

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:	PROTECT: Effects of defense priming on Norway spruce needle microbiome and pest resistance
2. Project code:	SNS-131

3. Project coordinator:	Melissa Hamner Magerøy
Email:	melissa.mageroy@nibio.no
Institution:	NIBIO

Activity report

4. Provide a project summary for the whole project period, including:

a) The purpose of the project/main problems/hypothesis addressed

The PROTECT project aimed to understand how chemical defense priming of Norway spruce seeds affects their resistance to pests and pathogens, and how this priming interacts with the spruce microbiome. The project was based on several hypotheses:

- That seed treatment with priming agents like methyl jasmonate (MeJA) and β -aminobutyric acid (BABA) would enhance plant resistance.
- That such treatments would alter microbial communities associated with spruce.
- That these microbial changes could have downstream effects—positive or negative—on plant health, photosynthetic capacity, and stress tolerance.

This work addressed a major problem in forestry: the need for sustainable pest and disease management strategies, especially under climate stress and reduced pesticide use.

b) A short description of the main activities of the project

- Seed treatments using priming agents.
- Forest soil collection from spruce forest in collaboration with Viken Skog, soil sterilization in collaboration with SoilSteam, and inoculation of sterile soil with *Amphinema sp.* mycorrhizal fungi.
- Planting, growing, and phenotyping seedlings in greenhouse microcosms over multiple years.
- Pathogen resistance tests using *Botrytis cinerea*, *Gremmeniella abietina*, *Grosmannia penicillata*, *Heterobasidion annosum*.
- Microbiome profiling using amplicon sequencing (16S and ITS).
- Metabolite profiling and gene expression analyses in 2-year-old plants.
- PhD exchanges and training, particularly with partners from NIBIO (Norway), SLU (Sweden), and LAMMC (Lithuania).

c) Achieved targets

- It demonstrated that MeJA seed treatment influences spruce seedling height and interacts with soil type to affect health outcomes.
- Microbial communities were characterized. Differences between soil types were detected, but there were no clear effects of seed priming on microbial diversity.
- Resistance to *Botrytis cinerea* was enhanced by MeJA in 4-week-old seedlings, suggesting practical potential for forestry.
- Several peer-reviewed articles and two meta-analyses were produced, as well as popular science

communications.

- All planned training activities and research stays were completed, with early-career researchers gaining experience and establishing networks that will continue throughout their careers. In total, 3 PhD students, 2 internships, and 3 master students were involved in some aspect of the project.

d) Did the network develop and deliver as planned? If not, please explain why

Yes, the network developed and delivered as planned. The team maintained strong collaboration through annual meetings, regular communication, and in-person research exchanges. The gender-balanced network included participants from Norway, Sweden, Finland, Lithuania, and Spain, and integrated early-career researchers effectively.

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

Peer-reviewed scientific publications:

- Huynh, N.B., Krokene, P., Nybakken, L., Čėsna, V., & Mageroy, M.H. (2024). β -aminobutyric acid does not induce defenses or increase Norway spruce resistance to the bluestain fungus *Grosmannia penicillata*. *Physiologia Plantarum*. <https://doi.org/10.1111/ppl.70009>
- Huynh, N.B., Krokene, P., Puentes, A., & Mageroy, M.H. (2024). Over 20 years of treating conifers with methyl jasmonate: Meta-analysis of effects on growth and resistance. *Forest Ecology and Management*, 561, 121893. <https://doi.org/10.1016/j.foreco.2024.121893>
- Fossdal, C.G., Krokene, P., Olsen, J.E., Strimbeck, R., Viejo, M., Yakovlev, I., & Mageroy, M.H. (2024). Epigenetic stress memory in gymnosperms. *Plant Physiology*, kiae051. <https://doi.org/10.1093/plphys/kiae051>

Manuscripts in submission:

- Huynh, N.B., Schmidt, A., Pennanen, T., Gershenzon, J., Mageroy, M.H. Methyl jasmonate seed treatment enhances Norway spruce seedling resistance to *Botrytis cinerea* via a multitude of defense responses.
- Rwizi, M.T., Čėsna, V., Krokene, P., Mageroy, M.H. Meta-analysis of effects of ectomycorrhizal fungi on conifer growth and stress tolerance.

