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RESPONSE ARTICLE

Applied nucleation is a straightforward, cost-effective forest restoration approach: reply to Ramírez-Soto et al. (2018)

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We agree with Ramírez-Soto and colleagues that applied nucleation can be an effective approach for tropical forest restoration both in lowland and higher elevation tropical forests. We also contend that it is cheaper than standard plantation-style plantings and is straightforward to train personnel to implement this approach.

Key words: active restoration, restoration costs, tropical

Ramírez-Soto et al. (2018) describe a multipronged strategy to restore tropical montane cloud forest, focusing on the applied nucleation approach to forest restoration (Corbin & Holl 2012). We agree with Ramírez-Soto et al. (2018) that all tropical forest restoration should include a careful diagnosis of the degree of land degradation prior to selecting a restoration strategy and the species to plant, monitoring of the efficacy of efforts, and active dissemination of information to and training of stakeholders. We write to highlight a factual error in one point and provide contrasting perspectives on two points in the article.

First, the authors incorrectly stated that “the majority of nucleation-based ecological restoration projects have been developed in lowland tropical forests ...” and cite Holl et al. (2011) and Scowcroft and Yeh (2013) to support this point. In fact, Scowcroft and Yeh (2013) was conducted in subtropical montane forest in Hawaii at 1,980 m, and Holl et al. (2011) reports on research from premontane moist to wet forest sites from 1,060 to 1,430 m in Costa Rica. The latter study overlaps in elevation range with the montane forest in Veracruz that the authors discuss (Williams-Linera 2002). We have published over 45 peer-reviewed articles and many general audience summaries evaluating the efficacy of applied nucleation for restoring vegetation, birds, invertebrates, nutrient cycling, and many other ecosystem attributes (e.g. Reid et al. 2014; Cole et al. 2016; Holl et al. 2017) over 15 years at several tropical premontane forest sites in Costa Rica. So, there has been extensive research on applied nucleation in higher altitude tropical forests.

Second, and more critical to the discussion of the merits of applied nucleation, Ramírez-Soto et al. (2018) claim that applied nucleation is more expensive than standard plantation-style tree planting. But, the cost figures they cite to support this point are from different countries and forest types, or in the case of the Mexico study from different states with very different economies (Oaxaca and Veracruz). Accordingly, values are not directly comparable as labor costs

are highly location-dependent. We have kept careful records of the costs of planting and maintaining plots (e.g. clearing competitive pasture grasses) under both applied nucleation and plantation restoration over the first few years following project initiation. We provide detailed estimates for applied nucleation (US\$357–620 ha⁻¹) and plantations (\$1,462–2,282) at our sites in Costa Rica by Zahawi and Holl (2009). Our experience suggests that the cost of applied nucleation is scaled to the area planted, which is substantially less than systematically planting a restoration area with trees. Hence, applied nucleation is less expensive than standard reforestation, which is one of its benefits rather than being an obstacle to restoration.

Third, the authors state that the nucleation restoration strategy requires specialized personnel. Whereas we do not dispute that well-trained personnel are critical to implementing applied nucleation, this is true for the oversight of any restoration project. Perhaps the only distinction with nucleation in this regard is the need to choose appropriate locations for tree nuclei and to ensure that project personnel know those locations for subsequent maintenance, but those are not particularly complicated points and do not require specialized training.

In closing, although we found cause to rebut a few aspects of this article, we are pleased to see nucleation projects being implemented in other tropical regions with extensive efforts to engage and capacitate stakeholders on this restoration methodology.

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