

Enhanced rock weathering as a restoration measure for acidified forests: from mineral dissolution to helicopter application

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Historical nitrogen and sulphur emissions have acidified forest soils, reducing pH and pH buffering capacity and depleting essential base cations like calcium (Ca), potassium (K), and magnesium (Mg). Temperate forests in the northern hemisphere are particularly affected, with nutrient imbalances threatening ecosystem services. This study investigates rock dust (RD)—ground igneous or metamorphic rocks—as a soil amendment to restore forest vitality. RD acts as a slow-release fertiliser, raising soil pH and increasing exchangeable Ca, Mg, and K without the carbon loss or eutrophication risks associated with quicklime or soluble fertilisers.

The study evaluated RD across three spatiotemporal scales: short-term lab experiments (days-months), mid-term mesocosm and field trials (3-7 years), and long-term field trials (34 years). Lab tests measured the acid neutralising capacity (ANC) of five RDs, revealing dissolution in two phases, with available ANC at 2-25% of calcite lime. A two-year mesocosm trial confirmed RD dissolution rates and ANC fractions could predict pH changes. Field experiments with 960 sycamore maple saplings in acidic soils (soil pH 3.1-3.5) showed RD increased growth by factors of 2 to 8, depending on site conditions and RD type, with water retention and nutrient release from the RD being key factors.

Broadcast RD applications (5-16 Mg/ha) over 3-34 years showed slow but long-term pH improvements in mineral soil (0.018 pH units/year initially, declining to 0.002 after 34 years). Base cation release was gradual, with most uptake in the forest floor. Higher RD doses (15-20 Mg/ha) or combinations with dolomite were suggested for faster pH restoration, though intense liming risks forest floor carbon loss. Tree growth assessments across ten locations (4-34 years post-application) indicated RD effectiveness when specific nutrient limitations (e.g., Ca or K) were addressed, with younger trees responding more positively.

Understory communities were initially disturbed but recovered over time, with species diversity (ENS) increasing. RD was safer than dolomite, promoting resilience without significant loss of calcifuge species. In conclusion, RD can buffer acidifying deposition (20 kg N/ha/year) for 10-70 years, making it a valuable forest management tool. However, site-specific conditions and RD composition are critical, and long-term monitoring is essential to optimize this restoration technique.