

Final report for SNS research projects 2022-2024

Submit the report to sns@slu.se by 24:00 CET, 1st of September, 2025, at the latest.
The report should not exceed 3500 words (including words in the template).

Please adjust the size of the box according to the length of your answer.

1. Project title:	 SYNERGIES: Enhancing the sustainable integration of wood biomass production with other ecosystem services
2. Reporting year:	2022-2025
3. Project coordinator:	UEF / Blas Mola-Yudego
Email:	blas.mola@uef.fi
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Activity report

4. Provide a project summary, including:
a) The purpose of the project/main problems/hypothesis addressed SYNERGIES seeks to enhance the sustainable production of wood biomass by integrating it with co-delivered ecosystem services across the Nordic–Baltic region, building on shared datasets to translate evidence into strategies that can be implemented in existing production practices and supply chains. It addresses key problems raised in recent debates on forest bioenergy, uncertain climate benefits and carbon neutrality, potential depletion of soil carbon and nutrients, and higher net emissions associated with intensified harvesting, while navigating the trade-offs between short-term substitution benefits and the long-term forest carbon sink amid tightening sustainability requirements and complex policy and producer choices. The core hypothesis is that further intensification can negatively affect soil, water and biodiversity; that these impacts are scale- and spatially dependent and modulated by management and end-use; and that sustainability can be improved by identifying synergies, such as erosion control, increased soil organic carbon, enhanced biodiversity and groundwater quality, so that new biomass systems co-produce multiple ecosystem services through appropriate landscape planning. b) A short description of the main activities of the project SYNERGIES delivered a coordinated research and dissemination programme centred on peer-reviewed publications, open datasets, and partner workshops that consolidated a common research agenda across the Nordic–Baltic network: it produced multiple open-access papers on biomass systems, sustainability criteria, and conversion pathways; curated geospatial datasets of biomass production systems for the Nordic area and Europe (released via Zenodo); convened four in-person workshops (Uppsala 2022; Joensuu 2023; Tartu 2024; Copenhagen 2025) to align methods, share results, and plan follow-on funding; and codified shared priorities through synthesis notes, policy briefs, webpages, and a doctoral-level course, thereby advancing comparable evidence bases and joint proposals for subsequent NordForsk and related calls. c) Achieved targets and to what extent the research plan was fulfilled Overall, the project substantially fulfilled and often exceeded its plan, with a few deliverables delivered later or in alternative forms. Workshops & common agenda: four full workshops were held (Uppsala 2022; Joensuu 2023; Tartu 2024; Copenhagen 2025), consolidating a shared agenda across partners (exceeds on number; delayed final event). Publications: the plan targeted six manuscripts (three research and three reviews); at least seven peer-reviewed, open-access papers were produced, with the balance towards empirical/analytical studies over formal reviews (substantially achieved). Datasets: harmonised Nordic–European datasets were delivered and openly released (achieved). Policy/synthesis outputs: synthesis notes, policy briefs, and related summaries materialised

as planned (achieved). **Training & courses:** results were integrated into teaching, including a dedicated doctoral-level course and supervision outputs (achieved). **Funding leverage:** the intention to prepare a major follow-on proposal was met via two NordForsk applications and several smaller grants, shifting emphasis from Horizon Europe. **Conferences:** planned conference visibility was partly met; IUFRO presentations were delivered, while the originally envisaged EUBCE contribution is not evidenced (partly achieved). **Questionnaire/AHP:** the expert-elicitation strand was executed and the dataset published. **Web presence:** partner webpages and communication channels were maintained (achieved).

5. Published outputs achieved as a consequence of the project (peer-reviewed articles, other publications)

Pineda-Zapata, S., & Mola-Yudego, B. (2025). European Biomass Production Systems: Characterization and Potential Contribution to Land Use Diversity. *GCB Bioenergy*, 17(7), e70057. [PDF][RG] <https://doi.org/10.1111/gcbb.70057>

Papamatthaiakis, N., Barbero-López, A., Eronen, E., Jänis, J., Mola-Yudego, B., & Haapala, A. (2025). Hydrothermal Liquefaction of Coffee Silverskin and Spent Coffee Grounds: Bioenergy and Biochemical Potential. *BioEnergy Research*, 18(1), 1-12. [PDF][RG] <https://doi.org/10.1007/s12155-025-10867-3>

