	60	30	75	55	60	90	50	30	0	
0.000	###	380	380	217	163	90	90	150	#	#	##	80	90	0	
0.000	###	360	360	214	146	75	90	150	#	50	70	60	80	0	
0.000	###	270	270	70	200	20	15	10	20	5	10	15	20	1	
0.000	###	270	270	107	163	35	45	40	15	20	10	20	30	1	
0.000	###	370	370	214	156	80	50	150	80	#	105	40	70	0	
0.000	###	320	320	160	160	#	90	120	#	#	110	50	80	0	
0.000	###	345	345	183	155	#	75	110	40	80	50	#	##	0	
0.000	###	280	280	120	160	#	#	90	#	#	##	#	##	0	
0.000	###	330	330	184	146	#	110	130	110	50	90	60	90	0	
0.000	###	340	340	175	165	80	#	180	#	#	##	40	50	0	
0.000	###	405	405	227	178	60	75	70	#	#	110	#	##	0	
0.000	###	325	325	160	165	#	60	90	#	90	90	80	30	0	
0.000	###	185	185	20	165	70	60	80	75	30	60	20	15	0	
0.000	###	300	300	140	160	#	#	90	60	#	50	50	90	0	
0.000	###	295	295	140	155	#	70	100	#	#	##	#	##	0	
0.000	###	360	360	203	157	35	30	70	75	50	55	80	30	0	
0.000	###	335	335	170	165	80	80	150	60	70	90	50	##	0	
0.000	###	380	380	207	173	40	50	60	#	90	170	70	80	0	
0.000	###	325	325	170	155	90	#	110	50	#	##	90	90	0	
0.000	###	325	325	160	165	#	110	110	#	#	##	60	90	0	
0.000	###	280	280	108	172	50	90	60	90	50	##	#	70	0	

Figure 10. Agroforestry tree measurements are made every three years, starting in 2011.

Farm machinery and labour

In order to allow for economic evaluations, the utilisation of farm machinery and the labour input on the agroforestry plots is recorded. Specific forms have been created in order to allow for easy recording by the farmer.

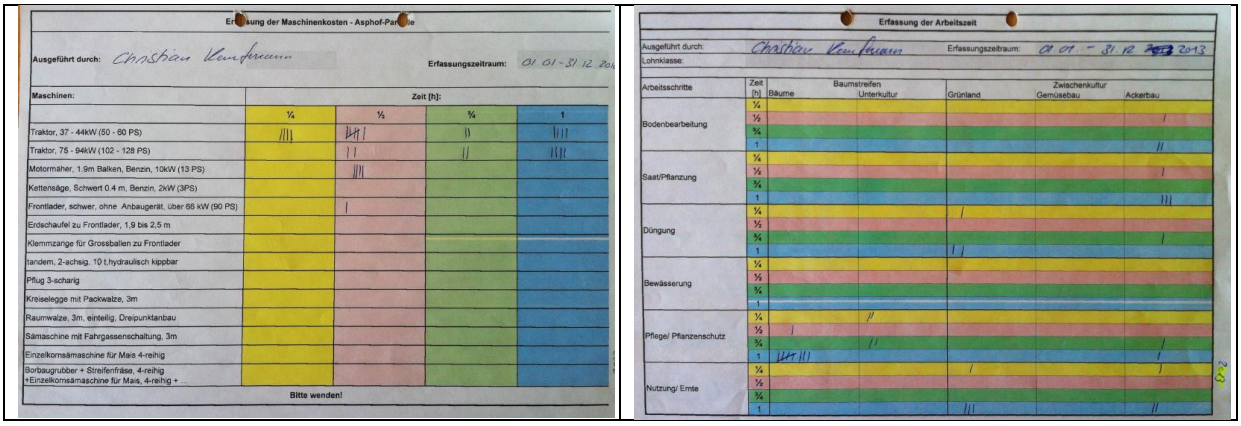


Figure 11. Utilisation of farm machinery and labour input to the Buus agroforestry plot in 2012

7 Biophysical modelling

The measurements on the Buus, Möhlin and Sursee agroforestry plots have been initiated to allow for the parameterisation of the YieldSAFE model (van der Werf et al. 2007) with measured time series, for three tree species (apple, poplar, cherry). In 2017, three tree measurement points (2011, 2014, 2017) will be available as well as data on crops for seven years. The measurements from the three plots are available to WP6. Additional measurements could be carried out on the trees if needed.

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