Tree Planter's Notes Volume 43, No. 4 (1992)

The Rain Forest in Tropical America: Forest Dynamics, Reforestation, Seed Handling, and Problems of Management

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During our lifetime we are seeing the high evergreen rain forests of tropical America being destroyed at overwhelming speed. There is still a considerable lack of basic knowledge about forest dynamics and proper management for this complex type of plant community. The understanding of the natural regeneration processes that take place after spontaneous gap formations in the mature forest is shedding light on this matter. The role of the fast-growing but short-living pioneer trees that first colonize light gaps in the reestablishment of the forest environment may be decisive in the development of management and reforestation techniques using native species. Seed storage and handling is difficult for most valuable timber and fruit species due to the high moisture content and rapid metabolic rate of most rain forest seed species. This creates a lack in both the availability of seeds of native trees for reforestation and the creation and maintenance of nurseries. Much more research is needed in order to solve these problems. Tree Planters' Notes 43(4):114-118; 1992.

The high evergreen tropical rain forest is a fantastically diverse plant community. It covers an important part of the tropical American continent. The largest forest extends for millions of square kilometers across the basin of the world's largest river, the Amazon. Although there are several smaller rain forests in tropical America, most are severely disturbed and reduced by human activities. A particularly important one starts at the Pacific Coast of Ecuador and Colombia, covers the Isthmus of Panama, and continues along the Atlantic Coast of all Central America to Guatemala, entering North America along southeastern Mexico. In Mexico it mainly stretches along the coast of the Gulf of Mexico between the mountains and the sea, continuing north into the State of San Luis Potosi, crossing the Tropic of Cancer about 400 km south of the U.S. border. In Central America and Mexico an enormous part of the forest has disappeared during this century and only isolated patches remain along the range. Some of the largest still-forested areas are in Panama and Costa Rica, on both sides of the Mexican-Guatemalan border, and in the Mexican state of Oaxaca. In Mexico, only 10% of the original forest still survives; the rest has been transformed into pastures or fields for crops such as sugar cane, corn, and coffee. The State of San Luis Potosí has lost all of its rain forest in just 20 years (Dirzo and Miranda 1991).

An important part of the basic knowledge of rain forests comes from research facilities situated along this range. These include, to the south, the island of Barro Colorado, Canal Zone, in Panama (Smithsonian Tropical Research Institute) (Leigh et al. 1982), in the middle at *La Selva* in Northern Costa Rica (Organization for Tropical Studies) (Clark et al. 1987) and at the northern part, at *Los Tuxtlas* volcanic area in the State of Veracruz, México (National Autonomous University of México) (Gómez-Pompa and Del Arno 1985).

The main difference between the rain forest and most temperate forests is the striking abundance of different kinds of trees. Most rain forests are composed of many species with little or no dominance of any species. A mean square hectare of Amazonian rain forest may have more than 200 different species of trees, with over 150 species in a Costa Rican forest and less than 100 species in a Mexican rain forest (Bongers et al. 1988).

The difference in richness of the forest between the south and the northern part of the range may be due to the age of the community. The present-day Mexican and northern Central American rain forest is of relatively recent origin because during the last ice age, about 10,000 years ago, the climate was drier in this region than it is now. It is even possible that the rain forest did not exist at that time or that it was much smaller and its expansion to the north began after the ice age (Toledo 1982).

The structure of the rain forest is highly complex. Any diagrammatic profile of the forest shows a complex array of plants yielding multiple strata. The lowest stratum is formed by herbaceous plants, small palms, seedlings of trees, and small saplings at ground level. Next, there is a layer of shrubs, small trees, and palms. Above these are medium size trees and occasionally more palms. Towards the top stratum there is the canopy of large trees (from 25 to 40 m in height, depending on the place), and over the canopy there may be scattered gigantic emergent trees that may reach over 70 m in the most luxuriant parts of the range. Growing on all tree sizes from small to large is an abundance of cryptogamous plants, climbers, epiphytes, and strangling trees that contribute to the complexity of the structure of the community (figure 1) (Richards 1952).

