Vegetation comparison of two agroforestry systems with very distinct tree management

Philipp Weida[1], Wiebke Niether[1], Sarah-Olivia Peter[1]
Contact: philipp.weida@ag.uni-giessen.de

[1]Chair of Organic Farming with Focus on Sustainable Soil Use, Justus-Liebig-University Giessen, Germany

MODEMA

A Germany-wide model and demonstration network for agroforestry: scientific evidence and practical support for farmers

Background

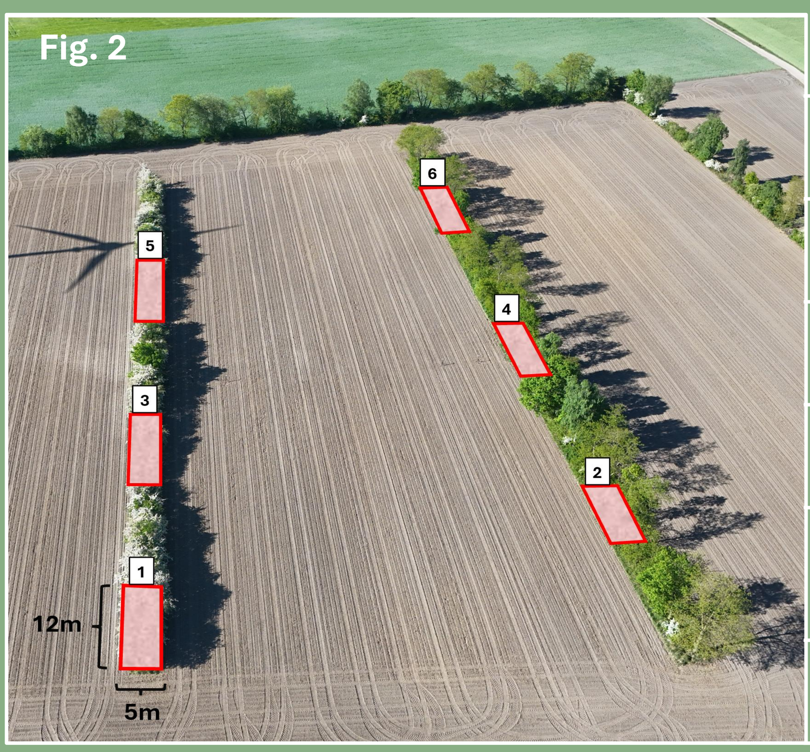
- The ongoing loss of biodiversity represents a global problem (Dempsey 2015, Holden et al. 2024)
- Agroforestry has been implemented as a measure to counteract the loss of biodiversity by increasing structural diversity within agricultural landscapes (BfN 2026, DeFAF 2024)
- Agroforestry systems in Germany differ greatly in tree row composition and management (Fig. 1,2 & 3)
  → **Vegetation surveys from practical fields help to proof biodiversity enhancement by agroforestry**

Research Questions

1. How diverse is the understory vegetation in the tree rows of the two agroforestry systems?
2. Does extensive management lead to higher plant diversity than intensive management?
3. What is the potential impact range of agroforestry on plant diversity in German agriculture?

