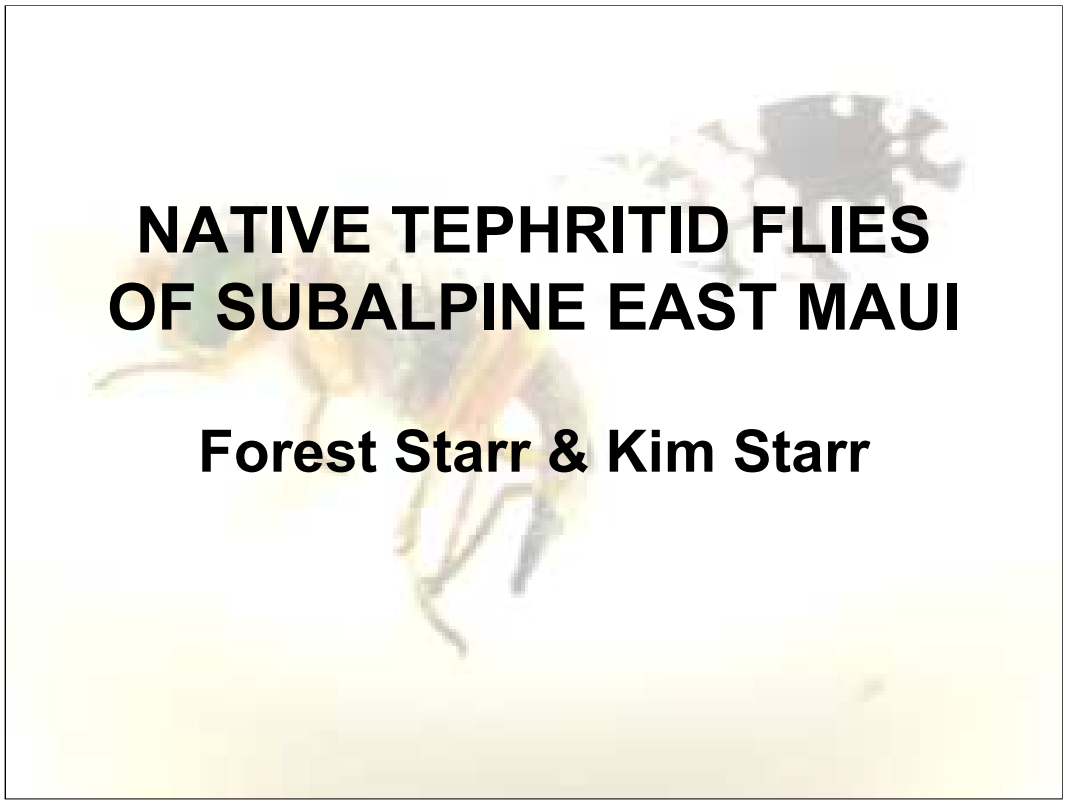


Today we're going to be talking about the Native Tephritid Flies of Subalpine East Maui.

TEPHRITID FLIES

Diptera: Tephritidae

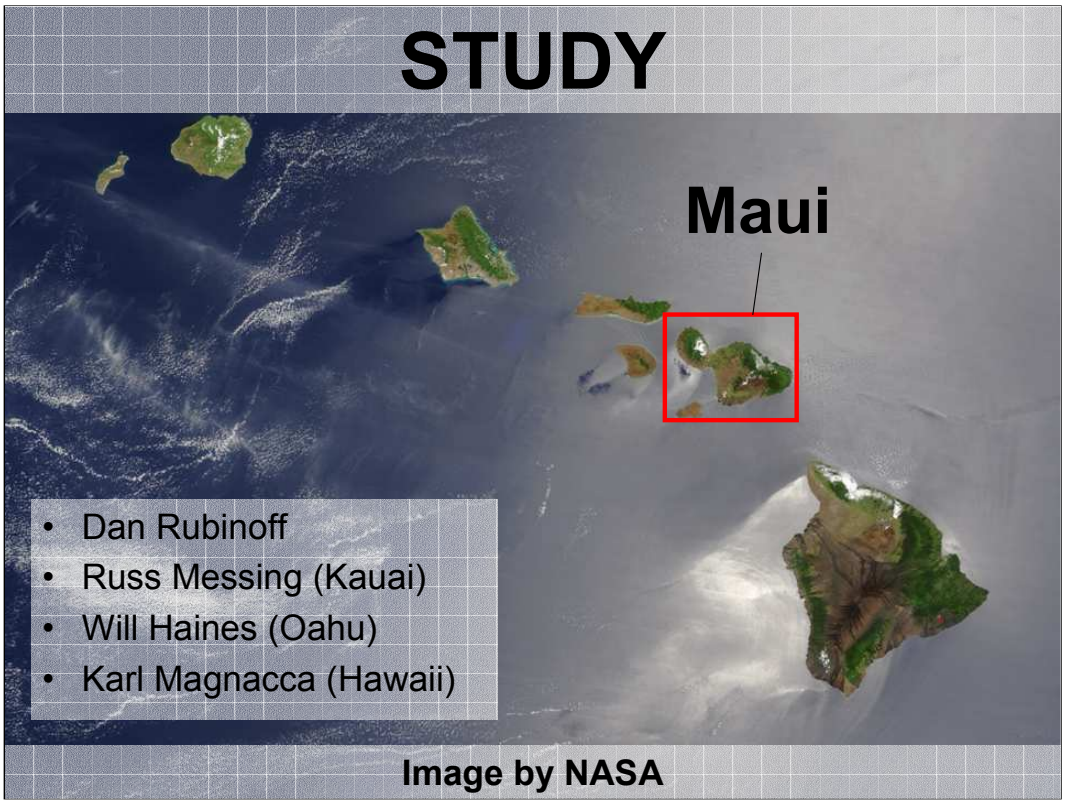
Here's a native Tephritid fly, Trupanea crassipes. It used to be common in the lowlands, even in Honolulu, but is now mostly restricted to high elevations on East Maui.

PREVIOUS COLLECTORS

- **Perkins** (Early 1900's)
- **Swezey** (1918 - 1934)
- **Bryant** (1932)
- **Kraus** (1947)
- ***Hardy** (1950s - 80s)
- **Beardsley** (1950s - 60s)
- **Montgomery** (1970s - early 80s)
- **Gagne** (1970s - early 80s)
- **Herr** (Late 1980s - early 90s)
- **Kaholoaa** (1990s - present)
- **Messing** (1990s - present)
- ***Brown** (2000 - present)
- **Starr**, **Haines**, & **Magnacca** (2010 - present)

Photo by Steve Montgomery

There have been a number of workers who have collected native Tephritid flies. Of these, Hardy described the most species. Today Jackie Brown has the best handle on the group. This is Betsy Gagne looking for Tephritids back in the day.



This project was spearheaded by Russ Messing and Dan Rubinoff. The goal was to update the distribution of native Tephritid flies in Hawaii. We did the field work on Maui. Similar field work was done on Kauai by Russ, on Oahu by Will Haines, and on the Big Island by Karl Magnacca.

There were two main methods used for finding flies, sweeping, as Kim and Raina are doing here in Haleakala National Park.

And host searching, looking for immatures, as Russ and I are doing here in a Tephritid hot spot further down the mountain.

We searched in high dry places, such as the seemingly barren Haleakala Crater.

In very wet places, such as the rain forest of Waikamoi.

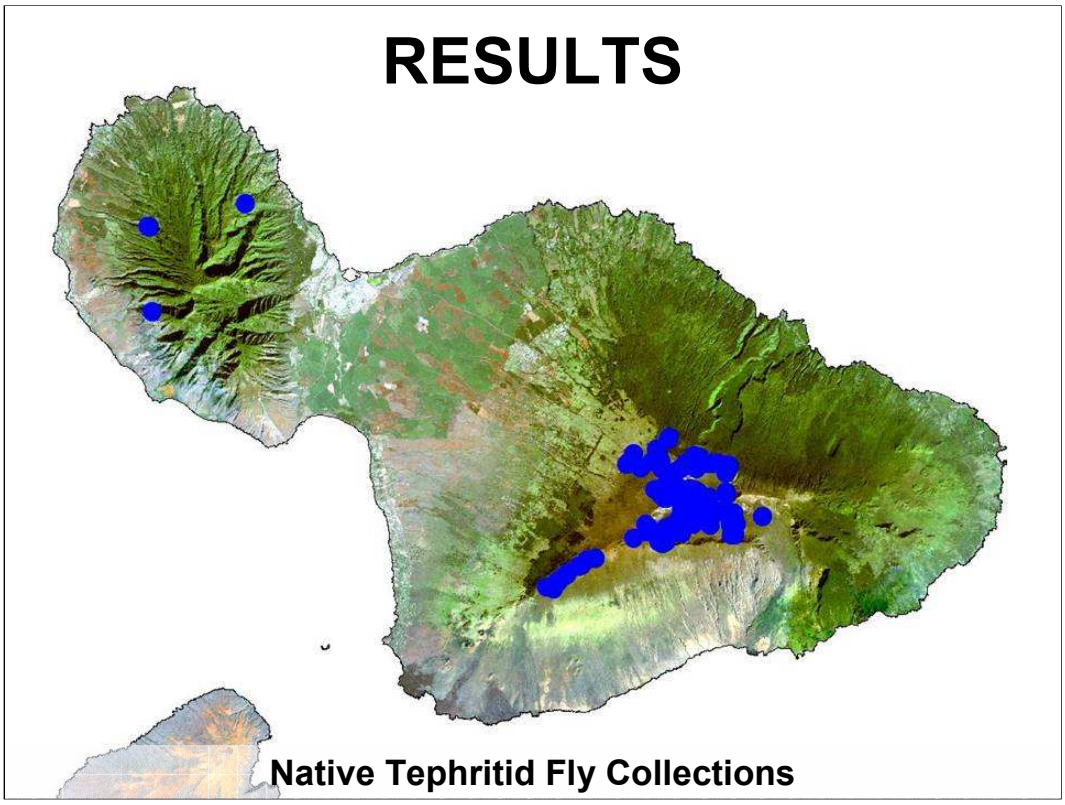
And in mesic areas, like the Honokowai Ditch Trail on West Maui.

Rearing

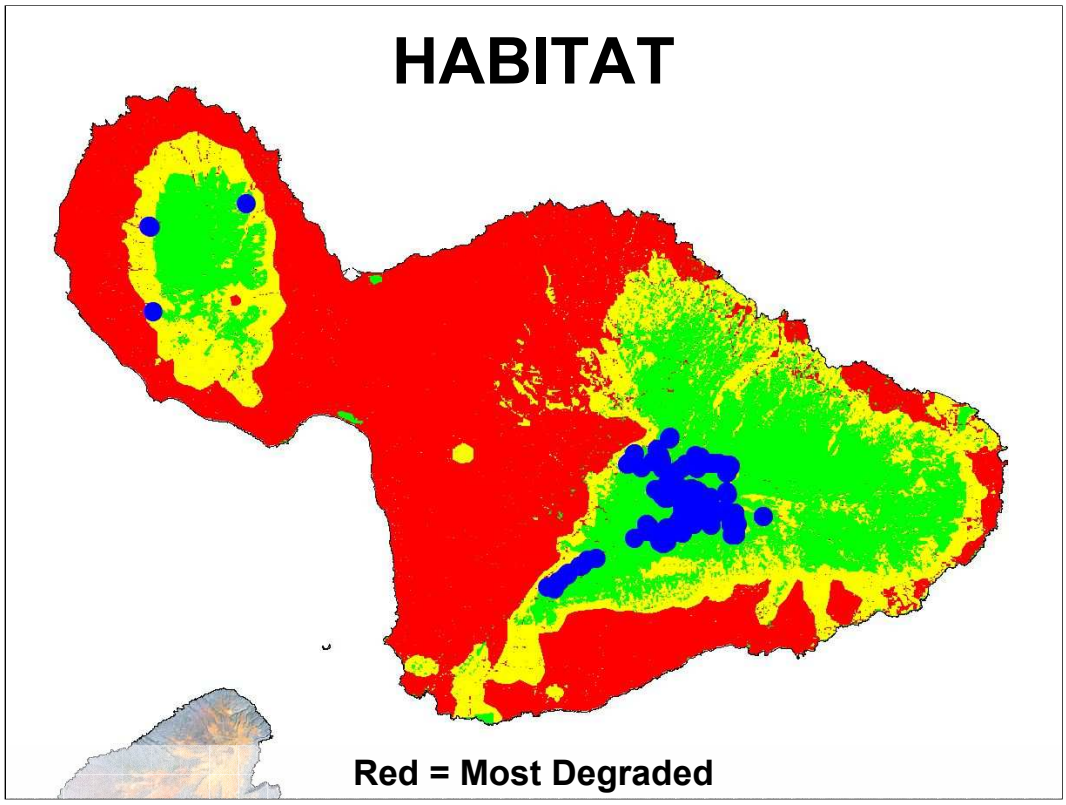
Collected material was brought to the lab and immatures reared.

