Field course

Deadwood and wood-inhabiting communities: decades after restoration in boreal forests

19-23.05.2025, Evo, Southern Finland

The course is organised in the framework of the Evo complex restoration experiment established in 2001, which manipulated tree retention, deadwood creation and prescribed burning in mature mesic Norway spruce forests. The programme consists of lectures in the field, groups work, individual assignments and the exam. The course is intended for master and doctoral students, and is worth 3 credits of ECTS (European Credit Transfer System).

Main topics

- The value of long-term research and especially the long-term experiments in forests
- Primeval vs managed forests: differences in structure, species composition and successional processes. Call for closer-to nature forest management and ecological restoration.
- Basics of deadwood ecology.
    - Deadwood-dependent species in boreal forests: their ecology and habitat requirements.
    - Deadwood inventories
    - Deadwood decomposition and nutrient cycling: theory, methodology of studies.
    - Fire and deadwood. Potential role of deadwood in the soil forming processes.
- Implications for forest management and ecological restoration.

Background

Human activity (e.g., silviculture, agriculture) has degraded most ecosystems worldwide. Ecological restoration encompasses a suite of strategies that are designed to halt and reverse the impacts of humans on nature. Restoration has proven potential to enhance structural complexity, benefit biodiversity, improve levels of ecosystem functioning and delivery of ecosystem services, and mitigate the effects of climate change. The Society for Ecological Restoration defines restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." Restoration may also provide sociocultural and economic benefits, for instance, strategies can boost the biodiversity of culturally important species and generate revenue in local communities. However, many approaches to restoration remain untested, and poorly-designed approaches to restoration can adversely affect nature and society. Assessing the benefits and trade-offs of restoration often requires an experimental approach that considers various contextual factors. For instance, successfully restoring forests in the boreal and tropical biomes cannot be done using the same approach, owing to biome-specific climatic conditions and biodiversity (e.g., the tree species which can grow), variability in people and culture, and differences in the amount of remaining natural habitat.

Natural forest dynamics and deadwood

Forests are a dominant ecosystem in the Nordic countries. In natural conditions, Nordic forests are characterised by even-aged, patchy-cohort, and fine-scale gap dynamics. Successional cycles are driven by natural disturbances including wildfires, windthrows, and biotic and abiotic diebacks of varying severity and size (Fig 1). As a result, features such as old living trees, kelo trees, and burnt areas are common. Deadwood - snags (standing dead trees), logs, stumps, and branches - serves as habitat, shelter, and a nutrient source for multiple organisms, which provide a wide range of ecosystem services, e.g., carbon and nutrient storage, decomposition, nutrient turnover, and pollination (Stokland et al., 2012; Löfroth et al., 2023) (Fig. 2). Many species are adapted to old-growth forest environments and their natural disturbance dynamics. As a result, they cannot survive in alternative forest systems.

In the modern day, the forests in the Nordic countries are mostly under intensive and long-lasting forest management, focused on wood production. Natural disturbance dynamics have been largely eliminated. For instance, forests are to a great extent excluded from the effects of forest fires because of intensive fire suppression management, which is supported by a dense forest-road network. Instead of irregular disturbance from wildfires, windthrows, and biotic and abiotic diebacks, managed forests are characterised by regular disturbance caused by thinning, clearcutting, and replanting. Management has resulted in a simplification and homogenization of Nordic forests, and most are now even-aged and single-species tree stands. Old living trees are nearly non-existent, and deadwood (and particularly large deadwood) is uncommon. Accordingly, levels of biodiversity have decreased.

