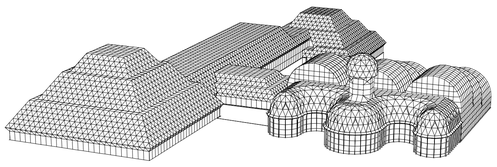

Biosphere 2 Tropical Rainforest

2010 Plant Survey

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Overview

Species die-off trends

•During the initial planting phases in 1991 and 1993, 366 plant species were introduced into the B2 rainforest.

• Despite the 1993 re-stocking and additions, the total species count fell precipitously to 157 by 1996—a 58% loss.

• After that point, species loss-rate decreased substantially despite changes in management practices and drought experiments.

• There are currently 90 species in the rainforest—25% of the original count (Figure 1).

• Despite the substantial die-off, the current species assemblage represents all major phylogenetic (evolutionary) groups (Figure 2).

• The Ferns and Cycads experienced the most rapid initial decline and are now each only represented by one individual plant. The one remaining Cycad, *Zamia fischeri*, happens to be an endangered species according to the IUCN Red List of Threatened Species (Figure 5).

Current species trends

• Similar to many tropical forests, the Pea (Fabaceae) and Palm (Arecaceae) families are our most abundant and species-rich tree groups with seven species each. It appears that only two tree species are successfully "recruiting", or contributing new individuals to the forest by viable seeds: one is a Pea, *Leucaena sp.*; the other is in the family Malvaceae, *Pachira aquatica*.

• With early species die-offs, the canopy never fully developed to create a well-shaded understory. Ground cover is largely dominated by the Zingiberales, the order of herbaceous plants containing Bananas and Ginger, which are typically early colonizers of light gaps in natural forests.

GIS map of the rainforest

• The geographical information system Arc-GIS is being used to create a comprehensive map of the B2 rain forest.

• The map provides a visual interface showing the topography, locations of all plant species, and infrastructure including the profile towers, instrumentation, paths, and even electrical outlets and water sources for facilitating research planning from off-site. These aspects can be viewed in a two-dimensional (Figure 3) or three-dimensional (Figure 4) format.

Objectives and methods

• The most recent prior survey was completed in 2000. Identifying, labeling, and mapping the locations of all extant plants in the rainforest provides a necessary base for forest research.

Plant database

• All plant species and individual locations are compiled in an Excel database, which will be combined with photos and map data in a comprehensive database using Oracle software.

• A photo database is under construction and currently contains over 1000 photos emphasizing details pertinent to species identifications.

Mapping the rain forest

• Past surveys were based on a comprehensive map of the biomes created by Teague & Co. in which the locations of all 1991 plants are indicated by their unique ID numbers. Subsequent surveys provided no information about locations of new recruits or the movement of clonal herbaceous species such as many in the order Zingiberales or family Araceae.

• I improved the survey method by cataloging all herbaceous species present in each of 81 25m^2 grid cells represented in the forest by labeled pvc tubes at each node (thanks Ashley, Evan, and Joost!). Each species is assigned an arbitrary location within each cell for visualization in GIS, and in this way the movement of herbaceous species over time can be monitored.

• Researchers are encouraged to use this system to map out locations of all research activities in an effort to enhance the informative value of past projects upon present research.

Next steps

• Labeling all trees in the forest with family, species, and common names, and unique individual ID numbers.

• Getting basic structural measurements such as tree diameter-at-breast-height and crown dimensions.

• Creating a photo-based identification key to the herbs.

