Evolution of UAS to Enhance IPM in Collier County, FL

Atom Rosales, MS

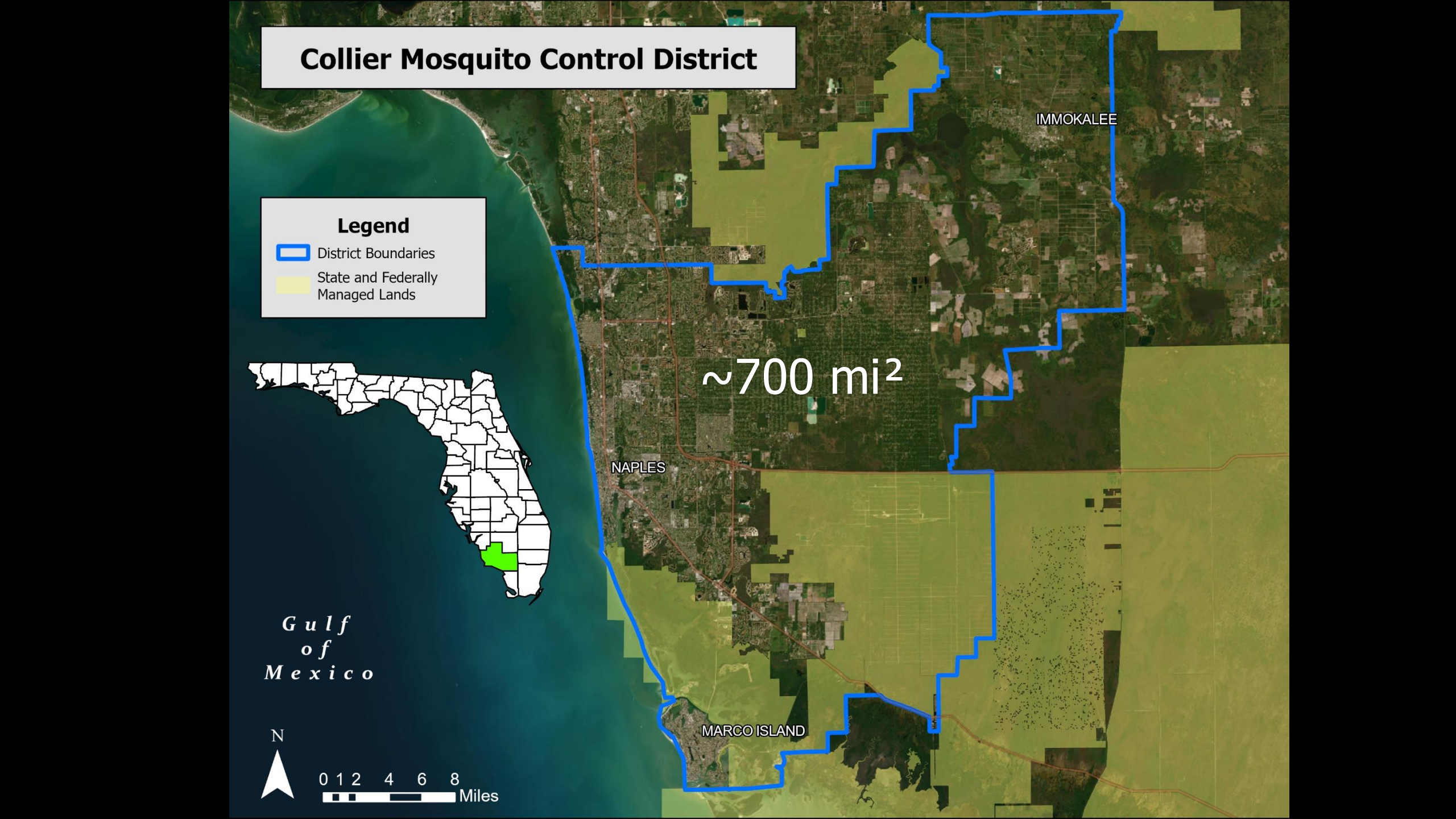
GMCA Annual Meeting

Jekyll Island, GA

October 22, 2026

COLLIER MOSQUITO CONTROL DISTRICT




Collier Mosquito Control District
Legend
District Boundaries
State and Federally Managed Lands
~700 mi²
IMMOKALEE
NAPLES
MARCO ISLAND
Gulf of Mexico
N
0 1 2 4 6 8
Miles

Species of Concern

- *Ae. aegypti*
- *Ae. albopictus*
- *Cx. quinquefasciatus*
- *Cx. nigripalpus*
- *Ae. taeniorhynchus*
- *Mansonia spp.*
- *Ae. atlanticus, Ae. infirmatus, Ae. pertinax, Ae. vexans*



Primary Challenges

- Increasing urbanization
- Abundant saltmarsh and freshwater habitats
- Proximity to public lands








WHAT
PEOPLE
THINK
WE DO

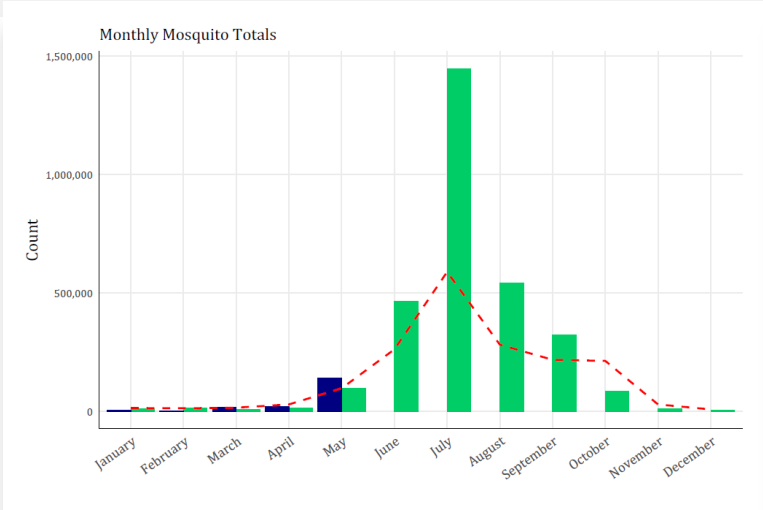

1986

What we actually do…

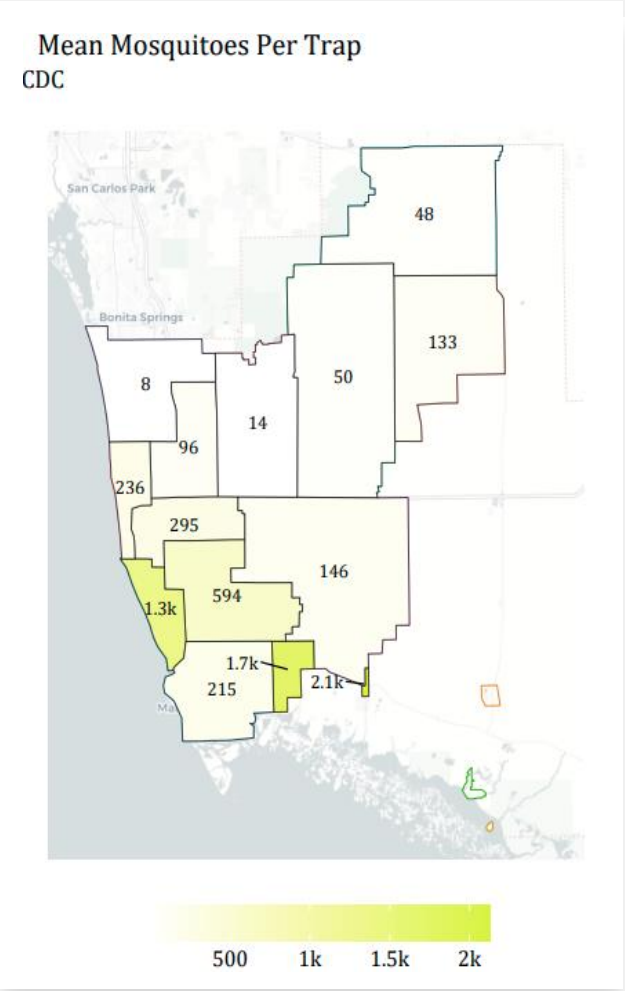


Surveillance data we collect

- Larval dips
- Trap data
- Landing rates
- Service requests
- In-house arbovirus testing