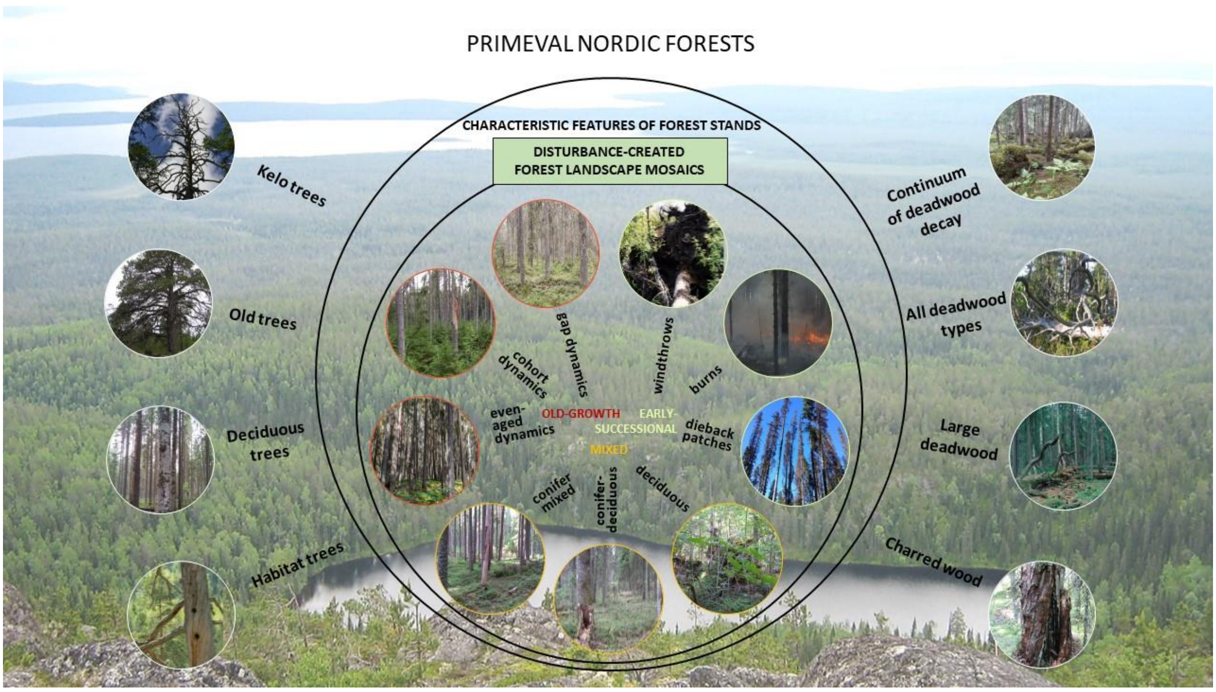

Fig. 1. Stand- and landscape-scale features of primeval Nordic forests. © Design: E. Shorohova. Photos: E. Shorohova, A. Korepin, I. Vanha-Majamaa, A. Ruokolainen, E. Oksanen, K. Shumsky, V. Girfanova, E. Muradova, A. Gladyshev

