Passive Rewilding Versus Assisted Ecological Restoration: A Comparative Evaluation of Trophic Cascade Recovery, Soil Biota Reconstitution, and Carbon Sequestration Efficacy Across Temperate Degraded Landscapes

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Abstract. Debates surrounding passive rewilding and assisted ecological restoration have intensified as land managers seek cost-effective, ecologically coherent strategies for reversing biodiversity loss and enhancing ecosystem service delivery in temperate degraded landscapes. This study presents a multi-site comparative assessment conducted across twelve degraded grassland and woodland sites in Western and Central Europe, evaluating trophic cascade reinstatement, soil macroinvertebrate and microbial community reconstitution, and net ecosystem carbon balance over a six-year monitoring period. Using structural equation modelling, diversity indices, and eddy covariance flux measurements, results indicate that assisted restoration yields significantly faster initial soil biota recovery, while passive rewilding demonstrates superior long-term aboveground structural complexity and trophic network redundancy. These findings offer nuanced, evidence-based guidance for policy frameworks targeting the EU Biodiversity Strategy 2030 restoration benchmarks.

Keywords: passive rewilding, assisted ecological restoration, trophic cascade recovery, soil biota reconstitution, carbon sequestration, temperate degraded landscapes, ecosystem service delivery, biodiversity strategy 2030, structural equation modelling

Introduction

The accelerating degradation of temperate terrestrial ecosystems represents one of the most pressing ecological crises of the contemporary era. Driven by decades of intensive agricultural land use, urban sprawl, and chronic nitrogen deposition, vast expanses of formerly biodiverse grassland, scrubland, and secondary woodland across Europe and North America have experienced profound losses in functional biodiversity, soil structural integrity, and trophic network complexity. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment Report has repeatedly underscored that approximately one million species currently face extinction risk, with land-use change identified as the dominant driver in terrestrial biomes. Against this backdrop, the European Union's Biodiversity Strategy for 2030 and the accompanying Nature Restoration Law — which mandates legally binding restoration targets for at least 20% of the EU's degraded terrestrial and marine areas by 2030 — have catalysed urgent scientific discourse regarding which restoration paradigm most effectively reconciles ecological recovery trajectories with socioeconomic feasibility. Two broad, philosophically and operationally distinct restoration paradigms dominate contemporary landscape ecology practice: passive rewilding and assisted ecological restoration. Passive rewilding, predicated on the deliberate withdrawal of anthropogenic management and the facilitation of spontaneous successional dynamics, has garnered substantial empirical support as a cost-efficient mechanism for reinstating self-regulating ecosystem processes, promoting keystone species recolonisation, and restoring trophic cascades without sustained resource expenditure. Conversely, assisted ecological restoration — encompassing targeted propagule introduction, topsoil amendment, hydrological manipulation, and active faunal reintroduction programmes — offers greater predictability, reduced time-to-target-condition latency, and greater regulatory compatibility with prescribed compositional benchmarks. Despite a burgeoning literature on each approach in isolation, rigorous side-by-side empirical comparisons across equivalent degraded landscape matrices remain scarce, particularly those integrating belowground biodiversity metrics — including soil mesofauna assemblage structure, mycorrhizal network connectivity, and microbial functional gene diversity — alongside aboveground trophic interaction assessments and eddy covariance-derived ecosystem carbon flux data. Furthermore, the relative performance of each paradigm under varying soil legacy contamination, landscape connectivity gradients, and climatic aridity indices has not been systematically quantified at a multi-site, multi-year scale applicable to policy-level decision-making. The present study addresses these critical knowledge gaps by reporting outcomes from a six-year, twelve-site longitudinal field experiment situated across a Western–Central European biogeographic gradient. The paper is structured as follows: Section 2 details the site selection criteria, experimental design, and multi-trophic monitoring protocols employed; Section 3 presents quantitative outcomes across carbon sequestration, soil biota reconstitution, and trophic cascade reinstatement metrics; Section 4 offers a comparative synthesis and discussion of

paradigm performance under varying abiotic and landscape-connectivity conditions; and Section 5 concludes with evidence-based recommendations for integrating both paradigms within adaptive, spatially prioritised national restoration frameworks.

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