Archiving

Vouchers were pinned, labeled, databased, and archived at the University of Hawaii.



So what did we find? Well, there are a lot of native Tephritid flies in sub-alpine East Maui. To some extent this is a function of our research on Silverswords and Fireweed, which gets us into these areas on a regular basis. However, that doesn't explain the lack of collections in the lowlands, where we do widespread work on Invasive Species.



What seems to be happening is the flies are mostly restricted to the least degraded areas, highlighted here in yellow and green.

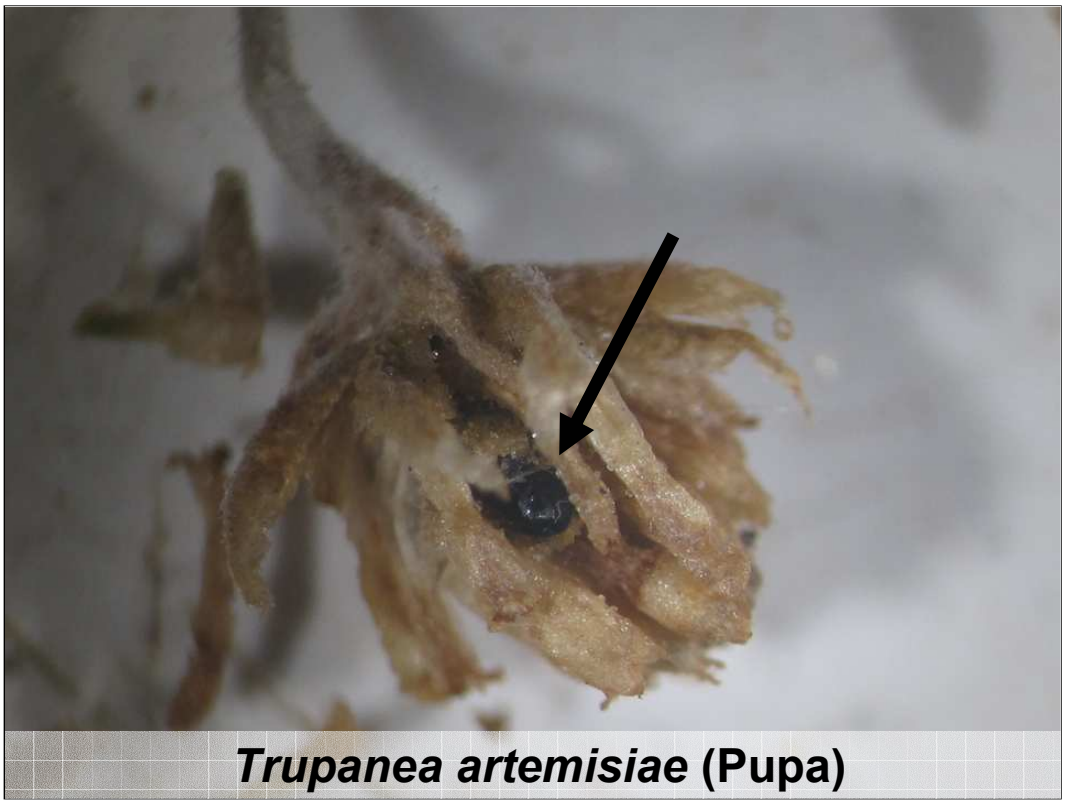
Here's one of the least degraded areas in Hawaii, Haleakala National Park. This is native Tephritid fly heaven, and the focus of this talk.

There are three main larval sites for native Tephritid flies: seed heads, shoot tips, and stem galls.

There are four genera of host plants for native Tephritids in Subalpine East Maui, all Asteraceae: Artemisia, Bidens, and the tarweeds Dubautia, and Argyroxiphium.

The first of these is Artemisia, which often hangs off cliffs. When we asked Steve Montgomery about tips for collecting from Artemisia he suggested spiked tobbies and net pole extensions.

Here's the flowers, where the larvae occur.



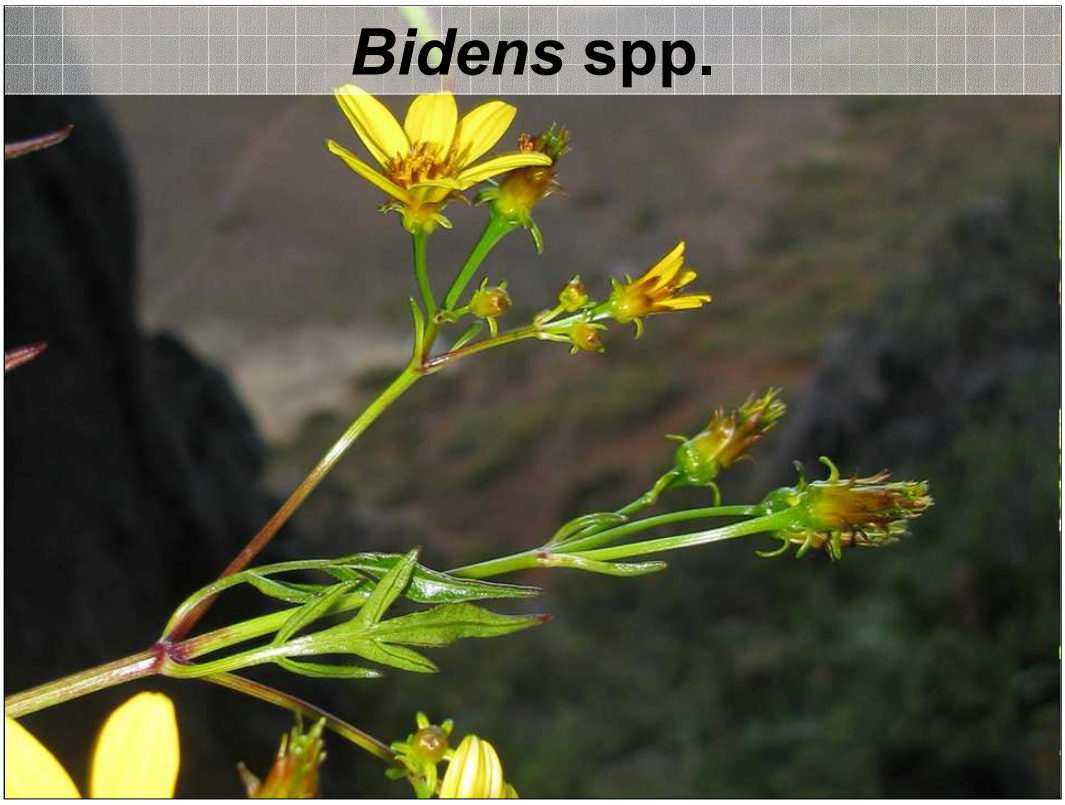
***Trupanea artemisiae* (Pupa)**

Here's an older seed head with a pupa.

***Trupanea artemisiae* (Adults)**

And the adult flies that emerge, Trupanea artemisiae.

Bidens spp.



Bidens is another favored host plant for native Tephritid flies.

Stem gall in *Bidens micrantha*
***Phaeogramma* sp.**

Here's a stem gall in Bidens. These have been collected barely a dozen times ever, and are difficult to rear, but we found them to be locally abundant in parts of West Maui.

Here's what that gall looks like in cross-section.

Dubautia spp.

Dubautia is a large genus and is a host for the most native Tephritid flies.

Pupa - *Trupanea cratericola*
Seed Head - *Dubautia menziesii*

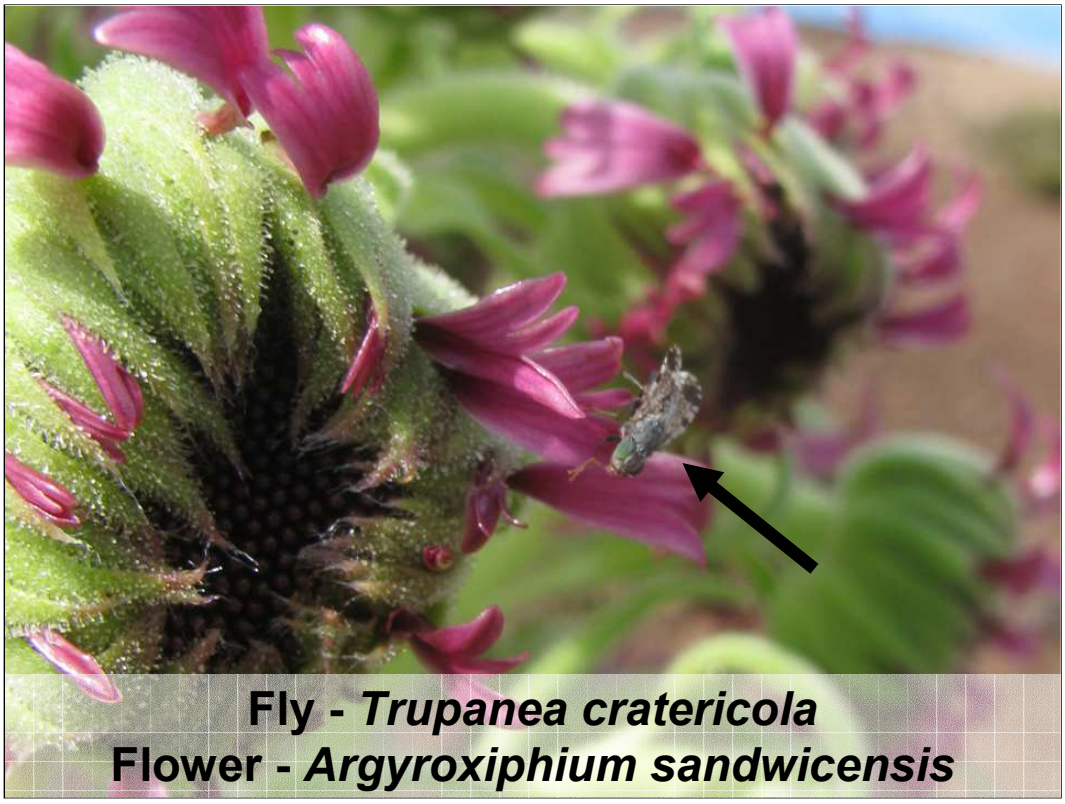
This is Trupanea cratericola in a seedhead of Dubautia menziesii. This is the most common plant / fly combination in subalpine East Maui. The flies peak in the Fall, in conjunction with Dubautia flowering.