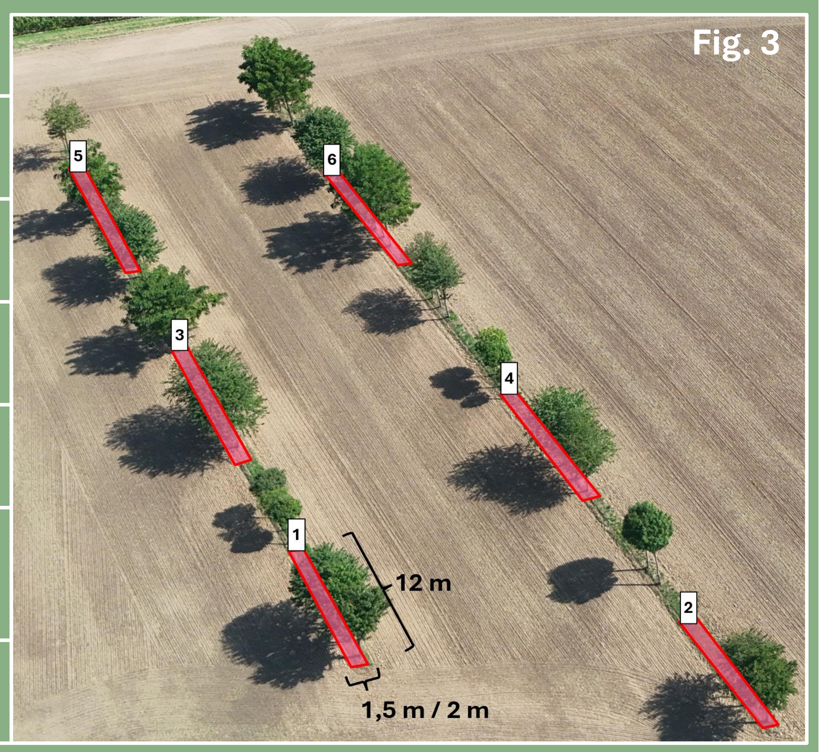
Research areas

Fig. 2



AFS North	AFS South
est. 1975 (51y)	est. 2012 (14y)
Organically	Conventionally
680 mm/y	700 mm/y
9,2°C	10,4°C
Deep, dry, acidic sandy soils	Blackish, clay-rich loess subsoil
densely covered TL	slightly vegetated TL

Fig. 3



Pict.1

Pict.2

Pict. 1 Tree Line (TL) 1 of the AFS North overed with *Crataegus laevigata*.
Pict. 2 TL of the AFS South with *Prunus avium* and *Juglans nigra*.
Fig. 1 Map of Germany with the two studied agroforestry systems of partner farms from the MODEMA project.
Fig. 2 & 3 Experimental design of the two investigated agroforestry systems with numbered plots in AFS North (VAN 1 – 6, 12x5 m) and AFS South (VAS 1 – 6, 12x1,5/2 m) with a total survey of 360 m^2 (North) and 126 m^2 (South).