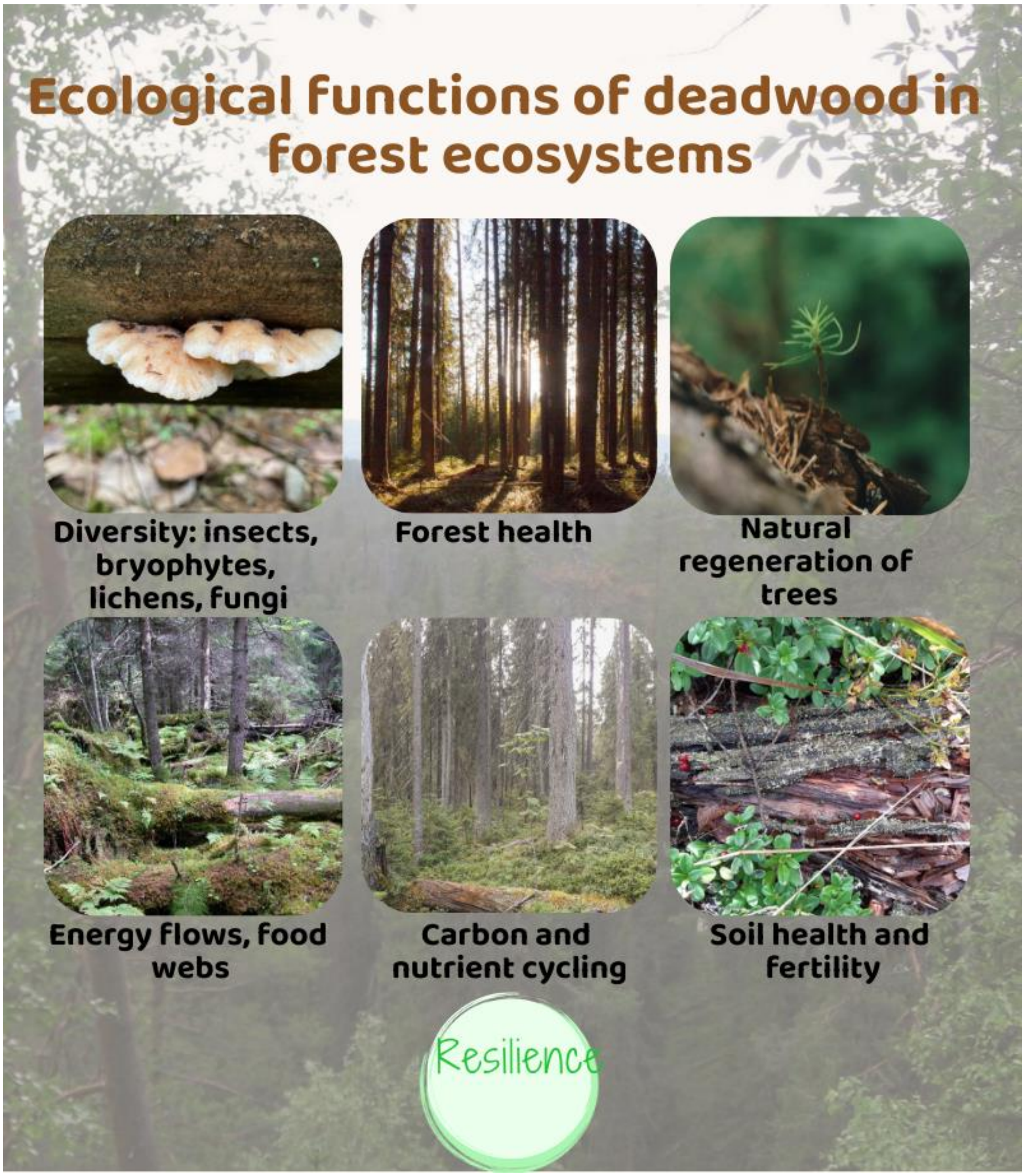

Figure 2. Ecological functions of deadwood in forest ecosystems. © E. Shorohova. Photos: E. Shorohova, D. Mirin, I. Vanha-Majamaa, A. Ruokolainen, E. Oksanen, A. Korepin.

Efforts are underway to restore managed forests in the Nordic countries towards more natural conditions, including to enhance forest structural complexity and levels of biodiversity and ecosystem functioning. Especially promising strategies include variable retention forestry, prescribed burning, and artificial addition of coarse woody debris. Assessing the impacts of these restoration strategies is best done using an experimental approach, owing to the various interacting factors that can influence complex forest systems. For instance, the biodiversity of species dependent on deadwood could be driven by either resource availability represented by deadwood amount or habitat heterogeneity characterized by deadwood diversity or both (Seibold et al., 2015; Sandström et al., 2019). Deadwood quantity and quality are regulated by various abiotic, biotic, and anthropogenic factors, interacting across landscapes and forest stands, as well as by natural disturbances and forest management practices (Shorohova and Kapitsa, 2015; Kapusta et al., 2020; Bujoczek and Bujoczek, 2022). Recognising the value of experimental approaches to restoration, several experiments were established in forests in Finland and Sweden in the 2000s to compare effects of various restoration treatments on different species groups (Gustafsson et al., 2020, Koivula and Vanha-Majamaa, 2020). These experiments are now amongst the oldest and most valuable restoration experiments worldwide, and are vital to determining how restoration can benefit nature and society over the long-term (Sandström et al., 2019; Koivula and Vanha-Majamaa, 2020). This is important, as the effects of restoration can be variable over time, yet long-term restoration experiments are rare.

