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OPINION ARTICLE

Hidden Costs of Passive Restoration

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Abstract

The first few years of tropical forest restoration can be expensive, especially when applied to expansive areas. In light of this, passive restoration has been recommended as a considerably cheaper or even free alternative. There are, however, both direct and indirect costs associated with passive restoration. First, the longer recovery time that is typically required in passive restoration can be perceived as project failure, especially when compared with nearby active restoration efforts. In the worst-case scenario, this can lead to the premature termination of a project by a landowner who would like to see more rapid or visible results. Second, passive restoration may be viewed as land abandonment, and in developing nations where land tenure is not always strictly enforced this may invite unanticipated uses, such as ranchers who may unintentionally or intentionally allow livestock to take advantage of the "unused" forage grass, thus setting back recovery efforts. Lastly, passive restoration does have direct financial costs, including material costs for establishing fences and repairing them, and labor costs for site vigilance. These upfront investments may need to be made repeatedly in passive restoration efforts, and for a longer time period than for an active restoration project. Both the direct and indirect costs should be considered prior to choosing passive restoration as a strategy in a particular restoration project.

Key words: active restoration, natural regeneration, secondary succession, tropical forests.

Introduction

Passive ecological restoration, also often referred to as natural regeneration or unassisted restoration, is the process of recovery that occurs without active human intervention. In many cases this requires the removal of persistent disturbances, such as fire or grazing (Holl & Aide 2011; Melo et al. 2013). Compared to active restoration, passive restoration is typically considered an inexpensive or even free alternative (Erskine 2002; Rey Benayas et al. 2008; Holl & Aide 2011), and it has the potential to achieve similar gains in biodiversity and ecosystem services (Chazdon 2008*a*; Rey Benayas et al. 2008; Jones & Schmitz 2009) with less legacy of human intervention. It also requires little technical expertise. Worldwide, passive restoration accounts for much more habitat recovery than active restoration (Rey Benayas 2000; Melo et al. 2013), and it is projected to be a key mechanism for the persistence of biodiversity over the next century (Wright & Muller-Landau 2006).

Nonetheless, passive restoration is feasible only in a subset of degraded ecosystems where disturbance has been light or short lived, natural communities are resilient, and degraded ecosystems do not represent alternative stable states (Zahawi & Augspurger 1999; Suding & Hobbs 2009; Holl & Aide 2011). Recovery of some ecosystems may be quite slow if important drivers of recovery such as the availability of propagules or dispersers are limiting (Hubbell et al. 1999), and the rate of passive restoration can be highly variable even across similar land-use types and hard to predict (Jones & Schmitz 2009; Good et al. 2012; Zahawi et al. 2013). Additionally, certain species are more likely to recover under passive restoration than others, which may necessitate a more proactive form of restoration (Meli et al. 2013). Factors affecting the rate and direction of passive restoration have been reviewed in detail elsewhere (e.g. Myster 1993; Chazdon 2008*b*; Holl & Aide 2011).

Here, we extend the discussion to include three potential costs that should be taken into account when considering a passive restoration approach. This essay was motivated by our observations from a long-term forest restoration experiment in southern Costa Rica (Cole et al. 2010; Holl et al. 2011; Zahawi et al. 2013), where we established 15 approximately 1-ha sites spread over a $>$100-km^2, mixed-agricultural landscape between 2004 and 2006. Restoration sites were located on lands owned by Costa Rican farmers, North Americans, and the Organization for Tropical Studies. At each site, we established three 50×50 m treatments on cleared, abandoned agricultural lands (primarily former pastures). Treatments included a passive restoration strategy (cattle excluded and no seedlings planted), an active strategy (mixed-species tree plantation), and an intermediate strategy (mixed-species tree islands with unplanted spaces between). During 9 years of monitoring at

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these sites, we have noted several noteworthy, hidden costs of passive restoration. In conversations with other scientists and practitioners, we have found that these issues are widespread across a range of regions and ecosystems.

Cost 1: Slow Recovery Can Be Perceived as Project Failure

Passive restoration is typically slower than active restoration for reestablishing ecosystem structure, function, and composition, particularly in the first few years after the outset of restoration (Jahnig et al. 2013; Roa-Fuentes et al. 2014). In our experiment, 3- to 4-year-old tree plantations generally had greater canopy closure, bird visitation, seed dispersal, and tree seedling establishment compared with passive restoration plots, which were dominated by grasses and early-successional shrubs (Fink et al 2009; Cole et al. 2010; Holl et al. 2011; Zahawi et al. 2013). Other measures such as avian foraging behavior and diversity were reported as similar among passive and active treatments in the study region (Morrison & Lindell 2011; Reid et al. 2012).

Although restoration speed may not be a concern for some stakeholders, local landowners can sometimes interpret slow recovery as a failed effort. It may be the case that passive restoration will catch up with active restoration over time and may ultimately develop an ecosystem that better resembles reference communities (Guerrero & da Rocha 2010), as active restoration may affect the successional trajectory and shift a system to a different endpoint (Carnevale & Montagnini 2002; Jones et al. 2004). But private landowners do not necessarily perceive this end result and are more focused on the short term. In our study, two landowners terminated contracts on their land based on perceived failure and chose to use their land for more "productive" uses such as agriculture or tree plantations. Many more have repeatedly queried us as to why we did not plant the entire area with trees and whether they could graze or plant in the "unused" area (our passive restoration plot), despite many informal discussions, general presentations, and written summaries explaining our experimental design.