Schilling, C., Mola-Yudego, B., Marinescu, M., Gaston, C., & Röser, D. (2025). Biomass gasification as a viable alternative for small-scaled combined heat and power technologies in remote communities in Canada. *BioEnergy Research*, 18(1), 19. [PDF][RG] <https://doi.org/10.1007/s12155-024-10812-w>

Mola-Yudego, B., Dimitriou, I., Gagnon, B., Schweinle, J., & Kulišić, B. (2023). Priorities for the sustainability criteria of biomass supply chains for energy. *Journal of Cleaner Production*, 140075. [PDF][RG] <https://doi.org/10.1016/j.jclepro.2023.140075>

Barbero-López, A., López-Gómez, Y. M., Carrasco, J., Jokinen, N., Lappalainen, R., Akkanen, J., Mola-Yudego, B., Haapala, A. (2024). Characterization and antifungal properties against wood decaying fungi of hydrothermal liquefaction liquids from spent mushroom substrate and tomato residues. *Biomass and Bioenergy*, 181, 107035. [PDF][RG] <https://doi.org/10.1016/j.biombioe.2023.107035>

Kons, K., Blagojević, B., Mola-Yudego, B., Prinz, R., Routa, J., Kulisić, B., ... & Bergström, D. (2022). Industrial End-Users' Preferred Characteristics for Wood Biomass Feedstocks. *Energies*, 15(10), 3721. [PDF][RG] <https://doi.org/10.3390/en15103721>

Xu, X., Englund, O., Dimitriou, I., Rosenqvist, H., Liu, G., Mola-Yudego, B. 2023. Landscape Metrics and Land-Use Patterns of Energy Crops in the Agricultural Landscape. *Bioenergy Research* [PDF][RG]. <https://doi.org/10.1007/s12155-023-10584-9>

Xu, X. 2023. Land-use patterns of energy crops in the agricultural landscape. *Dissertationes Forestales*, 337, 43 pp. <https://doi.org/10.14214/df.337>

NOTE: All articles have been published Open Access (gold); publication fees have been co-funded by the respective institutions or other existing projects.

Theses

Pineda, Sara. (ongoing) Strategic landscape-level integration of biomass production and ecosystem services at European level. Supervisors: Blas Mola-Yudego (UEF), Ioannis Dimitriou (SLU), Oskar Englund (MiUN), Lluís Coll

(UdL).

Xu, X. Q. (2023). Land-use patterns of energy crops in the agricultural landscape. *Dissertationes Forestales*, 337, 43 pp. <https://doi.org/10.14214/df.337> [Thesis]. Supervisors: Blas Mola-Yudego (UEF), Ioannis Dimitriou (SLU), Oskar Englund (MiUN), Opponent: Niclas Scott Bentsen (UHCH).

Deliverables

Map of biomass production systems in the Nordic area [ArcMap]

Dataset concerning AHP weights from 122 international experts, open access available [dataset]
<https://www.sciencedirect.com/science/article/pii/S0959652623042336#appsec1>

Pineda-Zapata, S., & Mola-Yudego, B. (2025). Dataset of European biomass production systems [repository][zenodo] <https://doi.org/10.5281/zenodo.15396453>

6. Other practical outputs of the project (websites, policy recommendations, conferences, scientific meetings, large-scale project applications, research training etc.)

Web-pages

The project has two running webpages, one within the University of Eastern Finland (UEF) and another one for Mid Sweden University (MiUN). These websites can be visited using the following links:

<https://sites.uef.fi/biopros/projects/synergies/>

<https://www.miun.se/Forskning/forskningsprojekt/pagaende-forskningsprojekt/synergies-enhancing-the-sustainable-integration-of-wood-biomass-production-with-other-ecosystem-services/>

Project applications

2025 NORDFORSK. SYNERGIES: *Fostering Resilient Forest Landscapes through Sustainable Biomass Integration and Ecosystem Service Co-production*. UEF, UHCH, SLU, EMU, MiUN. Budget: 957 854 EUR. (Submitted)

2025 Säästäamoinen Foundation, Sara Pineda, UEF, 10000 EUR (Granted)

2024 Biofuels from pioneer broadleaves to speed up independence of fossil fuels in Nordic-Baltic food systems (LUMI), NORDFORSK Energy Efficiency in the Food Systems for a Green Transition Call. Partners: SU (Sweden), SLU (Sweden), LUKE (Finland), UEF (Finland), EMU (Estonia). 9.5 M NOK. (Rejected)

2023 Finnish cultural foundation, Sara Pineda, UEF, 28000 EUR (Granted)

2022 Finnish cultural foundation, Nikolaos Pappamathakis, UEF, 26000 EUR (Granted)

2022 Hiltunen foundation, Nikolaos Pappamathakis, UEF, 3000 EUR (Granted)

Conferences

Nousiainen D., Mola-Yudego, B. 2024. Exploring forest conflicts in the EU - what did we learn? Oral presentation.

