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UAS FLIGHT OPERATIONS IN COMPLEX TERRAIN:
Assessing the Agricultural Impact from Hurricane Maria in the Central Mountainous Region of Puerto Rico

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BACKGROUND

Hurricane Maria struck Puerto Rico in September 2017 as a Category 4 storm causing major damage to infrastructure, agriculture and natural ecosystems, as well as the loss of many lives. Among the crops hardest hit was coffee, one of the most important crops in Puerto Rico. As a perennial system, coffee takes various production forms along a gradient from high shade/biodiversity coffee farms to low shade coffee monocultures and therefore offers an ideal means for the study of resistance and resilience of an agroecosystem to weather and climate disturbance. During the summer of 2018, 14 impacted farms across the production style gradient ranging in size from 10 to 100 acres were surveyed by a variety of UASs in order to investigate how a major weather disturbance affects production, biomass, biodiversity, and the recovery of each. All of the coffee farms were located within complex terrain and on the sides of mountains. This work addresses the flight challenges faced during the field campaign that include quickly changing terrain and tree canopies, limited launch and recovery areas, remote farms with limited access that was further exacerbated by storm damage, and mountain induced weather that produced complex flow patterns.

HURRICANE MARIA

Figure 1. Hurricane Maria's path across Puerto Rico.

Acknowledgements and Contact

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OVERCOMING PROJECT CHALLENGES

- **Terrain:**
  - ➢ All of the mapped coffee farms are located in the central mountainous region of Puerto Rico with most positioned on the side of mountains with steep topographical gradients
  - ➢ Non-uniform canopy with isolated high trees
  - ➢ Complex terrain offered limited areas for launch and recovery
- **Weather:**
  - ➢ Quickly changing mountain weather with superimposed flows from complex terrain
- **Farm Access:**
  - ➢ Many farmers were in distress and with farms that had reduced accessibility due to infrastructure damage

ASSESSING FARM HEALTH

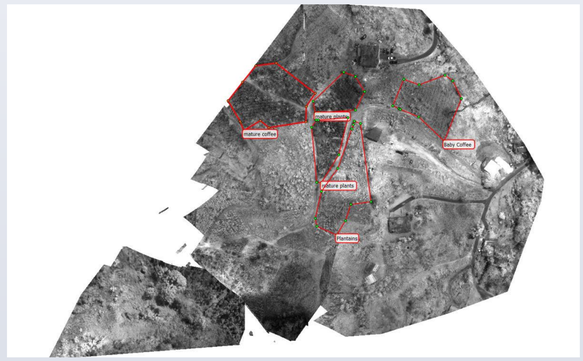

Figure 2. Reflectance map created in Pix4D.

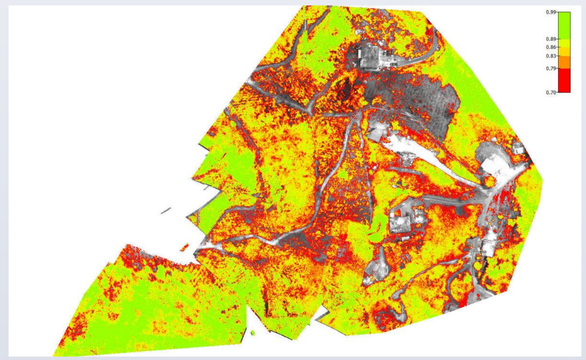

Figure 3. NDVI map created in Pix4D.

Figure 4. 3D digital surface model created in Pix4D.

FUTURE WORK

This work previews return trips that are being planned that will investigate:

1) How the style of coffee production makes a difference with regard to the damage caused by weather disturbances and how this damage affects production, biomass, and biodiversity, as well as their recovery.
2) The creation of new data science methods and tools that fuse fine resolution UAS imagery with moderate resolution satellite imagery, fine resolution LiDAR data, fine resolution meteorological data, and generally available GIS data.

- **Outputs:**
  - ➢ Orthomosaics ➢ Vegetation index maps ➢ Digital surface models ➢ Land cover classifications
  - → Ground collected data, canopy cover, leaf area index, above ground biomass, annotations

SETTING

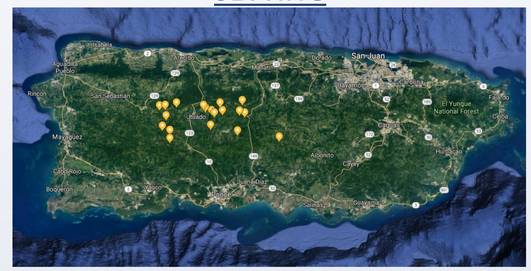

Figure 5. Location of the 14 coffee farms mapped in Puerto Rico during the initial 6 day field campaign.

Figure 6. Overhead view of a representative coffee farm.

UNMANNED AIRCRAFT AND SENSORS

The field campaign utilized various UA and sensors which included:

- senseFly eBee
- DJI Inspire I
- Airinov multiSPEC 4C
- Parrot Sequoia multispectral
- senseFly S.O.D.A.
- 4K camera

Figure 7. DJI Inspire I with the Parrot Sequoia multispectral sensor.

Figure 8. Launching and flying the senseFly eBee.

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