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Integrating forage trees into organic arable crop–grassland rotations: Design of a multifunctional agroforestry system

Context

Temporary grasslands are key components of agroecological farming

Trees can improve livestock resilience, productivity, and welfare

Our plot offers an interesting demonstration platform:

- Located in Frick, Switzerland, 400 m asl
- Clay-rich soil with limestone stones
- Managed by an organic dairy farm
- Four-year rotation (two-year grassland, cereal crop, grain legume)
- At the interface between researchers, farmers and citizens

Research area design

0.4 ha, 2 rows (full plot: 1.4 ha, 4 rows)

Multifunctional and multi-strata:

- Timber trees every 12.5 m
  (*Juglans regia*, *Sorbus torminalis*, *Prunus avium*)
- Forage trees between them (Table 1, Fig. 1)
  - Goat willow (*Salix caprea*)
    - Good nutritive value
    - High palatability
  - Hazelnut (*Corylus avellana*)
    - High tannin content
    - Good palatability (Vandermeulen et al., 2018)
  - Autumn olive (*Elaeagnus umbellata*)
    - N-fixing species
    - No precise data are available, but the related Russian olive (*E. angustifolia*) shows good forage potential

Conclusion

A research area including timber and forage trees has been successfully implemented

The research area can be divided into two blocks and four sections

Three forage tree species were selected for their contrasting traits

Finding suitable N-fixing species is challenging (invasive species, thorns, toxicity, lack of data, etc.)

Table 1: In vitro dry matter digestibility and crude protein and condensed tannin contents of the *Salix caprea* (willow), *Corylus avellana* (hazelnut), and *Elaeagnus angustifolia* (Russian olive). From Novak (2020) and Klich et al. (2018).
Russian olive (*E. angustifolia*) is presented due to the lack of data for autumn olive (*E. umbellata*)

Species	IVDMD (%)	CP (g.kg DM^{-1})	CT (g.kg DM^{-1})
Willow	70	159	52
Hazelnut	51	133	73
Russian olive	62	210	NA

