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Creating Foster Ecosystems to Accelerate Tropical Forest Regeneration

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Introduction

Human degradation of natural ecosystems, especially tropical forest destruction, has become an important issue to those concerned about environmental conservation. Tropical forest destruction deserves special attention. Tropical forests are extremely diverse ecosystems, providing many benefits for all life on earth. Tropical forests provide the basis for many products and medicines and also act as carbon "sinks", absorbing large amounts of carbon dioxide from the atmosphere. Moist tropical forests are some of the most productive areas on Earth, but since most nutrients and biomass are stored above ground, cleared land quickly loses its productivity.

The highest rates of land use change in the world occur in the tropics, where human populations are rapidly increasing.[2] These are also the poorest parts of the world. Land is usually cleared to be used for grazing or agriculture by subsistence farmers. However, as productivity declines, the cleared land is usually abandoned in five to eight years, and the farmer clears a new section of forest to farm. What is left are open fields dominated by shrubs and grasses in which the forest is slow to regenerate.[3] The longer an area has been disturbed, the longer it takes to regenerate. Degradation creates barriers for natural forest succession, and if left unmanaged, an abandoned field could take tens or hundreds of years to regenerate.[6] The methods described in this paper are designed to accelerate natural regeneration in cleared tropical forests through the use of plantations as "foster ecosystems".[4,]

Factors affecting regeneration

The creation of foster ecosystems focuses on improving conditions for natural succession and overcoming any barriers to regeneration. When land is degraded for a period of time, natural processes are disturbed and barriers form which block the natural pathways of forest succession. These barriers need to be removed before a restoration project can be attempted. If that isn’t done, the restoration may not be succesful. Barriers to be taken into account are low propagule availability, seed predation, seedling predation, seasonal drought, root competition, and poor soil conditions. These factors need to be addressed separately. Seed and seedling predation and root competition must be minimized while soil conditions and propagule availability on a site may need to be improved. We will look at these two goals separately.

Barriers to be minimized

While seed and seedling predation exists everywhere there are seeds, it is a particularly serious problem in some such as abandoned tropical forest clearings. Because of conditions unfavorable to tree growth, abandoned clearings are quickly overgrown by invasive grasses and shrubs, which in turn provide excellent habitat for seed predating ants and rodents.[3] A study by Nepstad (1991) in the Paragominas region of Amazonia placed seeds of different sizes in plots in an abandoned field. The study found that over 70% of seeds weighing less than 0.02 g were

removed or eaten within two days, with one species of seed entirely gone within 24 hours. Less than 20% of seeds weighing more than 5 g were removed from the plot in the first 200 days. However, even these large, thick-coated seeds become vulnerable as they emerge.

In the same study by Nepstad (1991), plots were set up to study root competition. Seedlings of *Schizolobium amazonicum* planted in plots with surrounding roots removed grew twice as fast as those planted in a fertilized plot without surrounding roots removed. Also, while no seedlings planted in the open field exceeded 55 cm. after 20 months, those planted in treefall gaps exceeded 200 cm. in height in the same time. Therefore, while seeds and seedlings are predated upon above ground, germinated seedlings face competition below ground from the roots of other vegetation. Thickly growing grasses have more roots and so are more harmful than more sparsely growing vegetation. Competing roots use up water and nutrients much needed by new seedlings.[3]

Trees can be planted to alleviate these problems. Although tropical systems are complex and different situations may require different approaches, *Albizia lebbek*, *Pincus caribaea*, and *Swietenia macrophylla* have worked well as "foster" trees in Puerto Rico.[5,2] Established trees shade out invasive grasses and shrubs under their canopies. Ant and rodent habitat and thus predation is decreased in this way. Because the ground vegetation has been destroyed, root competition for emerging seedlings is also greatly reduced. This makes seed survival, germination and growth more favorable under the canopies of existing trees.

Factors to be improved

Most of the nutrients and organic matter of a tropical rainforest are stored in above ground biomass. When the trees are removed from a site which is then grazed or farmed, soil conditions can become degraded. For a successful regeneration, these conditions must be alleviated and made conducive to tree germination and growth.[5,2] Most soil conditions can be improved by using plantations of selected tree species. Selected species, like *Albizia lebbek*, should grow well under edaphic conditions and should produce nutrient rich litter. Leguminous, nitrogen-fixing species are best.[4] Through a plantation, soil nutrients and organic matter can be increased by nitrogen fixation and litter fall. In addition, tree roots can assist in reducing the bulk density of a soil. Moisture conditions are also improved under planted trees. While soils dry out quickly in open field conditions, causing low water potentials, soils under trees tend to stay more evenly moist for longer periods of time.[3] A less obvious problem may be that soil microorganisms have been depleted on a site through intensive grazing or agriculture. The inclusion of native soils can help tremendously in speeding up a restoration project.[4] Nitrogen fixing plants along with *Rhizobium* or *Frankia* injections have a great effect on soil fertility. Increased soil microorganism diversity could improve the prospects of native forest colonization.[4]

