Fascinating things to do for tropical tree forest recovery

Yuri Jorge Peña-Ramirez[1], Lauren Nelson[2], and Ernesto Llamas [2]

[1]El Colegio de la Frontera Sur
[2]Journal of Sketching Science

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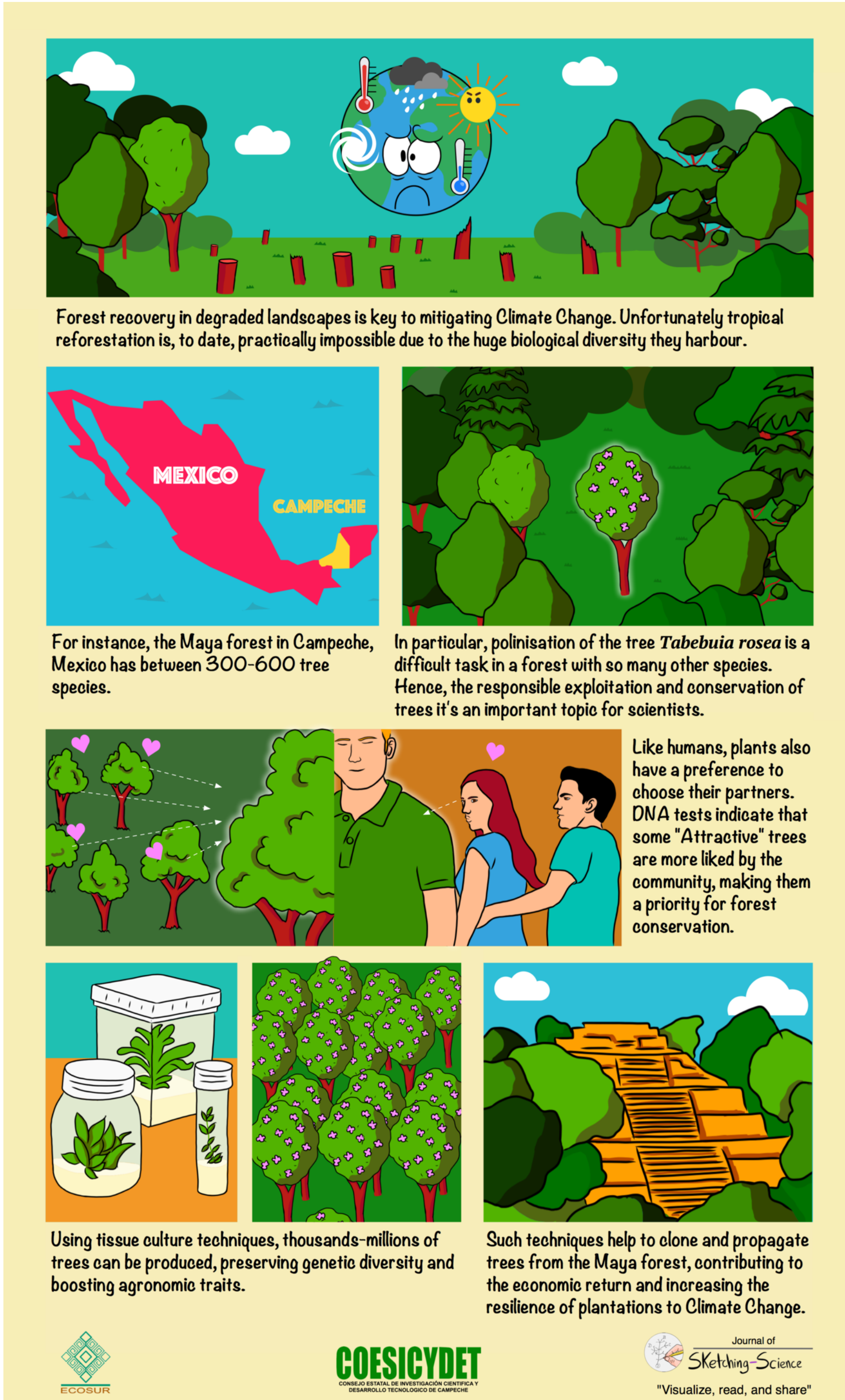
Forest recovery in degraded landscapes is key to mitigating climate change. Reforestation efforts have been successful in temperate environments, partly due to the limited number of tree species found in those ecosystems (*i.e.*contrast is, Therefore, up to five species). In contrast, tropical forest reforestation is to date, practically impossible due to the huge biological diversity they harbour. The Maya forest in Campeche, Mexico is estimated to contain 300 to 600 tree species. Hence, each species has a low density within a highly diverse matrix. Biological diversity of trees is maintained by a very complex network of interactions that scientists are starting to understand. One such interaction is related to how trees choose their partners. Yes, they do that. DNA progeny tests indicate that tropical trees are very promiscuous. In a single season, a *Tabebuia rosea* understand. (maculís in Mayan) tree can mate with hundreds of other individuals. Due to the low density in population, pollen (and pollinators) must find a way to connect with other individuals diluted among many other species. Moreover, some individuals are more liked by the community. How do we determine this? DNA from certain individuals is more frequently found in seeds from several trees in a region. Knowing this, what would happen if this particularly "attractive" individual was eliminated? We have to consider these "attractive" individuals as a priority for conservation. However, the "attractive" trees do not necessarily fit the timber industry's parameters. Commercial foresters look for tall, straight trees to produce first-class table cuts. Classic silviculture procedures are totally anthropocentric, ignoring trees mating preferences. As a consequence, tree breeding is complicated as trees may not mate with man-selected individuals, lowering seed production. When a commercially selected plantation is established near a natural forest, the "attractive" individual in the landscape may be overwhelmed by the huge amounts of pollen produced by plantations, contributing to loss of genetic diversity. Fortunately, for the maculís in Campeche, Mexico, foresters seed source was as diverse as the natural populations. DNA from "attractive" individuals was found in the same frequency both in plantations and in natural populations (Raggio, 2016). An educated propagation protocol for methods that avoid the risk of loosing "attractive" individuals (or their genes), must be based on the development of an Ideotype. This is an ideal imaginary tree which meets timber industry quality parameters, agronomic traits, and considers the species mating system. A tree that meets industrial, agronomic and biological expectations would, for instance be: straight, tall, fast-growing, pest-resistant, drought-tolerant (to face climate change), "attractive" for other trees, and so on. With knowledge of this desired ideotype, we can look into natural populations which are closer to the ideotype. Employing ideotype-based selection enables us to identify several elite maculis trees in the Maya forest (Solís-Guillén et al., 2017). Seed or vegetative collection of materials must be performed to capture genetic diversity, representing at least 90% of the natural genetic diversity of close natural populations. Once the germplasm (*i.e.* a collection of seeds or parts of the trees) has been sampled, it could be propagated vegetatively. Once plants, we are able to use them for buds and cuttings. In the lab, this ability can be turbo-powered by techniques of tissue culture called micropropagation and somatic embryogenesis. Both tools use plant growth regulators which are added to a nutrient-rich medium, acting as artificial soil. These conditions are optimal and can change the inner programming of tree tissues, switching them to a highly proliferative path, resulting in multiple sprouts from a single piece of tissue. In our group, we focused on another tropical tree: *Cedrela odorata* (or cigar box



