PROPAGATION AND INTRODUCTION

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Tropical Rain Forest Trees Propagated Using Large Cuttings (Nicaragua)

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Several researchers have found that attempts to propagate neo-tropical trees from seeds tend to be inefficient, labor intensive, and prone to low yields (Bonner. 1990; Maury-Lechon, 1993; Ray and Brown, 1994 and 1995). Moreover, they point out that nearly 70 percent of the monetary and human resources dedicated to neo-tropic forest restoration efforts involve seed collection and nursery care. With this in mind, we set out to explore whether large cuttings of local trees—a technique used by local farmers to build "living" fences—might be an economical way to propagate plants for restoration of tropical forests.

We conducted our research at the Región Autónoma del Atlántico Sur, near the town of Bluefields, Nicaragua. The field sites we chose were at La Unión and Bodega, and were surrounded by lowland primary and secondary forest. We also carried out greenhouse work at the University of Michigan's Matthaei Botanical Garden.

We set up experiments with three types of cuttings: small cuttings (25-50 cm [10-20 in]) from forest trees, branch cuttings, and large stakes. Large stakes were most successful. We planted these 1- to 1.5-m (3.3- to 5-ft) long and greater than 3 cm (1.2 in) in diameter cuttings at the beginning of the rainy season in June 1995. We chose two fenced-in pastures at each site—the one in La Unión being well-drained with brushy vegetation; the one in Bodega being two to three-years-old, subject to flooding, and with grassy vegetation. To obtain the stakes, we cut both tree branches and large saplings in the nearby forests and removed all branchlets and leaves. We treated all stakes with a fungicide (25 percent Captan) to protect any newly-formed roots from fungal infection (Hartmann and Kester, 1983) and improve the quality of the root cutting (Wells, 1963). At Bodega, we treated half of the stakes with fungicides and auxins (growth hormones, consisting of synthetic indolebutyric and napthalacetamidic acids [IBA and NAA]) at concentrations of 2,000 and 4,000 ppm, respectively. To plant the stakes, we drove each of them into a hole made in the ground with an *espeque*, or pointed stick. Two months later, we recorded the number of stakes that survived (retained a green cortex), the number of branchlets they produced, and the number of buds for each species. At Bodega, seven species (*Bixa orellana, Chimarrhis spp.,Cupania latifolia, Inga spp., Isertia haenkeana, Luehea seemanii, Pentaclethra macroloba*) had a 100 percent survival rate, and produced both branches and buds when treated with auxins. *Guatteria diospyroides* survived only half the time, but those plants did produce branches and buds. For three species (*C. latifolia, G. diospyroides, Inga* spp.), survivorship dropped to half or less when auxins were not used. *Vochysia ferruginea*, an economically and ecologically important forest tree, did not survive in either treatment.

Meanwhile, at the La Unión site, the stakes performed poorly. We believe this was due to a prolonged dry spell after beginning the experiment rather than the fact that none of the stakes were treated with auxins. Of the species tested, only four (*Isertia haenkeana, Quassia amara. Solanum* spp., and *Spondias mombin*) survived, but none exceeded 50 percent survival.

We also conducted trials using small, freshly-obtained cuttings (25-40 cm [10-16 in]) of *Cedrela odorata, Gliricidia sepium, Albizia saman*, and *Pachyra aquatica*. These cuttings, which were taken from saplings grown in the greenhouse, were treated with a fungicide (25 percent Captan). We tested them for the separate effects that both auxins and the position of cutting (apical, median, or basal) might have on root production.

Cedrela odorata proved an excellent sprouter. All cuttings from this species produced branches in four weeks, and almost all produced roots. We noted that the use of auxins had a significant positive effect on amount of roots produced, while the position of cutting did not affect the result. However, we did observe that larger diameter cuttings produced significantly more roots, especially when cuttings were made in the median and basal portions of stems.

Gliricidia sepium, a legume known for its rooting capacity, did not perform as well as *C. odorata*. In this case auxins did not make much of a difference, while the position of the cutting did, with basal cuts performing better than apical or median cuttings. In *Albizia saman*, five out of six cuttings produced roots, although in lesser quantities than either *C. odoratra* or *G. sepium*. Basal cuttings seemed to perform better than apical ones, but not significantly so. In *Pachyra aquatica* only two out of seven cuttings produced roots (both basal), with auxins apparently having no effect.

