# USING ENTRY LEVEL UAV FOR

BOTANICAL SURVEYS ON VERTICAL CLIFFS

OF KAUAI

HAWAIIAN ISLANDS

2400 miles

# HAWAII GEOLOGIC HISTORY
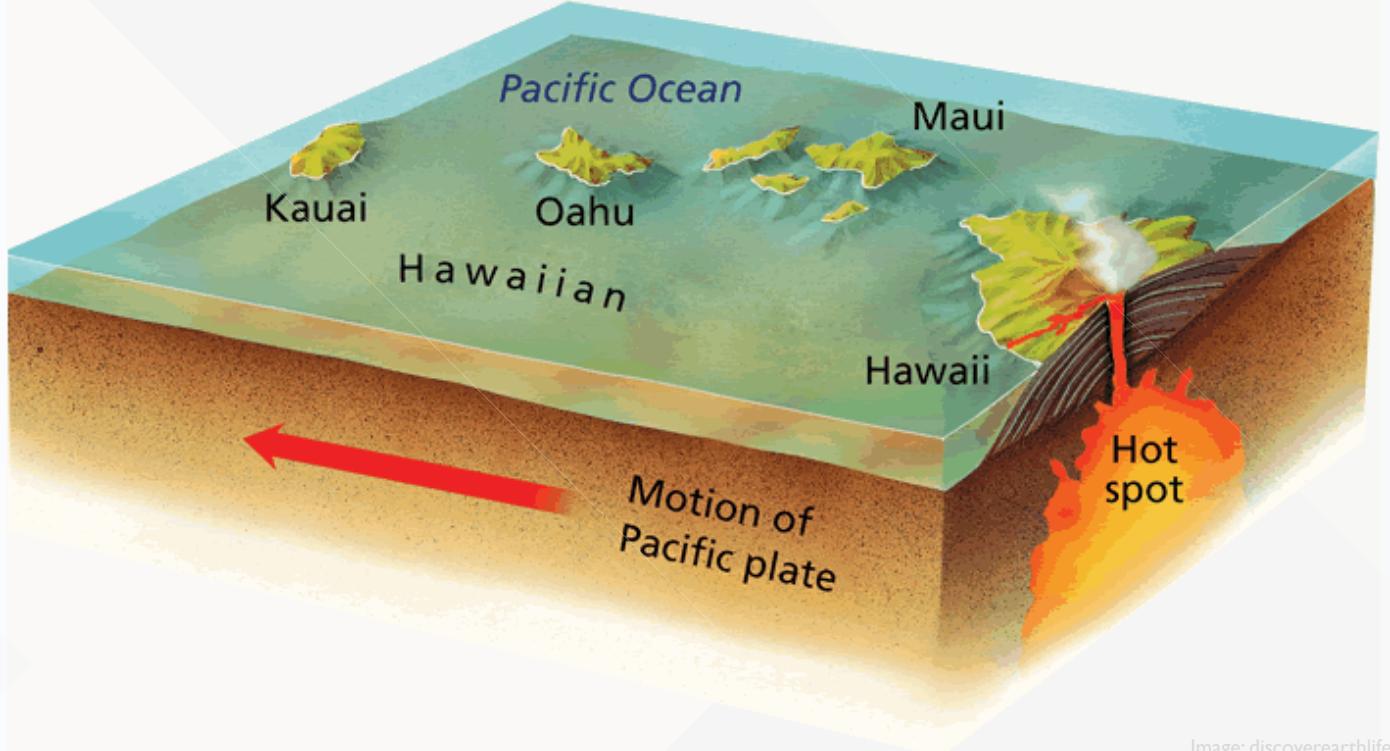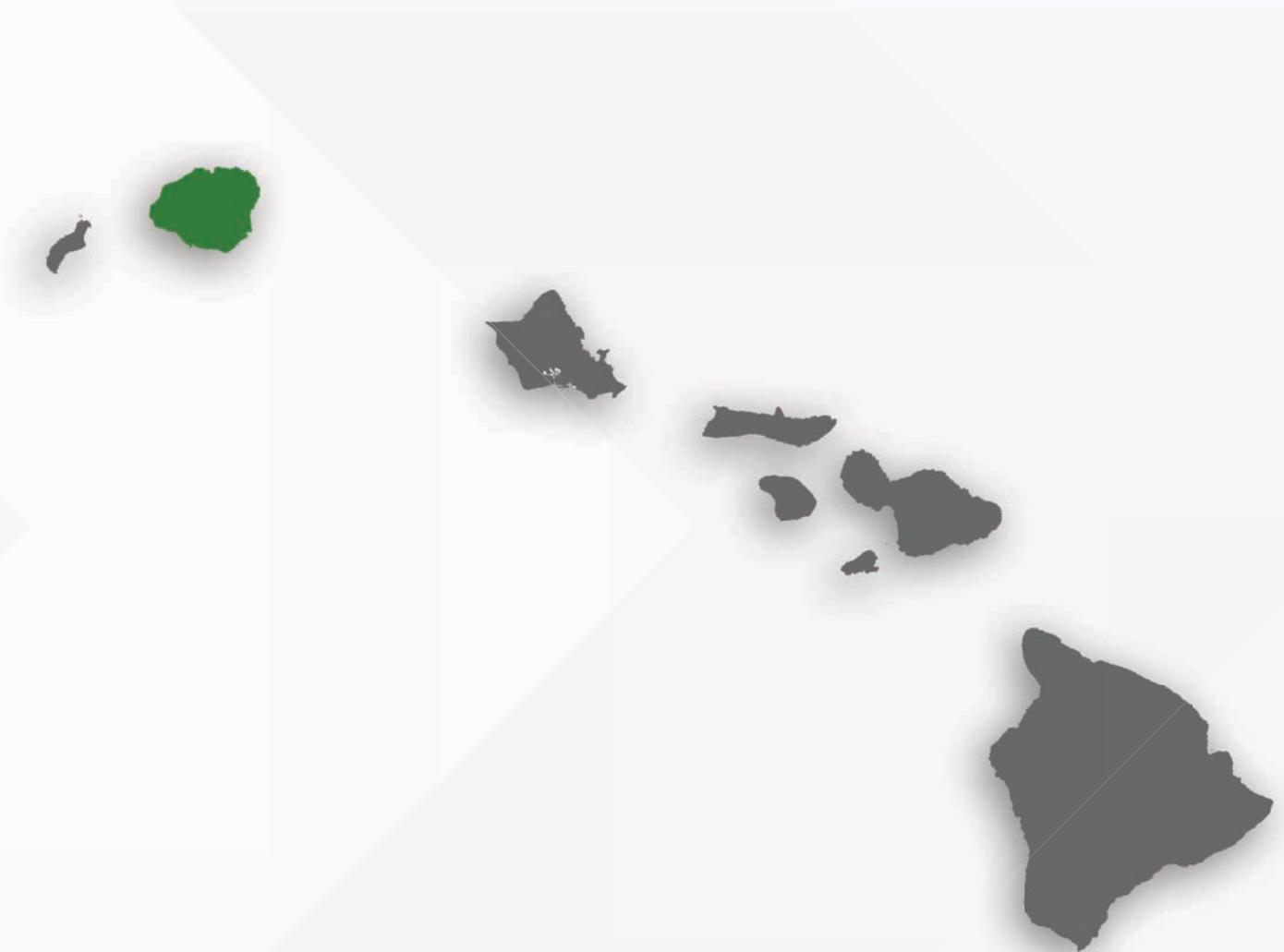
Image: discoverearthlife.com