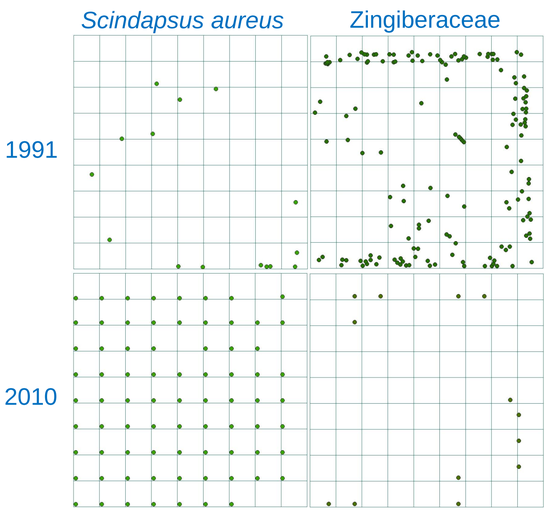

Figure 3: Maps from Arc-GIS showing distributions of the vine species *Scindapsus aureus* (left column) and the Ginger family Zingiberaceae (right column) at the initial planting in 1991 (top row) and the 2010 survey (bottom row) in the B2 tropical rainforest. Grid lines show the 81 25m^2 grid cells, which is represented physically in the rainforest by labeled pvc tubes at each node.

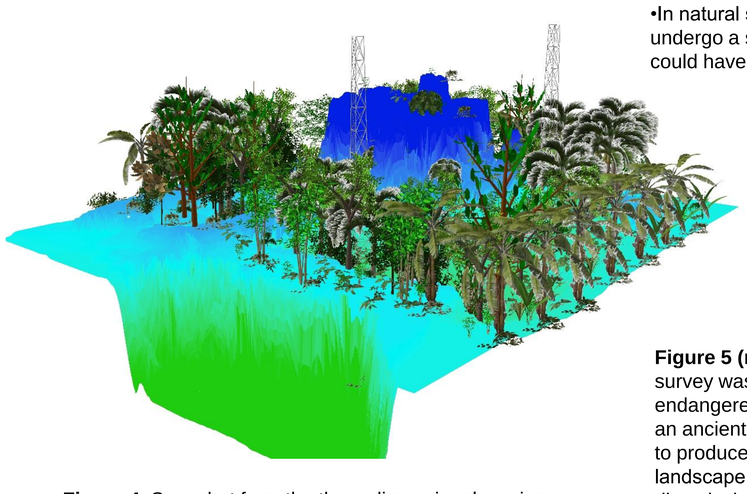

Figure 4: Snapshot from the three-dimensional version of the B2 tropical rainforest map in Arc-GIS. Tree and profile tower models imported from Google Sketchup.

Species loss over time in the B2 rainforest

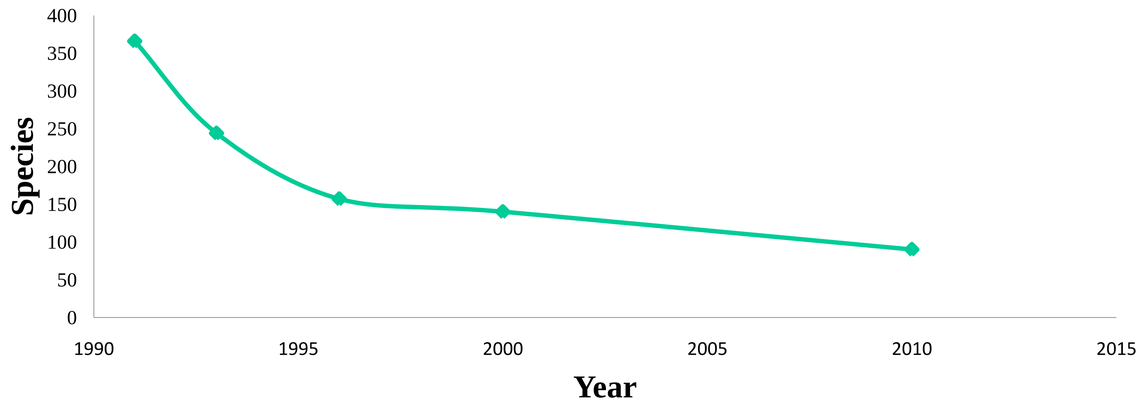

Figure 1: Graph of species loss over time as counted during surveys (points on line) in 1991, 1993, 1996, 2000, and 2010. For this graph, the new 50 species added in 1993 are included in the 1991 count in order to better demonstrate actual losses. As is, this curve still underemphasizes the initial rate of species losses due to restocking in 1993.