Results

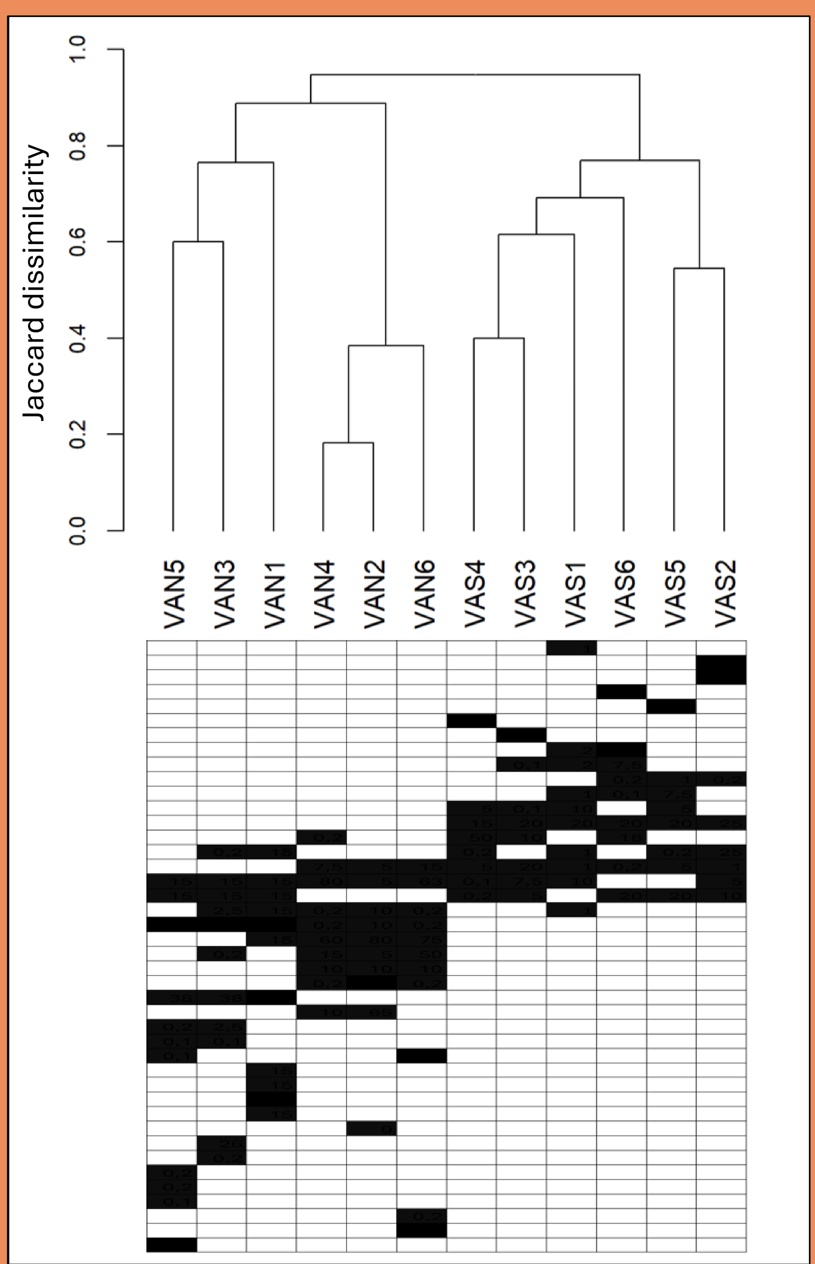


Fig. 4 Dendrogramm: Graphical representation of the complete linkage cluster analysis with sorted presence/absence table. The plots VAN1,3,5 and VAN2,4,6 are each representing one tree strip in the AFS North. Similarly, this applies to VAS1,3,5 and VAS2,4,6. In total there are twtrips per AFS. Table sorted by rows (not shown) and columns o tree s (shown) using Jaccard dissimilarity (D) and complete linkage cluster analysis. A black/empty field indicates the presence/absence of a species.