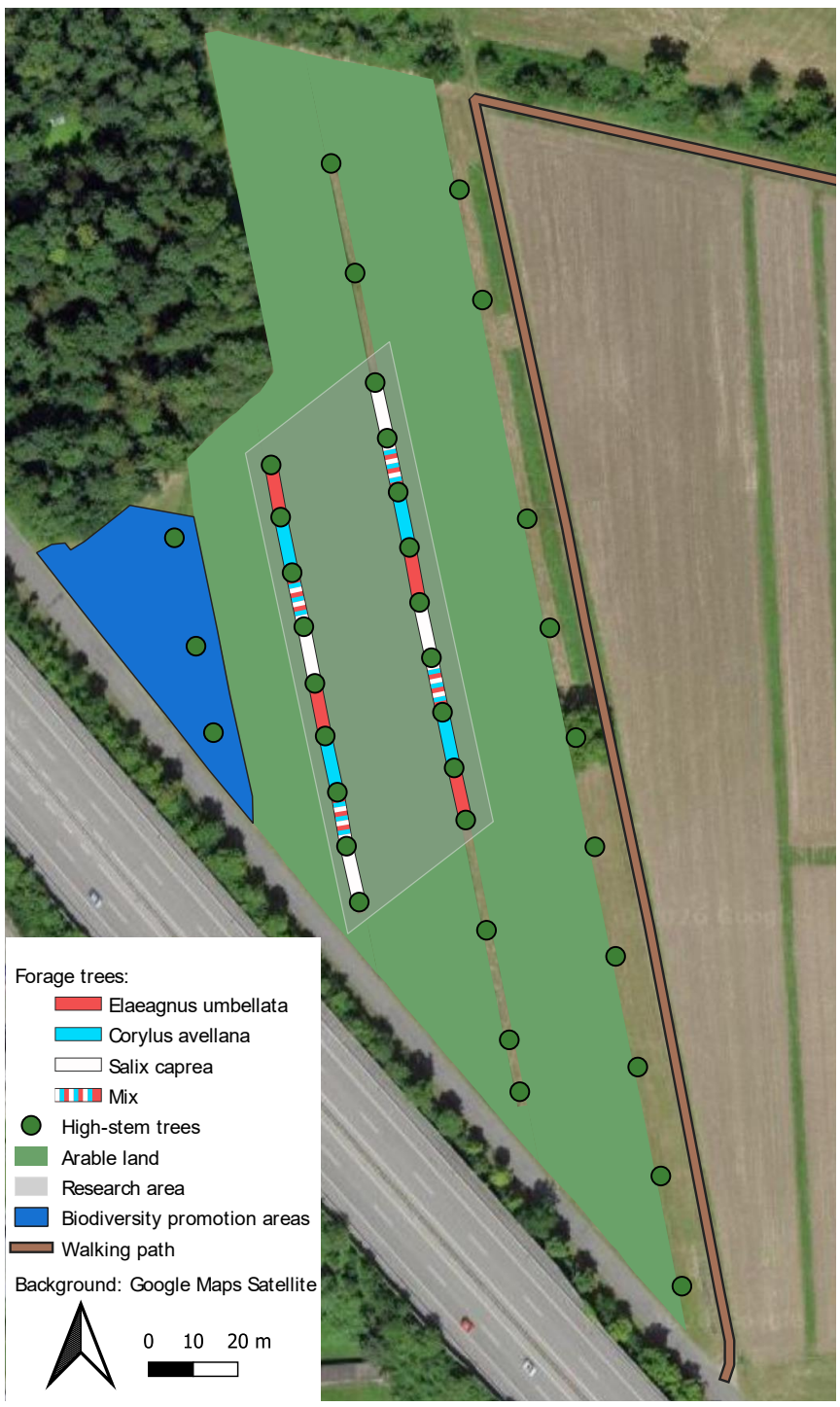

Fig. 1: Spatial layout of the FiBL multifunctional agroforestry plot

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Acknowledgement
We warmly thank the Leopold Bachmann Foundation for the funding of the project, all the people we interacted with to design this plot, and all the colleagues who supported the plantations and maintenance

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Highlights

- FiBL designed a multifunctional agroforestry system integrating forage trees into organic crop–grassland rotations
- Three selected tree species combine high biomass and protein- and tannin-rich foliage
- The plot was designed to meet farmers' and researchers' needs

Context

In organic farming, temporary grasslands are key rotation elements because they suppress weeds and pests while enhancing soil carbon and nitrogen stocks, but grassland productivity and quality are increasingly affected by climate change. Trees can reduce grassland and livestock vulnerability by providing forage during drought periods and protection against adverse weather conditions (Trouillard et al. 2024). Their nutritive value can match that of commonly used herbaceous forages, and some species may even exceed it (Mesbahi et al. 2025). Some species also contain high tannin and mineral concentrations that may improve animal health and mitigate methane emissions. Based on this knowledge, FiBL developed a demonstration agroforestry plot to intensify biomass production, improve animal welfare, and promote public awareness of agroforestry.

Site description

The plot is located in Frick, Switzerland (47°30'44.4"N, 8°01'19.9"E). The soil is clay-rich with limestone stones. It is near residential areas and bordered by a walking path. The plot is managed by an organic dairy farm, and half is subject to water protection restrictions. Its proximity to the Research Institute of Organic Agriculture (FiBL) headquarters makes it a research and demonstration platform. The design aimed to meet the needs of citizens, farmers, and researchers. The four-year rotation consists of two years of grass–clover, grazed after the first cut, followed by a cereal crop and a grain legume.

Plot design and selection of the forage tree species

The agroforestry design is an intra-plot multifunctional and multi-strata system. One row along the walking path is dedicated to fruit and berry production. The central part of the plot is used as a research area, where timber trees are planted every 12.5 m, with forage trees/shrubs between them. Besides producing wood and feed, these trees are intended to protect crops and dairy cows from weather extremes and enhance soil fertility, as fertilization is not permitted.

