Increasing Spatial and Temporal Monitoring of Phenology in Native Hawaiian Flora at Pu'u Maka'ala: How do Faunal Visitors Influence Phenology?

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Project Summary:

Plant phenology studies the timing of recurring events such as flowering or budding, and the seasonal or environmental factors that cause them. While strongly seasonal species in temperate zones often have well-understood mechanisms of phenology changes, in tropical ecosystems phenological cycles are less understood, and may vary more widely (Pau et al. 2020). Using existing and new data at Pu'u Makaala we can study drivers of native plant phenology in a tropical montane wet forest. However, examining native flora with enough resolution to examine both biotic and abiotic drivers of phenology shifts would be limited by sampling frequency and manpower. Camera data can be used to track phenology efficiently over time, such as when it is currently occurring on a small scale in the phenoCam network. We can process larger amounts of image data using machine learning techniques, both to track floral phenology and identify animal use patterns that may impact them. Since we currently do not have a complete understanding of the data that we will be dealing with, we envision using foundation vision models like Grounding DINO (Liu, Shilong et al.) and Segment Anything Model-2 (Ravi, Nikhila et al.) to extract initial labels in the dataset curation process. Subsequently, we will explore other object detection models like YOLO (R. Varghese et al. 2024) and RT-DETR (Y. Zhao et al. 2024) to create a more domain-specific detection framework. This project aims to increase understanding of fine-grained factors in native Hawaiian floral phenology in a montane wet forest using ML analysis of images and video through time.

Research Question:

The major question that we wish to answer is could we use AI to understand the triggers of phenophase changes in target floral species? This would mainly be done by using image data to track the plant phenology changes over time and also by observing the animal visitors and the impact they have on these changes. We further divide this into two sub-questions that we discuss below.

1) Sub-questions: Study Method Design:
    a. What is the best way to capture necessary data for tracking phenology at both a sufficient temporal and spatial resolution?
    b. Can we collect data to determine the causes of phenophase change, respective to both biotic and abiotic influences?
    c. What is the best way to process the data collected to:
        i) Track phenophase shifts in focal plants?
        ii) Measure and record animal visitors?
2) Sub-questions: Floral Ecology:
    a. Are Hawaiian native plant phenology changes triggered by biotic or abiotic factors?
    b. What role do animal visitors play in phenology shifts?
    c. What animals are using these plants and how? Are they native or invasive?

Project Goals:

This project aims to deepen our understanding of plant-animal interactions and their influence on floral phenology. A brief introduction to the key project goals is as follows:

1. Establish a robust baseline of floral phenology by capturing high-resolution temporal data.
2. Identify and categorize animal visitors interacting with focal plants (native and invasive).
3. Refine protocols for camera deployment, and data collection frequency, quantify animal usage, and interpret potential drivers behind observed patterns.

Fieldwork Approach:

The following are the approaches that we will potentially be undertaking during our fieldwork:

- **Camera Deployment:**
    - Select locations to place the cameras to capture target individuals
    - Calibrate camera settings for appropriate data capture for downstream ML/DL/CV tasks.
    - Observe preliminary image data to understand how various physical factors (light, soil dryness, fog, etc.) impact the data-capturing process, and make adjustments if necessary.
- **Supplementary Image Collection:**
    - Capture additional high-resolution images of target species and various phenophases to supplement later algorithm development

- **Insect Sampling (if needed):**
    - Select the insect trapping method most useful to capture our target community (malaise, yellow pan)

- Set out passive insect traps to sample existing community diversity and abundance
- Image in high resolution and identify to lowest reliable taxonomic level, for later automatic identification efforts

Relevance:

Understanding the drivers of plant phenological changes is central to ecology and conservation biology, especially in biodiverse and sensitive ecosystems like Hawaii. This project is aimed to help the conservation efforts of native species and provide management insights for controlling invasive species. It also supports the broader NEON mission to understand ecological dynamics at multiple scales, helping forecast ecosystem responses to environmental change.

Citations:

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