We infer from these small-scale trials that: 1) Local farmers are right: large stakes are more likely to root than short ones; 2) Young saplings, often quite abundant in the forest understory, are a good source of *in situ* propagation material; 3) Auxins benefit some species, regardless of the size of the cutting; and 4) Many cuttings can be obtained from a single branch since, in most cases, apical and median cuts performed as well as basal cuts.

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Air-Layering Shows Promise in Propagating Tropical Trees (Nicaragua)

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Propagators know that many tropical woody plants will produce aerial roots when their stems are put in a darkened room and provided with moisture and nutrients. In addition, studies have shown that auxins (growth hormones) can be used with air-layering to promote rooting of several tropical species (Torres and Kompen, 1990; Nagpal and Puri, 1986; Reddy and Srivasuki, 1990). This led us to hypothesize that existing trees in tropical forests could be used as nurse trees to produce air-layered plant material, thus avoiding the high cost of seed collection and nursery upkeep. To test our idea, we set up experiments at two forest sites (Bodega and La Unión) near the town of Bluefields, Nicaragua. We also did similar work in a greenhouse on the University of Michigan campus.

We conducted the forest experiment at Bodega using *Ficus* spp., *Terminalia amazonia*, and *Vismia macrophylla*; and at La Union using *Guatteria diospyroides*, *Hyeronima alchorneoides*, *Isertia haenkeana*, *Pentaclethra macroloba*, and *Protium schippii*. Working in local, mature forests, we chose branches or young shoots that were 1- to 2.5-cm (0.4- to 1-in) in diameter. We girdled each with a knife, removing a 1.5- to 2-cm (0.6- to 0.8-in) wide strip of bark from around an internode. Then, we treated the bare wood with Captan fungicide in a 25-percent talc mixture. To observe differences in the response of the cuttings to auxins, we added a mixture of indolebutyric acid (IBA) and napthaleneacetic acid (NAA) at 1000-2000 ppm to half the air-layered cuttings at Bodega, and to all the air-layers at La Unión. Lastly, we covered the treated area of each cutting with a mixture of moist leaf litter and locally-gathered, ground-up, decaying wood. We then enclosed each cutting in a sleeve of clear polyethylene, which we secured at each end with a twist of wire. Fourteen weeks later, we removed the polyethylene. All the wounds had produced calluses—in most cases, abundantly—and many species produced a significant number of roots.

All three species at Bodega produced abundant root masses without auxins, although *Ficus* species produced roots, both with and without auxins. At our La Unión site all of the species tested, except *Protium schippi*, formed roots on almost all their air layers. Our observations that *Hyeronima alchorneoides*, *Pentachlethra macroloba*, and *Terminalia amazonia* propagate easily by air-layering, while others such as *Protium schippi* do not, may demonstrate that excessive auxin concentrations will cause some species to fail to grow beyond the callus stage.

Although the number of air-layers per species was low (2-6), our impression from these studies is that air-layering shows great promise for propagating tropical trees. If they decide to try air-layering, we recommend, that restorationists consider both auxin concentrations and the season of the year (dry or rainy) because phenological stage may influence root formation differently for each tree species.

Table 1: **Response of five species of tropical seedlings to air layering in the greenhouse**

Species	Air-layers successfully rooted	Avg. # of roots
Carapa guianensis	3 of 4	5 to 8
Cedrela odorata	5 of 5 (2 individuals w/ 2 rooted layers on the same stem)	5 to massive
Swietenia humilis	4 of 5 (1 individual w/ 2 rooted layers on the same stem)	5
Gliricidia sepium	6 of 7 (2 of 3 individuals w/ 2 rooted layers on the same stem)	3 to massive
Luehea seemannii	4 of 7 (2 individuals w/ 2 rooted layers on the same stem)	3 to massive

Note: Some saplings had more than one air-layer on the same stem, thus the count in column 2 corresponds to the number of air-layers, not the number of saplings.

We also conducted a small-scale, air-layering experiment using greenhouse-grown saplings of five species: *Carapa guianensis*, *Cedrela odorata*, *Swietenia humilis*, *Gliricidia sepium*, and *Luehea seemannii*. All species tested have rooted, and at least 75 percent of the air-layers in any given species were successful. The use of auxin treatments did not affect the amount of roots produced. However, due to the small size of the experiment, our results are not statistically significant.

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