This course focuses around the Evo experiment, which is assessing how restoration involving standing retention, downed wood creation, and prescribed burning affects whole ecosystems at the stand-level. The experiment follows a statistically powerful before-after control impact (BACI) design, and is one of the oldest restoration experiments worldwide. We will focus on the experimental treatments' impacts on deadwood and associated species and processes, owing to the importance of deadwood to sustaining biodiversity in boreal forest ecosystems. As such, restoring a continuous supply of various amount and quality of diverse deadwood is vital to reverse the negative trends in biodiversity and forest ecosystem resilience (Löfroth et al., 2023).

During the course, we will explore the effects of prescribed burning, tree retention and downed wood creation on the forest structure, including the deadwood profile, soil formation under deadwood, as well as wood-inhabiting communities in managed boreal Norway spruce forest stands. The treatments have been in place for more than twenty-years. We will describe soil profiles through fallen logs and near fallen logs that are currently in a decay gradient (Shorohova et al., 2024). The students will practice morphological description of soil. Pit – mound systems will be partly covered in the course as well. More specifically, the following parts of the deadwood ecology will be covered.

- ✓ Deadwood inventories
- ✓ Wood-inhabiting fungi
- ✓ Xylophylous insects
- ✓ Ants, their role in biodiversity
- ✓ Epixylic vegetation
- ✓ Decomposition of deadwood, carbon and nutrient cycling
- ✓ Deadwood and soil.

The experiment

The stand scale treatments of the experiment included cuttings with a constant volume of dispersed retention trees (50 m^3 ha^{-1}, ca. 200 trees per ha), and three levels of downed deadwood creation (5, 30 and 60 m^3 ha^{-1}), in both upland and paludified biotopes of Myrtillus site type, with or without prescribed burning, with three replicates each (Table 1, Figs 3,4).

Follow-up studies include:

- Stand structure and tree mortality
- Tree regeneration
- Polypore diversity
- Coarse woody debris (CWD) and fine woody debris (FWD) dynamics
- Ground vegetation
- Epixylic lichens and bryophytes
- Dead wood decomposition and nutrient dynamics
- Soil microbiome
- Soil under deadwood.

Table 1. Experimental design: number of replicates per treatment. © Forest Ecology and Management https://doi.org/10.1016/j.foreco.2024.122013

48 Norway spruce-dominated mature managed forest stands on mesic-site type								
	Standing retention 50 m^3/ha						No cuttings	
	Deadwood creation							
	5 m^3/ha		30 m^3/ha		60 m^3/ha			
	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned
Biotope	Number of replicates							
Upland	3	3	3	3	3	3	3	3
Paludified	3	3	3	3	3	3	3	3