Shoot Tip - *Dubautia menziesii*
Pupa - *Trupanea limpidapex*

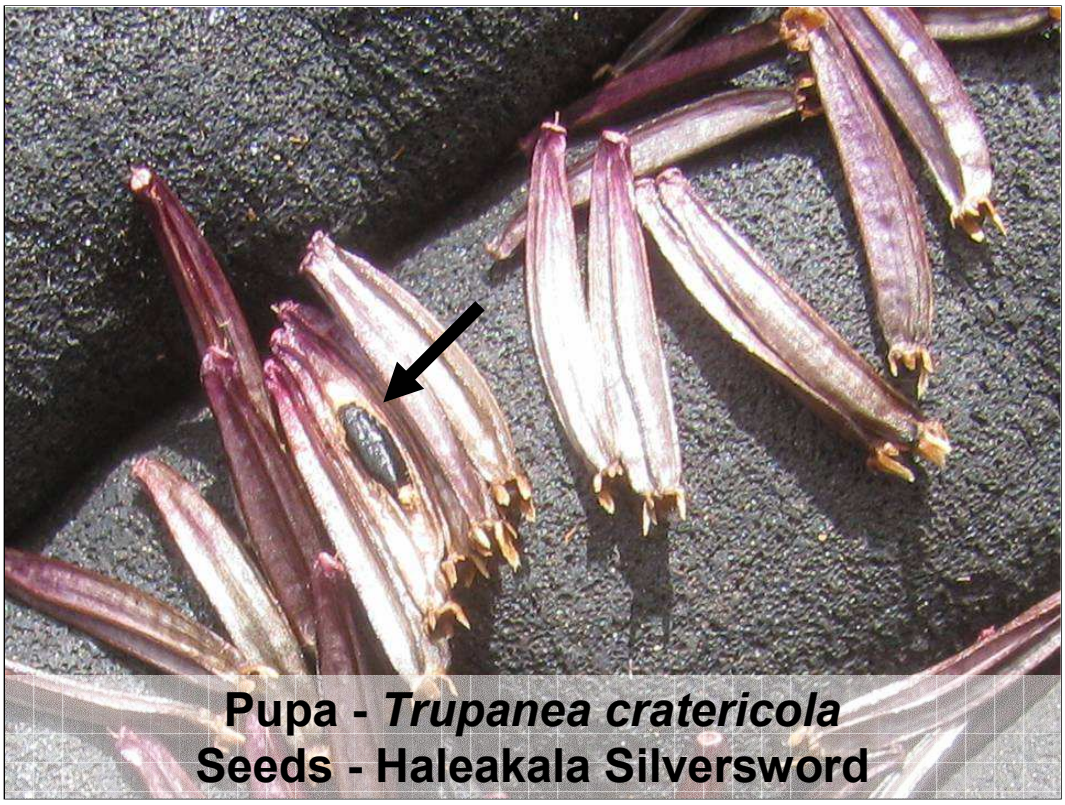
Less common, but still widespread, are the shoot tip flies, which peak in late Spring.

The rarest and most difficult to find and work with are the stem gallers. This is a pupa of an undescribed species from a Dubautia in Waikamoi.

Silverswords are great Tephritid food, an oasis in a barren landscape.



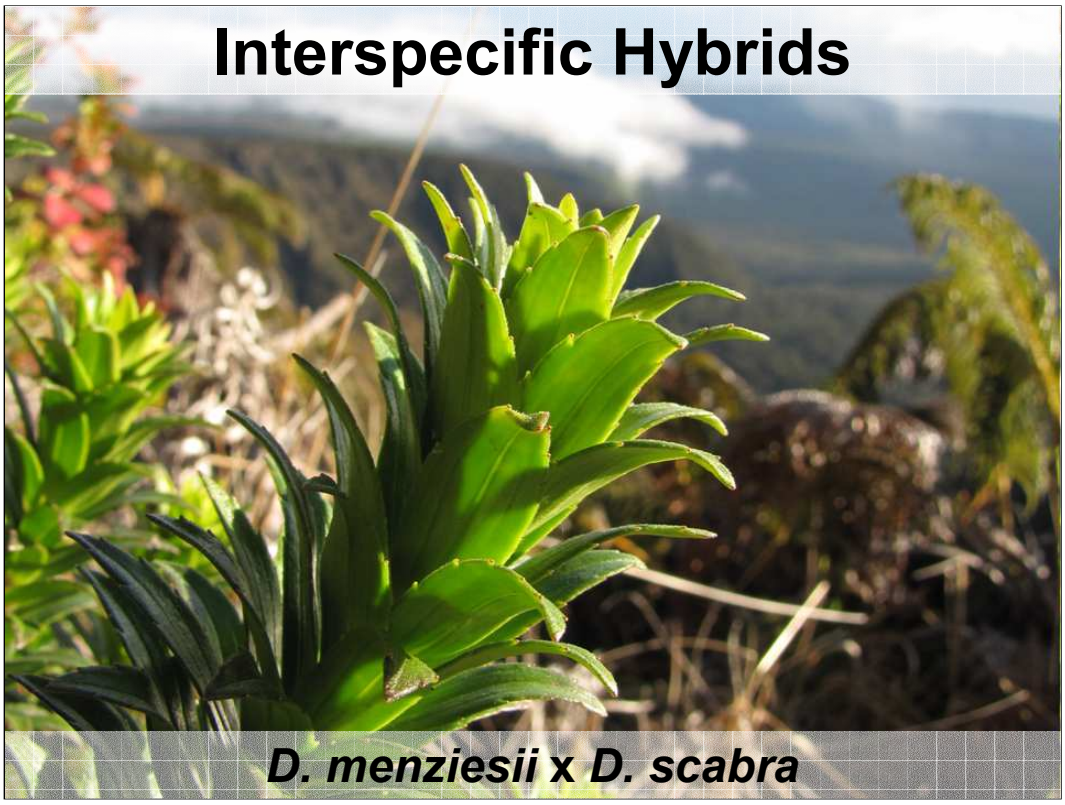
Here's a native Tephritid eyeing a silversword flower, wondering how many keiki she can stuff in there.



Here's a pupa in silversword seeds.

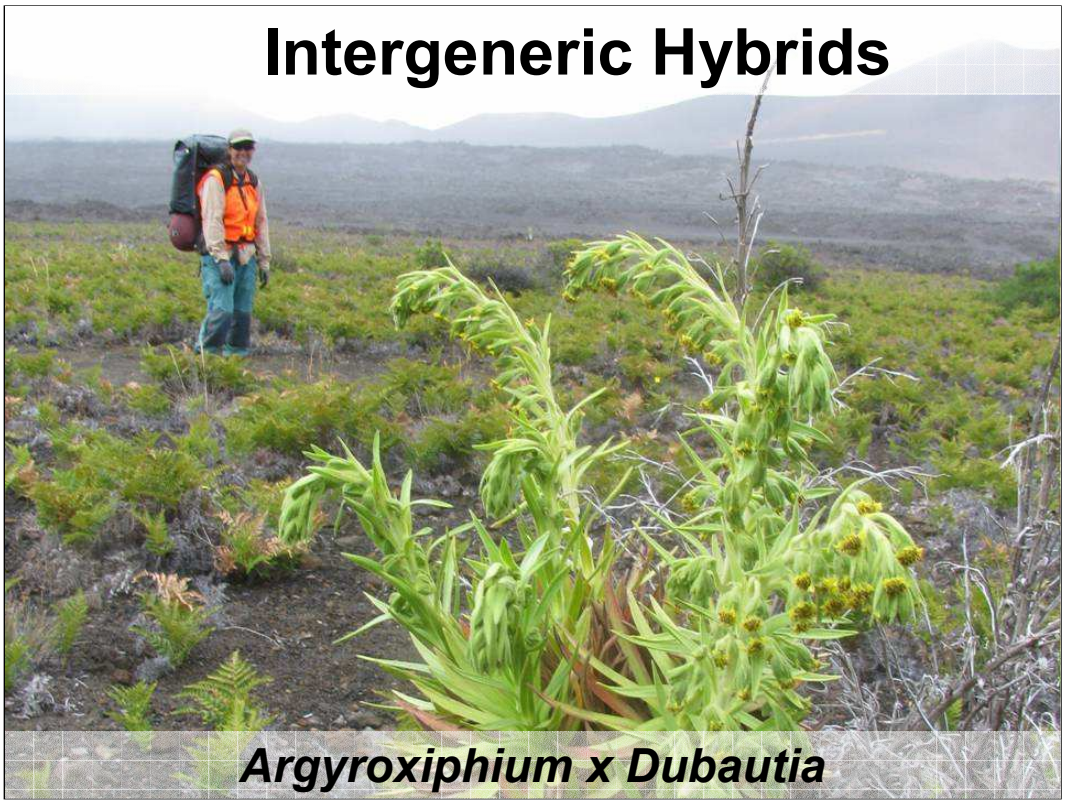
***Trupanea cratericola* (Female)**

And the adult fly that emerges, ready to start the cycle over again.



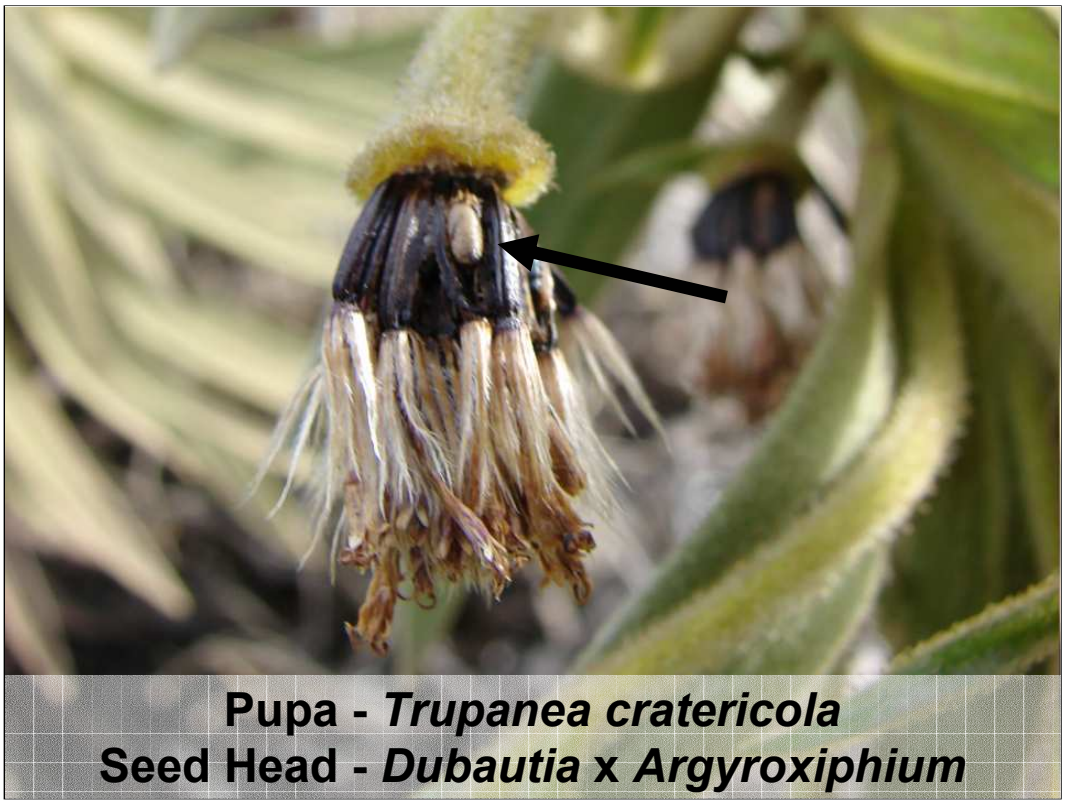
Do hybrids have flies? You bet. The same fly species occur on this hybrid as on nearby parent taxa.

Intergeneric Hybrids



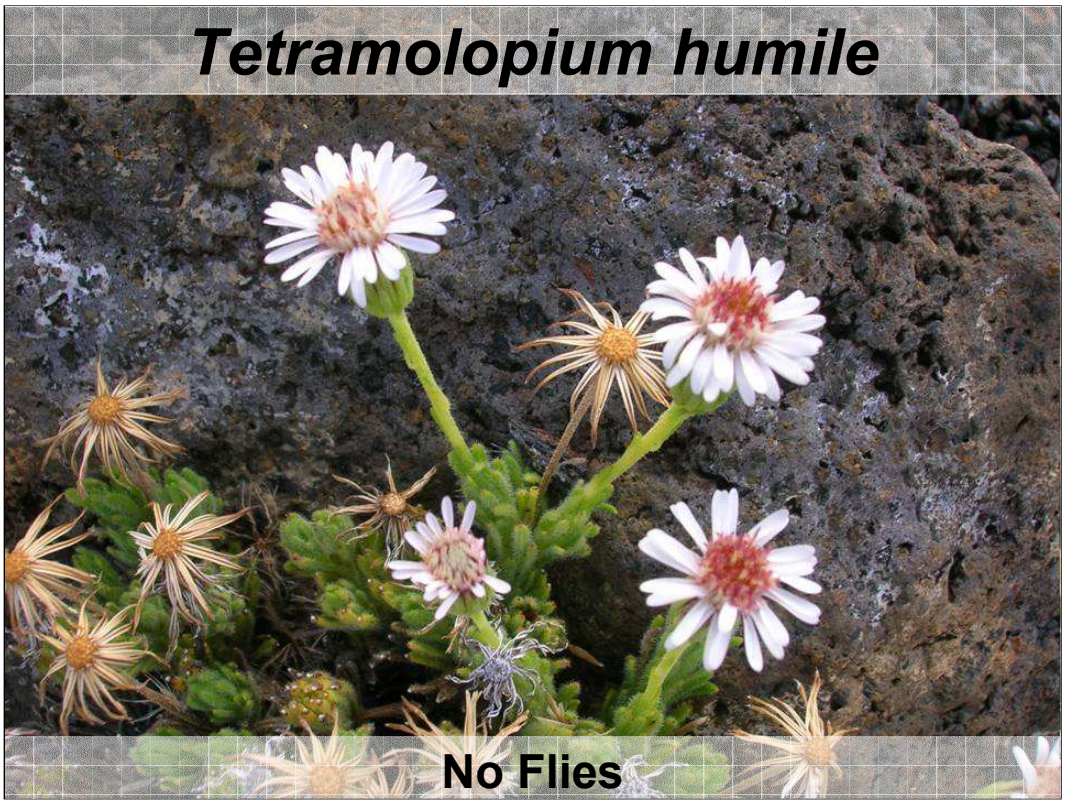
Argyroxiphium x Dubautia

The same holds true for inter-generic hybrids. No one had documented Tephritids from Silversword / Dubautia hybrids.