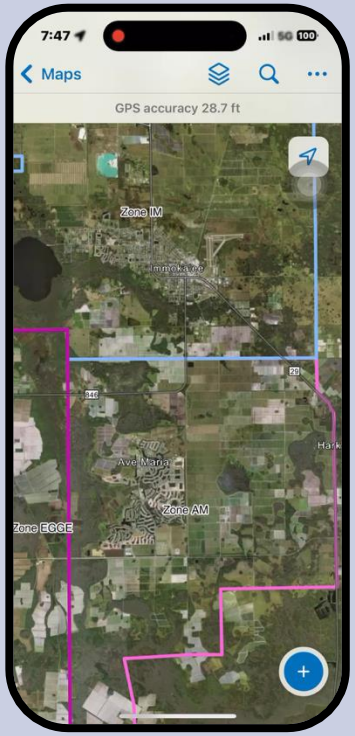




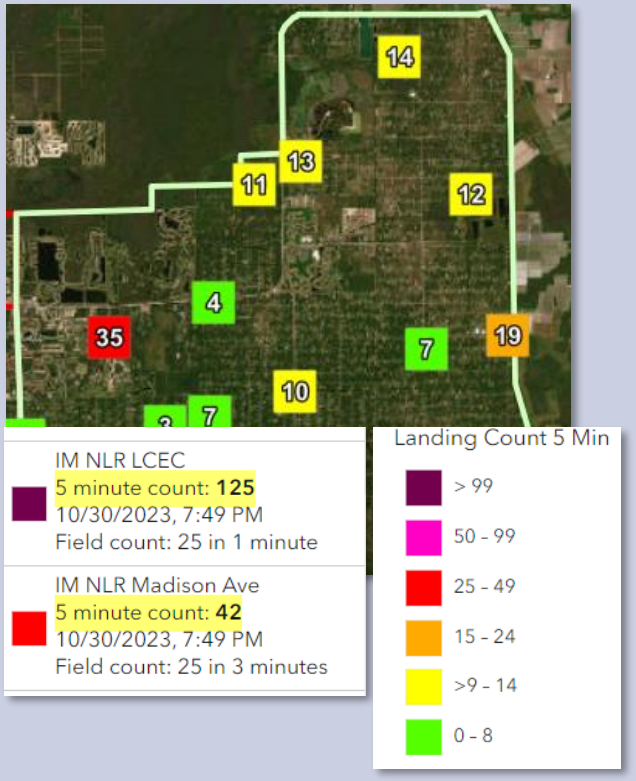


Field data collection process

1 Field data collected via mobile device



2 Data are fed into operational dashboards

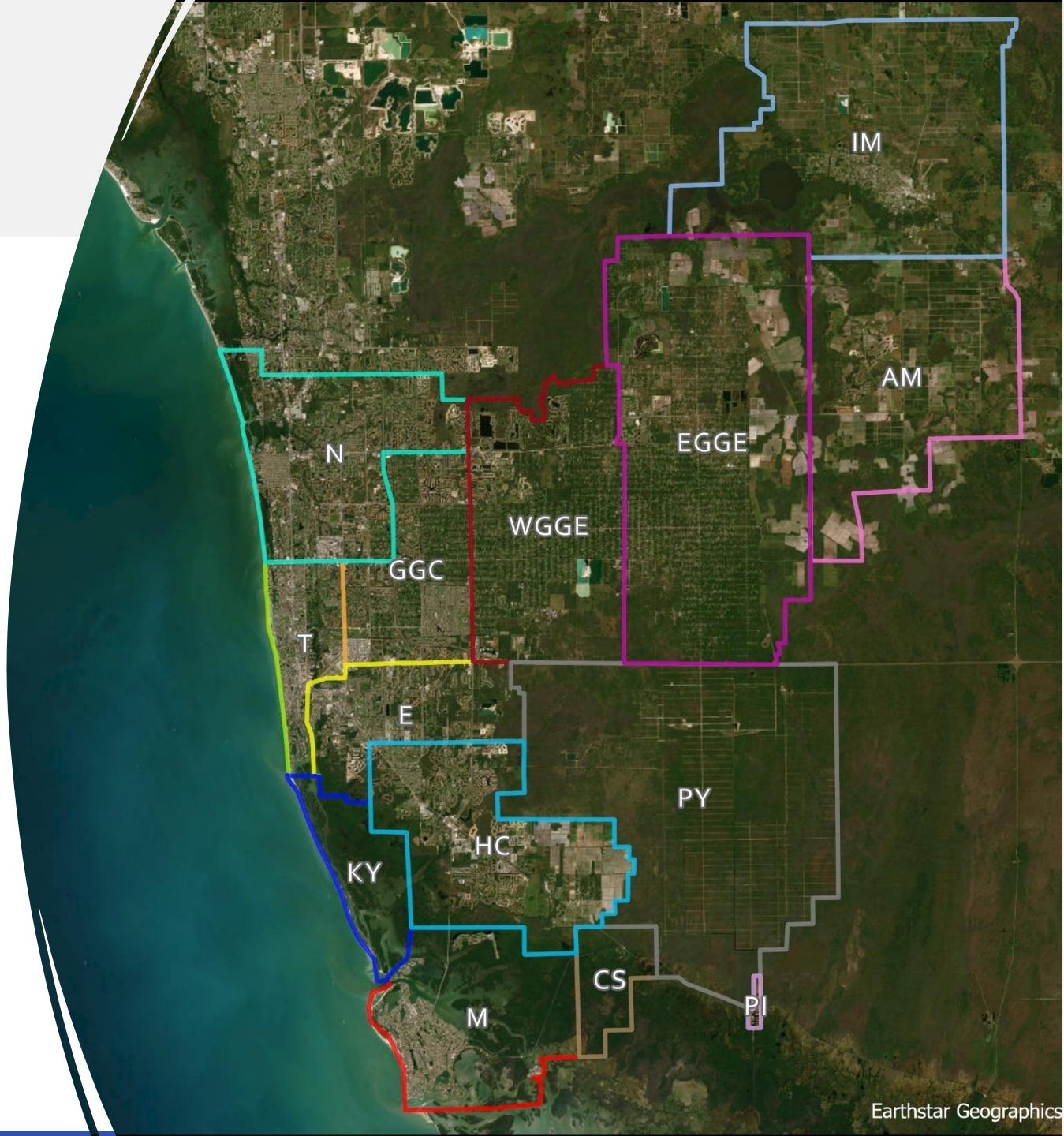


3 Treatment missions are planned based on field data



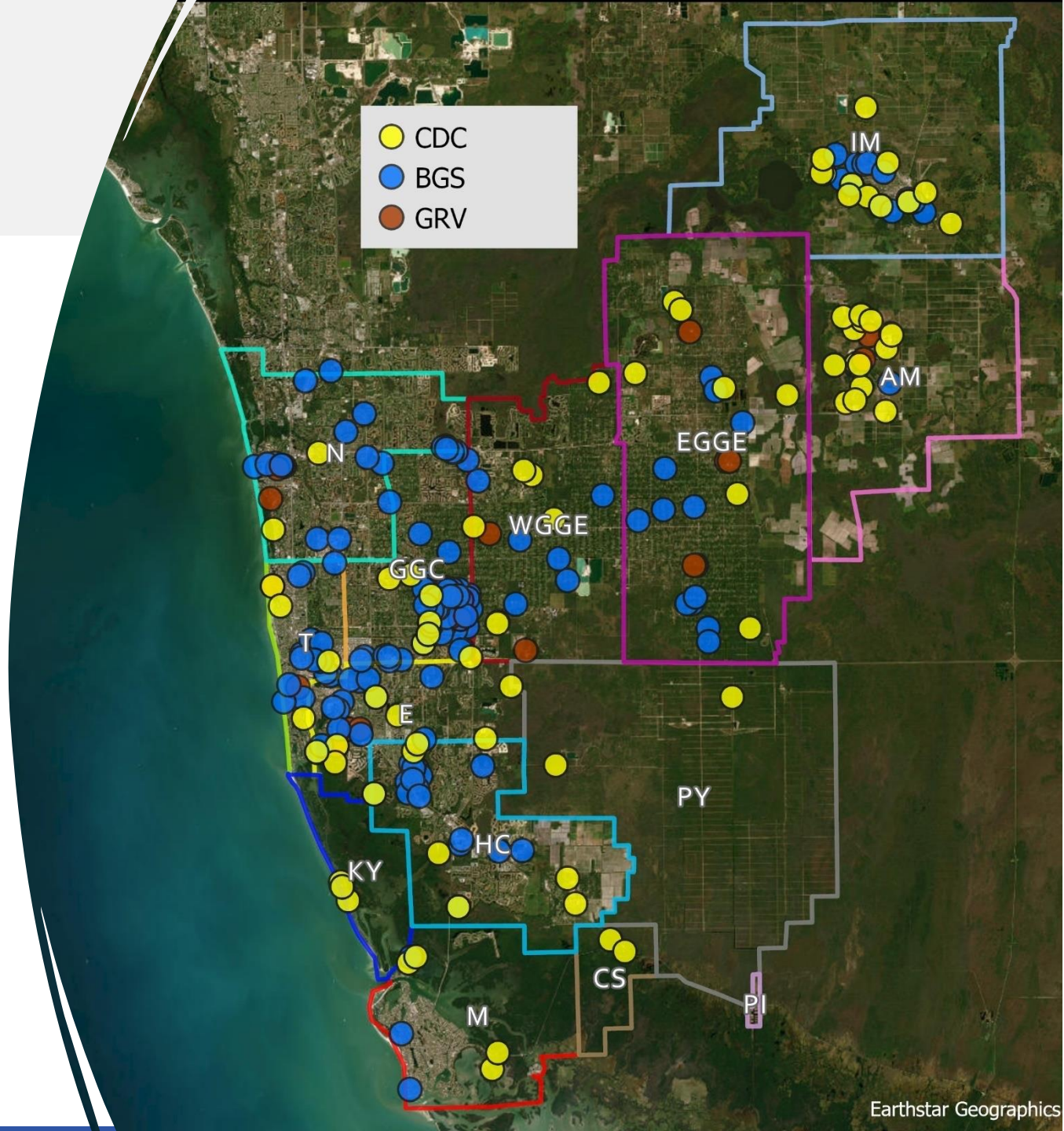