Figure 1—*Tree branches are densely covered with epiphytic plants, which increase their weight and make them more vulnerable to storms and wind.*

A limiting factor for the small plants in this system is the sparse level of radiant energy at the lowest stratum inside the forest. The available light for photosynthesis is reduced to a minimum, and many plants cannot grow sufficiently under this light. Only those situated under the reach of occasional sunfleks may receive enough radiant energy for growth. For most woody plants, the only chance to become successfully established and grow toward the canopy is an opening or a gap in the forest canopy that allows more energy to reach the ground level of their community (Chazdon 1988).

Rain Forest Dynamics

Canopy gaps are natural disturbances that occur randomly in the rain forest. The occurrence of gaps and their filling process explain much of the structure, regeneration mechanisms, and tree growth behaviors that characterize the rain forest of Central America and Mexico, which have been well studied (Brokaw 1985).

Gaps are not uncommon. It has been calculated that about 1% of the canopy area becomes a gap yearly (Popma et al. 1988). Branches and entire trees in the rain forest normally do not die of old age. The shallow roots that characterize these trees; the weight of their load of epiphytes and climbers; the water during the heavy rains; and the damage produced by termites, fungi, and other parasites make trees vulnerable to strong winds. Trees then fall violently to the ground during a storm, creating an opening in the canopy (figure 2).

Figure 2—*Most trees fall to the ground long before they are old enough to die of old age, creating a canopy gap.*

The sudden penetration of more light to the lower levels of the forest has consequences for all the plants in the newly created opening (figure 3). New branches of surrounding trees may grow toward the opening; arrested or slow-growing seedlings, saplings, and treelets may start growing much faster; some light-sensitive seeds may germinate; and even some understory plants may finally get enough energy to produce flowers and fruits. Gaps create new opportunities for many plants, allowing the renovation of the canopy and reinforcing the maintenance of the species diversity of the forest (Bazzaz 1984).

Figure 3—*The forest ground is covered by arrested or slow-growing seedlings of many tree species waiting for an opportunity (light gap) to grow toward the canopy.*

Large gaps in the rain forest are characterized by the emergence of special kinds of tree that are not present in mature forest patches. The **pioneer trees,** sometimes called **weed trees,** are characterized by their very fast growth and short life span; formation of very-low-density wood; an umbrella-like crown of strictly heliophilic leaves (requiring full sunlight); and a massive production of small seeds (figure 4). They survive in the medium to large gaps for 20 to 30 years until slower-growing mature-phase trees shade them. The best known pioneer tree of the Americas is the balsa tree, which produces a light wood that is very useful for wood carving and other modeling (Gómez-Pompa and Vázquez-Yanes 1981).

Pioneer trees are also common in some secondary fallows produced in disturbed areas when the soil and seed sources allow. They also grow along trails and roads built through mature forests and frequently along river banks.

Some authors consider pioneer trees healing vegetation (Gómez-Pompa and Vázquez-Yanes 1981). In fact, these trees help to restore the microclimatic conditions of the forest and the organic matter of the soil in the large openings. Due to the characteristics of their crowns, they do not produce deep shade, and therefore may favor the establishment and growth of mature-phase tree seedlings, which would ordinarily not survive. Although there has been little research about this subject, it is obvious that pioneer trees are going to play an important role in management and reforestation with native species. They might also contribute to the recuperation of soil fertility and microclimate, which would help the development of mature forest trees in

Figure 4—*Pioneers like these tall slender cecropia trees are large gap colonizers, which play an important role in the healing process of the forest.*

areas that are now devoid of original vegetation (Gómez-Pompa et al. 1990).

Reforestation Practices

The understanding of the natural regeneration processes of the rain forest will provide the basic information required for the proper management of the rain forest, which until now has been exploited in all the American tropics in an extremely destructive way. Timber resources of the forest, like the valuable minerals of a mine, can be exploited until depletion. If we continue this practice, the disappearance of the remaining valuable trees of the forest in most of the tropics is only a few years away (Wilson 1988).