Image: State of Hawaii DLNR

KAUAI LOCATION

- **5 million years old**

  oldest of the main Hawaiian islands

- **550 sq mi. area**

- **Over 400 inches of rain per year**

  at central Mt. Wai'ale'ale

- **65,000 – population**

HAWAII AS BIODIVERSITY HOTSPOT

- **Long Distance Colonization**

  Followed by amazing speciation of both flora and fauna
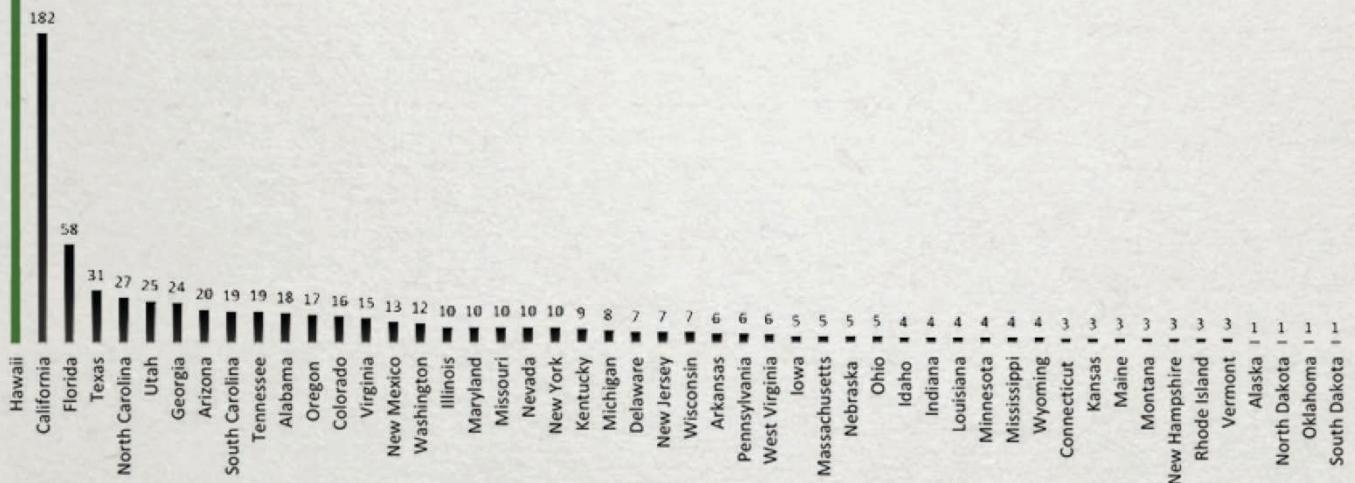
- **Highly endemic population**

  over 10,000 endemic species

- **Mostly Hawaiian Plants**

  90% of Hawaiian flowering plants found nowhere else on earth

Endangered Plant Species by State

Data : US Fish and Wildlife
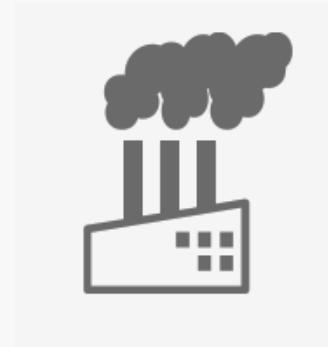
THREATS
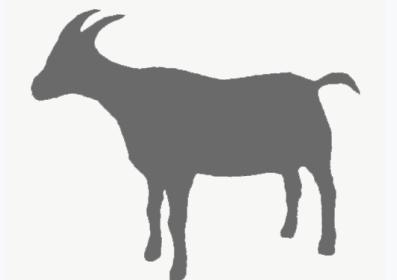
FERAL PIG
Sus Scrofa

AUSTRALIAN TREE FERN
Cyathea Cooperi

POLLUTION

WILD GOAT
Capra hircus
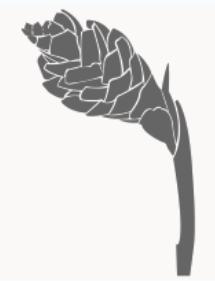
STRAWBERRY GUAVA
*Capra hircus*
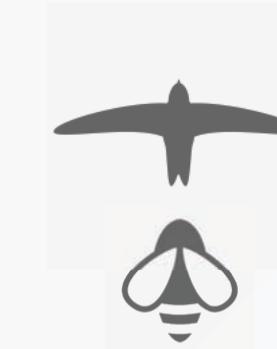
DEVELOPMENT