District Operations

- 14 Operational Zones



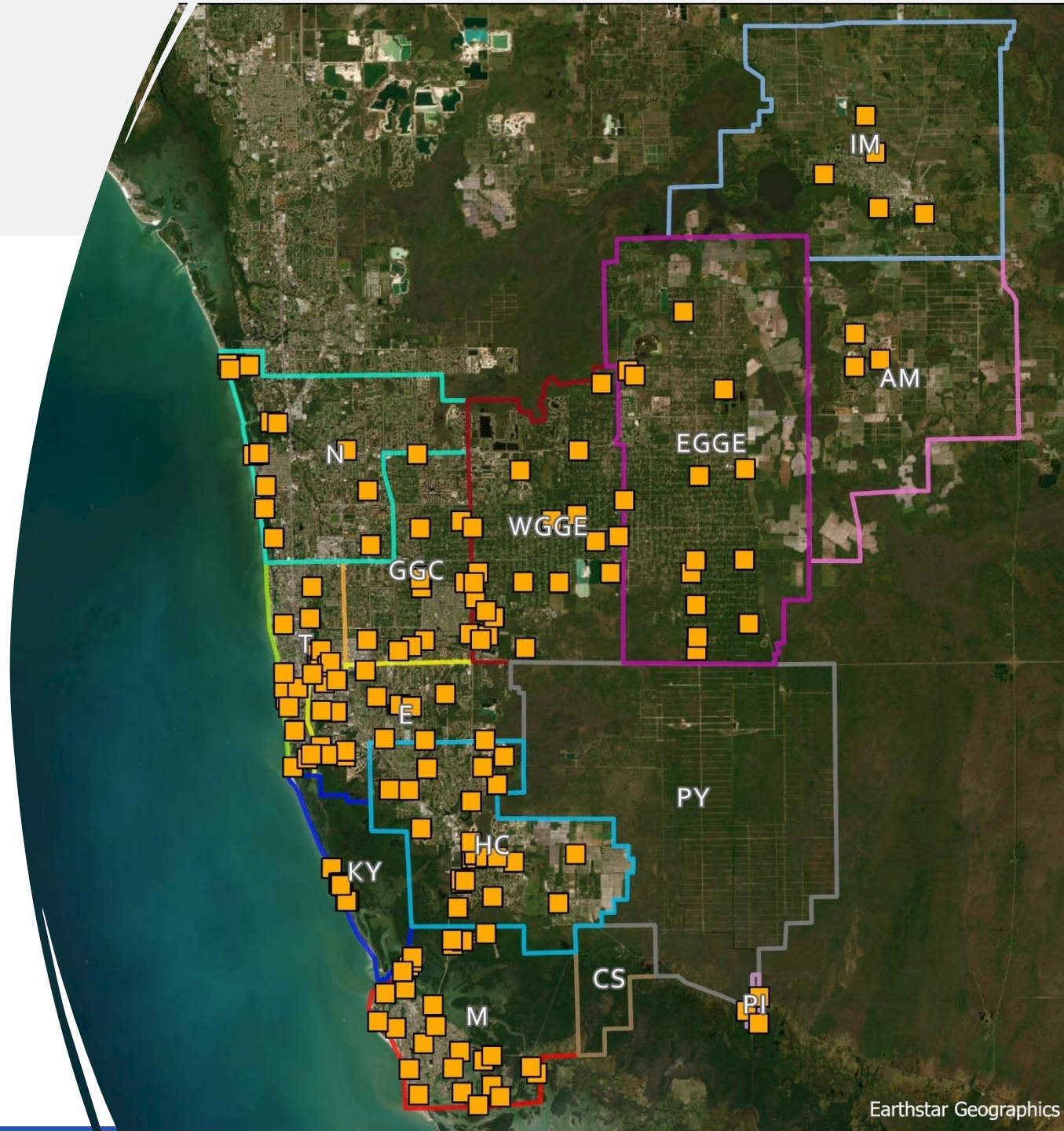
District Operations

- 14 Operational Zones
- CDC Light, BG-Sentinel, and Gravid traps



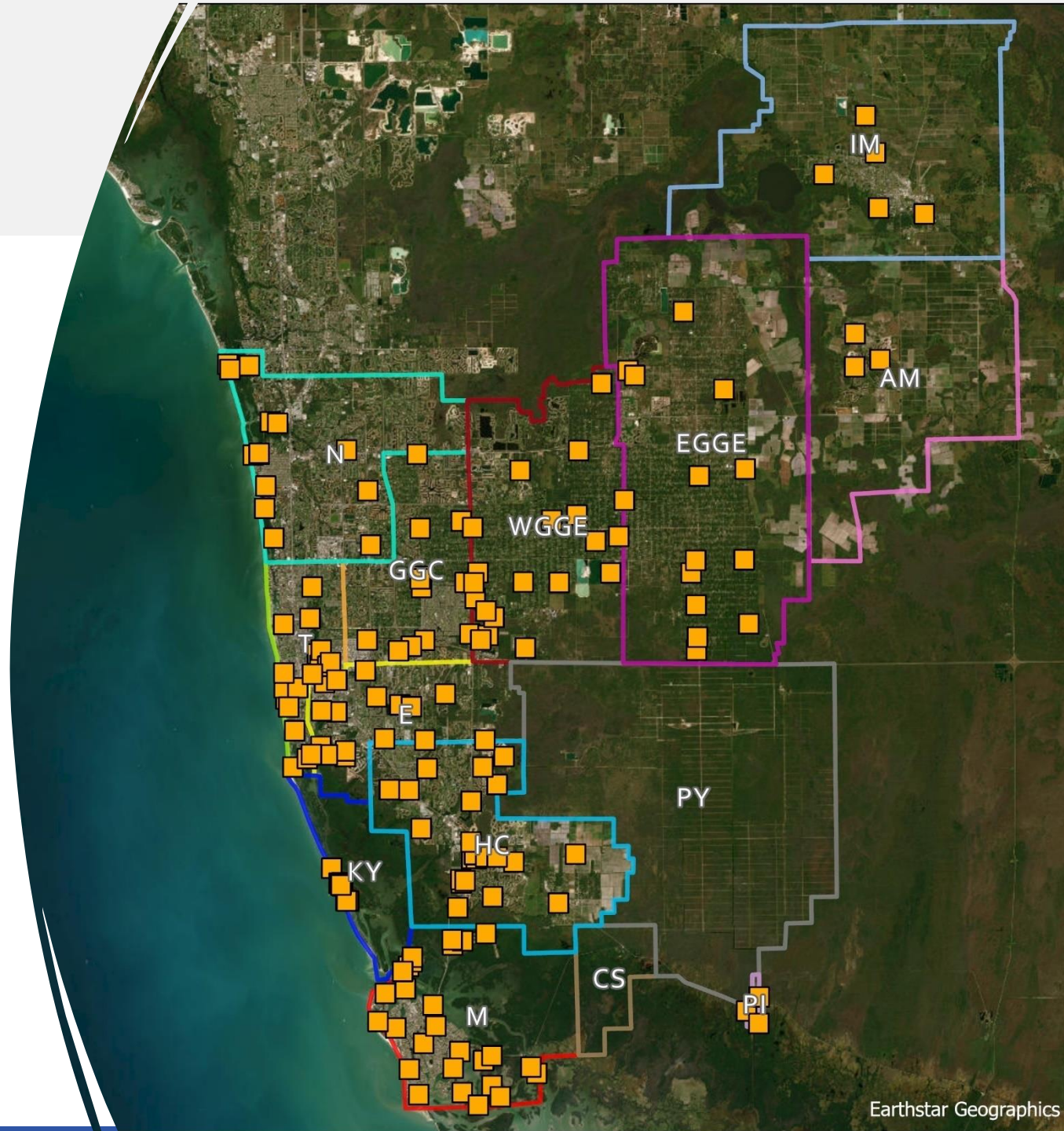
District Operations

- 14 Operational Zones
- CDC Light, BG-Sentinel, and Gravid traps
- Human landing rates