Popular science outputs/stakeholder communication:

- Krokene, P. & Mageroy, M.H. (2024). Tree Memories: How Can Trees Remember Without a Brain? *Frontiers for Young Minds*, 12:1400253. <https://doi.org/10.3389/frym.2024.1400253>
- Seminar on Integrated Plant Protection in Forest Plant production, organized by PROTECT, Formidlingskonferanse SKOG, 13 June 2023, Gardemoen, Norway
- Forsker på vaksinerer av granplanter» by Bjørn H. Pettersen, Viken Skog Newsletter, 20 July 2022. <https://www.viken.skoq.no/aktuelt/artikler/forsker-pa-vaksinerer-av-granplanter>

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

- Sparking Curiosity: Writing popular science for kids, SNS booth at the 2024 IUFRO World Congress, Stockholm.
- PhD students, N.B. Huynh (NIBIO), V. Čėsna (LAMMC) and K. Berggren Nieto (SLU) attended the 2024 IUFRO World Congress. N.B. Huynh also attended the American Society of Plant Biology 2023 meeting in Savannah, Georgia and IOBC-WPRS PR-IR 2022 in Sheffield. M. Mageroy (NIBIO) participated in 2024 IUFRO World Congress, IUFRO Division 7 Lisbon 2023, and Workshop on *Hylobius abietis* in Praha 2024.
- As a consequence of relationships formed in this project, V. Čėsna and M. Mageroy have recently been a part of an application to NordForsk Sustainable Future Forest. A. Puentes and M. Mageroy have also been a part of an application to BBRC.

7. How and within which areas was the project beneficial for the Nordic region (Denmark, Finland, Iceland, Norway, Sweden and the autonomous areas of the Faroe Islands, Greenland and Åland Islands)?

The PROTECT project contributed directly to the resilience and sustainability of Nordic forestry by advancing our understanding of how defense priming can be practically applied to protect Norway spruce—one of the region's most economically and ecologically important tree species. Showing that MeJA seed treatment can enhance seedling resistance to a key pathogen, the project placed a foundational "brick in the wall" of knowledge needed to

reduce reliance on chemical pesticides in forest nurseries and reforestation efforts.

The project also strengthened Nordic-Baltic research collaboration. It brought together partners from Norway (NIBIO), Sweden (SLU), and Finland (LUKE), and extended this network to include Lithuania (LAMMC) and Spain (University of Santiago de Compostela). Through cross-border coordination, shared experimental designs, and joint dissemination efforts, the project fostered a unified regional approach to plant health and forest sustainability.

A significant benefit to the Nordic and Baltic regions came from the investment in early-career researcher training. Two PhD students from Lithuania conducted research stays in Norway, gaining hands-on experience with defense priming experiments, molecular techniques, and plant-microbiome analysis. These exchanges not only built individual capacity but also forged institutional connections that will outlast the project. This aligns with the long-term goal of creating a skilled and networked new generation of forest scientists equipped to tackle future biotic challenges under climate change.

Participation

8. Number of participants involved in the project activities

(Please adjust the table with countries to match your project)

Country	Early-career researchers/ PhD students	Senior researchers	Stakeholders	Others (specify)	Gender			Total
					Women	Men	Other	
Denmark								
Finland		1			1			1
Iceland								
Norway	6	3	1		5	4	1	10
Sweden	1	1			1			1
Lithuania	2	1			2	1		3
Spain	1					1		1
...								
Total	10	6	1		10	6	1	16

Gender equality actions

In the beginning of the project period, you were introduced to the [gender equality guidelines](#) and asked to perform at least five points from the action step during the whole project period. Fill in the following evaluation scheme with the actions performed. It is new for SNS to introduce these gender equality guidelines to our funded projects, so SNS would really appreciate your feedback on the guidelines and how they have worked for you.