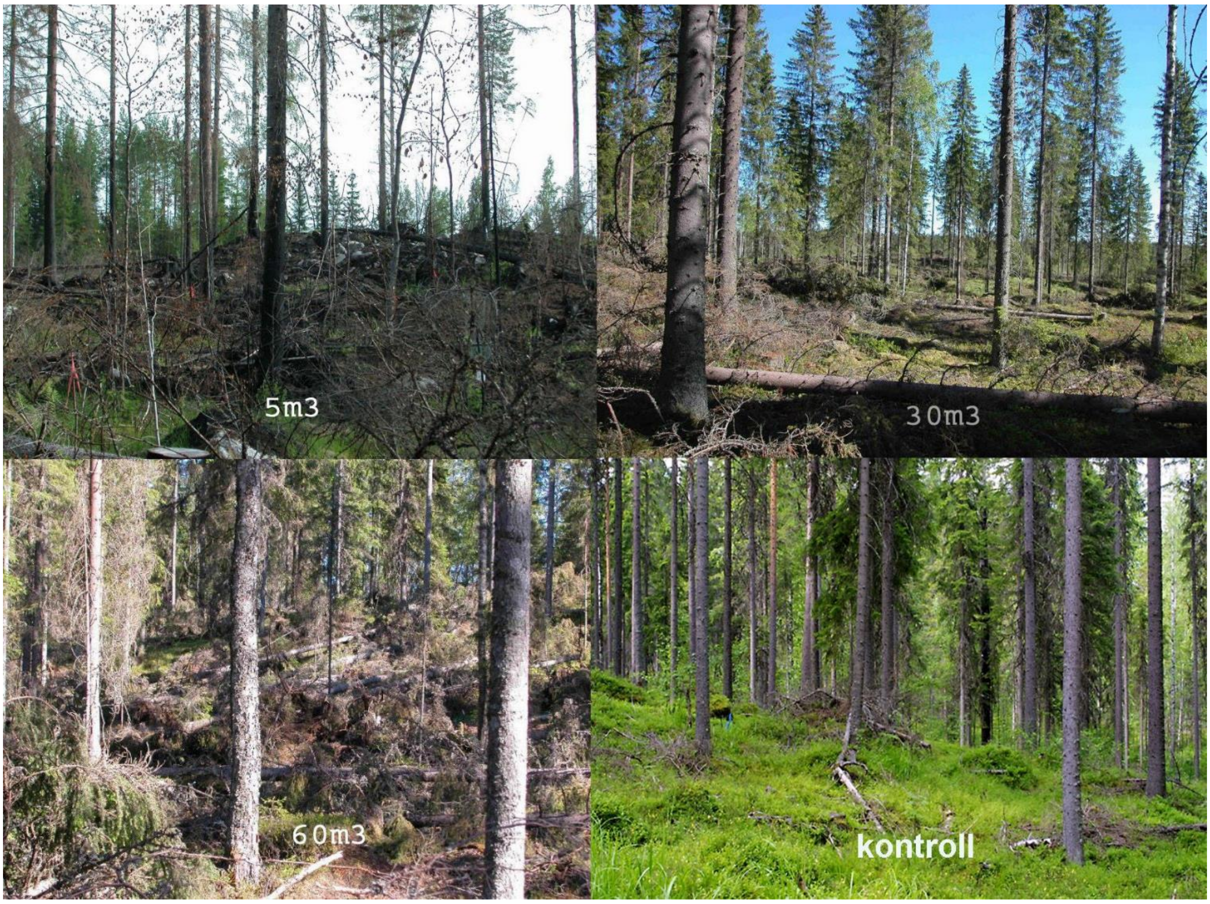

Figure 3. Standing retention and downed wood creation, 2002. Photos: Saara Lilja.

Figure 4. Standing retention, downed wood creation and prescribed burning, 2002. Photos: Saara Lilja.

After the treatments, the forest stand structure and deadwood diversified (Fig. 5)