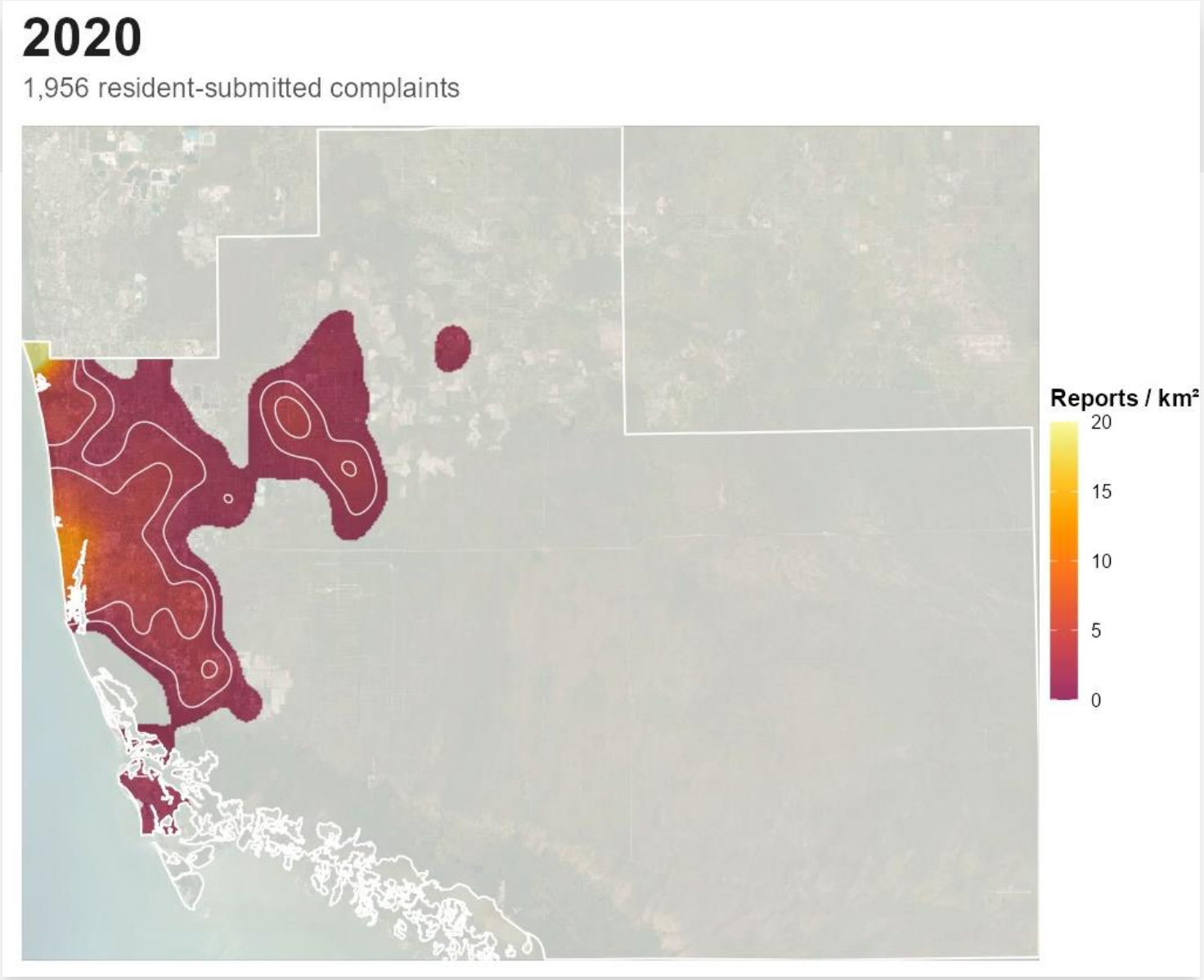
District Operations

- 14 Operational Zones
- CDC Light, BG-Sentinel, and Gravid traps
- Human Landing Rate stations



Mosquito Complaints

- Typical problem areas
- Unusual clusters
- Useful proxy for seasonal species
- Permanent resident population







