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Tropical dry forest restoration in the Guanacaste Conservation Area, Costa Rica

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Introduction

Five centuries ago magnificent, dense dry tropical forest covered more than 200,000 square miles of pacific coastal lowlands from Panama to Central Mexico. The endangered condition of Mesoamerican tropical forests today is the result of centuries of logging, farming and ranching (Tenenbaum 1994). Dry tropical forests receive no rain from December until spring and then are soaked with rain for the rest of the year (Holden 1986). According to Daniel Janzen, professor of biology at the University of Pennsylvania, "Dry forest is the most threatened of all the major lowland tropical forest habitats. It once covered more than half of the world's tropics, but now… less than 0.1% of the original tropical dry forest… has conservation status (1988a).

The Guanacaste project may be the single most significant ecological restoration effort in the neotropics (Allen 1988). Guanacaste National Park, located in northwestern Costa Rica, is an aggregation of 47,000 hectares of pastureland that was purchased for the project and 23,000 hectares which were Santa Rosa and Murcielago National Parks (Whelan 1987). Daniel Janzen, a tropical ecologist, conceived the Guanacaste idea when he saw his natural laboratory slowly shrinking; he realized that without land conservation and habitat restoration that tropical forest resources would be lost. Today, the Guanacaste Conservation Area is maintained by 130 temporary and permanent staff (www.acguanacaste.ac.cr 1999).

The two goals of the Guanacaste restoration project are: to connect islands of dry tropical forest in a sea of pastureland by restoring a native dry forest and to involve the Costa Rican people in Guanacaste National Park so that it becomes an invaluable part of their country.

Environmental situation

Most of Guanacaste Province is agricultural land. The land is farmed; mostly sugar cane, corn and beans are grown, and cattle are allowed to graze pastures. Tropical dry forest soil is good agricultural soil, therefore most tropical crop and pasturelands are located where there once were dry forests (Janzen 1986).

The easiest way to clear agricultural fields before planting is to burn the unwanted vegetation. This method is quick, inexpensive and not very labor-intensive, which suits the poor tropical farmer. Burning pastures, however, cuts into the forest a little bit more each year and allows the pasture grasses to move further into the forest. After the fire burns the pasture and forest vegetation to the ground, the invasive African grass jaragua, *Hyparrhenia rufa*, takes over and cattle are allowed graze it (Cherfas 1986). It is this jaragua pastureland that interrupts the fragments of dry tropical forest in Guanacaste National Park. Because there is very little natural dry tropical forest left, the Guanacaste National Park will be a conservation area that is a largely restored secondary successional forest.

Site Description

The Guanacaste Conservation Area (also known as Guanacaste National Park) lies in the far northwestern corner of Guanacaste Province in Costa Rica, only 30 km south of the Nicaraguan border (Janzen 1988b). The Guanacaste Area contains 120,000 terrestrial hectares and 70,000 marine hectares (Ministereo del Ambiente 1999). The area encompasses two young volcanoes, the Santa Rosa plateau, and a sizeable beach on the Pacific Ocean (Janzen 1988b). The altitude in Guanacaste ranges from sea level to 1,916 meters in the former Rincón de la Vieja Park (www.expresso.co.cr 1999). The region receives an annual rainfall of between 800 and 2600 mm, which generally falls between May and November (Gerhardt 1998). The temperature varies from 20 to 38 degrees Celsius, with the hotter temperatures occurring during the dry season (Janzen 1988b). During the dry season, at least 80 percent of the trees in Guanacaste Park lose their leaves and stand leafless for three to five months (Janzen 1988b). This characteristic of the tropical dry forest makes it unique among tropical forests and allows it to be inhabited by a diversity of animals.

Guanacaste National Park is very large for a tropical conservation area; the size is intended to maintain biodiversity. According to Janzen (1988b), there are five biological reasons to restore and protect a large area of tropical dry forest. First, in a tropical dry forest the scarcity of water during the dry season magnifies the differences between habitats and a large park provides a heterogeneous environment for a variety of organisms. Second, the large vertebrates that live in the Guanacaste Area, such as tapirs, jaguars, and mountain lions, require a lot of acreage to maintain a healthy breeding population. Third, many of the forest animals migrate to moist areas during the dry season; a large preserve is needed to protect migration routes and refuge habitat. Fourth, when wildland abuts agricultural land the edge effect can penetrate two kilometers into the forest. To minimize this effect a large and continuously forested area is needed. Finally, because the Guanacaste National Park is used for research, ecotourism, and conservation, a large area is required in order to provide replicate habitats for multiple users. The restoration plan calls for usage zones for the park and its wildlife. "Some species and habitats are plentiful, and you can allow tourists to destroy one or two of those, knowing that you can replace them quite easily. Others are rarer and access must be restricted. Still others are so rare that no one, not even scientists, can be allowed to disturb them… Guanacaste National Park is large enough to be user-friendly" (Cherfas 1986).

Another reason to restore and protect such a large parcel of wilderness is that the Guanacaste National Park encompasses a watershed that provides drinking and irrigation water to local communities (Allen 1988). Specifically, the watersheds of the Río Sapoá and the Río Tempisque are protected by the area (www.expresso.co.cr 1999).