Pupa - *Trupanea cratericola*
Seed Head - *Dubautia* x *Argyroxiphium*

But sure enough, when we looked, they were there.

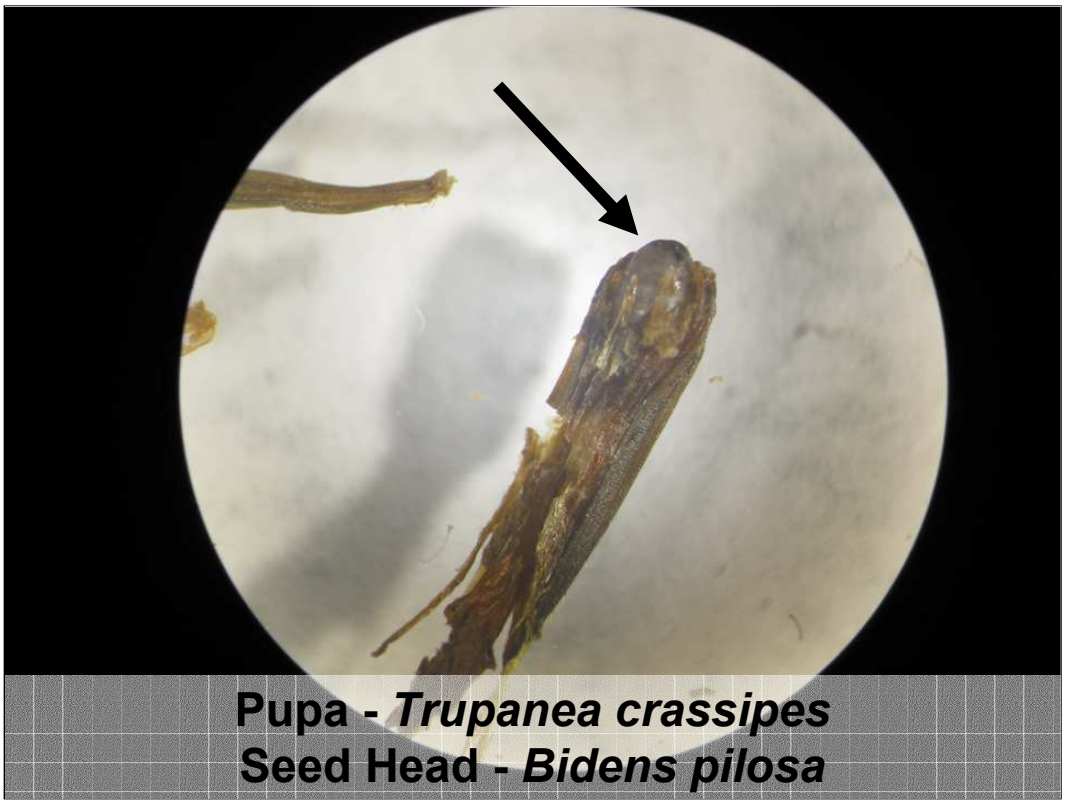


Not all native Asteraceae support native Tephritids though. We found no Tephritids on Tetramolopium.

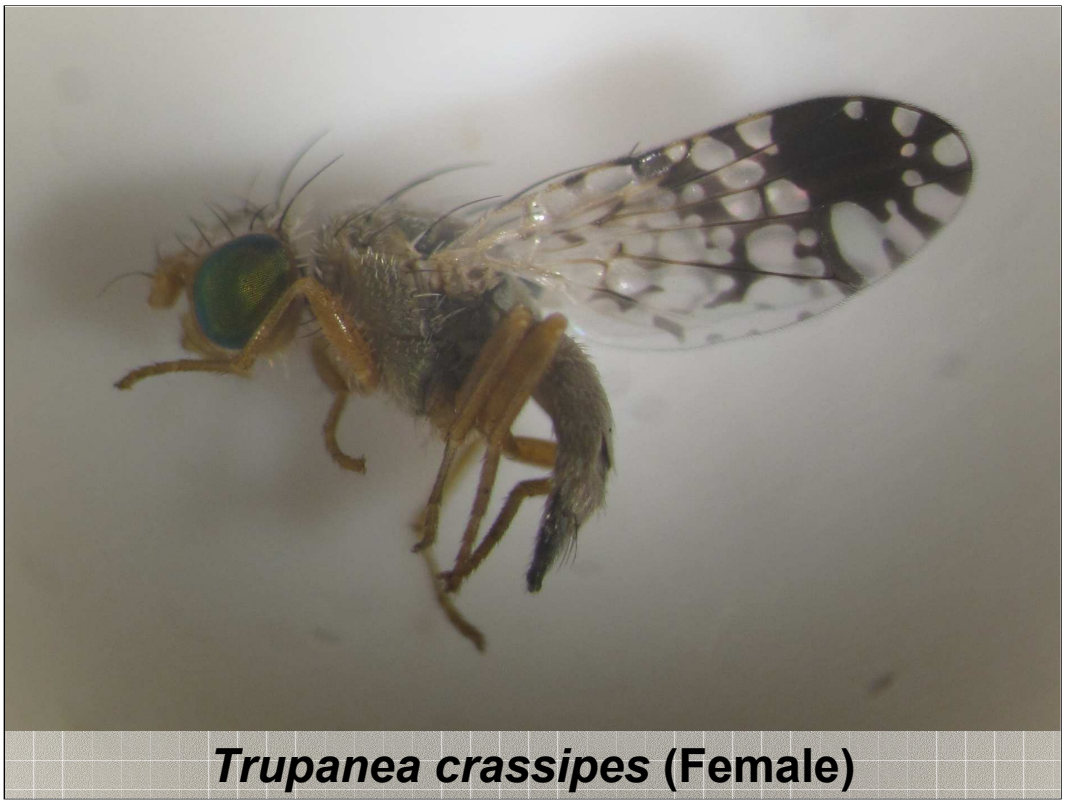
Likewise, most non-native Asteraceae, such as Heterotheca also failed to produce native Tephritids.

However, there was one exception, the non-native Bidens pilosa, which appears to be the current primary host for the native Trupanea crassipes.

You're likely familiar with Bidens pilosa, it isn't the most fun plant to work with. This boot is having a bad shoelace day.



But it seems to be working for Trupanea crassipes. Here's a pupa in a seed cluster.



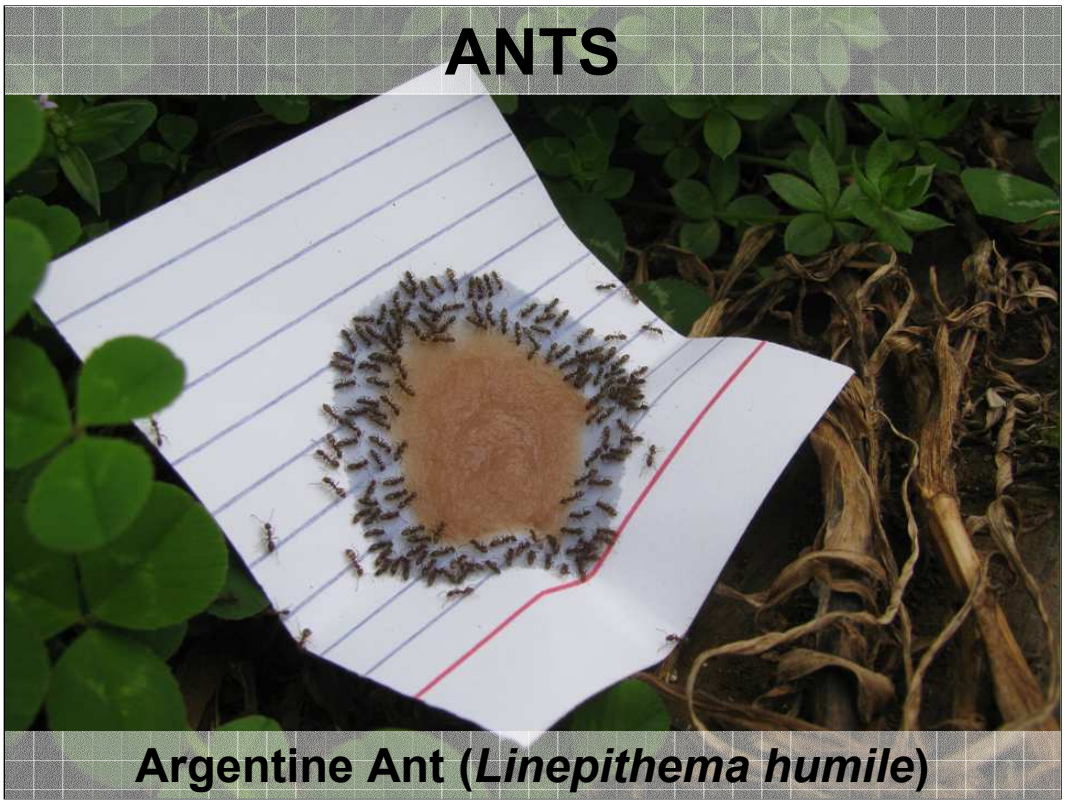
***Trupanea crassipes* (Female)**

And the adult fly that emerges from it, our old friend Trupanea crassipes, ready to start the cycle over again.

THREATS

But not all is easy living in the Tephritid world. While we're snug as a bug in our houses and cabins, they must survive out in the wild, in a world that is very different than it was before humans arrived to these islands.

ANTS



Argentine Ant (*Linepithema humile*)

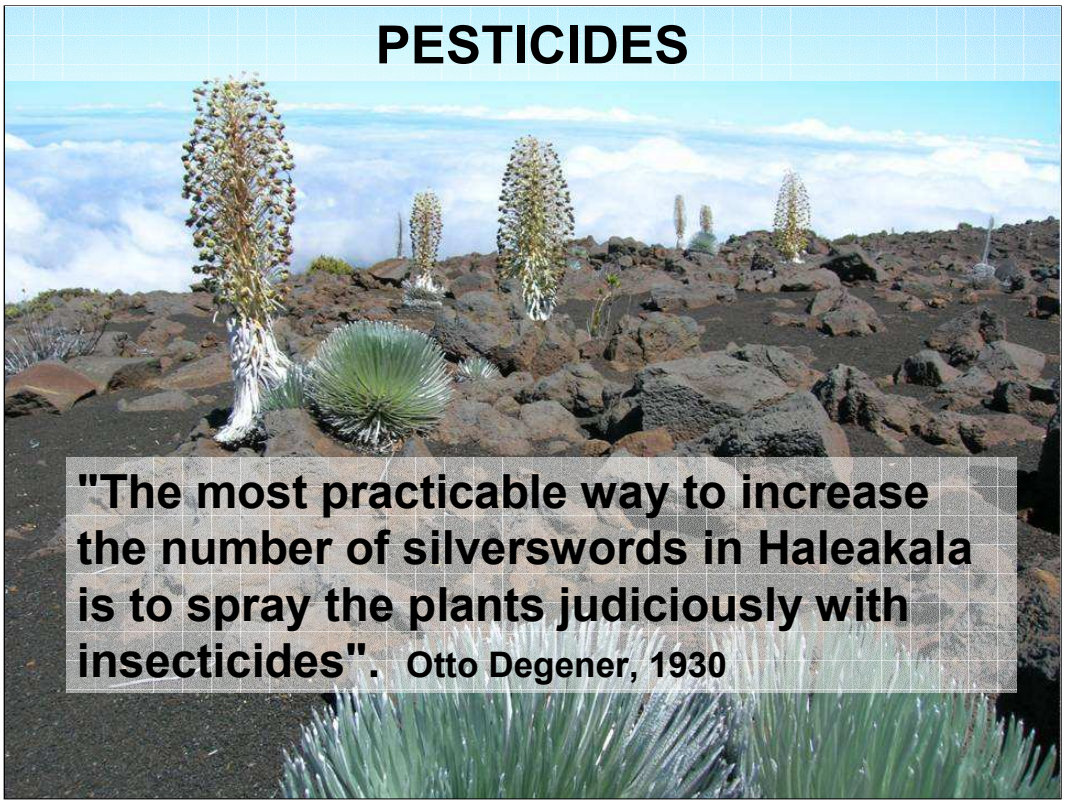
Ants pose a threat to the native arthropod fauna. How are the native flies affected? We don't know the nuances, but Tephritid flies seem to be able to survive and reproduce in ant infested areas.