	Art (species)	VAN5	VAN3	VAN1	VAN4	VAN2	VAN6	VAS4	VAS3	VAS1	VAS6	VAS5	VAS2	stability	ind. values	
	n (AFS)	28						19								
	n (plots)	10	11	11	10	10	11	8	8	10	9	8	8			
Nr.															L	N
A2	*Agrimonia eupatoria*									0,1				1	7	4
A24	*Juglans regia*												0,1	1	NA	7
A27	*Lolium perenne*												2,5	1	6	7
A15	*Cornus sericea*										0,1			1	NA	NA
A20	*Daucus carota*											0,1		1	8	4
A17	*Crepis pulchra*							0,1						1	7	6
A5	*Arrenatherum elatius*								15					1	8	7
A13	*Clematis vitalba*									15	0,1			2	7	7
A36	*Rumex obtusifolius*								0,1	0,2	15			3	7	9
A11	*Cirsium arvense*										0,2	2,5	0,2	3	8	7
A14	*Convolvulus arvensis*									0,2	0,1	15		3	7	x
A37	*Torilis arvensis*							0,2	0,1	15		0,2		4	7	4
A3	*Agrostis stolonifera*							15	15	0,1	15	15	37,5	6	8	5
A38	*Urtica dioica*				0,2			62,5	15		15			4	x	8
A23	*Geranium pusillum*		0,2	15				0,2		15		0,2	37,5	6	7	7
A22	*Galium aparine*				2,5	0,2	15	0,2	15	0,1	0,2	0,2	2,5	9	7	8
A19	*Dactylis glomerata*	15	15	37,5	87,5	2,5	62,5	0,1	15	62,5			2,5	10	7	6
A7	*Bromus sterilis*	15	15	15				0,2	2,5		15	15	15	8	7	5
A34	*Rosa agrestis Savi*		2,5	2,5	0,2	15	0,2			0,1				6	8	3
A1	*Achillea millefolium*	2,5	2,5	2,5	0,2	15	0,2							6	8	5
A21	*Festuca rubra*			15	62,5	2,5	62,5							4	NA	NA
A32	*Prunus spinosa*		0,2		15	2,5	37,5							4	7	x
A31	*Prunus serotina*				15	15	15							3	6	?
A16	*Crataegus laevigata*				0,2	15	0,2							3	6	5
A28	*Poa pratensis*	37,5	37,5	15										3	6	6
A33	*Rhamnus saxatilis*				15	62,5								2	7	2
A29	*Poa trivialis*	0,2	2,5											2	NA	NA
A41	*Vicia sativa*	0,1	0,1											2	NA	NA
A40	*Veronica hederofilia*	0,1					0,1							2	6	7
A4	*Anthriscus caucalis*			2,5										1	8	6
A9	*Celastrus orbiculatus*			2,5										1	NA	NA
A26	*Ligustrum vulgare*			15										1	7	3
A39	*Verbascum phlomoides*			0,1										1	8	6
A8	*Carpinus betulus*					0,1								1	4	x
A35	*Rosa arvensis*		2,5											1	5	5
A18	*Cynosurus cristatus*		0,2											1	8	4
A6	*Bromus hordeaceus*	0,2												1	7	3
A12	*Claytonia perfoliata*	0,2												1	6	7
A10	*Chaerophyllum aureum*	0,1												1	6	9
A30	*Prunus japonica*						0,2							1	NA	NA
A25	*Lamium hybridium*						0,1							1	NA	NA

Tab. 2 Sorted species list showing the percentage coverage of the species found, their continuity across all plots surveyed (stability), and the weighted indicator values according to Ellenberg.
Tab. 3 The table shows the Shannon-Wiener index (H´), evenness (E) and the weighted indicator values for light (X_L) and nitrogen (X_N) for every plot as well as the mean values over all plots.

AFS North	n	H´	E	X_L	X_N		AFS South	n	H´	E	X_L	X_N
plots							plots					
VAN1	11	1,97	0,82	6,9	5,5		VAS1	10	1,19	0,52	7	6
VAN2	10	1,59	0,69	7	3,1		VAS2	8	1,32	0,64	7	6
VAN3	11	1,48	0,62	6,5	5,6		VAS3	8	1,72	0,82	7,3	5,7
VAN4	10	1,39	0,61	6,9	5,5		VAS4	8	0,58	0,28	7,9	7,4
VAN5	10	1,19	0,52	6,5	5,7		VAS5	8	1,32	0,64	7,4	5,2
VAN6	11	1,48	0,62	6,9	6,4		VAS6	9	1,45	0,66	7,3	6,8
mean	**10,5**	**1,52**	**0,65**	**6,78**	**5,29**			**8,5**	**1,26**	**0,59**	**7,32**	**6,16**

Methods

Indicator values (Ellenberg) (Tab. 1 & 2)
Alpha- and Beta diversity Indices used:
- Species number (α) (Tab 1 & 2)
- Shannon-Wiener index (α) (Tab. 2)
- Jaccard Index (β) (Fig. 4)

Results

- AFS North contained more species of segetal flora (Tab. 1, 2)
- Plant diversity (H´) in both systems was classified as moderate (Tab. 2)
- The Jaccard Index revealed clear differences in species composition between the two agroforestry systems and between the two tree strips of AFS North (Fig. 4)
- AFS South showed higher mean values of the weighted indicator values (X_L, X_N) than AFS North (Tab. 2)
- No rare or endangered species were found in any surveyed plots (Tab. 1)

