

From Mediterranean Drought to Boreal Change: AnaEE-ERIC Facilities for Experimental Research on Forest Resilience

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Abstract

Ecosystems across Europe are increasingly exposed to multiple climatic and anthropogenic disturbances, yet differences in experimental design and environmental context often constrain comparisons across regions. This work highlights AnaEE-ERIC's capacity to support coordinated research on forest ecosystem responses to global change through complementary experimental (open-air and enclosed), analytical, and modelling facilities. A comparative synthesis was conducted using five AnaEE facilities representing Mediterranean and boreal environments: Oak Observatory at the Observatory of High Provence (O3HP), Puéchabon Experimental Site, Free-air O₃ Exposure (FO3X O3-FACE), Station for Measuring Ecosystem-Atmosphere Relations (Hyytiälä-SMEAR II), and the Boreal Forest Regeneration Platform (BoFoReg). Their experimental treatments, monitored variables, spatial scales, and ecosystem contexts were assessed to identify opportunities for cross-facility research. The synthesis demonstrates that these facilities collectively support long-term studies and targeted experiments involving precipitation exclusion, soil warming, ozone exposure, forest-management treatments, and interactions among drought, nutrients, pathogens, and plant-associated microorganisms. Measurements span tree growth and phenology, plant ecophysiology, carbon and water fluxes, soil respiration, microclimate, biodiversity, greenhouse gases (GHGs), volatile organic compounds (VOCs), pollutants, and aerosols. Mediterranean facilities support established experiments on drought responses and interacting environmental pressures, while boreal facilities provide complementary capabilities for controlled forest-regeneration studies, long-term ecosystem monitoring, and comparisons of contrasting forest-management treatments, including clear-cutting, continuous-cover forestry, and unmanaged controls. Together, these complementary capabilities provide a foundation for harmonised research across contrasting European climatic zones. AnaEE-ERIC can therefore strengthen understanding of forest resilience, improve the comparability of ecosystem experiments, and support modelling and evidence-based adaptation of European forests under accelerating global change.

Keywords: *forest resilience, ecosystem experimentation, climate change, drought, research infrastructure*

Introduction

European forests are increasingly exposed to drought, warming, air pollution, and interacting biotic pressures. Their responses vary with climatic conditions, forest structure, and species composition, making it challenging to generalise findings from individual research sites. AnaEE-ERIC addresses this challenge by connecting experimental, analytical, and modelling facilities that manipulate global-change drivers and monitor ecosystem responses. This work assesses how selected Mediterranean and boreal facilities can form a coordinated framework for research on forest resilience.

Methodology

A structured comparative assessment was conducted using current facility descriptions and published examples from five AnaEE-ERIC facilities: O3HP, Puéchabon, FO3X O3-FACE, Hyytiälä-SMEAR II, and BoFoReg. Facilities were evaluated by ecosystem context, experimental treatments, study duration, monitored variables, and potential for cross-site research. The comparison identified complementary capacities for coordinated experiments and ecosystem measurements across Mediterranean and boreal forests.

Results and Discussion

The selected facilities span drought-prone Mediterranean forests, boreal forest ecosystems, and forest-regeneration systems. O3HP combines long-term precipitation exclusion, canopy access, atmospheric and soil monitoring, and soil-warming treatments, supporting mechanistic studies of downy oak responses (Laoué et al., 2023). Puéchabon adds throughfall exclusion × thinning, extreme-drought and soil-warming experiments, and continuous CO₂ and water-flux observations (Limousin et al., 2026). FO3X O3-FACE enables open-air ozone exposure combined with drought, nutrients availability, pathogens, and plant-associated microorganisms (Ghosh et al., 2026). Hyytiälä-SMEAR II has continuously measured ecosystem-atmosphere interactions in a managed Scots pine forest since 1996, including GHGs, VOCs, pollutants, aerosols, meteorology, and biogeochemical cycles (Schiestl-Aalto et al., 2025). New plots compare clear-cutting, continuous-cover forestry, and untreated controls. BoFoReg provides controlled chambers, nursery facilities, and field environments for manipulating growth conditions during early stage of tree development (Luoranen et al., 2024; Riikonen et al., 2026). Together, these facilities integrate open-air experiments with long-term ecosystem measurements across scales. Harmonised variables and metadata would strengthen cross-biome comparisons and model calibration.

Conclusion

AnaEE-ERIC integrates diverse experimental approaches and long-term ecosystem research across Mediterranean and boreal forests, from seedlings to mature stands and ecosystem-atmosphere fluxes. Harmonised protocols would help distinguish site-specific responses from general mechanisms and improve forecasts of forest stability.

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