Cost 2: Passively Restored Sites Can Be Viewed as Unused Land

Passive restoration areas often appear "messier" than active restoration, resulting in thickets of impenetrable vegetation made up of shrubs, vines, and grasses, rather than systematically planted vegetation. To the untrained eye this may look like abandoned land, as people typically consider restoration to have a strong proactive component that is neat and orderly. Indeed, in the first few years after initiating our experiment, livestock passed through the barbed wire fences surrounding 13 of our 15 sites. In some cases, animals (cows, horses, and goats) probably escaped accidentally from adjacent land, but in other instances wires were visibly cut, indicating that someone intentionally allowed their animals into the plots to forage. Damage from these break-ins was almost always concentrated in passively restored plots, where pasture grasses generally persisted much longer than in tree plantations and were perceived as unused forage.

Animal break-ins to our plots were typically short lived and caused minimal damage as our sites are visited regularly to safeguard the integrity of the experiment. If larger areas of land are left to passively recover, however, particularly in more remote areas, it is unlikely that most resource management agencies would have the staffing to regularly visit lands. In such cases, livestock can rapidly consume the majority of vegetation, and essentially restart succession. Recovery may be set back several years in such cases, which represents a major lost time investment and the net result could be a human-induced alternate stable state.

Land tenure policies and traditions can further complicate this scenario. In Latin America, for instance, national policies in several countries historically empowered settlers to claim ownership of unused lands that they improved by clearing and burning (Fearnside 1993; Edelman & Seligson 1994; Nygren 1995). Generally, these squatter laws were used for clearing primary forest, but they have also been applied to land "abandoned" by former owners. Such land tenure policies have led to legal disputes of ownership that can tie up properties for years, and landowners may be reluctant to undertake practices that encourage these activities. In contrast, actively planting trees, for reforestation or restoration, clearly demonstrates that somebody is "using" the land and this can be applied as a form of land claim in some regions (Fortmann 1987; Unruh 2008).

Cost 3: Passive Restoration Is Not Free

In most situations, the cost of passive restoration is less than that of active restoration (e.g. Birch et al. 2010; Melo et al. 2013). This is due to the fact that there are no costs for typical restoration activities, such as collecting, growing, and planting seeds or seedlings; recontouring the land; weed control; or irrigation. It is important to recognize, however, that some costs are almost always incurred in passive restoration efforts, and initial funds have to be secured to begin a restoration project. In our experiment, such costs have included material supplies (such as for fence construction), labor for periodic fence repairs, and travel and labor expenses for regular visits to ensure that sites have not been disturbed by livestock or other intrusions. That said, a number of studies show that restoration projects can lead to a return on initial investment (e.g. Brancalion et al. 2012; De Groot et al. 2013), and funds to cover initial restoration expenses from payments for environmental services are becoming more commonplace (Bullock et al. 2011).

Although most incursions have been livestock related in our study, there are a host of other potential impacts from humans. For example, we have experienced cases of people clearing footpaths to walk through our sites and the expansion of an adjacent road that "spilled" into a passive restoration plot in the first years of our study requiring us to relocate the plot to a different part of the farm. Such incidents require not only repairs to fences but also often visits to the instigators or landowners in an effort to stop such an event from recurring again. In fire-prone systems, labor to scan for fires, set firebreaks, and respond to fires may also be a major expense (Janzen 2002). In turn, farmers who apply herbicides and other pesticides in their fields may be tempted to apply them in "messy" passively restored plots, which could alter the successional dynamics of the plot and incur both direct and indirect costs. All these disturbances can be expected in lands perceived to be unused but are rarely reported in the literature. Given the typically slower pace of recovery in passive restoration and the appearance that the land is abandoned (points 1 and 2), more frequent monitoring of unplanned anthropogenic disturbances is needed over a longer time period than in actively restored plots and this is an additional cost.

Conclusions

Passive restoration strategies may have significant advantages for practitioners including typically lower costs and the potential for reduced legacy effects, but they also come with a novel set of considerations. Namely, it may not be intuitive to local human communities that weedy-looking sites undergoing natural regeneration are not failed or abandoned projects. These misperceptions may lead to unforeseen costs and difficulties with local stakeholders that can set back or even terminate restoration projects.

We see several avenues for practitioners to plan for these outcomes. Clear communication with stakeholders, such as landowners and local residents, about the potential recovery speed and appearance of different restoration strategies will likely reduce misunderstandings or frustration over slow initial changes in naturally regenerating plots. Similarly, investments such as informational signage and/or site maintenance and vigilance above-and-beyond the minimum cost of passive restoration will likely help to avoid setbacks in achieving restoration goals. Finally, passive restoration may be a more appropriate strategy in situations where land tenure is clearly defined, time is not of the essence, and/or restoration sites are farther from human communities.

Despite the clear differences in direct costs between passive and active restoration, broad generalizations about the relative cost-benefits of each strategy are difficult to make given that the restoration costs of both approaches vary greatly depending on methods used, cost of salaries in a given region, and other factors, and these costs are rarely reported in the literature (Bullock et al. 2011; De Groot et al. 2013). Although active restoration is on average considerably more expensive (Birch et al. 2010; Bullock et al. 2011), if areas undergoing passive restoration are extensively damaged owing to conflicting land uses or misperceptions then an active restoration strategy will be needed. In many cases, however, the trade-offs will need to be weighed carefully in the context of the pace of natural regeneration of the system, perceptions of neighboring landowners, relative expenditures for different restoration approaches, and the funding goals of a given project (Holl & Aide 2011).

Implications for Practice

- Misperceptions of passive ecosystem recovery can create hidden costs for restoration projects that must be considered when selecting a restoration strategy.
- Passive restoration has financial costs, such as labor for site vigilance, which should be budgeted for to ensure that recovery can occur.
- Education about or signage of passive restoration may help to increase the likelihood of ecosystem recovery.

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