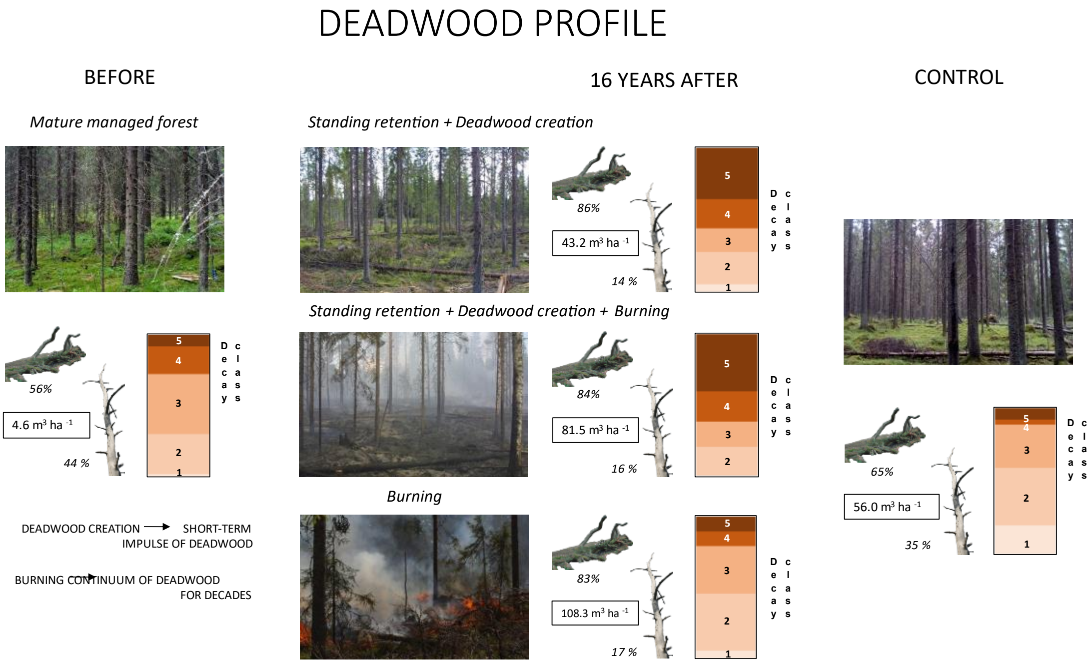

Figure 5. Effects of tree retention, prescribed burning and deadwood creation on the deadwood profile. © Forest Ecology and Management https://doi.org/10.1016/j.foreco.2024.122013 Design E. Shorohova. Photos: E. Oksanen.

During the course, we will establish a bridge between research and practice. We will discuss the implications of the results of the Evo experiment to practical forest management and ecological restoration.

Course Completion - Course components

- Lectures (8 x 2h)
- Completing required and optional reading (8 x 4h)
- Revision of material for exam (10 h)
- Field exercises based on course topics (4 x 2h)
- Final exam (essay on a given topic) (4 x 3 h)

Learning outcomes

After the course, the student

- has advanced knowledge of the scientific basis and practices of closer-to-nature forest management, ecological restoration and nature conservation,
- knows and can explain the main concepts, theories and practical approaches of biodiversity conservation in managed forests,
- is able to analyze the relationships and tradeoffs between biodiversity conservation and forest management,
- gets skills in identifying indicator species and evaluating biodiversity, learns some rare and threatened species,
- has improved skills in performing fieldwork including the skills in sampling deadwood and soil.

Assessment practices and criteria

The grade is given on a scale of 0-5; 0=fail, 1= pass, 2= satisfactory, 3= good, 4= very good and 5=excellent.

Study points

- 3 ECTS

Study materials

The materials will consist of lecture notes, textbook chapters, scientific literature, assigned individual tasks. Further information is provided during the course.

Textbooks, scientific papers, web resources

The experiment

Vanha-Majamaa, I., Lilja, S., Ryömä, R., Kotiaho, J.S., Laaka-Lindberg, S., Lindberg, H., Puttonen, P., Tamminen, P., Toivanen, T. and Kuuluvainen, T., 2007. Rehabilitating boreal forest structure and species composition in Finland through logging, dead wood creation and fire: the EVO experiment. *Forest Ecology and Management*, *250*(1-2), pp.77-88.

Reference: characteristic features of old-growth forests

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- Luonnontilaiset metsät ja vanhat metsät Suomessa : Euroopan komission ohjeet ja kansallinen tarkastelu (helsinki.fi) *Scientific report, in Finnish*