Biodiversity

The Guanacaste Conservation Area is home to approximately 23,000 species (65% of the estimated number of species in Costa Rica). "Janzen says that there are 20% to 40% fewer plant and bird species in this type of forest than in a rain forest; the variety of insects and mammals is about the same" (Holden 1986). Abundant and diverse fauna have been observed in Guanacaste National Park. By 1995, one hundred and fifty-five species of mammals (more than half being

bats), 253 species of birds, 100 species of amphibians and reptiles and more than 10,000 species of insects (including 3,140 species of butterflies and moths) had been observed (www.nacion.co.cr 1995).

Restoration Plan

The dry forest restoration project is based on the Clifftop study by Daniel Janzen, from the University of Pennsylvania (Allen 1989). In the 1980s, Janzen protected seven acres of pasture from both jaragua and fire to see what would happen. Janzen found that the area recovered quickly to forest. In Janzen's plot the pioneer species blew in from the forest edge over 150 meters away. The wind-dispersed seeds germinated in the plot and a peninsula-shaped extension of the old forest formed (Allen 1989). As the seedlings grew to provide shade and habitat for animals, vertebrates brought in the seeds of their favorite fruits in their excreta and spittle. As a result of these two methods of seed dispersal, the Clifftop forest is changing character is it grows older (Allen 1989). Based on the Clifftop experiment, the Guanacaste restoration project is under way: fires are being suppressed, hunting prohibition is enforced, and trees are being planted (Allen 1988). In addition to managed restoration, natural recolonization of native species is being encouraged and community education and outreach work is being done.

Fire Control

Fire must be controlled or the Conservation Area will continue down the trail to almost pure jaragua grassland (Janzen 1988b). Because there is no lightning, there are no natural fires during the dry season in Guanacaste province. "All fires in Guanacaste National Park are anthropogenic…The most dangerous grass stands are unbroken (ungrazed) 1- to 2-meter tall dense swards of jaragua…. During the dry season, most ungrazed pastures generate enough grass fuel to carry a fire hot enough to kill all above-ground parts of small woody plants, and subleathally damage the large trees" (Janzen 1988b). Because the dry tropical forest trees have not been historically exposed to natural fires, none have evolved a resistance to fire and cannot compete with the jaragua after a fire.

The purpose of the fire control plan is to prevent the expansion of the invasive African jaragua grass and to allow "tree invasion" into the pastureland through seeds dispersed by animals and the wind (Whelan 1987). In order to control the fires, the park staff clears fire breaks and maintains fire-access roads. The fire crew also rushes to any fires spotted by the lookout, stationed on one of the volcano peaks, and extinguishes them quickly (Tenenbaum 1994). Grazing of jaragua by cattle is also being considered as a management tool (Cherfas 1986).

Natural recolonization

With adequate fire protection to control the jaragua, a forest can move several hundred meters into an old pasture in ten years, just as a result of seed dispersal (Whelan 1987). The first seeds brought into an abandoned pasture are generally wind-dispersed seeds from the forest's edge. Of the 215 tree species at Santa Rosa National Park, 25% have wind-dispersed seeds and are effective pioneer species. In an area of Santa Rosa last affected by fire in 1979, twelve species of trees constituted at least 90% of the vegetative cover in 1986. The wind-dispersed species in the

plot were representatives of the families: Leguminosae, Boraginaceae, Verbenaceae, Tilaceae, Meliaceae, Bignoniaceae, Cochlospermaceae, and Hippocrateaceae (Janzen 1988a). Most of the wind-dispersed initial colonizers are large trees (attaining heights of 15-25 m) and live for 50 to several hundred years (Janzen 1988a). The wind-dispersed dry forest trees lack fruit (precisely because their seeds are wind-dispersed, they do not need to waste the extra energy involved in forming fruit to attract animals dispersers) and its seeds are protected from animal predators. Therefore the initial successional forest is not good habitat for animals (Janzen 1988a).

As well as the forest encroaching into pasture from the forest's edge, an isolated tree may appear in the middle of a pasture from dung dropped by a cow or horse while grazing the field (Whelan 1987). In the case of a solitary tree, called a nuclear tree, the tree acts as an island that begins to grow into the surrounding pasture. When the tree gets large enough to provide shade for domestic grazing animals and habitat for birds, it attracts seed dispersing animals that bring in the second wave of seeds. The small forest-island that springs up around this tree may eventually join the native forest to reclaim the pastureland (Whelan 1987).

These two methods of natural recolonization after a disturbance are very important in the restoration plan for Guanacaste National Park. The park staff is controlling the fires to allow the natural tree species to encroach on the abandoned pastureland. In addition, the staff is modeling its planting scheme after the nuclear trees. The islands of dry forest in the abandoned pastures are also being encouraged to expand into the fields, hopefully some day all of the forest fragments will join in a closed canopy.

