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Survival first, biomass later: trade-offs shaping dryland restoration outcomes in the sahel

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Abstract

Introduction

Land degradation severely constrains livelihoods and ecosystem services across the Sahel. Large-scale restoration commonly combines soil and water conservation (SWC) structures with plantings of native woody species, yet post-planting survival and biomass accumulation remain highly variable, limiting long-term restoration outcomes.

Objectives

We quantified survival and aboveground biomass of native woody plantings across restored degraded sites and tested how SWC structures, geomorphological units, post-planting management, and planted-species diversity shape restoration performance and trade-offs between survival and biomass.

Methods

We inventoried 2,097 planted trees belonging to six native species (*Acacia nilotica*, *A. raddiana*, *Senegalia senegal*, *Vachellia seyal*, *Bauhinia rufescens*, *Ziziphus mauritiana*) across 14 restored sites in three villages of the Tahoua region (Niger). Aboveground biomass was estimated using allometric models. Drivers of individual survival were analysed using Bayesian logistic regression, and plot-level biomass was analysed using Bayesian log-normal regression, with predictors including SWC structure type, geomorphological unit (plateau, pediment, slope), management regime, and planted-species diversity (Shannon-diversity).

Results

SWC structures exerted strong but contrasting effects on restoration performance. Trenches, half-moons, stone bunds, and stone bund combined with trenches generally increased survival and biomass, with the strongest and most consistent positive effects associated with trenches. Benches and stone wall-trench combinations were associated with lower survival and biomass. Post-planting management was decisive: sites combining guarding, maintenance, and replanting achieved the highest survival and biomass, whereas weakly managed or unmanaged sites performed substantially worse. Planted-species diversity increased biomass production but had no detectable effect on survival.

Conclusions

Restoration outcomes in Sahelian drylands are shaped by clear trade-offs between survival and biomass. Survival emerges as a prerequisite for productivity and is primarily controlled by post-planting management, whereas biomass accumulation depends on both management and the capacity of SWC structures to enhance resource availability. Geomorphology plays a secondary, context-modifying role.

Keywords: Aboveground biomass, Bayesian modelling, land restoration, Sahel, soil and water conservation, survival, water harvesting, woody species diversity