Three forage tree/shrub species were selected, including one N-fixing species. Selection criteria were: adaptation to local soil and climate, absence from the Swiss invasive species list, rapid growth, tolerance to frequent pruning at browsing height, absence of spines or thorns, and no toxicity. Proven palatability for cattle was desirable. The selected species were goat willow (*Salix caprea*), hazelnut (*Corylus*

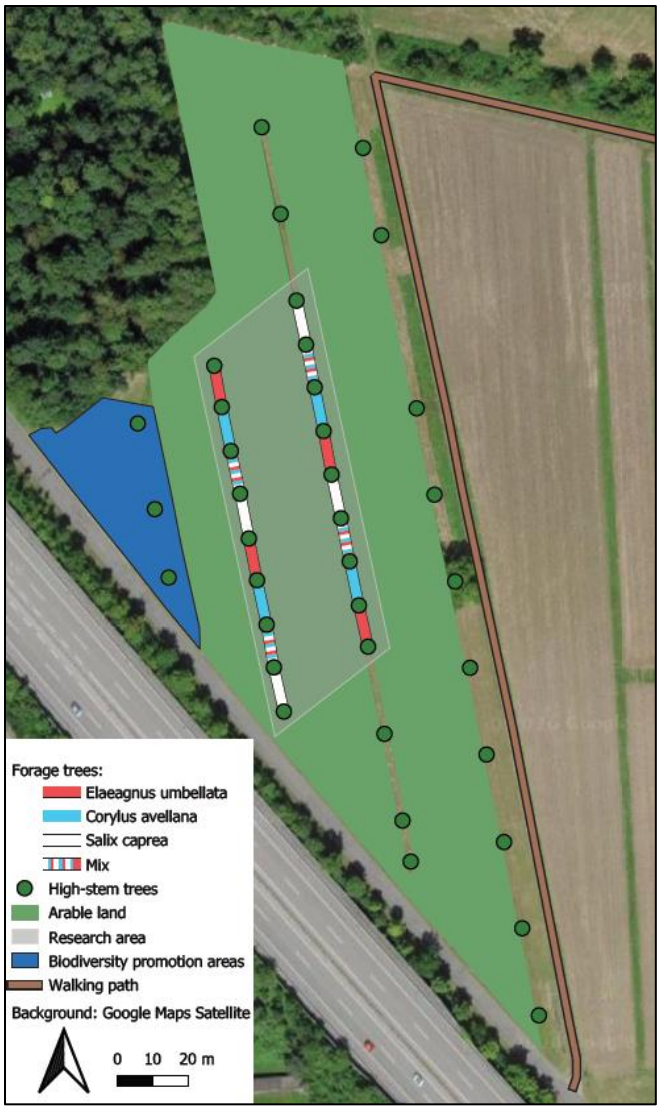

Figure 1: Design and spatial arrangement of forage trees within the agroforestry plot

avellana), and autumn olive (*Elaeagnus umbellata*). Goat willow is commonly used as animal feed and has a crude protein (CP) content of 159 g kg^{-1} DM, 70.4% digestibility, and of 52 g kg^{-1} DM tannin. Hazelnut shows lower nutritive value (133 g kg^{-1} DM CP; 51.1% digestibility) and high tannin levels (73 g kg^{-1} DM), but good palatability (Vandermeulen et al. 2018; Novak 2020). No precise data are available for autumn olive, but the related Russian olive (*E. angustifolia*) shows 210 g kg^{-1} DM CP, 62% digestibility and good palatability (Klich et al. 2018).

A plot designed for practice and research

The plot was designed for practical farming, demonstration, and scientific research (Figure 1). Row spacing facilitates agricultural operations, and grazing areas can be subdivided with or without tree access. For research purposes, the design ensures low complexity and replication. The forage-tree area is divided into two blocks (north and south), each containing two sections. Each section includes four bands: one per species plus one mixed band. Each band contains seven trees, enabling the study of species effects on crops, grassland, and soil properties. The layout also facilitates division into four comparable paddocks for studying cattle feeding behaviour and learning. Finally, rows can be used to test management factors like cutting frequency on biomass production and leaf composition.

Acknowledgements

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Keywords

Corylus, design, *Elaeagnus*, fodder, *Salix*

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