**BLACK RAT**
Rattus rattus
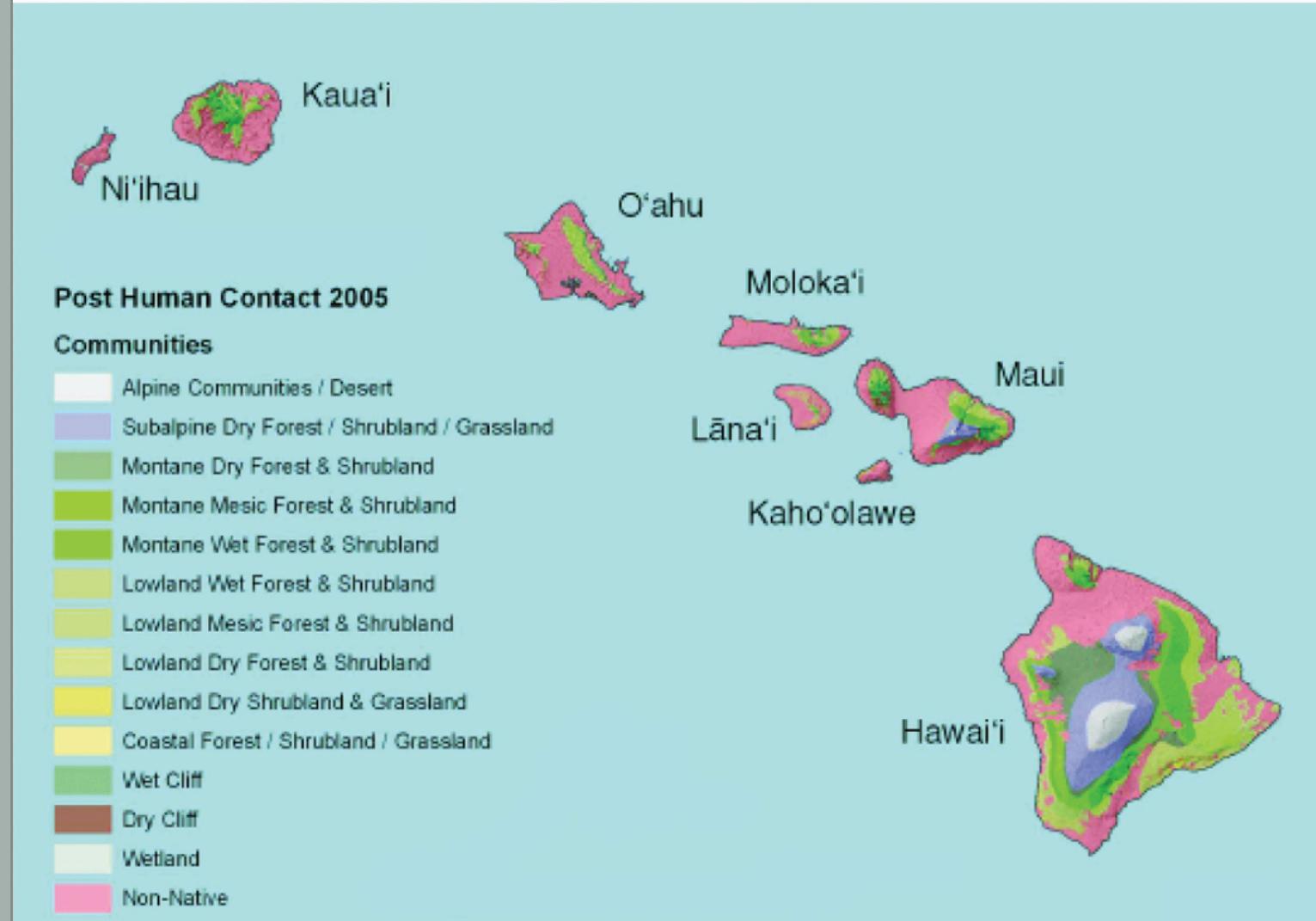
HIMALAYAN GINGER
Hedychium gardnerianum

POLLINATOR LOSS

HABITAT NICHES OF HAWAII
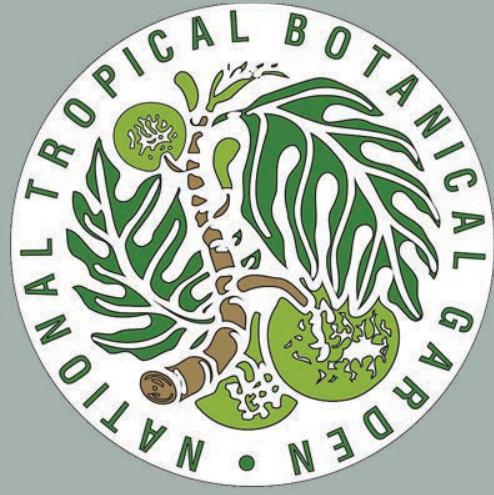
- **Estimated 88 distinct habitat niches**

  33 in Native Forest and 36 in Native Shrubland

- **High Variability of :**

  Precipitation, Elevation, Aspect, Soil types

- **Most diverse communities**

  Lowland Mesic and Wet Summits

- **Dry forests only have 5% remaining**

Kaua'i

Ni'ihau

O'ahu

Moloka'i

Maui

Lāna'i

Kaho'olawe

Hawai'i

Post Human Contact 2005

Communities

- Alpine Communities / Desert
- Subalpine Dry Forest / Shrubland / Grassland
- Montane Dry Forest & Shrubland
- Montane Mesic Forest & Shrubland
- Montane Wet Forest & Shrubland
- Lowland Wet Forest & Shrubland
- Lowland Mesic Forest & Shrubland
- Lowland Dry Forest & Shrubland
- Lowland Dry Shrubland & Grassland
- Coastal Forest / Shrubland / Grassland
- Wet Cliff
- Dry Cliff
- Wetland
- Non-Native

EXTINCTION

- **Hawaii is the epicenter of U.S Extinctions**

- **Home to 40% of all endangered species in the U.S.**

- **While only 0.2% of total landmass**

- **Estimated 271 species have been lost in the past 200 years**

NATIONAL TROPICAL BOTANICAL GARDEN

To enrich life through discovery, scientific research, conservation, and education by perpetuating the survival of plants, ecosystems, and cultural knowledge of tropical regions.

FLORIDA

The Kampong

Tropic of Cancer

Limahuli Garden and Preserve

KAUAI

Allerton & McBryde Gardens

OAHU

Kahanu Garden

MAUI

Awini Preserve

Ka'upulehu Preserve

HAWAII
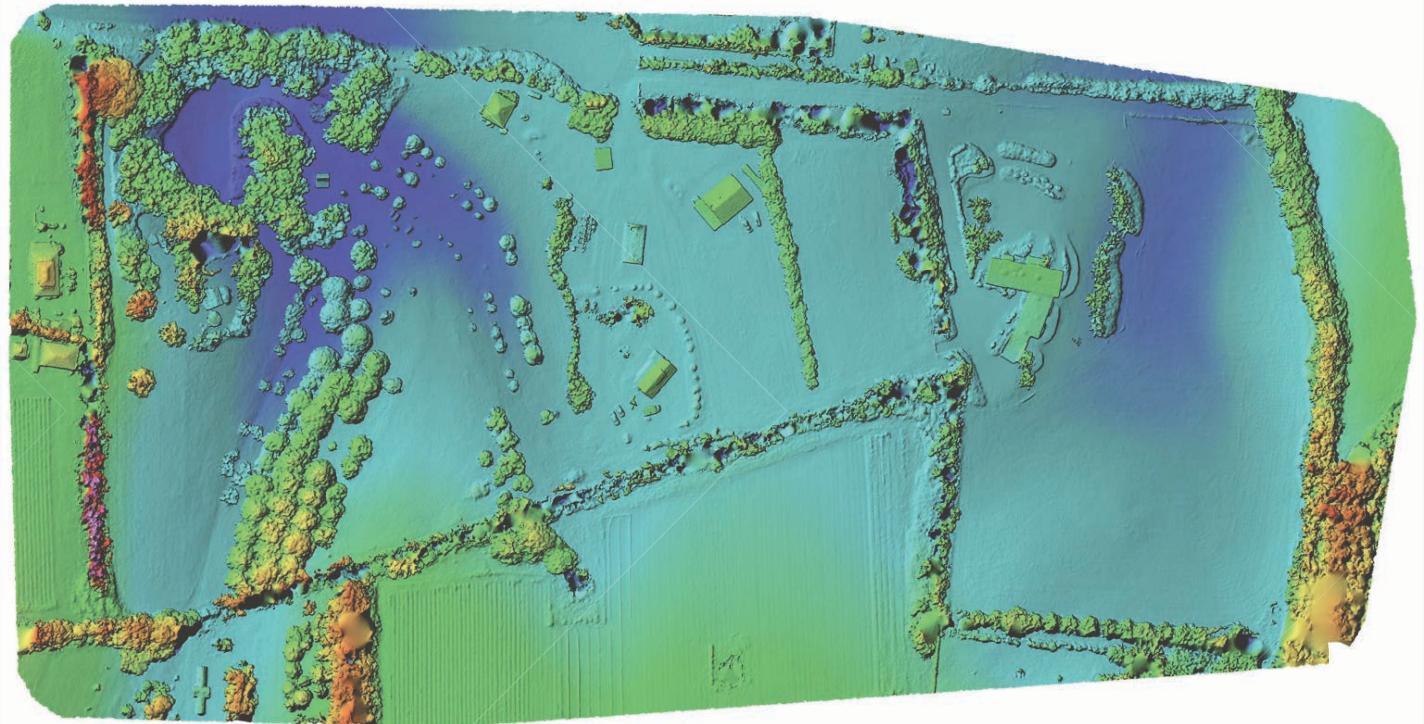
OUR STAFF

- Herbarium

- Seed Lab

- Nursery

- Living Collections

- Field Collectors

Courtesy Image

Image : Ken Wood

DRONE TRENDS

- Lower price making UAV more accessible to public

- Increased quality of sensors

- Operation becoming much more user friendly

- Software developer releasing more customized products

- Most UAV markets are expanding

STRUCTURE FROM MOTION

- Uses multiple photos from different angles (a.)

- Creates "Point Cloud" of matched points (b.)

- Turns points into 3D surface or "mesh" (c.)

