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Time matters: Temporally changing effects of planting schemes and insecticide treatment on native timber tree performance on former pasture

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ABSTRACT

Reforestation of former pastures with native timber trees holds potential to improve small-scale farmers livelihoods while supporting ecosystem functioning and biological diversity. To promote successful reforestation with native tree species, more knowledge is needed, particularly on effects of species identity, tree diversity, and insecticide application on tree survival and growth at different time periods after plantation establishment. We assessed these effects for three native Central American timber species and compared results gained 2 and 5 years after tree establishment. Survival, stem diameter, and tree height were quantified for *Tabebuia rosea*, *Anacardium excelsum*, and *Cedrela odorata*, planted in (1) monocultures, (2) three-species mixtures, and (3) three-species mixtures treated with insecticides during the first 2 years of seedling establishment. We further tested how survival and growth performance were affected by the individual tree position within reforestation tree stands to account for border effects in small-scale tree patches in pasture-afforestations. Survival was significantly affected by tree species identity with the highest survival in *T. rosea* and the lowest survival in *C. odorata*. Tree growth was affected by tree species identity, tree diversity, insecticide treatment, environmental heterogeneity, and border effects, but these effects varied across the individual tree species. Interspecific analyses revealed significant differences between species. *A. excelsum* trees attained the largest and *C. odorata* the smallest size after 5 years of growth. Across species, tree growth in years 3–5 after tree planting was highest in mixtures treated with insecticides during tree establishment, followed by monocultures and then unprotected mixtures. Enhanced growth in monocultures compared to unprotected mixtures was particularly found in *T. rosea* during early establishment, and in *A. excelsum* at a later stage of tree stand development. Growth-enhancing effects of planting schemes may be related to differential responses to herbivore damage and to tree-tree competition. Positive border effects, i.e. a significantly enhanced growth at the border of a tree stand, were found for *T. rosea* in all three planting schemes and for *A. excelsum* in protected mixtures. Our results suggest that besides early, restricted insecticide application, tree diversity within stands should be considered as management measure to enhance timber tree growth on former pasture. The finding of enhanced growth of native timber trees at the border of small tree stands suggests small patches of native timber trees planted on former pasture as a promising reforestation strategy in Latin America.

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1. Introduction

Ongoing worldwide deforestation has resulted in large-scale land degradation with associated losses of biological diversity and reduced ecosystem services including carbon storage and pro-

tection of soil and water quality (Dirzo and Raven, 2003; FAO, 2010). Although processes of land-use change are complex, the conversion of forests to agricultural land and pastures has been identified as the greatest direct driver of deforestation in Latin America, with 27% of the land surface now being used as cattle pastures (Geist and Lambin, 2002; FAO, 2009). To restore ecological functions and biodiversity, reforestation of degraded tropical landscapes is imperative but has to reconcile tree planting with agricultural use and landholder needs in order to be feasible in rural landscapes (Lamb et al., 2005). Examples are silvopastoral reforestations that combine native timber trees and pastures (Dagang and Nair, 2003; Wishnie et al., 2007; Riedel et al., 2013), intensive silvopastoral systems (Murgueitio et al., 2011), or the

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