26th IUFRO World Congress, Stockholm, June, 2024

Nousiainen D., Mola-Yudego, B. 2024. Burn them all? – Analysis of the current forest bioenergy dispute (partial results and observations). Poster. 26th IUFRO World Congress, Stockholm, June, 2024

Mola-Yudego, B. 2024. Assessment of the priorities for the sustainability criteria in the supply chains of biomass for energy production (presentation). GBEP Task Force on Sustainability – Bioeconomy Workstream. Technical Meeting – Bioenergy as part of a circular bioeconomy, 11 April 2024 Oral presentation.

Mola-Yudego, B. 2022. Strategic land-use planning to co-deliver biomass and ecosystem services. Yangling International Agri-Science Forum. Agri-forum Yangling (presentation). Parallel Session II: Forest and Grass Systems and Carbon Sinks. Abstract + Oral presentation. 16-18 September, 2022

Mola-Yudego, B. 2022. Yangling International Agri-Science Forum. Agri-forum Yangling (presentation). Parallel Session II: Forest and Grass Systems and Carbon Sinks. Session Chair, mangroves and risks. 16-18 September, 2022

Mola-Yudego, B. 2022. Energy transition: Biomass sustainability in the Nordic countries. International Conference Advances in renewable and clean energy technologies ARCT. June 7- 10, 2022. Invited Speaker.
<https://www.arctconference.com.br/program>

Englund, O., Mola- Yudego, B., Börjesson, P., Cederberg, C., Dimitriou, I., Scarlat, N., Berndes, G. 2022 Widespread deployment of grass in crop rotations, a multifunctional climate mitigation strategy.
<https://www.ieabioenergy.com/blog/publications/widespread-deployment-of-grass-in-crop-rotations-a-multifunctional-climate-mitigation-strategy> Abstract. Dec 2022.

Mola-Yudego, B. 2022. Determinants of the sustainability profile of biomass supply chains for energy. IEA Task 43, Bioenergy Task Leaders Meeting (online). 18 Oct, 2022 - 20 Oct, 2022.

Mola-Yudego, B. 2022. Integration of biomass crops in agricultural landscapes to provide ecosystem services. IEA Bioenergy WS27: Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits. 23-24 May, 2022. Online. Video at <https://www.youtube.com/watch?v=IHkehRQdoVs>

Workshops

1st SYNERGIES Workshop, Uppsala, 21-23 Nov, 2022. The first SYNERGIES Workshop took place in Uppsala (Sweden) hosted by SLU. Project partners from the UEF (Finland), MiUN (Sweden) and EMÜ (Estonia) attended in person, and from UHCH (Denmark) online.

2nd SYNERGIES Workshop, Joensuu, 8-11 Feb, 2023. Workshop took place in Joensuu (Finland) hosted by UEF. Project partners from UEF (Finland), MiUN (Sweden), SLU (Sweden) attended in person and from UHCH (Denmark) online.

3rd SYNERGIES workshop took place in Tartu, Estonia 25-29 Jan, 2024. Project partners from UEF (Finland), MiUN (Sweden), SLU (Sweden) and EMU (Estonia) attended in person and from UHCH (Denmark) online.

4th SYNERGIES workshop took place in Copenhagen, Denmark 17-19 March 2025. Project partners from UEF (Finland), UHCH (Denmark), MiUN (Sweden), SLU (Sweden) and EMU (Estonia) attended in person.

Courses

Production of Non-Food Biomass, Uppsala, 21-25 NOV, 2022 and NOV, 2025, 2 ECTS. SLU (presential). The course was intended for PhD students, within the scope of the project. The major focus of the course was on the available and potential sources of non-food biomass from forestry, agriculture, residues, and other sources within the

Nordic region that can be used in a biobased economy for biofuels, biomaterials, among others. Lecturers were invited from all SYNERGIES partner institutions (UEF, MiUN, EMÜ, KU). 8 students attended the course. We are preparing to offer it again in 2025.