- This surface is used to produce the orthophoto

- Photo can then be draped over surface to produce the 3D model
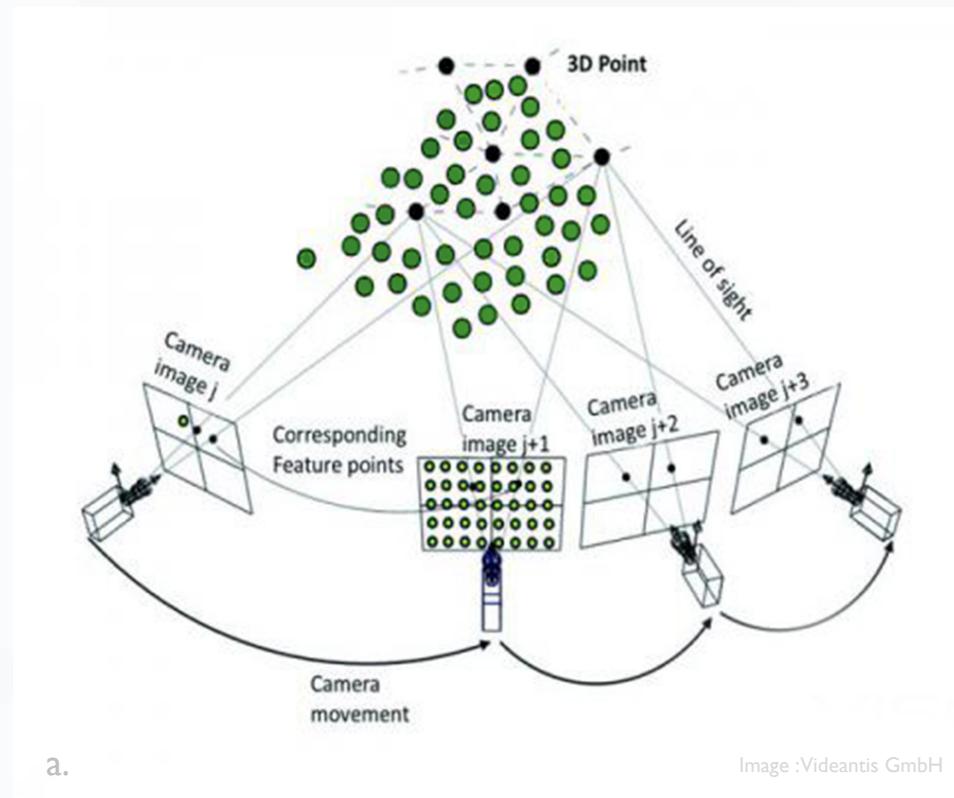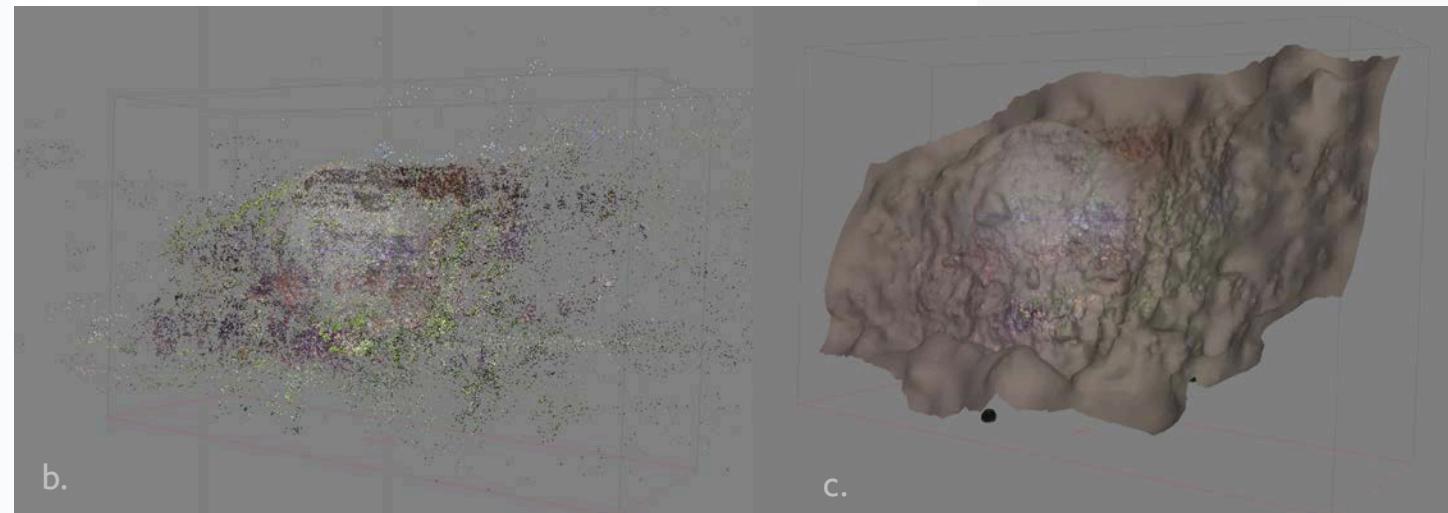
Image : Videantis GmbH

Images : Ben Nyberg, Preliminary Tests

GOALS & OBJECTIVES

- Use Geographic Information System (GIS) software to establish survey areas that include: high density of rare plants and steep slopes over 45 degrees,

- Develop and test flight planning systems to accomplish surveys of vertical surfaces using UAV in challenging areas,

- Validate results from test sites to assess accuracy and effectiveness of these methods

- Carry out aerial surveys that create high-resolution orthophotos (2D) and 3D models,

- Analyze these outputs to assess their usability in identification and mapping of rare and endangered plants to aid botanists in the location and collection of these difficult to reach plants,

- Compile a "recommended operations" document for future projects.

MATERIALS: UAV

DJI Phantom 3 Advanced

Weight : 1280g or 2.8 lbs
Size (diagonal): 14 in

Range : Up to 5 km or 3.1 miles
Operation Time : ≈ 23 minutes
Max Speed : 16 m/s

Camera : Sony EXMOR 12.4 MP
Lens: 20mm, f/2.8
Field of View : 94°
Max Image Size: 4000 x 3000
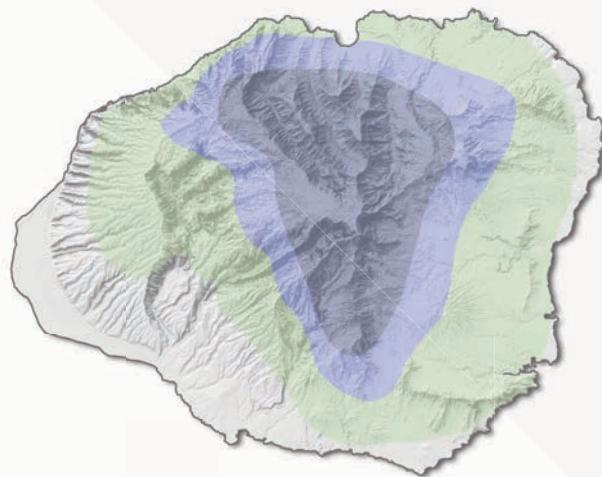
Cost : $800
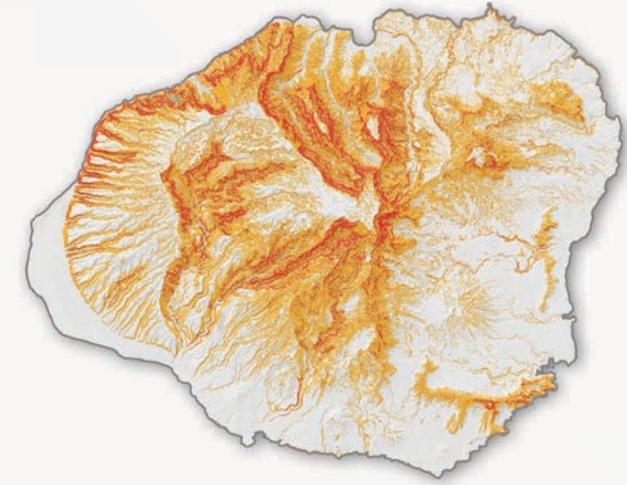
MATERIALS: DATA
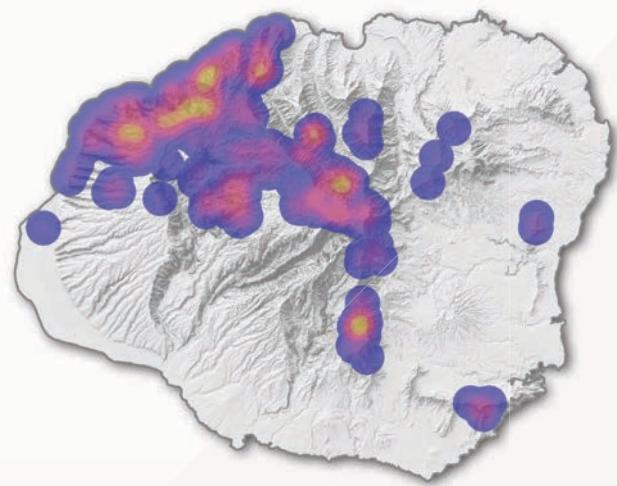
- **Digital Elevation Models**
  5m NOAA produced
  1m LIDAR-based from NSF