WASPS

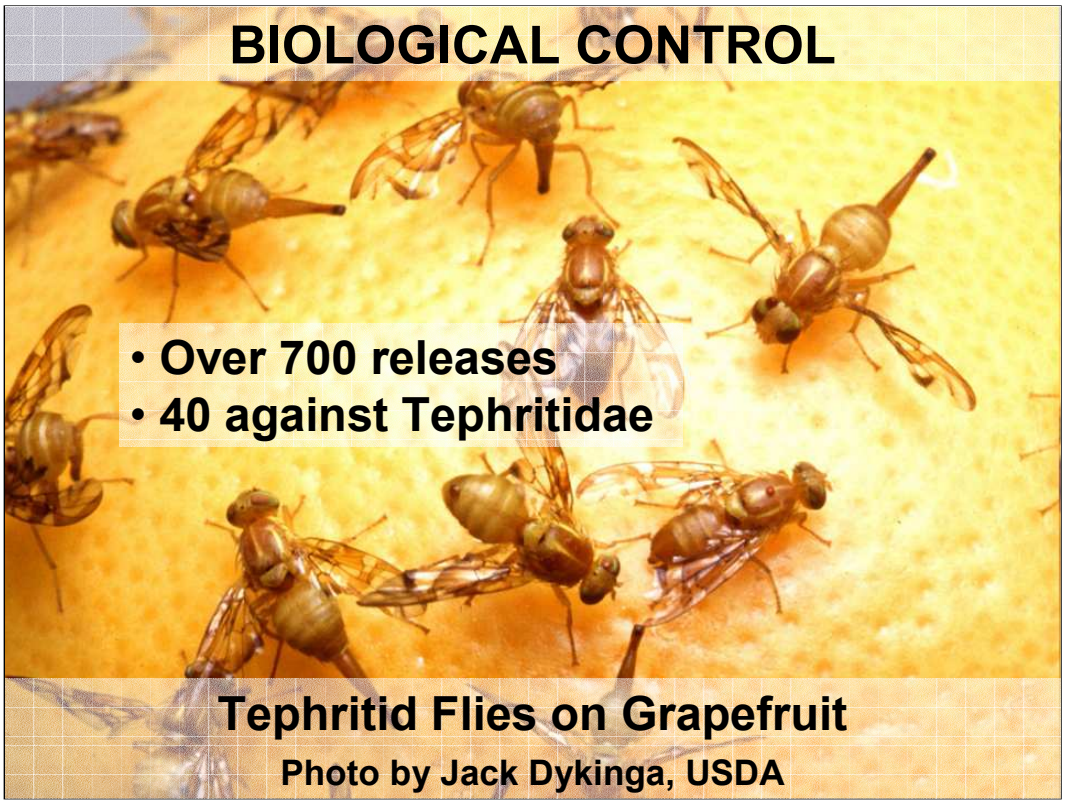
Yellow Jacket (*Vespula pensylvanica*)

The same is true for Vespula wasps.

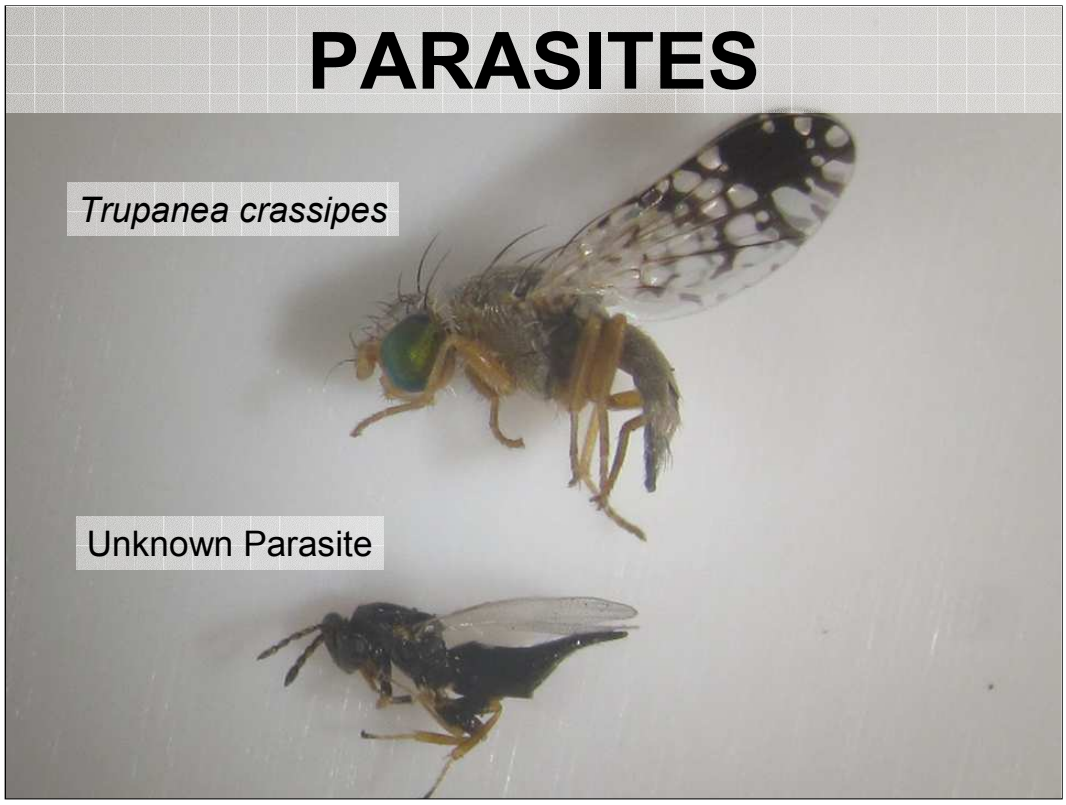
A nest like this brings in thousands of prey items per hour, yet somehow the Tephritids are able to survive in Vespula infested areas.



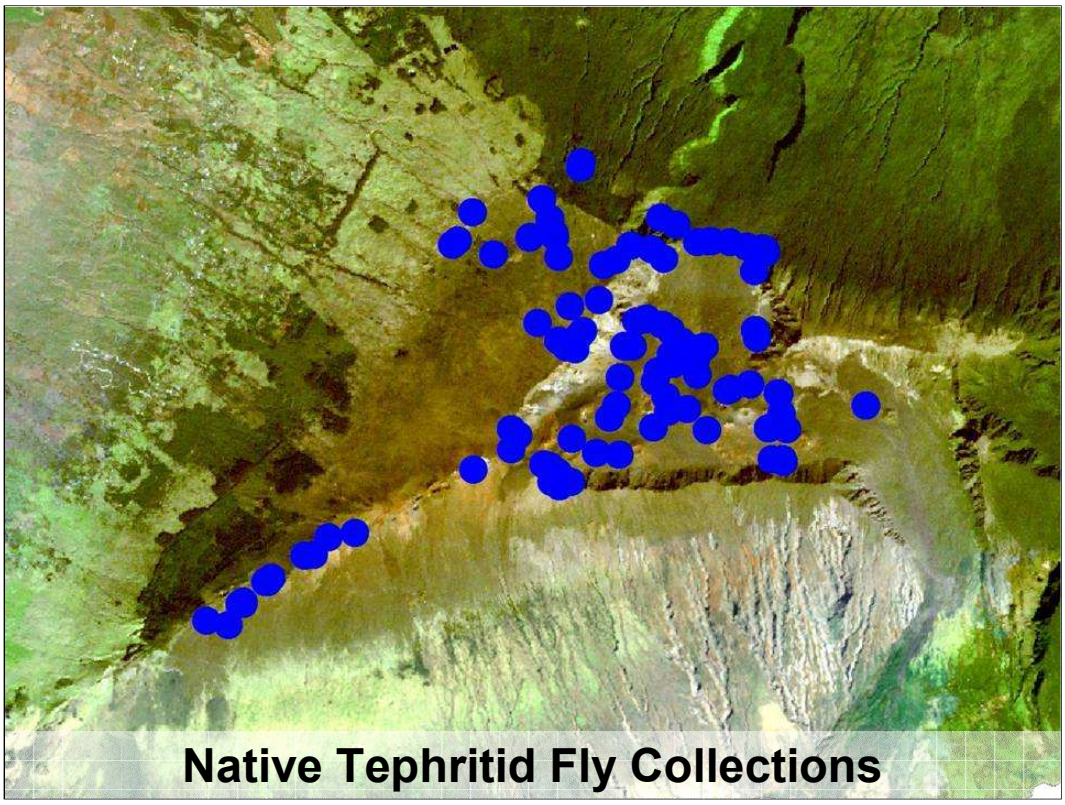
Native Tephritids attack native plants. Otto Degener decried "The most practicable way to increase the number of silverswords in Haleakala is to spray the plants judiciously with insecticides". Which they did for a few years, but it didn't work. It wasn't until 50 years later folks figured out silverswords are self-incompatible. By spraying the plants they were killing the pollinators.



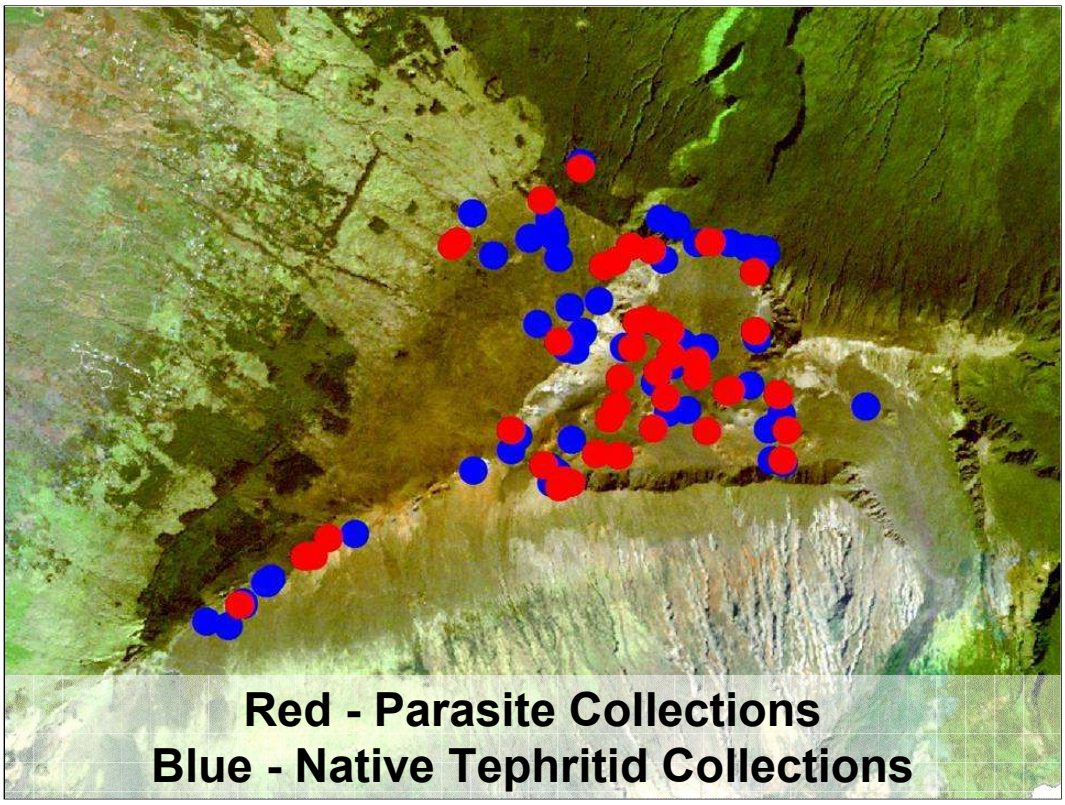
Over 700 organisms have been released for biological control in Hawaii, more than any other place in the world. Of these 40 have been against Tephritid flies. Despite these efforts, non-native fruit flies still pose a major burden for Hawaii Agriculture. As a result, there likely will be future introductions against Tephritids. To date there has been no record of purposely introduced organisms attacking native Tephritids.



