2. Abstract

The carbon exchange between the atmosphere and post-mining sites along the chronosequence of primary succession and the impact of different restoration practices—reclaimed and unreclaimed—on carbon fluxes in these disturbed areas remains poorly understood. Therefore, four eddy covariance (EC) towers were installed to address this gap in Sokolov, northwest Czechia. Two towers were installed at reclaimed and unreclaimed sites during the early stage of succession to address Questions 1 and 2 (**Publication 1**), and the remaining two during the mid-stage to address Questions 3 and 4 (**Publications 2 and 3**).

As hypothesized (H1), both reclaimed and unreclaimed early-stage sites were net CO_2 sources (addressing Question 1). Four years later, both sites showed potential as carbon sinks on a monthly scale, particularly in May and June, suggesting that both restoration practices can enhance carbon sink capacity. Significant effects on net ecosystem exchange (NEE), gross primary production (GPP), ecosystem respiration (Reco), and latent heat (LE) were also observed (addressing Question 2). Initially, differences between the two sites were mainly due to higher Reco at the unreclaimed site and higher LE at the reclaimed site, particularly after heavy summer rainfall. The rainfall likely enhanced microbial activity in decomposing fossil carbon at the unreclaimed site due to its lower bulk density, while increased LE at the reclaimed site was due to higher runoff on compacted soil (supporting H2). By the end of the study (2023), differences were driven by the rapid growth of alder seedlings at the reclaimed site (supporting H2; **Publication 1**). By mid-succession, both reclaimed and unreclaimed sites functioned as moderate to strong carbon sinks 35 years after restoration (supporting H3; **Publication 2**) and as robust carbon sinks 39 years after restoration at the unreclaimed site (**Publication 3**). Unlike the early stage, unreclaimed sites had stronger carbon sinks than reclaimed sites during mid-succession, attributed to lower Reco, particularly in the fall (supporting H4; **Publication 2**).

Overall, the output of the thesis suggests that spontaneous succession can be an effective strategy for restoring mined areas in Central Europe or other regions with sufficient water availability. This approach not only enhances carbon sequestration in both the early and mid-stages of succession (**Publications 1, 2, and 3**)—even significantly more than an agroecosystem in Central Europe (**Publication 4**)—but also can establish a climax forest in about 100 years in Central Europe (**Publication 5**).