- **Environmental Layers**
  USGS rainfall data
  Solar Radiation
  Average Wind Speed

- **Rare Plant Data**
  Collection Points
 Plant Ranges
  Rare plant Hotspot Models
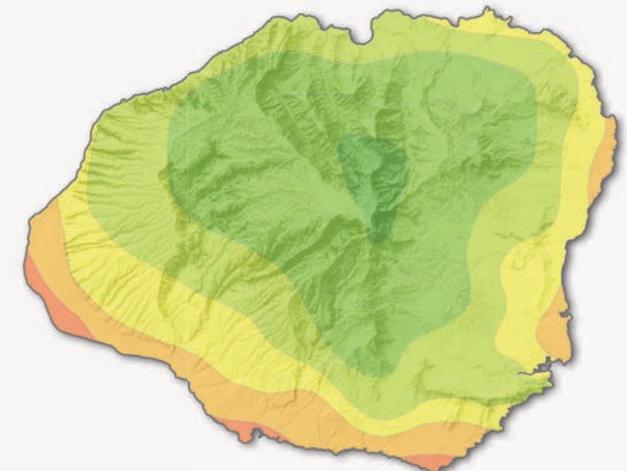
Rainfall

Slope

Rare Plant Hotspots

Solar Radiation

MATERIALS: SOFTWARE

- **Geographic Information System**
  ESRI ArcGIS

- **Flight Planning**
  DroneDeploy
  AutoPilot
  Pix4d Capture
  MapPilot
  Universal Ground Control

- **Image Processing**
  Agisoft PhotoScan
  Pix4d MapperPro
  Maps Made Easy
  ESRI Drone 2 Map

1. IDENTIFY WORK AREAS
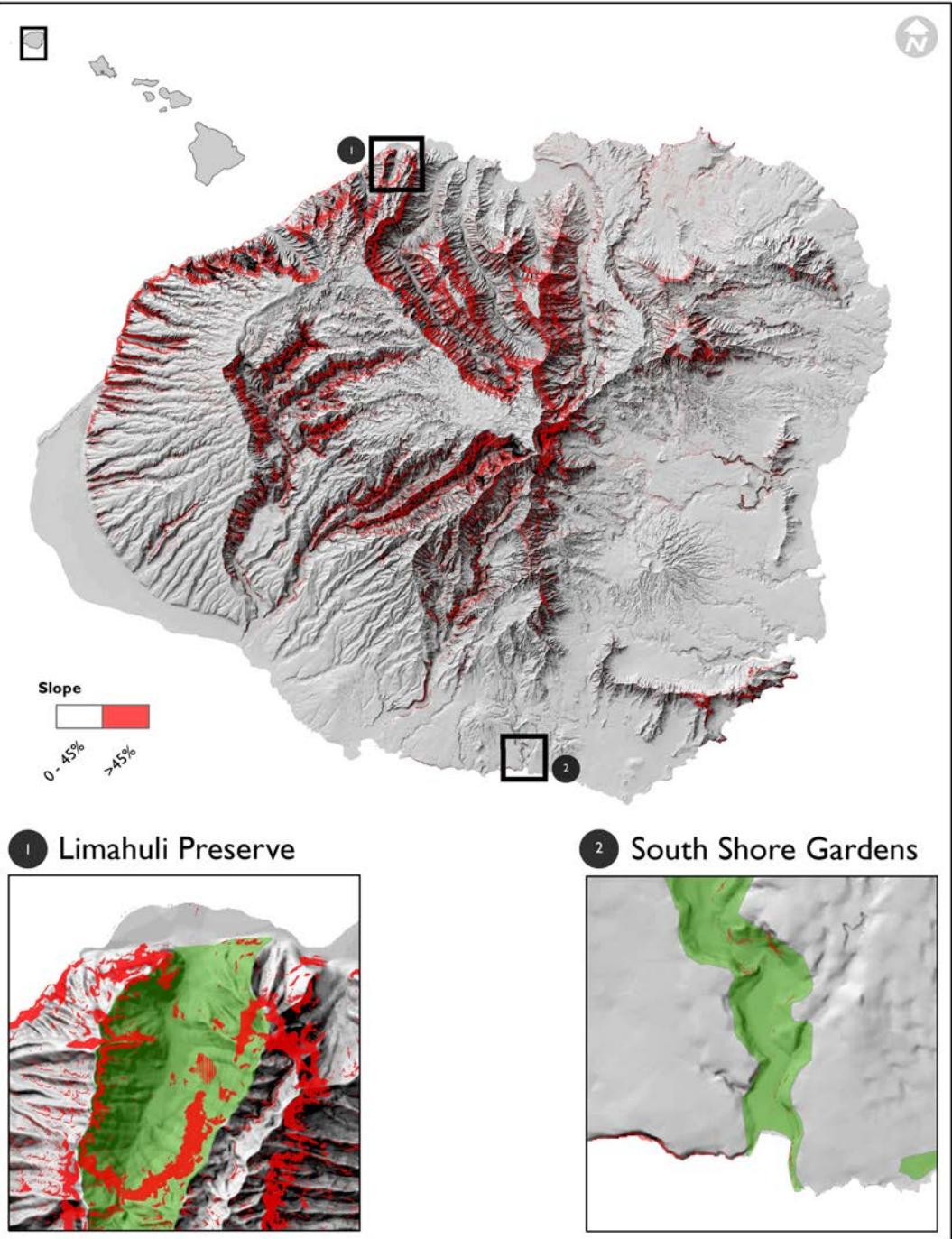
- Discussions with Botanists

- GIS modeling - Potential for rare or endangered plants, and

    High slope cliff areas (>45 degrees)

- Submit Proposals - seeking access and approval for surveys

    on State Land

- Acquire Funding – field trips, and helicopter time

1 **2** **3** **4**

Slope
0 - 45% >45%

① Limahuli Preserve

② South Shore Gardens

PROPOSED TEST SITES

- Safe – No interference with other aircraft
  Low human presence in the area

- Accessible – Easy to get to
  Can repeat missions as needed

- Line of Sight – Survey areas are visible
  Possibility of manual flights

- Small Area – Manageable areas
  One/Two Battery missions

TEST SITE #1

LIMAHULI GARDENS AND PRESERVE

- **Area**
  900-acre Valley
  300-acres in Hanging Valley

- **Biodiversity**
  Second most biodiverse valley
  in the state
  Many highly-endangered plants

- **Cliff Areas**
  800 ft. Cliff and Waterfall separate
  the upper and lower preserve
  Makana – iconic northshore monolith