<https://web.archive.org/web/20221223173914/https://wiki.uef.fi/display/~mola@uef.fi/Production+of+Non-Food+Biomass>

Planned course synergies in curriculum

This is a list of courses targeted for common teaching activities planned after the project:

UEF 6 ECTS (MSc) Production and energy use of lignocellulosic biomass. Invitation: UHCH

UEF 6 ECTS (MSc) Bioenergy markets and policy. Invitation: SLU/UHCH

UEF 3.5 ECTS (MSc) Research Methodology in Forest Sciences. Invitation: MiUN/UHCH

UHCH 15 ECTS (MSc) Ecology and Ecosystems in relation to Environmental Economics. Invitation UEF

UHCH 7.5 ECTS (MSc) Ecosystem Services from Forest and Nature. Invitation UEF/EMU

UHCH 7.5 ECTS (MSc) Land Use and Environmental Modelling. Invitation UEF/MiUN

Policy recommendations & synthesis papers

Mola-Yudego, B., Dimitriou, I., Gagnon, B., Schweinle, J., & Kulišić, B. 2024. Weighting sustainability criteria for biomass supply chains. IEA Bioenergy: Task 43: 01 2024 Summary Series. 2pp.

Kons K, Blagojevic B, Mola-Yudego B, Prinz, R, Routa J, Kulisic B, Gagnon B, Bergström, D. 2022. Industrial End-Users' Preferred Characteristics for Wood Biomass. Synthesis paper. IEA Bioenergy: Task 43: 07 2022 Feedstocks. 3pp.

Dissemination

The following 1-page articles have been written for linkedin as a campaign to reach the general public of the scientific outcomes of the project (average dissemination, 3000 views)

[What is the role of energy crops in the agricultural landscape?](#)

[Energy crops are established for the production of oils or biomass to be used as fuel.](#)

[When discussing the sustainability of biomass, should we give priority to the economy over the environment?](#)

[European biomass plantations can enhance land use diversity](#)

[European landscape diversity and land uses](#)

[Biomass Industrial End-Users: what they really want?](#)

[Oyster mushroom cultivation is a relatively new and efficient agricultural product that is expanding in many countries](#)

[The sustainability of biomass supply chains is a controversially debated topic](#)

[Coffee industry waste into a renewable energy resource?](#)

[Where are Europe's biomass fields?](#)

Other dissemination channels included: Twitter/X/Blusky.

Submissions

Mola-Yudego, B., Esposito, L., Pineda-Zapata, S., Khanam, T., Selkimäki, M., Pappamathaikis, N., Prinz, R., Escuer, J., Shanskiy, M., Acuña, M., Bentsen, N. S., Stupak, I., Englund, O., & Dimitriou, I. (2025). Sustainability profiles and ecosystem services of biomass feedstocks for energy. Manuscript to be submitted for publication to Biomass and Bioenergy (Dec 2025).

Viskadourou, S., Pineda-Zapata, S., & Mola-Yudego, B. (2025). Landscape-level assessment of native forests and commercial Populus sp. plantations. Manuscript to be submitted for publication to Forest Ecology and Management. (Jan 2026)

Mola-Yudego, B., Selkimäki, M., Pineda, S., Kangas, P., Xu, X., Pappammatthaiakis, N., Hoyos, J., Miranda, A., Khanam, T., Dimitriou, I., Stupak, I., Englund, O., Escuer, J., & Shanskiy, M. (2025). Energy crops in Northern Europe: 30 years of development. Manuscript to be submitted for publication to Scandinavian Journal of Forest Research. (Feb 2026)

Mola-Yudego, B., & Englund, O. (2025). Producing wood for energy: A winter's tale. Manuscript to be submitted for publication to Frontiers for Young Minds. <https://kids.frontiersin.org/> (Nov 2025)

7. How and within which areas was the project beneficial for the Nordic countries?

The project generated tangible benefits for the Nordic countries by strengthening scientific collaboration, data harmonisation, and evidence-based policy support in the field of sustainable biomass production and ecosystem service integration. It consolidated a network of Nordic and Baltic institutions, fostering joint research on biomass supply systems, carbon dynamics, and biodiversity impacts, thereby enhancing regional capacity to address climate and energy targets. Through shared datasets, harmonised indicators, and comparative analyses of management practices, the project improved the basis for national sustainability assessments and cross-border policy alignment. Workshops and coordinated publications provided a forum for dialogue among researchers, policymakers, and stakeholders, particularly targeted through synergic projects (IEA Task 43 meetings, UNITE Flagship and H2020 Eco2Adapt parallel projects) leading to common research agendas and strengthened participation of Nordic partners in forthcoming European initiatives. Collectively, these outcomes reinforced the Nordic region's leadership in sustainable bioeconomy research and its capacity to produce regionally relevant, scientifically robust evidence for decision-making.