Guidelines and principles of closer-to-nature forest management

- ✓ European Commission, Directorate-General for Environment, *Guidelines on closer-to-nature forest management*, Publications Office of the European Union, 2023, **https://data.europa.eu/doi/10.2779/731018** Guidelines on Closer-to-Nature Forest Management (europa.eu) *Handbook*
- ✓ Larsen, J. B., Angelstam, P., Bauhus, J., Carvalho, J. F., Diaci, J., Dobrowolska, D., ... & Schuck, A. (2022). *Closer-to-Nature Forest Management. From Science to Policy 12* (Vol. 12, pp. 1-54). EFI European Forest Institute. (EFI_fstp_12_2022.pdf (unito.it) *Scientific book*
- ✓ Korhonen, K.T., Huuskonen, S., Kolström, T., Kurttila, M., Punttila, P., Siitonen, J. & Syrjänen, K. 2021. Closer-to-nature forest management approaches in Finland. Natural resources and bioeconomy studies 83/2021. Natural Resources Institute Finland. Helsinki. 25 p. Closer-to-nature forest management approaches in Finland (luke.fi) *Scientific report*
- ✓ Aszalós, R., Thom, D., Aakala, T., Angelstam, P., Brūmelis, G., Gálhidy, L., ... & Keeton, W. S. (2022). Natural disturbance regimes as a guide for sustainable forest management in Europe. *Ecological Applications*, *32*(5), e2596. Natural disturbance regimes as a guide for sustainable forest management in Europe - Aszalós - 2022 - Ecological Applications - Wiley Online Library *Scientific article*
- ✓ Messier, C., Puettmann, K.J. and Coates, K.D. eds., 2013. *Managing forests as complex adaptive systems: building resilience to the challenge of global change*. Routledge. *Scientific article*
- ✓ Gustafsson, L., Bauhus, J., Asbeck, T., Augustynczik, A. L. D., Basile, M., Frey, J., ... & Storch, I. (2020). Retention as an integrated biodiversity conservation approach for continuous-cover forestry in Europe. *Ambio*, *49*, 85-97. Retention as an integrated biodiversity conservation approach for continuous-cover forestry in Europe (springer.com) *Scientific article*
- ✓ Gauthier, S. *et al.* (2023). Ecosystem Management of the Boreal Forest in the Era of Global Change. In: Girona, M.M., Morin, H., Gauthier, S., Bergeron, Y. (eds) Boreal Forests in the Face of Climate Change. Advances in Global Change Research, vol 74. Springer, Cham. https://doi.org/10.1007/978-3-031-15988-6_1 Ecosystem Management of the Boreal Forest in the Era of Global Change | SpringerLink *Scientific book*

- ✓ Bravo-Oviedo, A., Pretzsch, H., & del Río, M. (Eds.). (2018). *Dynamics, silviculture and management of mixed forests* (Vol. 31). Berlin: Springer. Dynamics, Silviculture and Management of Mixed Forests | SpringerLink *Scientific book*
- ✓ Routa, J., & Huuskonen, S. (2022). Jatkuvapeitteinen metsänkasvatus: Synteesiraportti. Jatkuvapeitteinen metsänkasvatus: Synteesiraportti - Jukuri (luke.fi) *Scientific report, in Finnish*
- ✓ Metsänhoidon suositukset - Tapio *Webpage, handbook on closer-to-nature forest management in private forests in Finland according to the recommendations by Tapio, in Finnish and Swedish*

Scientific evidence on the impact of closer-to-nature forest management and ecological restoration

- ✓ Koivula, M., & Vanha-Majamaa, I. (2020). Experimental evidence on biodiversity impacts of variable retention forestry, prescribed burning, and deadwood manipulation in Fennoscandia. *Ecological Processes*, *9*(1), 11.
- ✓ Koivula, M., Louhi, P., Miettinen, J., Nieminen, M., Piirainen, S., Punttila, P. & Siitonen, J. 2022. Talousmetsien luonnonhoidon ekologisten vaikutusten synteesi. Luonnonvara- ja biotalouden tutkimus 60/2022. Luonnonvarakeskus. Helsinki. 83 s. Talousmetsien luonnonhoidon ekologisten vaikutusten synteesi (luke.fi)
- ✓ Angelstam, P., Asplund, B., Bastian, O., Engelmark, O., Fedoriak, M., Grunewald, K., ... & Öster, L. (2022). Tradition as asset or burden for transitions from forests as cropping systems to multifunctional forest landscapes: Sweden as a case study. *Forest ecology and management*, *505*, 119895.Tradition as asset or burden for transitions from forests as cropping systems to multifunctional forest landscapes: Sweden as a case study - ScienceDirect
- ✓ Hertog, I. M., Brogaard, S., & Krause, T. (2022). Barriers to expanding continuous cover forestry in Sweden for delivering multiple ecosystem services. *Ecosystem services*, *53*, 101392. Barriers to expanding continuous cover forestry in Sweden for delivering multiple ecosystem services - ScienceDirect
- ✓ Larsen, J.B., 2012. Close-to-nature forest management: the Danish approach to sustainable forestry. *Sustainable forest management—current research*, pp.199-218.
- ✓ Huuskonen, S., Domisch, T., Finér, L., Hantula, J., Hynynen, J., Matala, J., ... & Viiri, H. (2021). What is the potential for replacing monocultures with mixed-species stands to enhance ecosystem services in boreal forests in Fennoscandia?. *Forest ecology and management*, *479*, 118558. What is the potential for replacing monocultures with mixed-species stands to enhance ecosystem services in boreal forests in Fennoscandia? - ScienceDirect