Image : NaluIsland.com
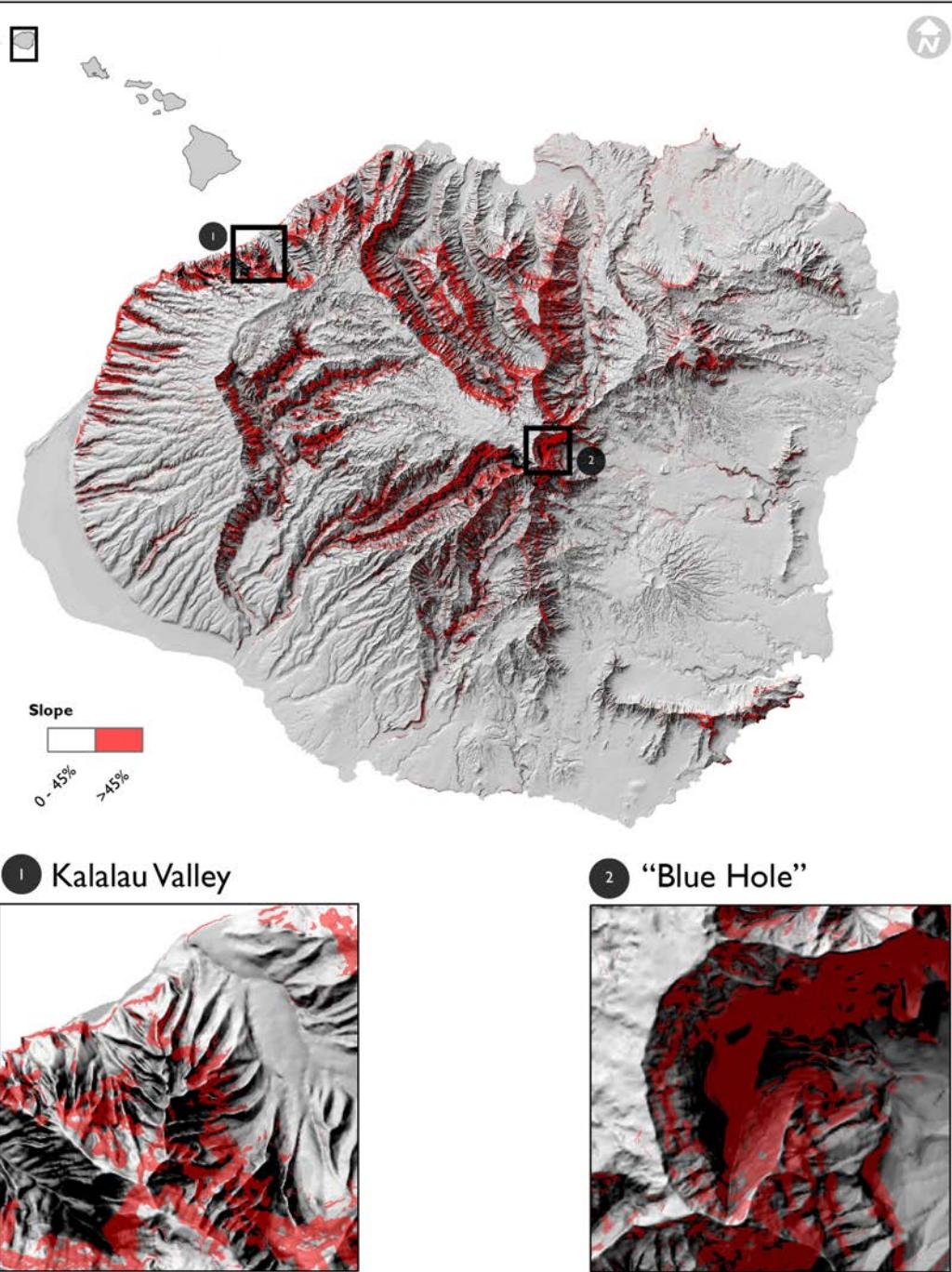
TEST SITE #2

## ALLERTON & MCBRYDE GARDENS

- **Area**
  320-acres
  Two Gardens
  Curated Conservation Collection

- **Biodiversity**
  1000's of rare plants from throughout the tropical world

- **Cliff Areas**
  "Schidea Cliff" used as cliff restoration site
  Rock outcrop near beach featuring many out-planted species

Image : Wikipedia Commons

PROPOSED WORK SITES

- Difficult Access – Cliff Areas (slope over 45%) and remote locations

- High Biodiversity – Areas known to be ideal habitat for many rare species

- Permission – Many areas are on State land Permission to access required

- Under 400 ft Elevation – FAA requires all drones operate under this altitude

Slope
0 - 45%   >45%

1 Kalalau Valley

2 "Blue Hole"

WORK SITE #1

KALALAU/HONOPU VALLEYS

- **Area**
  Entire Valley over 2500 acres
  Area of Interest about 500 acres
  Very remote location

- **Biodiversity**
  Most biodiverse valley in Hawaii
  Many native species found nowhere else