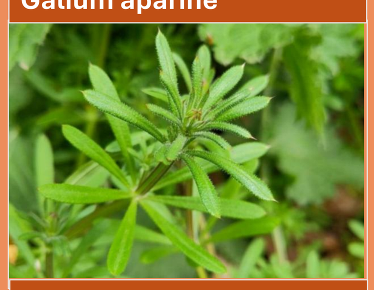
Ligustrum vulgare

Found in AFS North
Pict. 3

Rhamnus saxatilis

Found in AFS North
Pict. 4

Galium aparine



Found in both AFS
Pict. 5

Torilis arvensis

Found in AFS South
Pict. 6

Agrostis stolonifera

Found in AFS South
Pict. 7

Discussion

AFS North

- contained **more plant species**
- exhibited **greater structural diversity**
- greater **variety of microhabitats**
- more shade and **stress tolerant species**
  → Supports higher ecological functionality

AFS South

- dominated by **grasses** and **nitrophilic species**
- more **disturbed** and **nutrient rich** environment
  → associated with less diverse plant communities

The understory vegetation diversity (H´) in both AFS is still higher than of conventionally managed wheat fields (H´= 0,45 – 0,84) or fruit orchards (H´= 0,75 – 0,97).

Highlights

- Tree row structure and management strongly influences understory plant diversity and composition in agroforestry systems
- Extensively managed, older and structurally complex agroforestry systems appear to provide a greater potential to support biodiversity

References
BUNDESMINISTERIUM FÜR UMWELT, KLIMASCHUTZ, NATURSCHUTZ UND NUKLEARE SICHERHEIT (BMUKN) (2026): Bundesamt für Naturschutz (BfN), Bundesprogramm Biologische Vielfalt – Bonn. In: https://www.bfn.de/thema/bundesprogramm-biologische-vielfalt , 03.01.2026
Dempsey, J. (2015) Fixing biodiversity loss. Environment and Planning A: Economy and Space, 47(12), 2555-2572. https://doi.org/10.1177/0308518X15608079
DEUTSCHER FACHVERBAND FÜR AGROFORSTWIRTSCHAFT (DeFAF) e.V. (2024): MODEMA - Aufbau eines Modell- und Demonstrationsnetzwerks für Agroforstwirtschaft in Deutschland – Cottbus. In: https://agroforst-info.de/modema/#ergebnisse , 04.01.2026
Holden, L., Lee, R. G., Orsini, L., Eastwood, N., Zhou, J., Čavoški, A. (2024) Biodiversity management challenges: A policy brief. Environmental Law Review, 26(2), 141-150. https://doi.org/10.1177/14614529241247361
SAWICKA, B., KROCHMAL-MARCZAK, B., BARBAŚ, P., PSZCZÓŁKOWSKI, P., ĆWINTAL, M. (2020): Biodiversity of weeds in fields of grain in South-Eastern Poland. In: Agriculture, 10(12), 589. https://doi.org/10.3390/agriculture10120589.
Stamin, F. D., & Cosmulescu, S. (2025): Assessing the Vegetation Diversity of Different Forest Ecosystems in Southern Romania Using Biodiversity Indices and Similarity Coefficients. *Biology*, *14*(7), 869. https://doi.org/10.3390/biology14070869
Pict. 3,4,5,6 & 7: https://plantnet.org/en/; Annemarie Ahrens-Stehle 2025, Sylvain PIRY – Tela Botanica 2007, Allen S. Lüdtke 2026, philippe hornus 2019, Lucas Förderer 2019

Copyright: JLU NEUE WEGE SEIT 1607 – Justus-Liebig-Universität Giessen; Professur für Ökologischen Landbau; DeFAF Deutscher Fachverband für Agroforstwirtschaft
Erstellt im Projekt: MODEMA
AGROFORST NETZWERK www.agroforst-info.de/modema
Gefördert durch: Bundesministerium für Landwirtschaft, Ernährung und Heimat aufgrund eines Beschlusses des Deutschen Bundestages; FNR Fachagentur Nachwachsende Rohstoffe e.V.