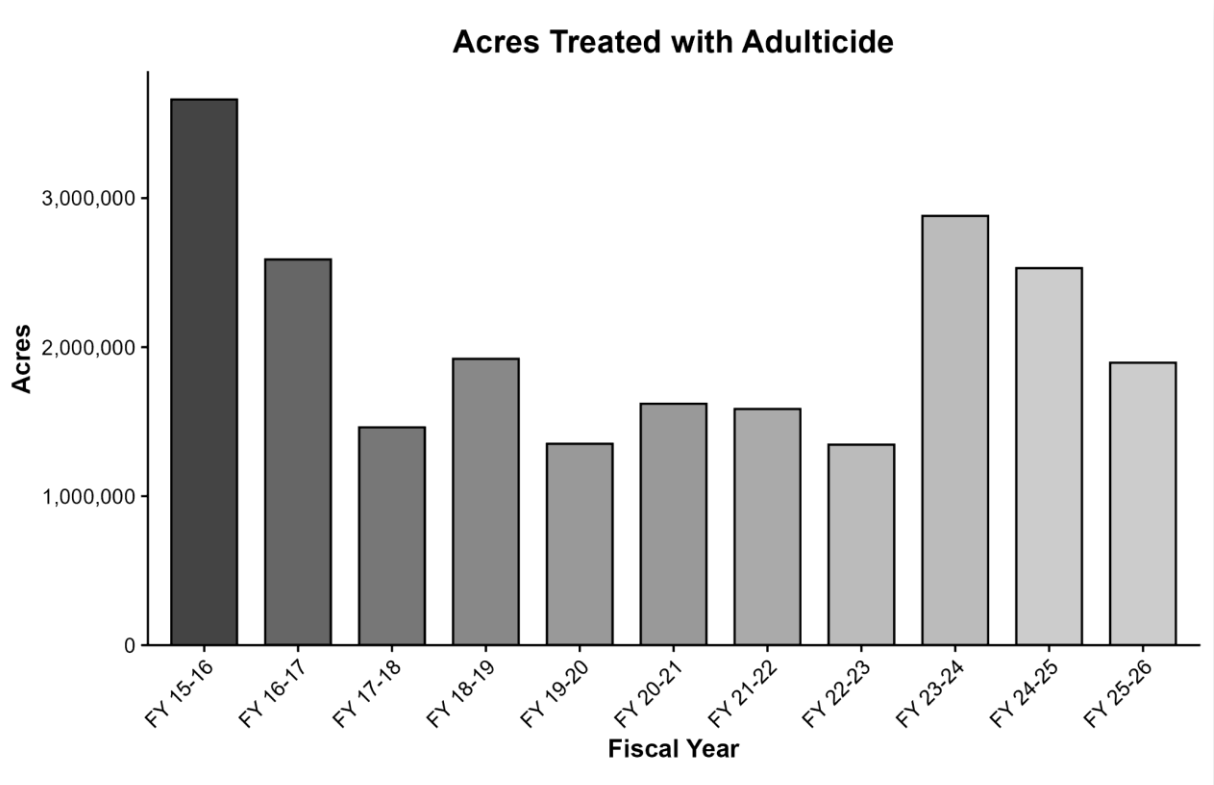


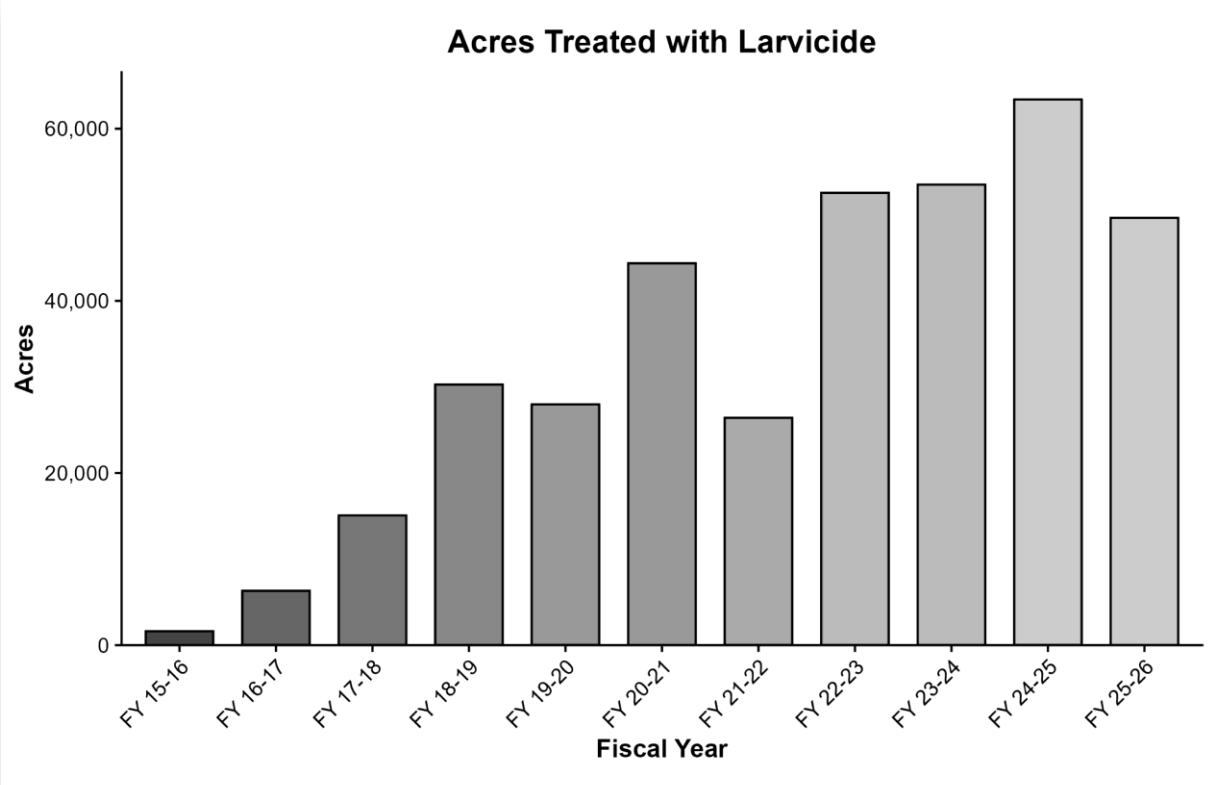




COLLIER MOSQUITO CONTROL DISTRICT

Treatment Operations





District Overview



Technical Development (2026)

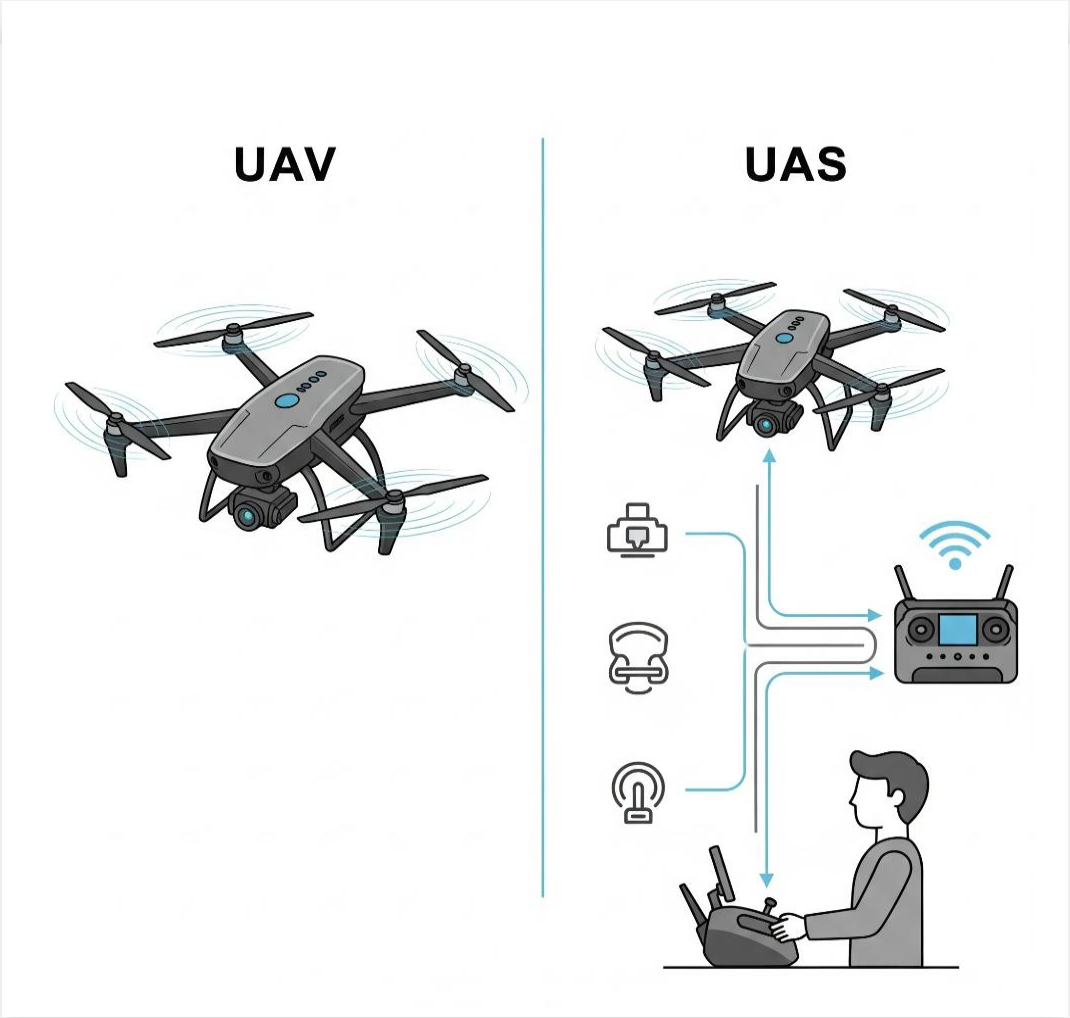
- Atom Rosales – Director of Technical Development
- Olivia Konieczny – GIS Specialist
- Joseph Bonaccorsi – UAS Specialist
- Nevaeh Greco – GIS Specialist
- Mason Cramer – UAS Intern





What are Drones?

- Drones, Unmanned Aerial Vehicles (UAVs), and Unmanned Aerial Systems (UAS)
- *Remotely operated* - Aircraft without the possibility for direct human intervention
- Autonomously flight via GPS or other guidance system