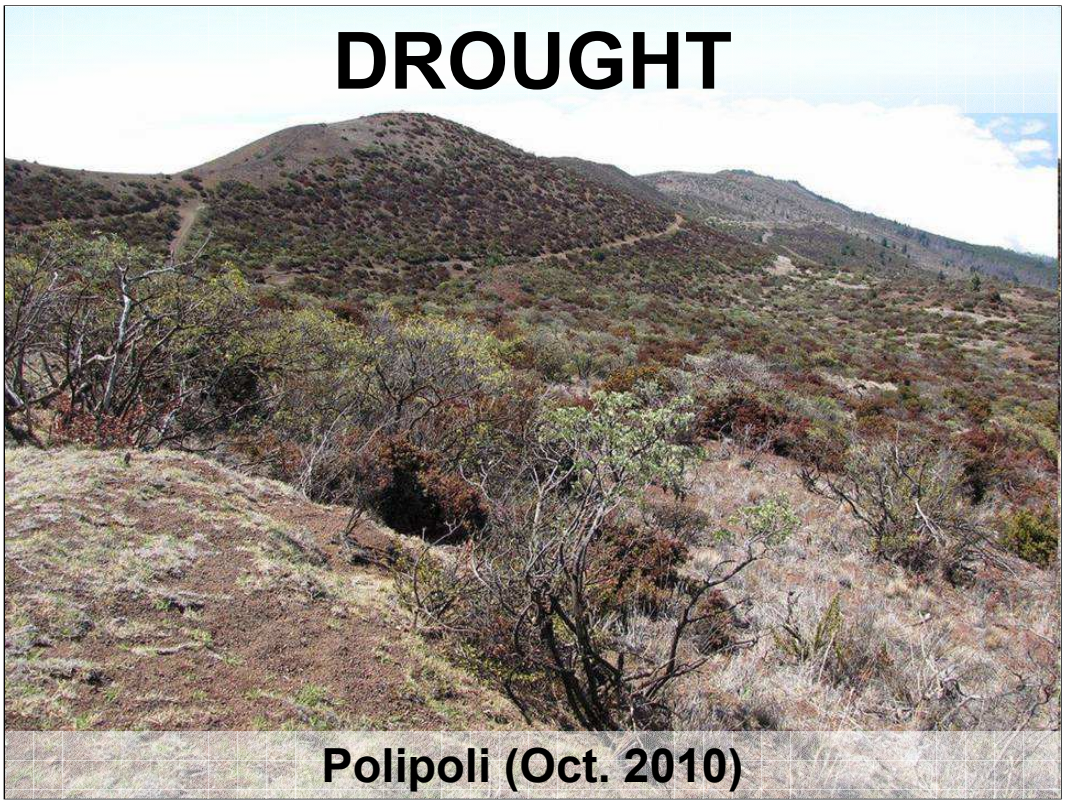
There are however many parasites attacking native Tephritids. We have yet to identify the material we collected, but previous work suggests these parasites are accidentally introduced species, rather than purposely introduced or native species.



Here are the places we found native Tephritids in subalpine East Maui.



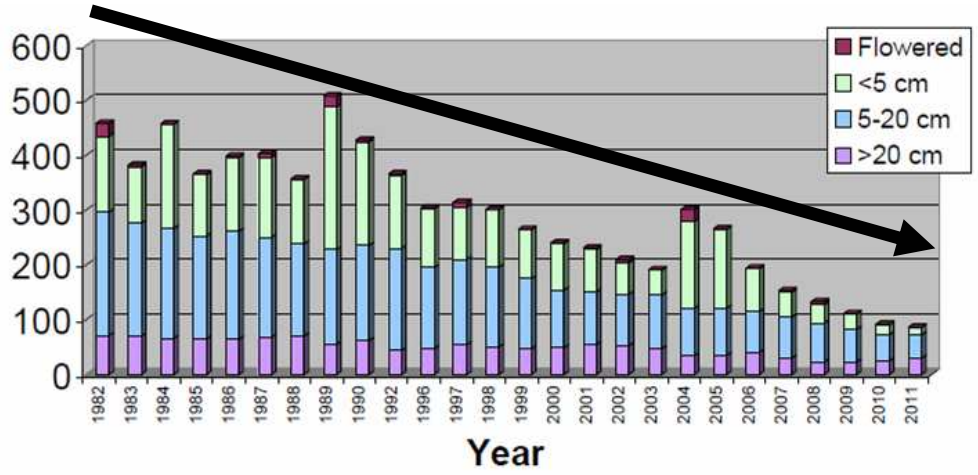
And here's where we found parasites. They are everywhere. We don't know the exact identities of these parasites, but there are at least 5 different types, and their populations seem to cycle relative to Tephritid abundance.



Weather affects native Tephritids. This is Polipoli during the height of the recent heavy drought.

Here's Kim looking for flies during the drought. Needless to say it was slim pickings.

CLIMATE CHANGE



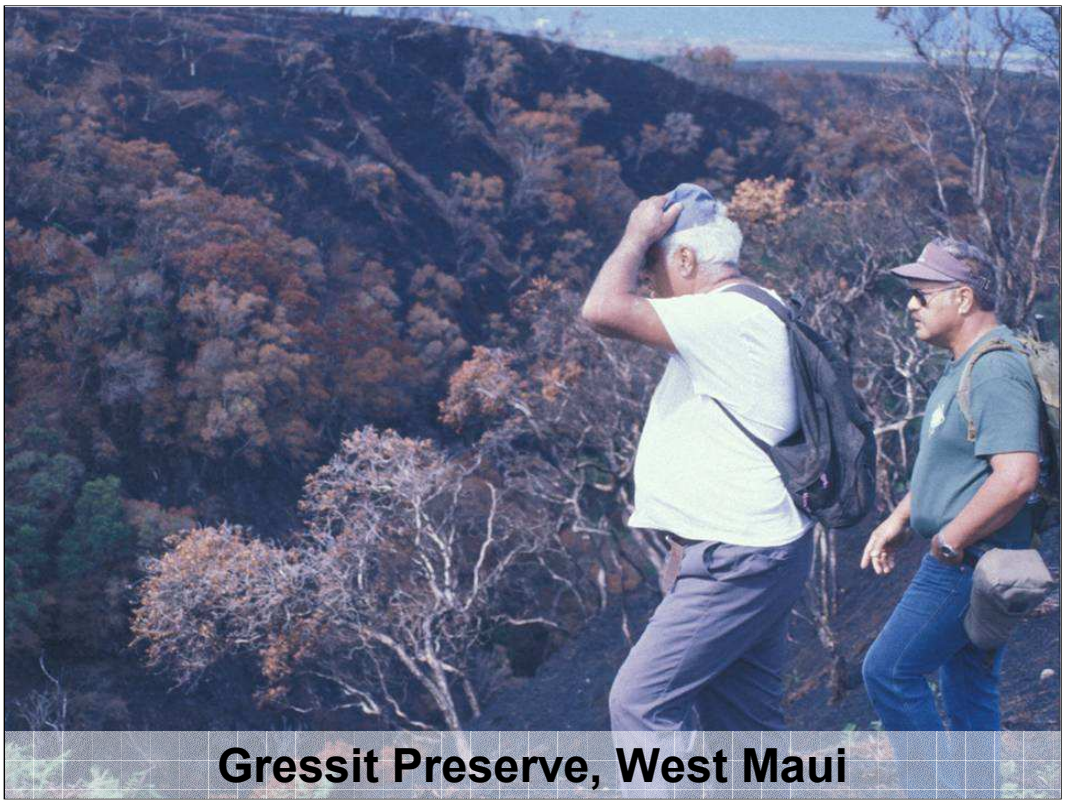
Number of Live Silverswords

One or two years of drought hurts, but our work with silverswords suggests drought effects have been going on for decades.

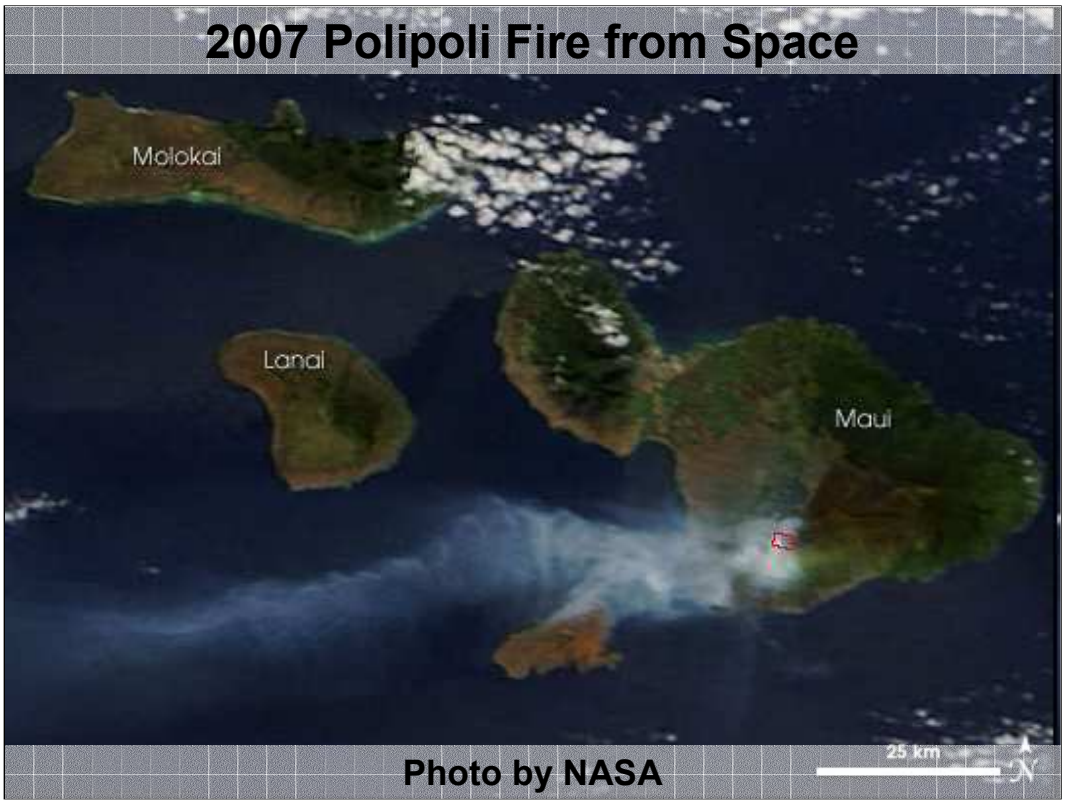
This silversword is showing severe drought stress. Without rain this sword will soon die. As the plants go away, so do the flies.