Logging in tropical America is still seen by many conservationists as the beginning of the end of the rain forest. Loggers remove valuable timber by opening roads into the forest. Slash-and-burn farmers then move in using the same roads. Because of the lack of proper management techniques, the rain forest can be still considered a nonrenewable resource (Gómez-Pompa et al. 1972).

The exploitation of valuable timber species, such as mahogany *(Swietenia spp.),* in the tropical American rain forest has been very damaging. This species is now risking extinction in parts of its distribution. Some attempts have been made to develop nurseries to produce saplings of mahogany in nurseries in order to replant the forest. Although a common practice in temperate forests, the results with mahogany have been very often very disappointing in plantations because insects destroy most of the saplings. This is a good example of how the extreme complexity of the biotic interactions in the rain forest requires much more research before we will be able to develop proper management techniques for many species.

In the American tropics, reforestation with native species of the rain forest is seldom attempted. More often, exotic trees such as eucalyptus, gmelina, and the tropical pines from the Caribbean islands and Asia are used in order to create a fast-growing monoculture forests for timber and cellulose. These managed forests totally replace the native plants and animals and offer a striking contrast to the native forests in terms of levels of biological diversity.

Tree Seed Problems in the Tropics

The seeds of different plant species are exposed to the environment with a wide range of moisture contents, metabolic rates, and variable dormancy mechanisms, which influence their viability in the soil or in artificial storage (Priestley 1986). These seed attributes are closely related to the characteristics of the environments in which the plants live.

The availability of seeds for reforestation of the rain forest is one of the main problems that must be solved in order to develop techniques of management for native species. Most rain forest trees produce big fleshy seeds that germinate quickly and give rise to seedlings with extensive root and foliar surfaces. These traits might be related to the almost continuously favorable conditions for germination that characterize the rain forest as well as the intense competition for light among plants existing at ground level beneath the canopy and the high level of seed predation and deterioration created by the continuous high temperatures and moisture levels of the environment (Foster 1986).

Most rain forest mature-phase seed species are characterized by the lack of a period of dormancy, a high moisture content, and rapid respiration rate (Garwood and Leighton 1990). This combination of characteristics fits the tropical recalcitrant type of seeds first described by Roberts (1973) and redefined by Bonner and Vozzo (1987). By definition, they are hard or impossible to store for long periods of time. Survival of the seeds in the field is often unpredictable because it depends on the balance between water absorption from the soil and water loss by transpiration (Vázquez-Yanes and Orozco-Segovia 1990). The inability to store seeds means that, for most rain forest trees, the remaining patches of forest are the only available sources of seeds for planting and nurseries.

Most forest seed suppliers in the tropics market mainly exotic species and some rain forest plants that produce storable seeds (orthodox type: Roberts 1973) like ceiba *(Ceiba* spp.), balsa *(Ochroma* spp.), tropical-cedar *(Cedrela* spp.), teak *(Tectona grandis* L.), limba *(Terminalia* spp.) and few others. Most rain forest species having valuable or potentially valuable timber and fruit or medicinal trees are not available in any seed storage bank (Chin and Roberts 1980, FAO 1975, Willan 1985).

Native tree seedling nurseries for reforestation are poorly developed in most tropical rain forest areas. Because of the lack of seed handling techniques and seed reforestation methods, combined with the economical and methodological exploitation difficulties produced by the diversity and complexity of the rain forest.

Conclusions

Although there has been an increasing interest in developing basic research on rain forest structure and dynamics in the American tropics by U.S. and Latin American scientists, there is still a consider able lack of information on conservationist methods of management, reforestation with native species, and seed handling.

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Acknowledgments

We thank MC Guillermo Ibarra for taking the photographs for this paper at *Los Tuxtlas* rain forest, Veracruz, México.