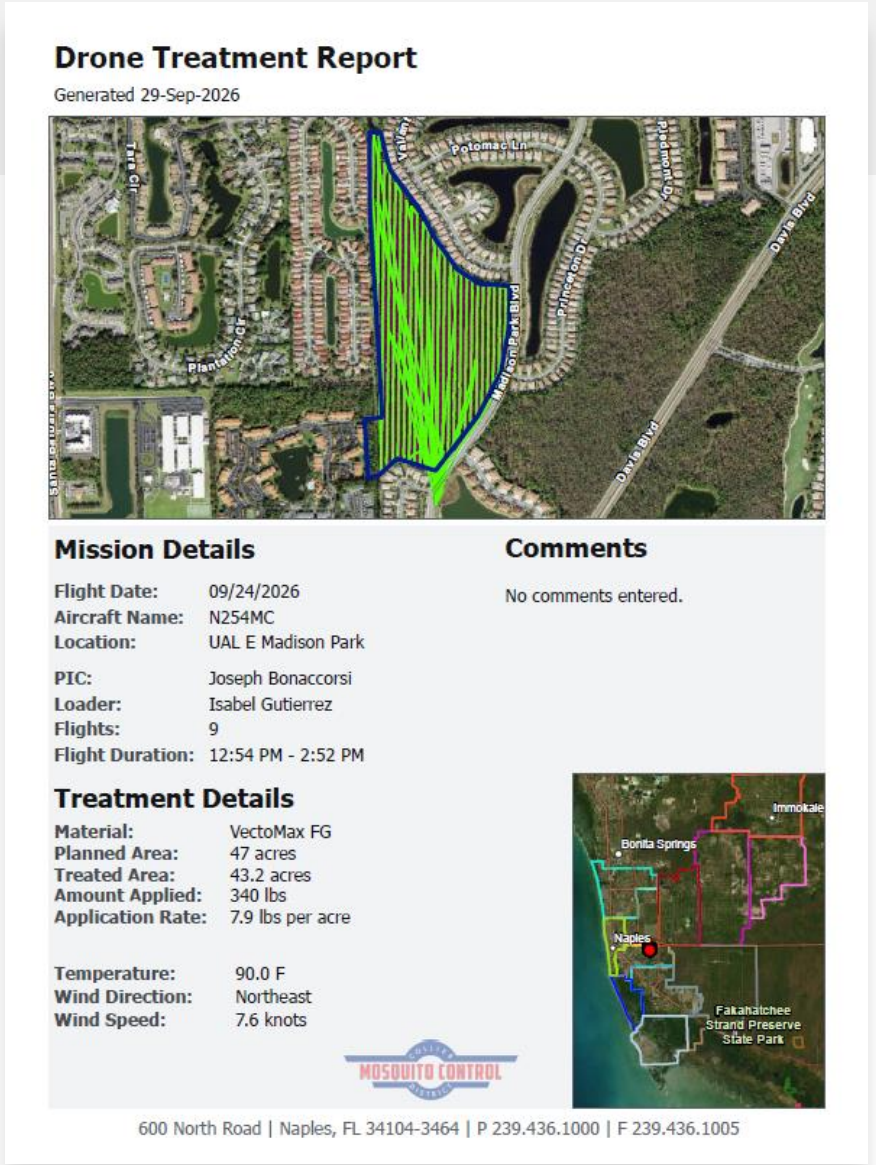


How we operate

- Public Aircraft Operations (PAO) under a Certificate of Authorization (COA) issued by the FAA
- COA authorizes the flight, larvicide applications follow relevant federal/state regulations
- Must provide 24-hour notification for treatment (NOTAM)
- Post-mission treatment reports (digital + hardcopy)







Drone Treatment Report

Generated 29-Sep-2026

Mission Details

Flight Date:	09/24/2026
Aircraft Name:	N254MC
Location:	UAL E Madison Park
PIC:	Joseph Bonaccorsi
Loader:	Isabel Gutierrez
Flights:	9
Flight Duration:	12:54 PM - 2:52 PM

Comments

No comments entered.

Treatment Details

Material:	VectoMax FG
Planned Area:	47 acres
Treated Area:	43.2 acres
Amount Applied:	340 lbs
Application Rate:	7.9 lbs per acre
Temperature:	90.0 F
Wind Direction:	Northeast
Wind Speed:	7.6 knots

600 North Road | Naples, FL 34104-3464 | P 239.436.1000 | F 239.436.1005

COLLIER MOSQUITO CONTROL DISTRICT

Where we started

- 2019 – Department Established
- 2023 – Fleet and Personnel Overhauled (FS 940.50 / 60GG-2.0075)









Initial Limitations

- Small UAS larvicide capacity
- Few compliant UAS on the market
- Shortage of trained/certified staff
- Lack of specialized roles and duties





2026 Drone Fleet



Skydio X10



IF1200A



PrecisionVision 40X

PrecisionVision 40X

- **120 lb**. gross weight
- **40 lb.** payload capacity
- Gravity-fed, casting arm
- ~5.7 acres treated per load (5-10 minutes)
- 12-15 mph
- 100 acres/day





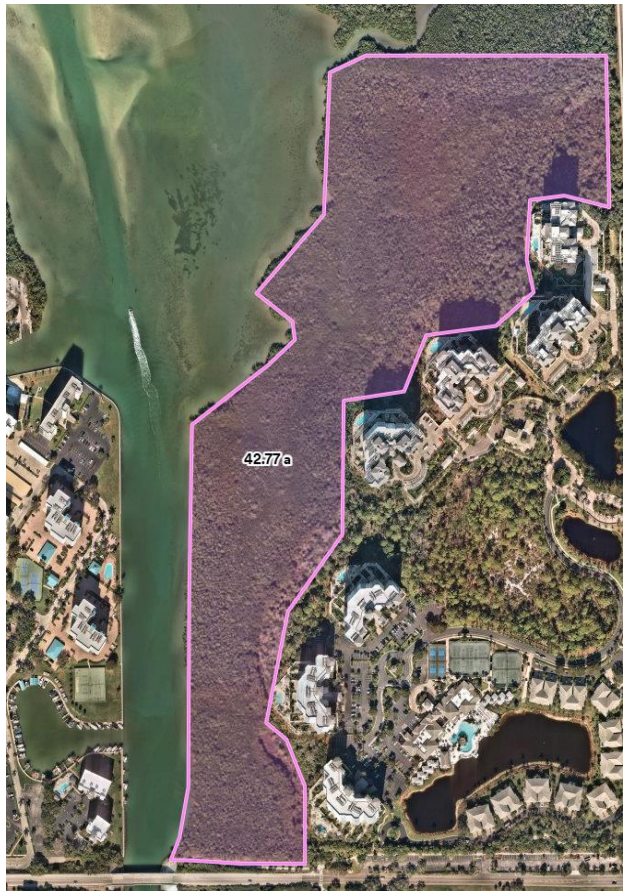
Why larvicide with drones?

- Surgical applications in hard-to-reach or hazardous areas
- More efficient than ground-based equipment
- Ease of use



What makes a suitable drone area?

- Size *(~1 to 100+ acres)*
- Expediency needed
- Precision required
- Hazards present (e.g., High-rises, towers)





Target species

- Primarily flood water species
  - *Aedes taeniorhynchus*
  - *Culex nigripalpus*
  - *Psorophora spp.*
  - *Aedes spp.*
- Other taxa
  - *Mansonia spp.*
  - *Anopheles spp.*





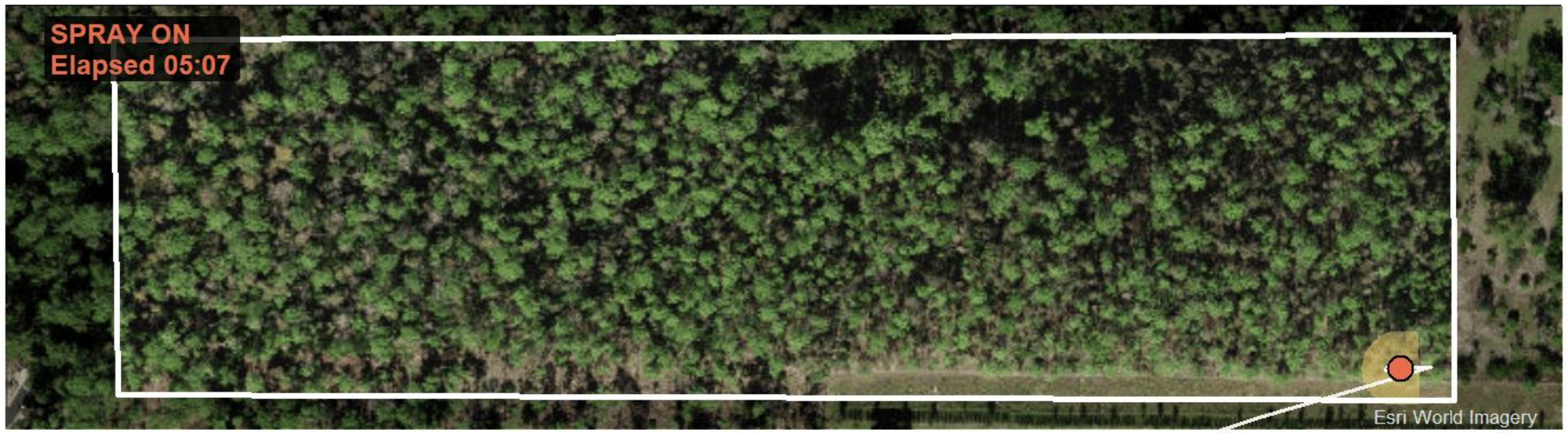
“Silverwood”



“Dog Swamps”