FIRE

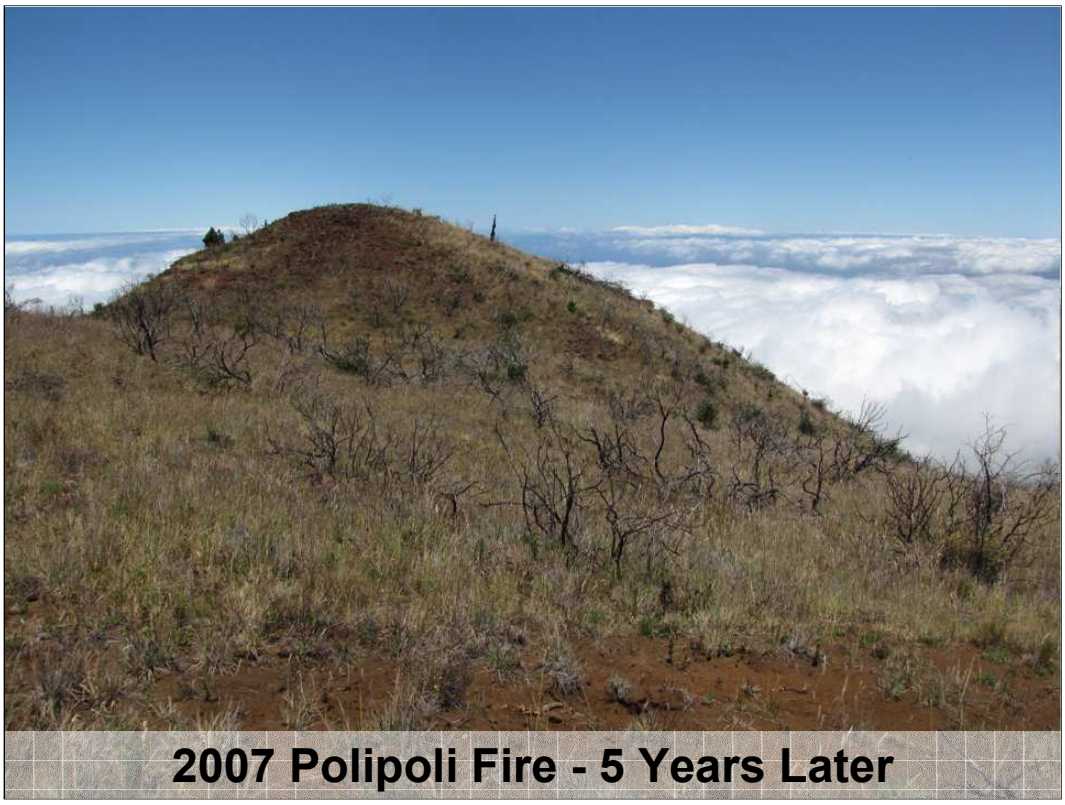
Fire can change a place in an instant.



Here's Rene Sylva and Charley Lindsey assessing the Gressit Preserve on West Maui after a fire.

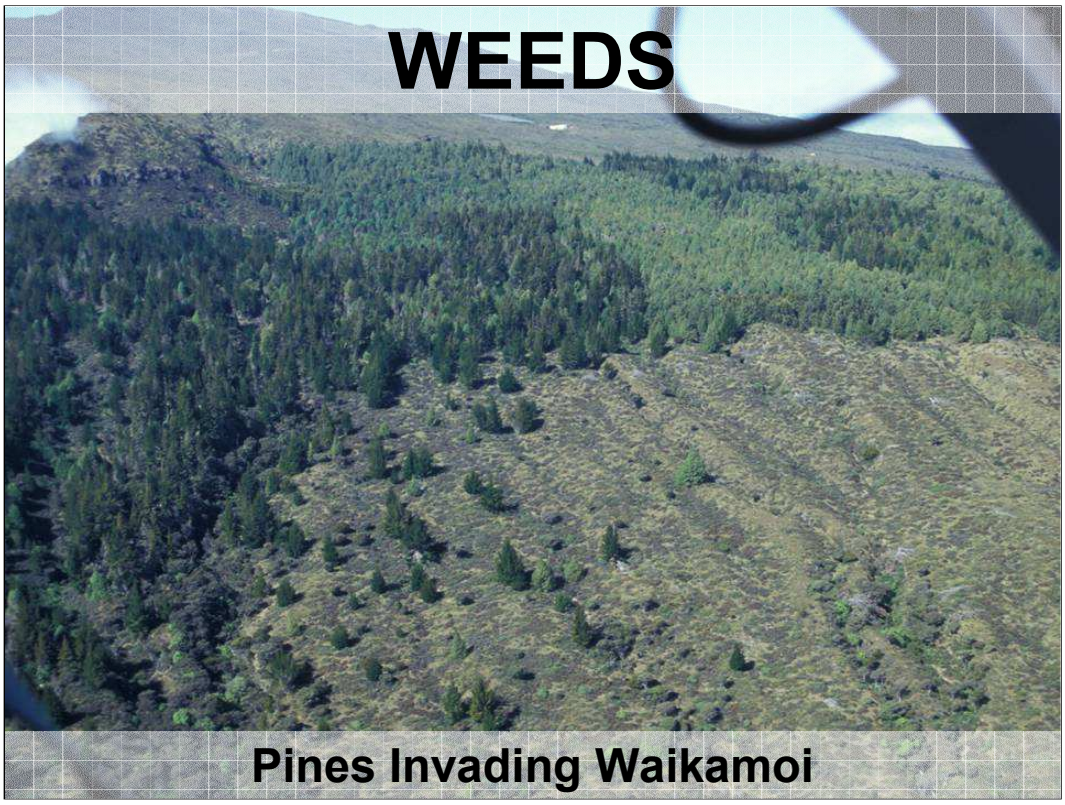


And here's what Polipoli looked like from space when it was on fire in 2007.

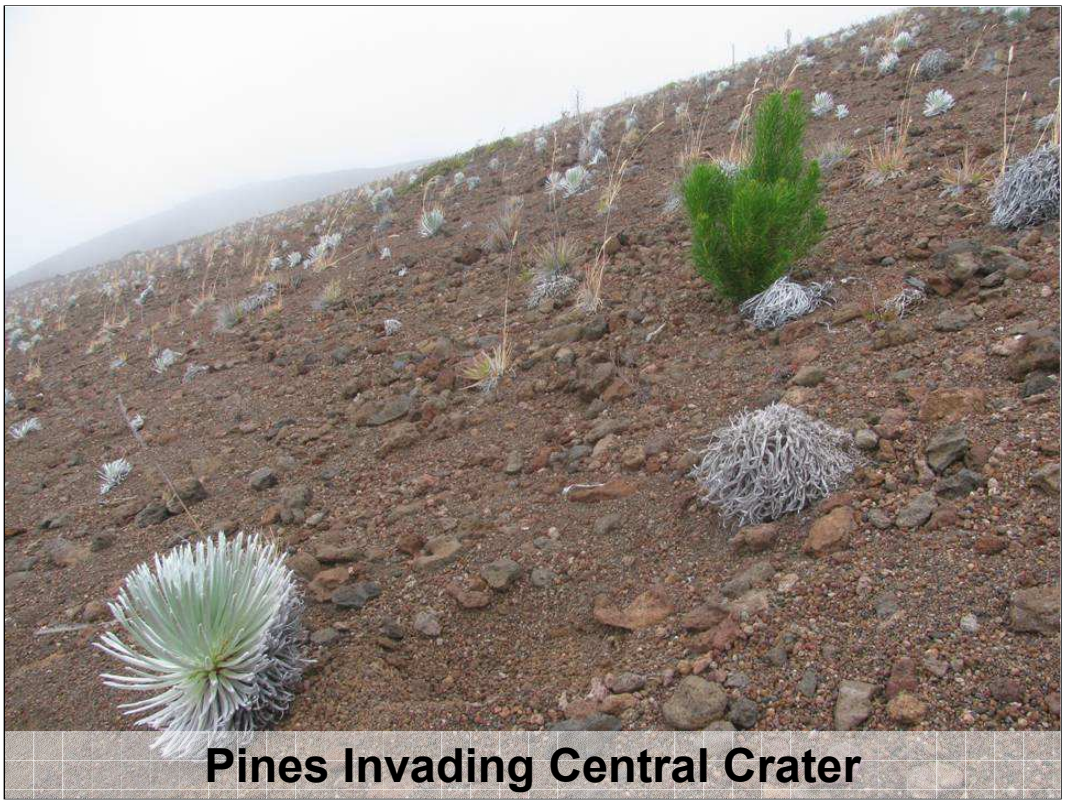


2007 Polipoli Fire - 5 Years Later

Five years later, this is what Polipoli looks like on the ground today. What used to be a native shrubland is now a non-native grassland, with some invading pines. There is basically nothing here for native Tephritids.



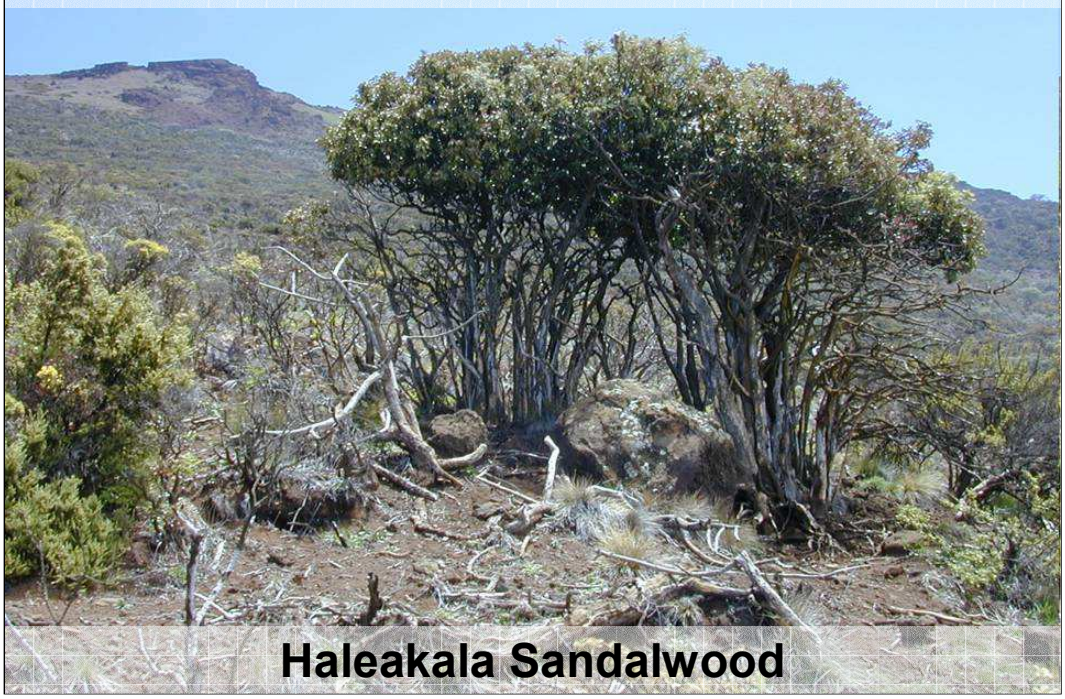
Pines are also invading the shrubland of Waikamoi, displacing native fly hosts in the process.



Pines Invading Central Crater

But they're not stopping at the shrubland, here's a pine in a silversword patch in the middle of the Central Crater. Without management these pines will shade out and displace the silverswords. As the plants go away, so do the flies.

UNGULATES



Haleakala Sandalwood

Ungulates are a threat to native Tephritids, because they damage native plants.

Haleakala Silversword - Goat Damage

Here's a goat browsed silversword. As the plants go away, so do the flies.

So what does the future hold? It would be nice to be able to manage Tephritids remotely from some otherwordly outpost.