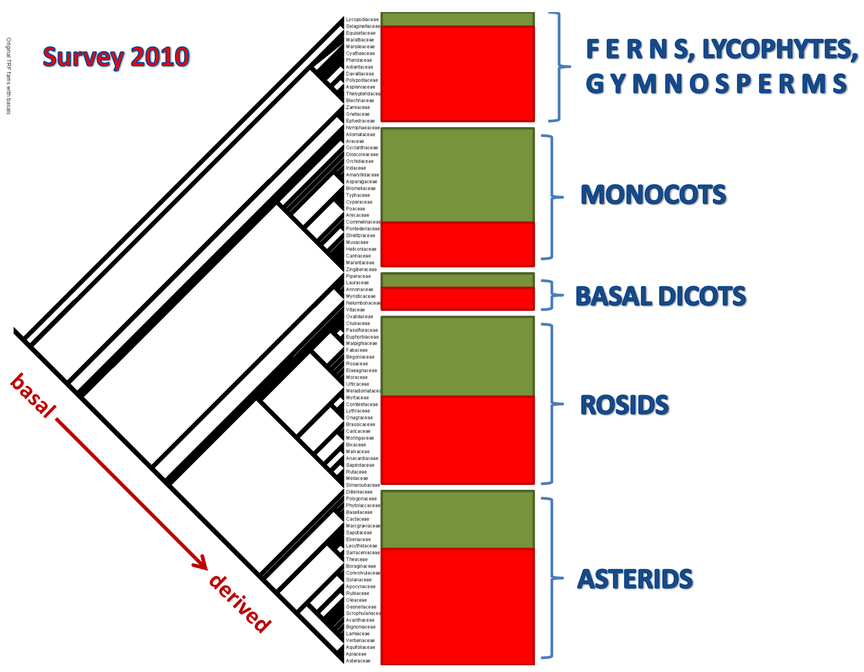

Figure 2: Phylogenetic tree of plant families from original plantings. Boxes show proportions of families lost (red) relative to initial number of families (red+green) in each major clade. Ferns, Lycophytes and Gymnosperms are included together as a single 'basal plant group'.

Utilizing the plant survey

• Kolby Jardine and I recently completed an initial survey of the volatile organic compounds (VOC) emitted by different plant species in the rainforest. Using the phylogenetic tree of current plant species as a backbone, we designed a sampling plan that would detect any high-level phylogenetic trends in VOC emissions, e.g., are there certain compounds that are emitted by only one of the two major groups in the Rosids, or by all Rosids but not the Monocots or Asterids? Without me on site, Kolby could have taken this approach and used the GIS map to determine which species that would satisfy this sampling design were within reach of his air lines and outside air intake. We used the GIS map to keep a record of all branch enclosure locations.

• What factors have driven the evolution of the B2 TRF plant community? For tall trees, there has probably been a strong selection for heat tolerance traits due to hot air accumulating at height beneath the glass. I would like to test this hypothesis by assessing what percentage of the tree community emits isoprene, a VOC commonly thought to mitigate heat stress in plants. A survey of several Amazon rain forest sites found that 38% of trees emitted isoprene. If over 50% of B2 rainforest species emit isoprene, there would be strong evidence that heat stress has been a selective pressure on our tree community, and that isoprene emission has been an important factor in the mitigation of this stress.

•In natural systems, forest edges typically experience temperatures up to 5˚ C higher than forest interiors and therefore may undergo a similar community selection process. Similar results found by a complimentary study in a natural tropical system could have important implications for predicting forest-atmosphere interactions in increasingly fragmented forest landscapes.

Figure 5 (right): An exciting find during the survey was the survival of *Zamia fischeri*, an endangered species of Cycad. Cycads are an ancient lineage and among the first plants to produce seeds. They dominated the landscape during the dinosaurs' era, but their diversity has since diminished and many are now endangered. This species is only found naturally in a small range in Mexico.