Another important aspect of the natural recolonization process that is recognized by researchers in Santa Rosa Park is that many tropical dry-forest seeds must pass through animals in order to grow. The seeds of some trees that produce fruits, such as the guapinol, may germinate when they drop to the ground, but will not grow because the fruit that surrounds the seed prevents the seedling from sending roots into the ground (Whelan 1987). Because animal seed dispersal is so important in the dry tropical forest, habitat protection for animal species is critical. Animal protection is also important if the park is to sustain a healthy ecosystem with its full complement of plant and animal species occupying their respective ecological niches.

Managed restoration

"The park staff plants 4,000 to 9,000 trees each year in the most denuded areas" (Tenenbaum 1994). In 1993, the crew planted a total of 440 acres of trees. "To mimic natural groves, the trees are planted in groups of 12 to 15" (Tenenbaum 1994). "We're trying to restore the forest as naturally as we can. You want nature to select the strongest trees – they are all natives so they all have the capacity to adapt to these conditions," says Gisela Brenes, chief of restoration programs (Tenenbaum 1994). The park staff is trying to help the natural recolonization process along by supplementing the wind and animal dispersed seeds with planted seeds. Each tree that is planted is numbered so that its survival can be monitored. "The approximate three-year survival rate of the native tree species is around 3%" (Tenenbaum 1994). In a study by Gerhardt (1998), the major cause of seedling mortality in a tropical dry forest was defoliation during dry season drought.

Sustaining the Forest

Natural recolonization was chosen as a major restoration strategy because of the economic situation in Guanacaste Province and the rest of Costa Rica. Janzen has noted that the Gross National Product of Costa Rica is the same as the annual budget of the University of Pennsylvania. Keeping costs down was a very important part of the Guanacaste project. The project has a $3,000,000 endowment, which helps to support ongoing management costs, but the project will not survive the ups and downs of the Costa Rican economy without some intrinsic value (Janzen 1987).

In order to tie the local people of Guanacaste to their park, the restoration project employs local farmers to control the fires and manage the site. Each of 30 caretakers is presently responsible for between 1,000 and 2,000 hectares of land (Whelan 1987). Guanacaste National Park also employs only Costa Ricans and tries to promote from within the park staff. This is intended to foster a sense of ownership and responsibility for the restoration among the employees. The park does a lot of environmental education in local schools, inviting classes out to the park for biology lectures and environmental learning (Allen 1988). Janzen has trained several local people as parataxonomists who identify and catalog all of the species in the park.

The parataxonomists coordinate with the Instituto Nacional de Biodiversidad (InBio) in San Jose, Costa Rica (www.acguanacaste.co.cr 1999). The species that are identified are also smelled and tested for natural chemicals that could be sold to pharmaceutical companies (Allen 1988). This concept of bioprospecting is new in the tropics. The pharmaceutical companies have not, in the past, paid for the natural chemistry that they encounter in national parks, however Janzen expects that will change (Allen 1988).

In addition to the bioprospecting, a restoration and silviculture experimental station is managed at Guanacaste National Park. The program compiles information on the restoration of the degraded environment and on the practice of accelerating the natural restoration. The silviculturalists who work at the station have worked on more than 42 species and are elucidating the information needed to grow these trees for timber in other parts of the country (www.acguanacaste.co.c 1999). The silviculture station also has a nursery of more than 40,000 seedlings, which are used for restoration in the park and sold to local governments and industry for use in watershed reforestation, timber production and fruit production.

Evaluation

The Guanacaste National Park restoration project is being monitored for success in growing a dry forest and maintaining species diversity. While these ecological factors are important in evaluating the success of the project, the evaluation will never really be finished because in a country like Costa Rica the economy could dive at any time and the forest would be harvested for timber. The planners of the Guanacaste restoration are hoping that by involving the community in the restoration and forming a natural area that brings money into the area, they will foster a dependence on the National Park so that nobody will destroy this resource (Tenenbaum 1994).

Results

Based on research in Santa Rosa National Park, much of the pastureland is expected to be a closed canopy forest in two to five decades and a mature forest in about 300 years (Allen 1988). The areas that have been protected from fire for ten years now have ten to fifteen foot tall trees living where there once was pasture. "By 1993, the fires within the Conservation Area had diminished more than 90 percent, to about 5,200 acres per year" (Tenenbaum 1994). It appears that the Guanacaste restoration project is well on its way to meeting its goals of a full-scale dry tropical forest reforestation. The evaluation process, however, is far from finished. The tree species that live in the dry tropical forest have a life expectancy of hundreds of years, so the ultimate success of the project will not be assessed until some time in the year 2299.

Critique

The Guanacaste National Park restoration is a sound program. Because of the fiscal constraints of restoring a forest in a developing country, the process of natural recolonization along with managed restoration is a very practical technology, which takes into account the locally available resources. The process of bioprospecting and allowing researchers to work in the forest will bring in a considerable income for the continuing management of the park. The silviculture program will also provide funding and technical knowledge, which can be sold to private industry.

The Guanacaste restoration project would be a good model for other dry forest restorations in developing nations. The techniques used at Guanacaste would have to be tested on a small scale at other sites to determine applicability before a full implementation, but the methods used at Guanacaste are very sound. Utilizing locally available resources and concentrating on project sustainability – both ecological and economical sustainability – are essential for a tropical restoration project.

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