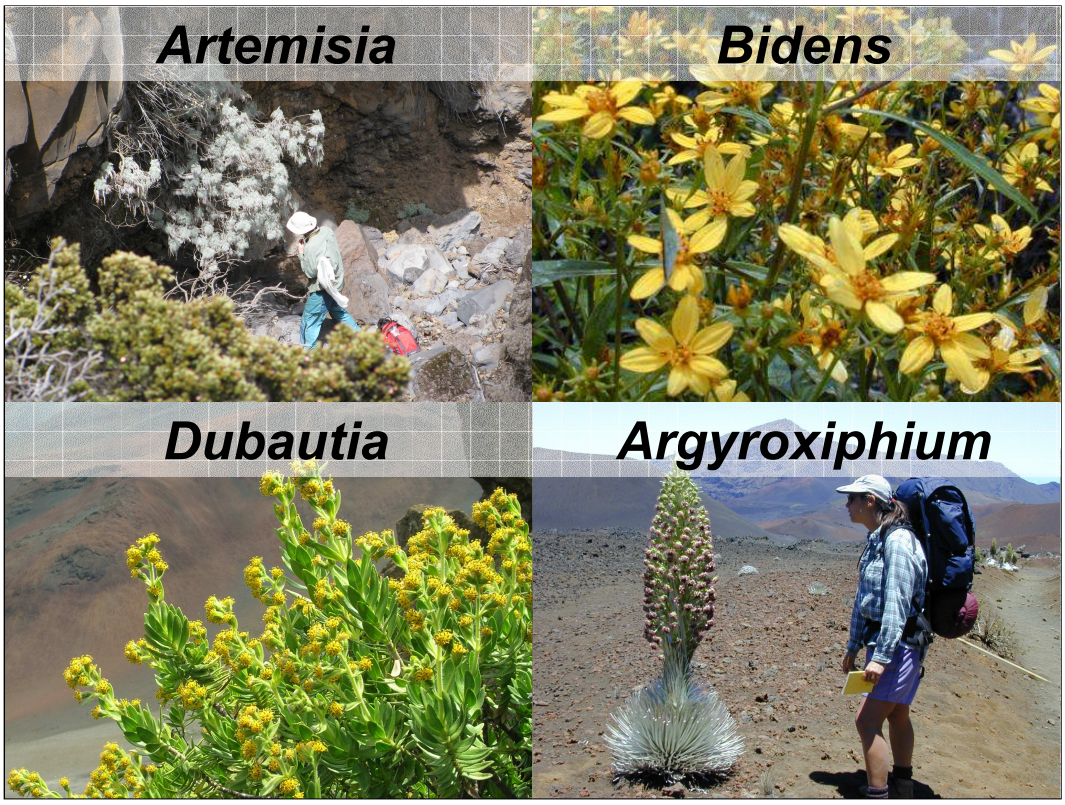
But protecting flies still requires boots on the ground, and the first step is usually a fence. This is Haleakala National Park, the bulk of which is fenced, which greatly benefits native Tephritids.

EXCLOSURES

Polipoli

In areas where large scale fencing doesn't seem likely, such as Polipoli, small exclosures have been put in place.

Into these protected areas were planted silverswords. The goal was mainly to protect the plants, but there is the added bonus of protecting the flies.

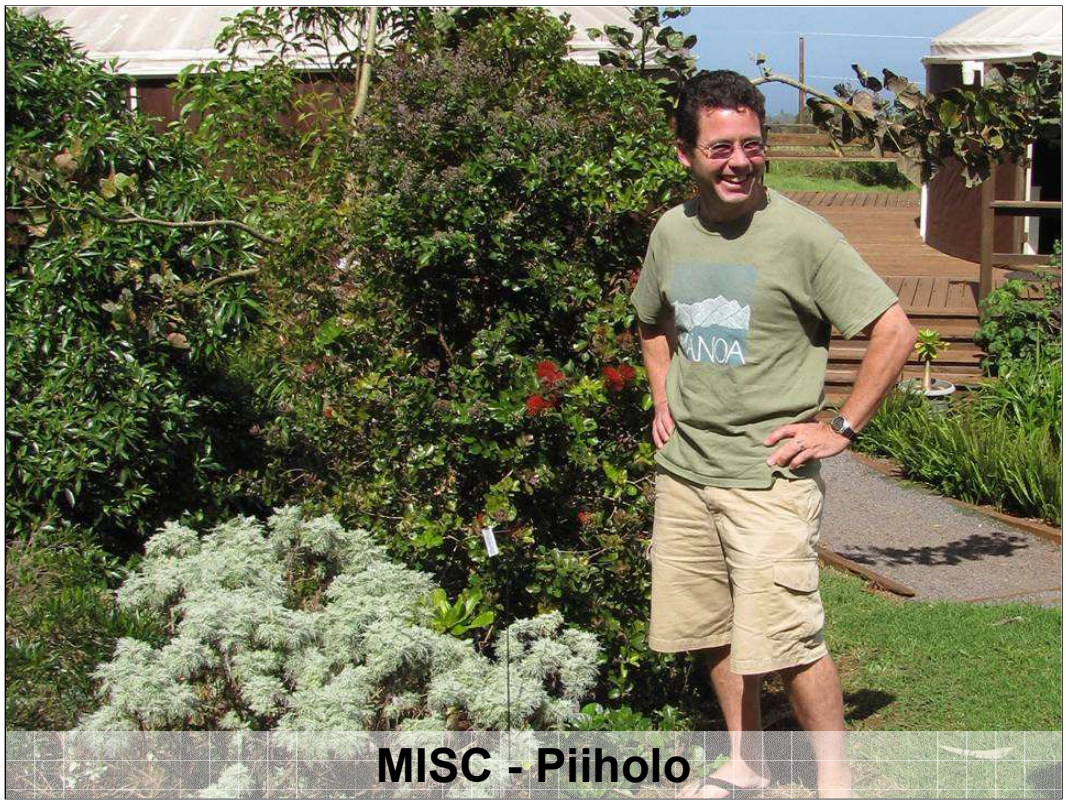


But don't just include rare plants, include as many Tephritid hosts as possible.

And don't just plant in wild locales. Sure, Tephritids are at home here.

But they're also at home here, on an Artemisia next to the side of the road by Park Headquarters.

And amazingly, they're at home here, doing a little wing dance on the Artemisia we planted in our yard in Olinda.



And here on the Artemisia Chuck Chimera planted at MISC Headquarters in Piiholo. That's why he's so happy.

And here, at Enchanting Floral Gardens. We call this "Plant It and They Will Come", and it may become an increasingly important aspect of insect conservation.

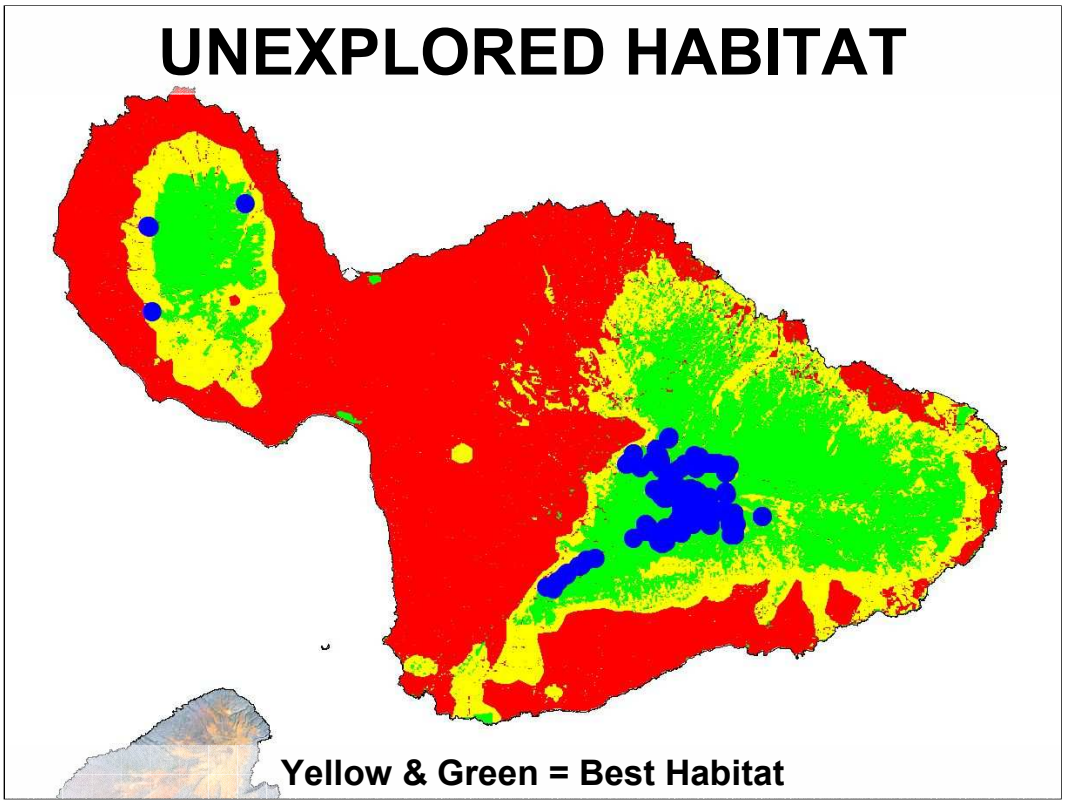
UNSURVEYED AREAS

That said, there are still vast areas that nature specially built for Tephritids, and it's here they're best preserved. However, many of these places have yet to be surveyed for Tephritids.

We made a few arduous treks into some of these unexplored areas, and after much hard work and getting skunked more times than we would like...

***Trupanea* n. sp. *waikamoi* - 1st Male**

We were able to find the first male of an as yet undescribed species, from deep within Waikamoi Preserve.



And there is still a ton of good habitat completely unexplored for Tephritids, highlighted here in green. This isn't due to lack of interest.

It's due to extreme logistics. Some of the least explored areas on Maui include.

The Koolau Gap and the entire North Slope. Stretching from Haleakala Crater to the sea, it's virtually unexplored.

Kipahulu Valley

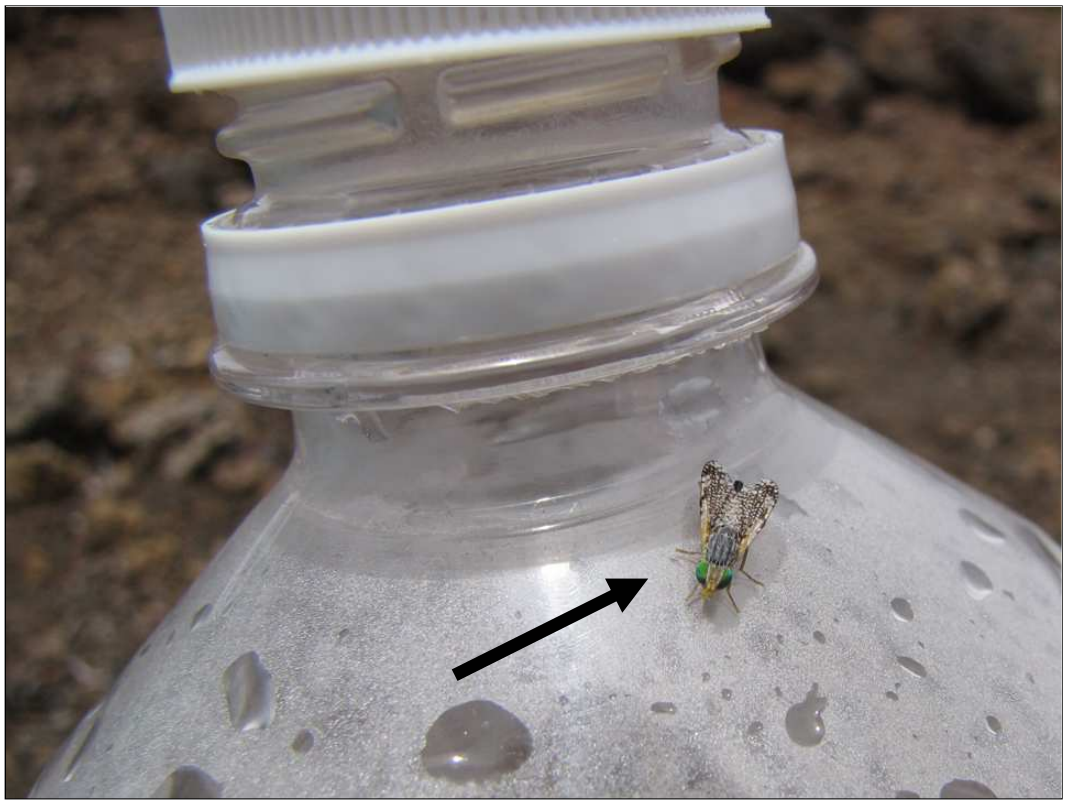
There has been some work in the bogs around Kipahulu Valley, but there is still much to do, and the surrounding areas are basically unexplored.

And West Maui, from dry ridges to summit bogs. These areas hold a rich flora know to support native Tephritids, and some work has been done, but the bulk of the mountain is virtually unexplored.

So, the next time you're up in Subalpine East Maui, and find yourself gazing in awe at a Haleakala Silversword.

Or zipping past a trailside Dubautia without giving it a second glance.

Or trudging up Switchbacks in weather that isn't quite rain but has you soaked the bone.



And especially before you take a drink of water. Think of the native Tephritid Flies. They're right there, hidden in plain view, and have so much to tell us about the natural world around us.

We hope this talk has given you some insights and appreciation for the native Tephritids of Subalpine East Maui. Time truly is fun when having flies. Thanks. Aloha.