Forest fires and prescribed burning

- ✓ Knowledge compilation on forest fires in the Nordic region. rapport-210928-2.pdf (nordicforestresearch.org)
- ✓ Aalto, J. U. H. A., & Venäläinen, A. (2021). Climate change and forest management affect forest fire risk in Fennoscandia. *Finnish Meteorological Institute, Reports*, *2021*, 3. IBA FOREST FIRES - Finnish Meteorological Institute (ilmatieteenlaitos.fi) *Scientific report*
- ✓ Tuli metsässä -sanasto (metsakeskus.fi) Vocabulary of the terms related to fire, in Finnish, Englich and Swedish

- ✓ Lindberg, H., Punttila, P., & Vanha-Majamaa, I. (2020). The challenge of combining variable retention and prescribed burning in Finland. Ecological Processes, 9(1), 4.
- ✓ Kulotus - Kuvaus | Metsänhoidon suositukset (metsanhoidonsuositukset.fi) Webpage, handbook on prescribed burning in private forests in Finland according to the recommendations by Tapio, in Finnish and Swedish
- ✓ Ecological restoration and management in boreal forests - best practices from Finland - julkaisut.metsa.fi *Handbook on ecological restoration, including chapter on prescribed burning*
- ✓ Cogos, S., Roturier, S. & Östlund, L. The origins of prescribed burning in Scandinavian forestry: the seminal role of Joel Wretlind in the management of fire-dependent forests. Eur J Forest Res 139, 393–406 (2020). https://doi.org/10.1007/s10342-019-01247-6 The origins of prescribed burning in Scandinavian forestry: the seminal role of Joel Wretlind in the management of fire-dependent forests | European Journal of Forest Research (springer.com)
- ✓ Ramberg, E., Strengbom, J. & Granath, G. Coordination through databases can improve prescribed burning as a conservation tool to promote forest biodiversity. Ambio 47, 298–306 (2018). https://doi.org/10.1007/s13280-017-0987-6 Coordination through databases can improve prescribed burning as a conservation tool to promote forest biodiversity | Ambio (springer.com)

Ecological functions of deadwood

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Deadwood enrichment in forests

- ✓ Lahopuun turvaaminen - Kuvaus | Metsänhoidon suositukset (metsanhoidonsuositukset.fi)
- ✓ Lahopuu | Metsähallitus (metsa.fi)
- ✓ Metsien ennallistamismenetelmät | Metsähallitus (metsa.fi)
- ✓ Kyaschenko, J., Strengbom, J., Felton, A., Aakala, T., Staland, H., & Ranius, T. (2022). Increase in dead wood, large living trees and tree diversity, yet decrease in understory vegetation cover: The effect of three decades of biodiversity-oriented forest policy in Swedish forests. *Journal of Environmental Management*, *313*, 114993. Increase in dead wood, large living trees and tree diversity, yet decrease in understory vegetation cover: The effect of three decades of biodiversity-oriented forest policy in Swedish forests - ScienceDirect

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- ✓ Vítková, L., Bače, R., Kjučukov, P., & Svoboda, M. (2018). Deadwood management in Central European forests: Key considerations for practical implementation. *Forest ecology and management*, *429*, 394-405.Deadwood management in Central European forests: Key considerations for practical implementation - ScienceDirect

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- ✓ European Commission, Directorate-General for Environment, *Guidelines on closer-to-nature forest management*, Publications Office of the European Union, 2023, **https://data.europa.eu/doi/10.2779/731018** Guidelines on Closer-to-Nature Forest Management (europa.eu)
- ✓ Shorohova, E., Lindberg, H., Kuuluvainen, T., & Vanha-Majamaa, I. (2024). Deadwood enrichment in Fennoscandian spruce forests–New results from the EVO experiment. *Forest Ecology and Management*, *564*, 122013. Deadwood enrichment in Fennoscandian spruce forests – New results from the EVO experiment - ScienceDirect

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