Participation

8. Number of participants

Country	Early-career researchers/ PhD students	Senior researchers	Stakeholders	Others (specify)	Gender			Total
					Women	Men	Other	
Denmark		2			1	1		2
Finland	4	2			4	2		6
Estonia	2	2			2	2		4
Norway								
Sweden	1	2				3		3
...								
...								
...					7	8		15

Total								
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9. List the participating institutes/sectors

Univ. Eastern Finland UEF
 Univ. Copenhagen UHCH
 Swedish University of Agricultural Science SLU
 Mid-Sweden University MiUN
 Estonian University of Life Sciences EMU

Economic report

10. Received grant from SNS in total (SEK):

828 641 SEK

11. Transfer of SNS funds to project partners

Country	Partner/organisation	Sum (SEK)
Denmark	Univ. Copenhagen	149155
Finland	Univ. Eastern Finland	298311
Sweden	Swedish University of Agricultural Science + Mid-Sweden University	140869+140869
Norway		
Iceland		
Other countries (specify)	Estonian University of Life Sciences	99437
Total SUM		828641

12. Costs

in SEK	SNS funding	Co-financing		Total
		Cash	In-kind	
Travel and accommodation	194 457,09			194 457,09
Meeting costs	20 871,09			20 871,09
Communication				
Salary and OH	636 888,44	81 050,11	3 330 014,64	4 047 953,19
Other costs (specify)	117 808,58			117 808,58
Total SUM (SEK)	970 025,19	81 050,11	3 330 014,64	4 381 089,95

13. Economic result (deficit or surplus):

Costs exceed the budget compared to all funding sources (SNS funding, co-funding in cash and in-kind)

14. Optional: Comments to the economic reporting:

15. Submit a popular science piece as a separate document for dissemination in SNS' various channels with *emphasis on application of results and benefits for the Nordic society*.

Provide pictures (size at least 500x500 pixels and resolution at least 72 pixels) as separate files (.jpg). Include caption to each picture and the name of the photographer.

I hereby declare that the above statements are true to the best of my knowledge

Signature of the main applicant/project coordinator

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Signature	Institution	Date
Blas MOLA		
Printed name		

Signature of the department head at the department of the main applicant

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Signature	Institution	Date
Jukka TIKKANEN		
Printed name		

Second applicant's signature, place and date

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Signature	Institution	Date
Ioannis DIMITRIOU		
Printed name		

Third applicant's signature, place and date		
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Signature	Institution	Date
Oskar ENGLUND		
Printed name		

Fourth applicant's signature, place and date		
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Signature	Organisation	Date
Inge STUPAK		
Printed name		

Fifth applicant's signature, place and date		
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Signature	Organisation	Date
Merrit SHANSKIY		
Printed name		

Tämä dokumentti on allekirjoitettu sähköisesti UEF Sign-järjestelmällä
This document has been electronically signed using UEF Sign



Päiväys / Date: 15.10.2025 14:20:10 (UTC +0300)

Blas Mola

Professori

Metsätieteiden osasto

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Organisaation varmentama (UEF-käyttäjätunnus) (eIDAS-tunnistamisen varmuustaso: korotettu)
Certified by organization (UEF user account) (eIDAS level of assurance: substantial)

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Kaksiosainen henkilötunnistus (sähköposti- ja puhelintunnistus) (eIDAS-tunnistamisen varmuustaso: korotettu)
Two-factor person identification (email and SMS identification) (eIDAS level of assurance: substantial)

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Kaksiosainen henkilötunnistus (sähköposti- ja puhelintunnistus) (eIDAS-tunnistamisen varmuustaso: korotettu)
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Kaksiosainen henkilötunnistus (sähköposti- ja puhelintunnistus) (eIDAS-tunnistamisen varmuustaso: korotettu)
Two-factor person identification (email and SMS identification) (eIDAS level of assurance: substantial)