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Research

Underground deserts below fertility islands? Woody species desiccate lower soil layers in sandy drylands

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Woody plants in water-limited ecosystems affect their environment on multiple scales: locally, natural stands can create islands of fertility for herb layer communities compared to open habitats, but afforestation has been shown to negatively affect regional water balance and productivity. Despite these contrasting observations, no coherent multiscale framework has been developed for the environmental effects of woody plants in water-limited ecosystems. To link local and regional effects of woody species in a spatially explicit model, we simultaneously measured site conditions (microclimate, nutrient availability and topsoil moisture) and conditions of regional relevance (deeper soil moisture), in forests with different canopy types (long, intermediate and short annual lifetime) and adjacent grasslands in sandy drylands. All types of forests ameliorated site conditions compared to adjacent grasslands, although natural stands did so more effectively than managed ones. At the same time, all forests desiccated deeper soil layers during the vegetation period, and the longer the canopy lifetime, the more severe the desiccation in summer and more delayed the recharge after the active period of the canopy. We conclude that the site-scale environmental amelioration brought about by woody species is bound to co-occur with the desiccation of deeper soil layers, leading to deficient ground water recharge. This means that the cost of creating islands of fertility for sensitive herb layer organisms is an inevitable negative impact on regional water balance. The canopy type or management intensity of the forests affects the magnitude but not the direction of these effects. The outlined framework of the effects of woody species should be considered for the conservation, restoration or profit-oriented use of forests as well as in forest-based carbon sequestration and soil erosion control projects in water-limited ecosystems.

Keywords: afforestation, ecosystem engineering, forest–grassland mosaic, sand soil, soil moisture, tree–grass coexistence



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