- **Cliff Areas**
  Up to 3000 ft cliffs
  Many very narrow slot canyons


Image : Wikipedia Commons

WORK SITE #2

"BLUE HOLE"
WAI'ALE'ALE CRATER

- **Area**
  Crater area is 100 acres
  Much more if you count the 3D
  surface of the cliffs
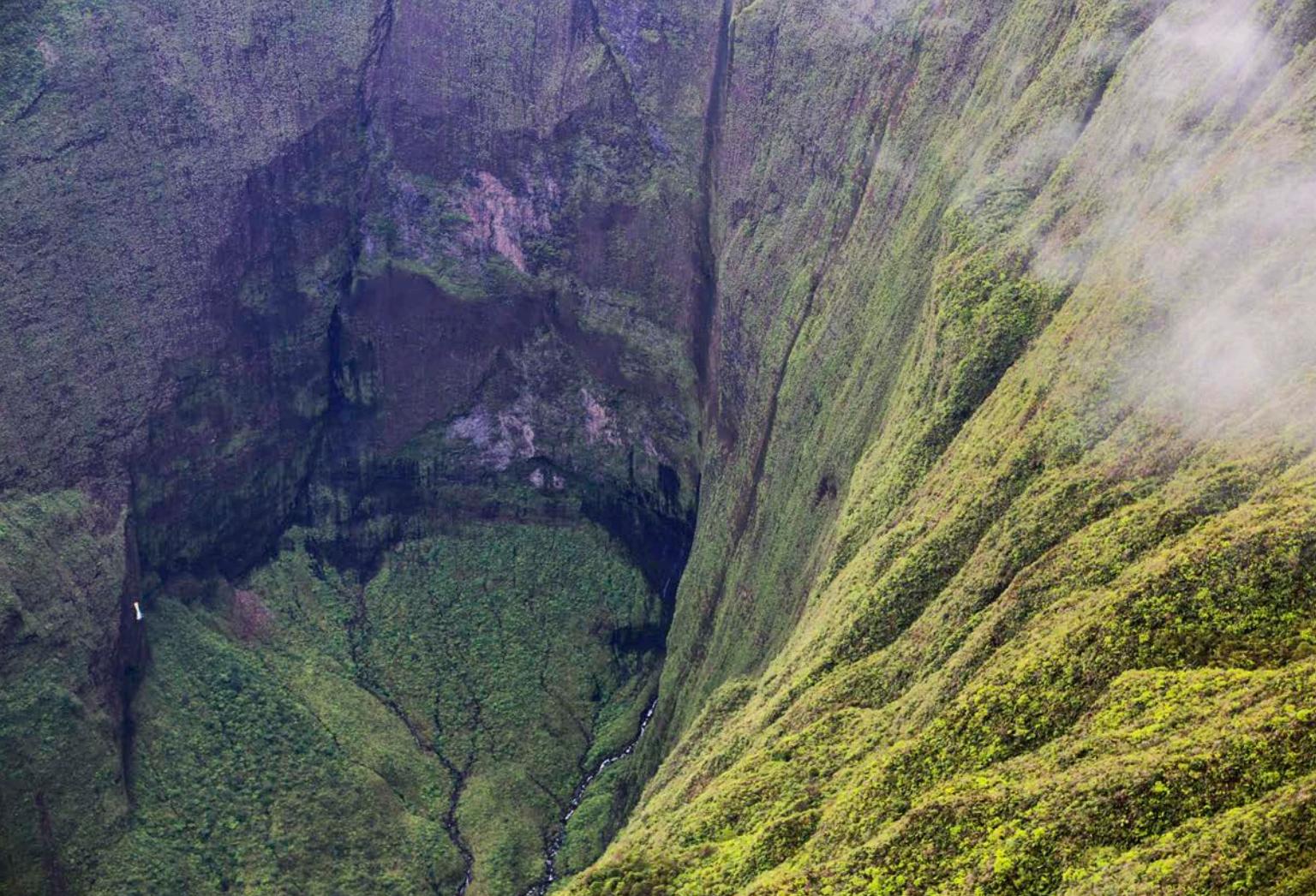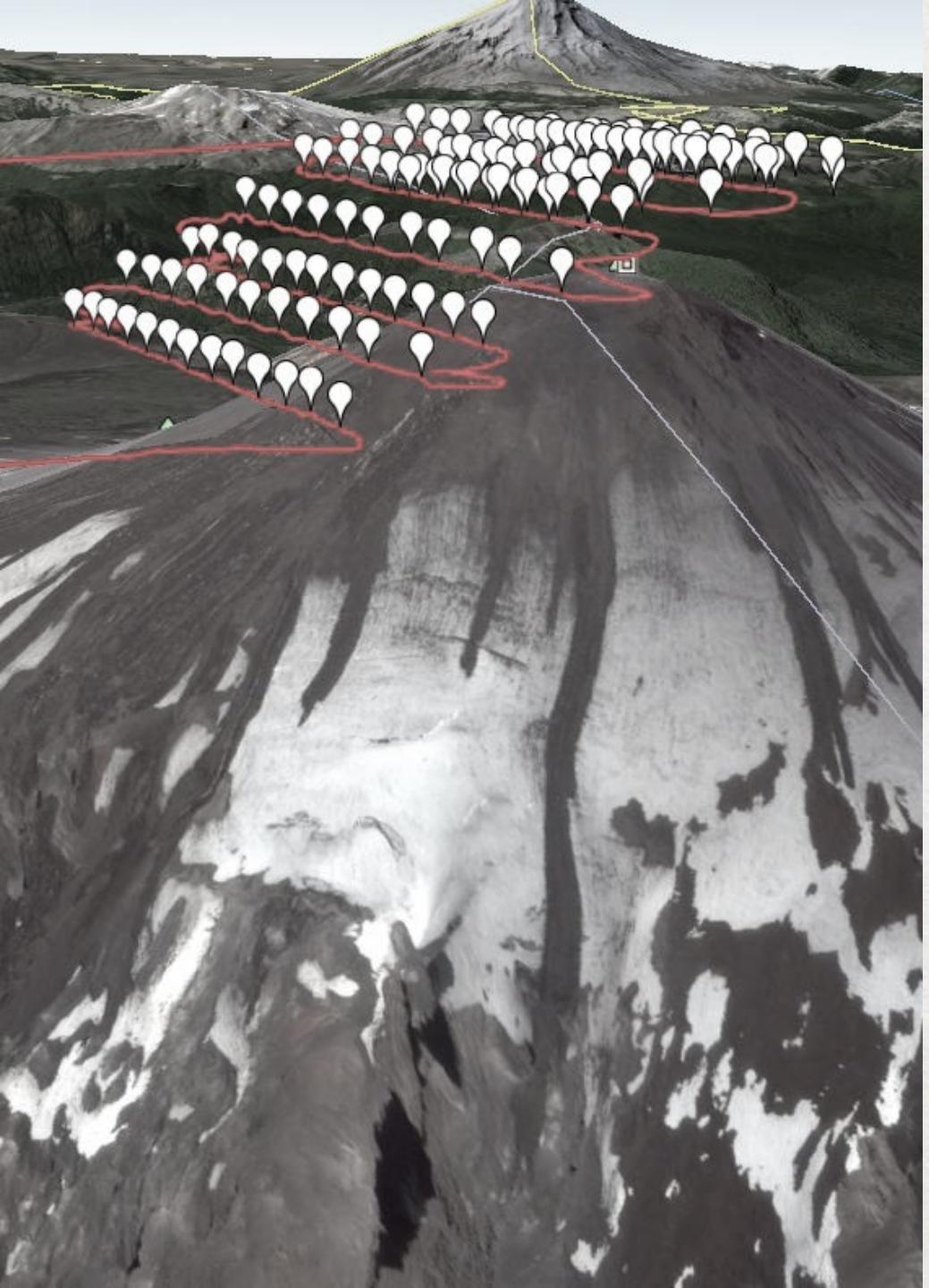
- **Biodiversity**
  Home to a few species which exist
  nowhere else on earth

- **Cliff Areas**
  Over 4000 ft cliffs
  Drains one of the wettest spots on
  earth –Mount Wai'ale'ale

Image : Ben Nyberg

2. TEST SYSTEM

Iterative Process of System Tests
- Flight Planning
- Test Flights – Image Collection
- Image Processing

Proposed 3-step Process
- use manual survey to create high resolution 3D model
- plan automated flight using 3D model
- collect imagery at minimum distance from cliff
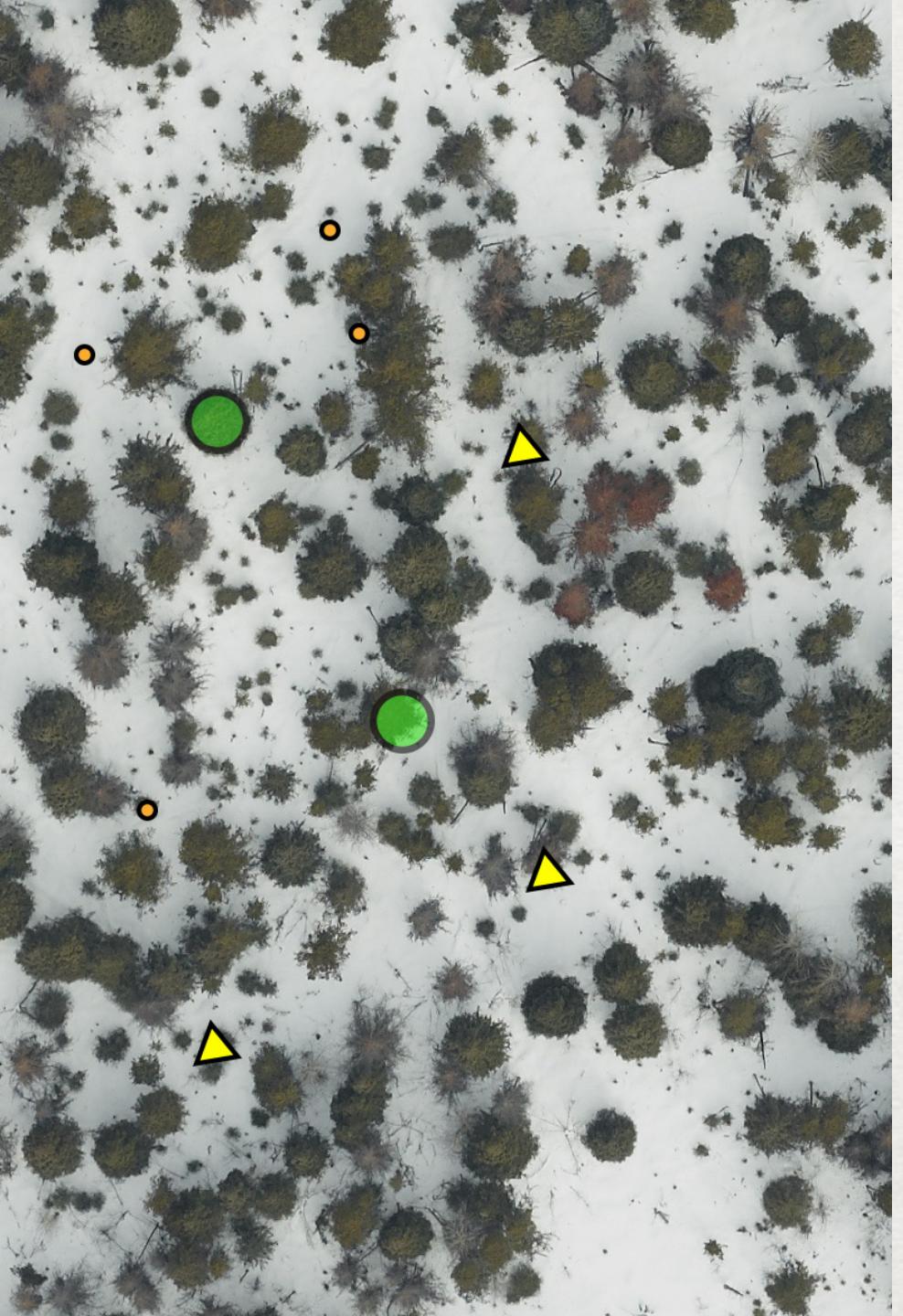
Purchase additional batteries and upgrade processing power of desktop computer