9. Evaluation scheme	
a) Outcome of completed analysis step:	Our network maintained a gender-balanced composition throughout the project, including a healthy mix of female and male researchers at both early-career and senior levels.
b) Outcome of completed planning step:	As a result of our balanced team, this naturally led to an even distribution of responsibilities across genders. We planned hybrid meetings (online and in-person) to accommodate participants with family obligations or mobility constraints.
c) Outcome of completed action steps (please list each action)	Maintained gender balance in the network composition – Our project had a roughly equal number of men and women across all participating

point performed and their outcome)	institutions and career stages. Encouraged inclusive participation in meetings – Early-career researchers and students were encouraged to share ideas and lead discussions during project planning, conducting experiments and meetings. Supported flexible work formats – Meetings and deadlines were structured to support good work-life balance, which benefitted caregivers and promoted wellbeing.
d) How did the actions/tools work for your network:	The actions and tools were effective in raising awareness of unconscious biases and blind spots that can contribute to inequality and inequity, even in well-meaning environments.
e) How could SNS provide more support to your network in the work toward gender equality:	Further support could include targeted funding or fellowships for women returning to research after a career break and developing countries.
f) General feedback to the gender equality guidelines:	I found the seminar with Tomas Brage very enlightening.

Economic report

The economic reporting should include the total received grants and costs for the whole project period

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

1 014 000

11. Allocation of SNS funding

Country	Partner/institution	Sum (SEK)
Denmark		
Finland	LUKE	
Sweden	SLU	
Norway	NIBIO	1 014 000
Iceland		
Other countries (specify) Lithuania Spain	LAMMC USC	
Total SUM		1 014 000

12. Costs

(in SEK)	SNS funding	Co-financing		Total
		Cash	In-kind	
Travel and accommodation	88 724	233 978		322 702
Meeting costs	33 303	3 552		36 855

Communication	1 667			1 667
Salary and OH	436 996	5 810 441		6 247 437
Other costs (specify)	419 353	580 640		999 993
Total SUM (SEK)	980 100	6 628 611		7 608 654

13. Economic result (deficit or surplus):

-190 (difference in Received grant and Costs is due to SEK to NOK exchange rates)

14. Optional: Comments to the economic reporting:

Travel cost includes research visits by PhD student and attending conferences.

Meeting cost includes project meetings and arranging a seminar for stakeholders.

Salary cost includes hours for project leader, PhD student and technical support.

Other costs include laboratory consumables, reagents, greenhouse rental, kits, and sequencing.

Co-financing was provided by NFR project grant 324129 to Melissa Magerøy.

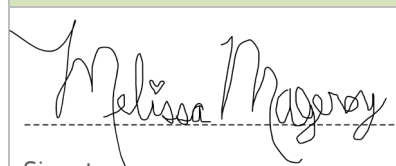
15. Submit a popular science piece as a separate document for dissemination in SNS' various channels with emphasis on application of results and benefits for the Nordic society.

Please see separate document for instructions.

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

(Please adjust the number of signature boxes to the number of applicants)

Signature of the main applicant/project coordinator

		NIBIO NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH	04.06.2025
Signature	Institution		Date
Melissa H Magerøy			
Printed name			

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

		NIBIO NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH	11.06.25
Signature	Institution		Date
Marianne Stenrød			
Printed name			

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Second applicant's signature, place and date

 	 LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY	05.06.2025
Signature	Institution	Date
Vaida Sirgedaitė-Šežienė		
Printed name		

Third applicant's signature, place and date

 	 Luke NATURAL RESOURCES INSTITUTE FINLAND	05.06.2025
Signature	Institution	Date
Taina Pennanen		
Printed name		

Fourth applicant's signature, place and date

 	 SLU Swedish University of Agricultural Sciences	05.06.2025
Signature	Institution	Date
Adriana Puentes		
Printed name		