Drone application flight pattern

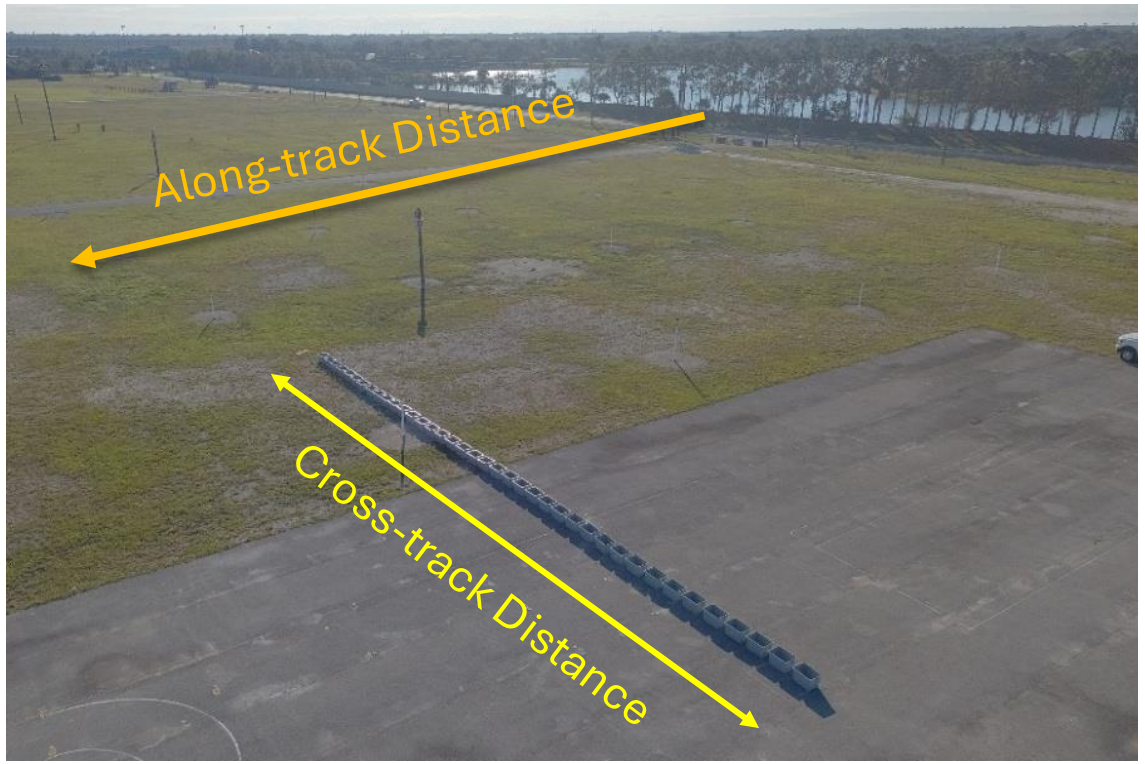


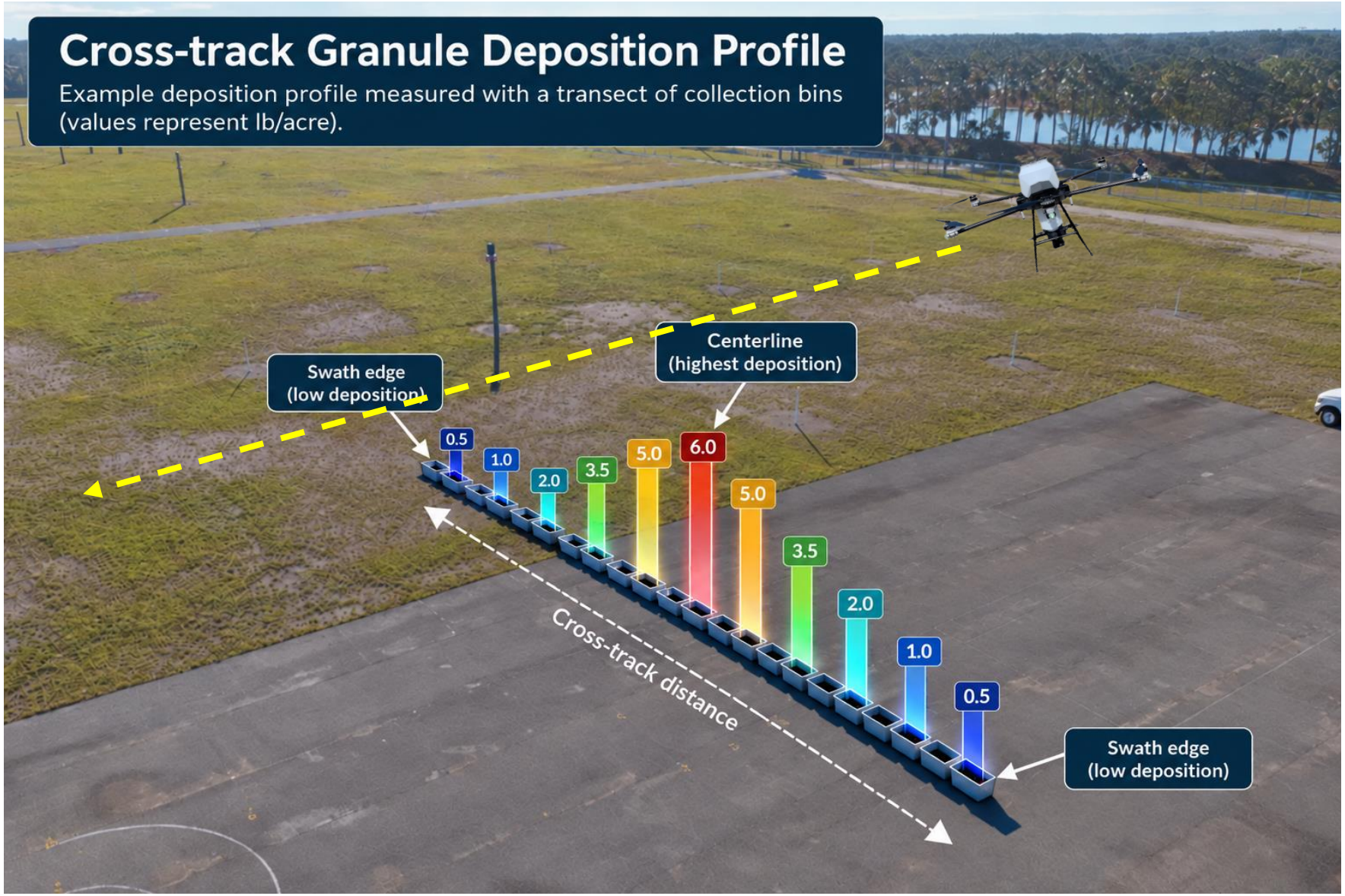
Drone larvicide materials

Material / AI	Primary Use	Residual/Why we use it
Duplex-G 5.35% Bti + 1.60% (S)-methoprene	Nearby freshwater habitats	3-4 weeks; lab-rearing checks are easier to manage near the District
Fourstar Bti CRG 10.0% Bti	Coastal saltmarsh	3-4 weeks; Controlled-release Bti for repeat flooding; used exclusively for *Aedes taeniorhynchus*
VectoMax FG 4.5% Bti + 2.7% Bsph	Remote freshwater habitats	2-3 weeks; Backchecks easier and avoids emergence-rearing requirement
Natular G30 2.5% spinosad	Persistent problem areas	3-4 weeks; Can cause non-target effects to aquatic invertebrates so used sparingly for stubborn areas
VectoPrime FG 6.07% Bti + 0.10% (S)-methoprene	Single-brood floodwater habitats	Single-brood; Can be used pre-flood/treatment and very effective
AquacBac 200G 2.86% Bti	Cheap, low abundance habitats	Single-brood; Mixed effectiveness in heavily vegetated areas