1 **2** **3** **4**

2B. VALIDATION

- Test software to assess error and feasibility

- Use known plant locations as Ground Control Points (GCP) for use in validating results

- Select Ideal system: Flight planning methods and software, Image collection methods and processing software

- Acquire necessary software licenses

**1** **2** **3** **4**

3. DATA COLLECTION & PROCESSING
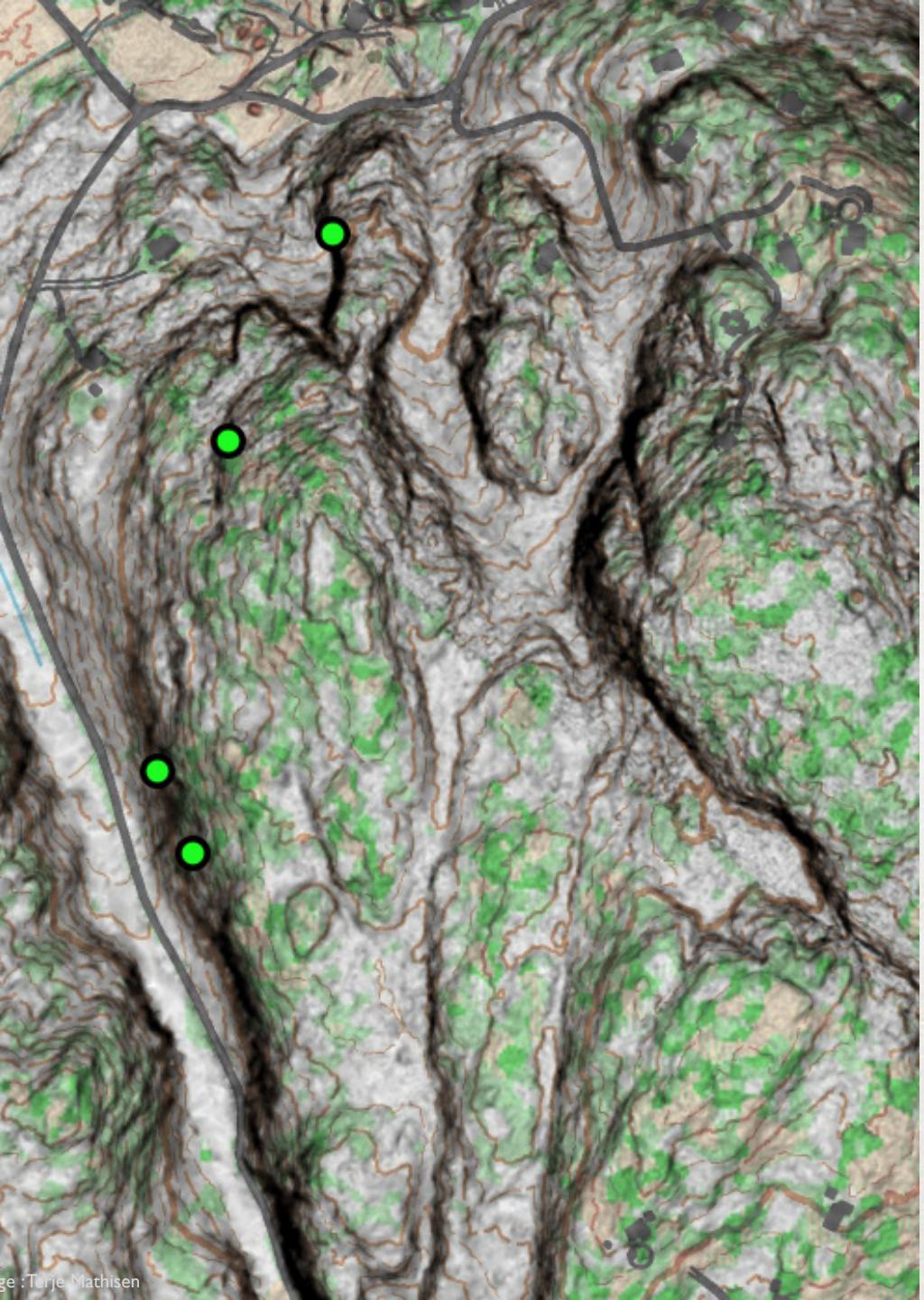
- Schedule field trips and coordinate with partners

- Carry out field work and UAV flights.
  This may take multiple trips into the field per location.

- Process data using Structure from Motion software to produce Orthophotos, DEM's, and 3D models

1 **2** **3** **4**

4. CREATE MAP PRODUCTS & "RECOMMENDED PROCEDURES" DOCUMENT

- Use collected imagery to locate and map plants with the help of botanical experts

- Produce maps to assist field missions to collect seed or cutting from these plants

- Complete final report summarizing my findings

- Create Step-by-Step Guide to replicate the survey

> 1 > 2 > 3 > 4

IMPLICATIONS

- Increased Safety
  - Provide access to dangerous locations

- More Efficient
  - Ability to survey larger areas in less time

- Rare Plant Discoveries
  - Increased genetic diversity of collections
  - Additional source for seed and cuttings
  - Updated habitat requirements
  - Guides further explorations

- Application to other fields
  - Bridge/Utilities surveys (Dams, Power infrastructure, etc.)
  - Geological Surveys (Resource exploration, Geomorphology)
  - Biological Surveys (Bird nests, Bee hives, etc.)

TIMELINE

	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Identify Study Areas	8 weeks								
Testing Systems		8 weeks							
Validation and Review			6 weeks						
Data Collection					10 weeks				
Processing						6 weeks			
Report and SOP								6 weeks	
Presentation									4 weeks

ACKNOWLEDGEMENTS

- Joe Bishop – Penn State Advisor
- Ken Wood – NTBG Botanist
- Ryan Perroy – University of Hawaii Drone Specialist
- ESRI Support – Troubleshooting GIS Issues
- Noun Project – Awesome Design Stock

THANK YOU.

QUESTIONS OR COMMENTS ?

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