Spanish red cedar), another native tree from Mesoamérica. Starting from twigs or seeds from adult trees that had been previously selected with the help of the ideotype, a process for the clonal propagation for this species was established (Peña-Ramírez et al., 2010b) (Peña-Ramírez et al., 2010a). With this tool, thousands or millions of trees can be produced, propagating not only trees but genetic diversity and clones that are able to fit industry quality parameters. A surprising advantage of using tissue culture, is the ability to induce a rejuvenation process in the tissues. Remember Dolly the sheep? Dolly was a cloned sheep borns old, who carried markers in her DNA (*i.e.* epigenetic markers) that instruct the body to adopt the age of the donor sheep. Epigenetic markers in the DNA of trees also limit adult tree propagation. Frequently, it is hard to establish twigs that have come from mature trees as individual plants or derived trees, did not develop as a young tree; they remain "vintage". Epigenetic markers are naturally reset from adult to young at the moment of fecundation (*i.e.*this grown, proliferated tree native to Meso américa : cedar). with born "old", carrying instructed Often "adult" "young" Reserve the plants. when pollination occurs for trees), but it is also feasible to reset the program employing plant tissue culture combined with grafting mature tissues over young ones. Subsequent rounds of grafting eliminate epigenetic markers linked to adult behaviour such as flowering, or lateral instead of vertical growth. By taking advantage of this technology, we were able to colones and propagate mature elite trees from the Calakmul Biosphere Reserve, in the Maya forest, inducing juvenile traits on derived plantlets. We are currently focused on refining our protocols for scaled-up production of plants. When a planter ventures into silviculture, plant material is paramount as trees are a long-term investment. It is beneficial to have superior quality material derived (*i.e.* cloned) from strictly selected donor trees with juvenile traits, for fast growth and genetic diversity. This will contribute not only to the economic return, but increasing the resilience of plantations to adverse environmental conditions as a consequence of climate change. Successful plantations will satisfy the market demand, reducing the pressure on natural forests.

Contributions

- Dr. Yuri Jorge Peña-Ramirez wrote the article. He is a researcher at El Colegio de la Frontera Sur in Campeche, Mexico. His work focus on biotechnology of tropical plants. (Twitter @Biotec_Forestal)
- Lauren Nelson edited the article. Lauren is a Ph.D. student at Newcastle University (UK), researching computational drug design alongside the Northern Institute for Cancer Research. Lauren also writes a scientific blog aiming to stop science from seeming so boring. (Twitter @ashortscientist; Instagram @ashortscientist; Blog: ashortscientist.wordpress.com).
- Ernesto Llamas made the illustrations. He obtained his Ph.D. in Biotechnology from Universitat de Barcelona doing his research at the Centre for Research in Agricultural Genomics. Creator, editor and illustrator of Sketching Science. (Twitter @neto_flames; Instagram @eellamas).

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