The last and probably most important factor in a successful regeneration is the availability of tree propagules. Many tropical trees can propagate by roots, by residual seeds, or by seeds disseminated from an adjacent forest. Root and stump sprouts will be active on a logged site, but if that site is farmed or grazed for several years, remnant tree roots are destroyed. Residual seeds of the native forest may also have been destroyed or are unable to germinate and survive.[3] If no

live propagules exist on the site, seeds must be disseminated from adjacent areas or introduced by humans.[6]

The role of plantation trees in this context is to attract seed disseminating bird and mammal species. Appropriate plantation species should provide perches and/or food for disseminating birds and bats. Frugivorous birds and bats (e.g. *Ducula spp., Penelopides panini subspp., Cynopterus spp.*) will be attracted to the tree to perch or eat its fruit. In the process, they disseminate seed from previously eaten fruit. Nepstad (1991) found 400 times more seeds under tree crowns than in open field conditions. Up to 18 species were found under individual tree seedlings, while only 2 were found in the open field.

Plantation strategies

Pastures and abandoned croplands become "old fields", grass and shrub fields, when pathways of tree invasion are blocked.[3] Because they reduce the barriers to tree invasion, trees emerging in the open fields improve the probability that other plant species will invade. A study by Parrotta (1993) in Puerto Rico on a *Albizia lebbek* plantation. After 4.5 years, eleven tree and shrub species and eleven vine species were found on the site. In addition, sixteen species of forbs and four species of grasses were on the site. By comparison, a site left to natural processes and not planted with trees contained only one species of vine, twelve species of forbs and three species of grasses.

When creating a foster plantation, steps may be taken to improve the speed and efficiency of native forest regeneration. Trees can be planted in different patterns, or different species can be planted. However, because of the complexity of tropical ecosystems, it is very difficult to control the direction of a regeneration project. For any project, many different species compositions are possible. This depends greatly on the species composition of the surrounding forest.[2]

Different species in a plantation may aid regeneration in different ways. For example, while *Albizia lebbek* produces litter and improves soil conditions, *Psidium gaujava* provides a good food source for disseminators. The greater the number of fruiting plants on a site, the faster the rate of forest regeneration. In addition to spreading the seeds of those plants, frugivorous birds and mammals import seed from the surrounding forest.[6]

The pattern in which trees are planted is also important. The ideal method would be to plant trees evenly towards the center of the field, allowing disseminators to penetrate deep into the field away from forest edge.[3] However, because funds may be limited, less trees may have to be planted. Two methods for this situation are to plant trees in strips or in islands. Planted forest strips, or corridors, should extend away from the edges of natural forest stands at intervals easily transversed by disseminators (20-30m). Plantation islands are trees planted together in groups. Islands should also be planted so they are 20-30m from forest edges and other islands. For both the strip and island methods, it is expected that as those systems develop, they will spread outwards and eventually overlap, creating a continuous forest.[4]

Conclusion

Because of the complexity of tropical forest ecosystems, different sites require different restoration techniques. Restoration managers should have a good understanding of plant and animal life histories, seed ecology and dispersal characteristics, germination microhabitat requirements, and habitat requirements of potential seed dispersing birds and mammals. Managers then have the ability to adapt their techniques to changing conditions.[2]

Contrary to management intensive restorations, restorations using foster ecosystems rely on natural regeneration. Fallow is used to do most of the rehabilitation.[2] Through experiments in Puerto Rico[1,2,4,5], Amazonia[3], and the Philippines[6], researchers have developed strategies for tropical forest regeneration. These strategies attempt to remove barriers and improve conditions for native tree invasion. All researchers agree that a greater diversity of plantation species improves chances for a successful regeneration. This also allows natural selection processes to decide on the best species composition on a site.[7]

With the high rate at which tropical forests are being destroyed, regeneration efforts are extremely difficult and relatively insignificant. Refining "foster ecosystem" techniques may be a feasible way to regenerate large areas of deforested land. It will be important that any such efforts are documented so that future project managers can learn and adapt their efforts for their specific sites. Without proper documentation, it will be difficult to develop this promising technique.

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