Learning experiences of Unmanned Aerial Vehicles used for maple observations

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Cloud forests containing *Acer binzayedii* in Mexico are structurally complex. The forests have a tall canopy composed of firs, pines, walnuts, oaks, *Podocarpus* (conifer), and *Zinowewia* (Celastraceae) which are among the tallest trees. The understory and the shrub layer are dense, comprising saplings from different trees species, ferns, and shrubs. This multilayer structure and tree heights make the emergent layer of the canopy difficult to access and reduces the ability to select the exact location of a sample.

This particular constraint does not allow observing or acquiring the samples needed to conduct the studies on floral development and seed production: the reproductive maples are too tall. The limitation has been traditionally overcome by collecting samples from the ground, and in many other forests or urban sites the use of cranes or tree climbing is often the solution.

Long-established methods to access tree canopies are diverse. A central component is the rope-based climbing method because the equipment is inexpensive and easy to transport. However specialized training is needed to execute the climbing. On the other hand, cranes, towers, platforms are expensive and restrict the number of trees sampled to those around the infrastructure. Other methods comprise the use of firearms, slingshots, throwlines, and fogging trees. Besides the training needed to manipulate firearms to shoot down the samples, there are legal restraints in Mexico, certain degree of risk, and it also involves training. Ropes to pull down branches are an option only to relatively low height. A combination of the rope method involves slingshots or line launchers. A downside of this method is that it can cause injuries to the tree, and often the flowers are damaged by the rope or by the surrounding branches.

In order to acquire a closer look at the canopy and to be able to collect samples from the trees, the Unmanned Aerial Vehicles (UAVs) have recently entered to the scene. The device allows a more accurate look at the emergent layer and can help to measure the spatial distribution of the species of interest. Professional UAVs have high-resolution cameras and some allow the attachment of a robotic arm device designed to collect branches. Nevertheless, UAV sampling has some limitations, such as maintaining a distance from the tree to prevent contact with the propellers. This particularly issue can limit the access to the outer edges of the trees. The effective time of the flight time with a fully loaded battery, with a mission established and sensors can last 15 minutes, thus multiple sets of batteries are needed to be carried in the field. In some locations, the noise of the propellers can disrupt the habitat or create unsafe situations with bees.

The tool used to collect samples affects the sample selection; in some cases may not be the most appropriate sample for a research project. In addition, the traditional methods to access the canopy trees can be time consuming. Thus, more effective tools will allow better accessibility to the canopy and will result in better studies.

Under a structurally complex cloud forest context and in the absence of *Acer binzayedii* reproductive trees in arboretums, it was decided to use an UAV as a first option to track the flower and fruit development. Among the goals of the project are identify the reproductive trees, find the inflorescences, observe the flower and fruit development, and to select the trees with mature fruits to be collected and germinated. It is assumed that the UAV will help to observe the canopy or tall branches and it will help finding reproductive trees and detecting individuals with mature fruits. In addition, it is important to explore other areas of the ravine in which the species is suspected to grow, thus could corroborate the presence or absence in the surrounding areas.

For this purpose, visits to the cloud forest with *Acer binzayedii* were planned every week during the flowering season, which we have timed in December. Monthly visits during the fruit development phase (January through July), and again weekly visits around the time the samaras are mature, which it is considered to be in August. At each visit, temperature sensors were placed at the ground level to obtain records every 30 minutes/24 hrs. Relative humidity both at the ground level and forest interior was also recorded. Samples of buds, branches, leaves, and flowers/samaras were collected in every visit.

Field observations were initially planned to begin in 2020, but systematic visits were not able to begin until December 2021. The observations during 2020 were not continuous due to travel bans and restrictions related to the pandemic, nevertheless no fruits were observed during 2020.

The firsts explorations identified reproductive trees and the abundance of flowers (Fig. 1). The UAV was effective at detecting the inflorescences but it was not so effective to get a closer look of the flowers despite the resolution of the camera attached. It is important to point out that the inflorescences could not be seen from the ground, so the use of the UAV was effective to overcome this issue. Due to the branching patterns of the trees, the operation of an UAV with a collecting arm might not be possible without damaging the UAV, thus, other collecting methods will be necessary. However, this is not an easy task due to the heights of the trees.

The tall trees, colors of the trees and samaras, and the light passing through the canopy are other factors that complicate the identification of reproductive structures with a naked eye from the ground. Nevertheless, the use of an UAV helped to solve this problem. Although the green color of the samaras was very similar to the color of the new leaves, it was possible to observe abundant samaras in many trees (Fig 2.). On the other hand, during winter, the red color of the leaves helped to spot the location of the maple trees along the ravine (Fig. 3). The forest area has been partially explored to evaluate the extent of the distribution of the trees (Fig. 4).

Piloting an UAV requires training, and more important is to gain the skills to operate it within a structurally complex forest. Yet, the UAV has been useful to track the development of the reproductive structures of the trees, but this task will require long-term observations and the analysis of that data in conjunction with the microclimatic data. Thus, this is a work in progress.