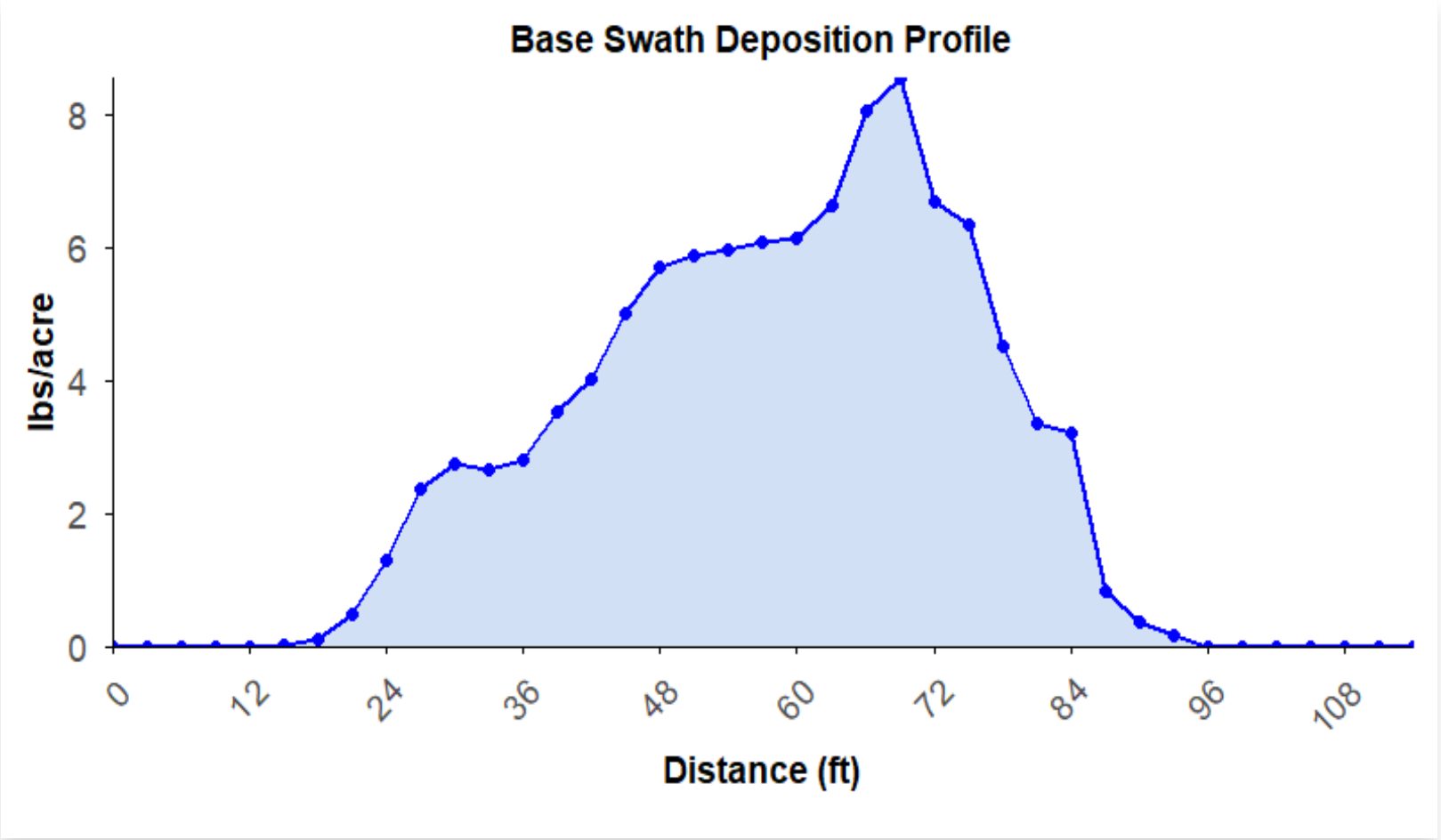
Swath characterization

- Cross-track (lateral) deposition is measured from multiple single-passes
- The same configuration is used for each pass (speed, altitude, payload settings)
- Individual pass results are inspected and averaged together



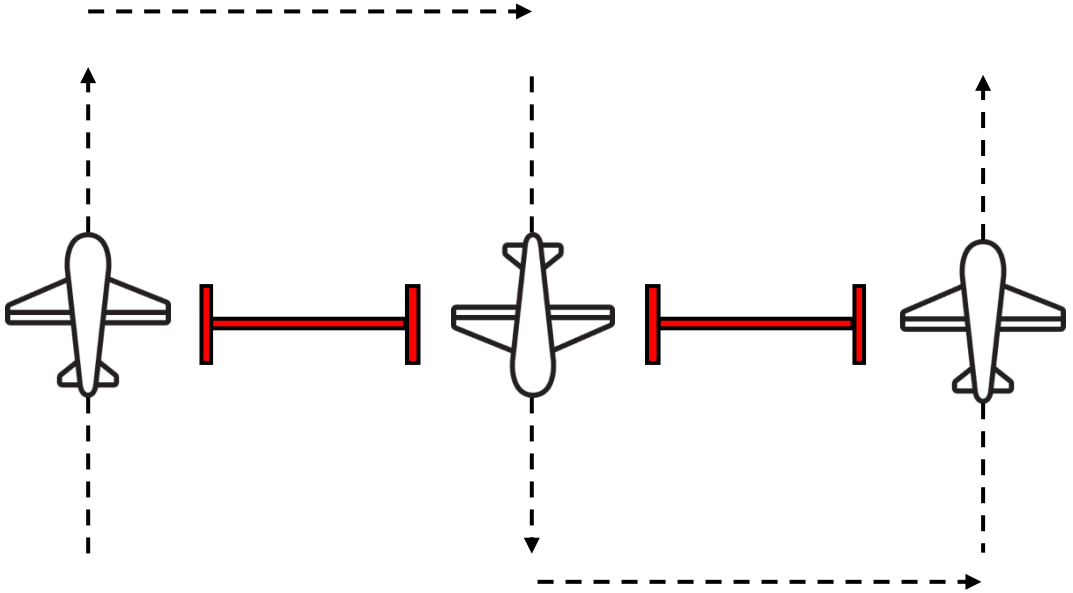

Cross-track Granule Deposition Profile
Example deposition profile measured with a transect of collection bins (values represent lb/acre).
Swath edge (low deposition)
Centerline (highest deposition)
0.5
1.0
2.0
3.5
5.0
6.0
5.0
3.5
2.0
1.0
0.5
Cross-track distance
Swath edge (low deposition)

Single-pass swath is *not* operational/effective swath!



Effective (operational) swath

- Effective swath is the actual flight-line spacing (ft) used during missions





Effective (operational) swath

- It is selected based on:

1. Dosage = mean application rate (lb/acre)

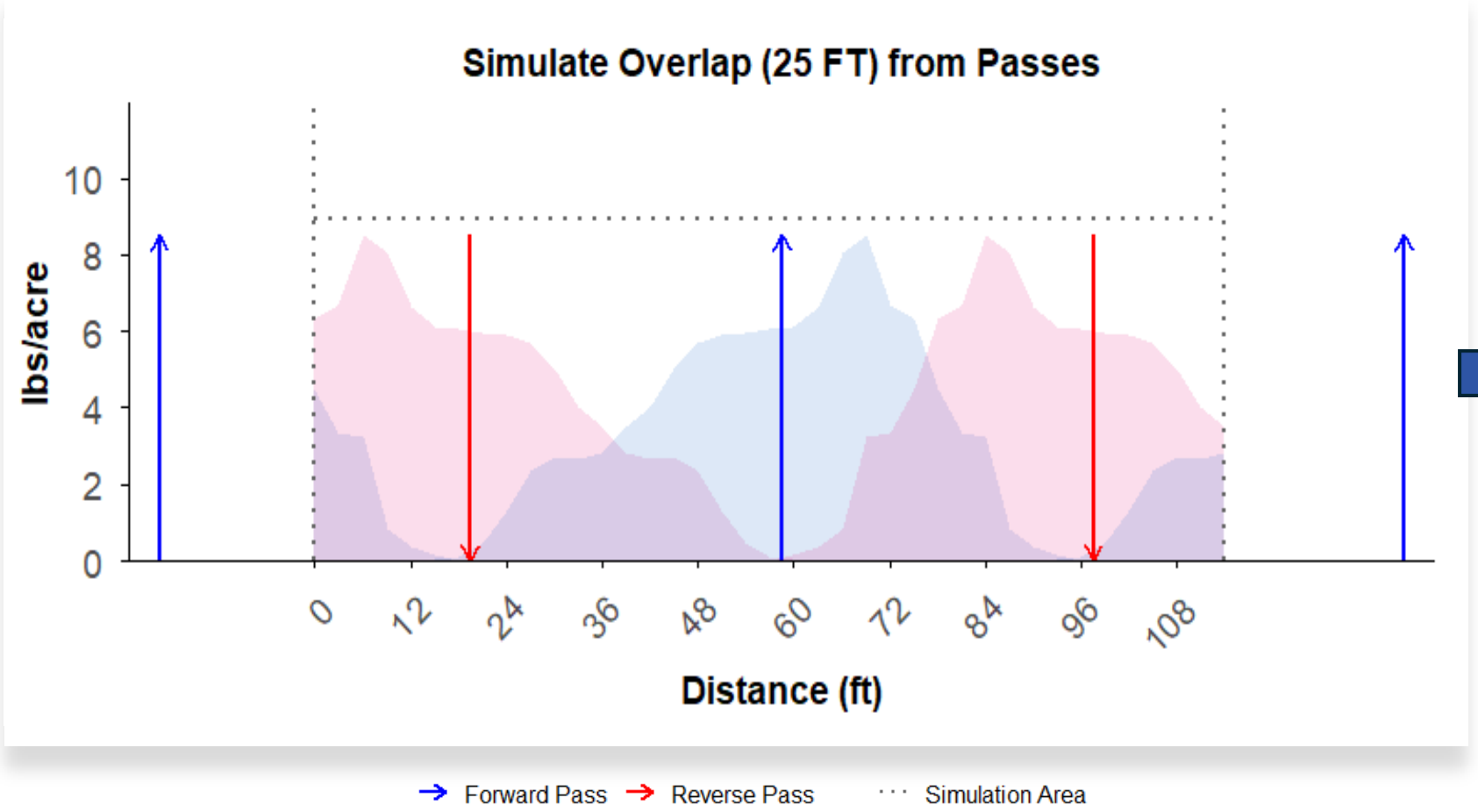


2. Uniformity = coefficient of variation (CV)



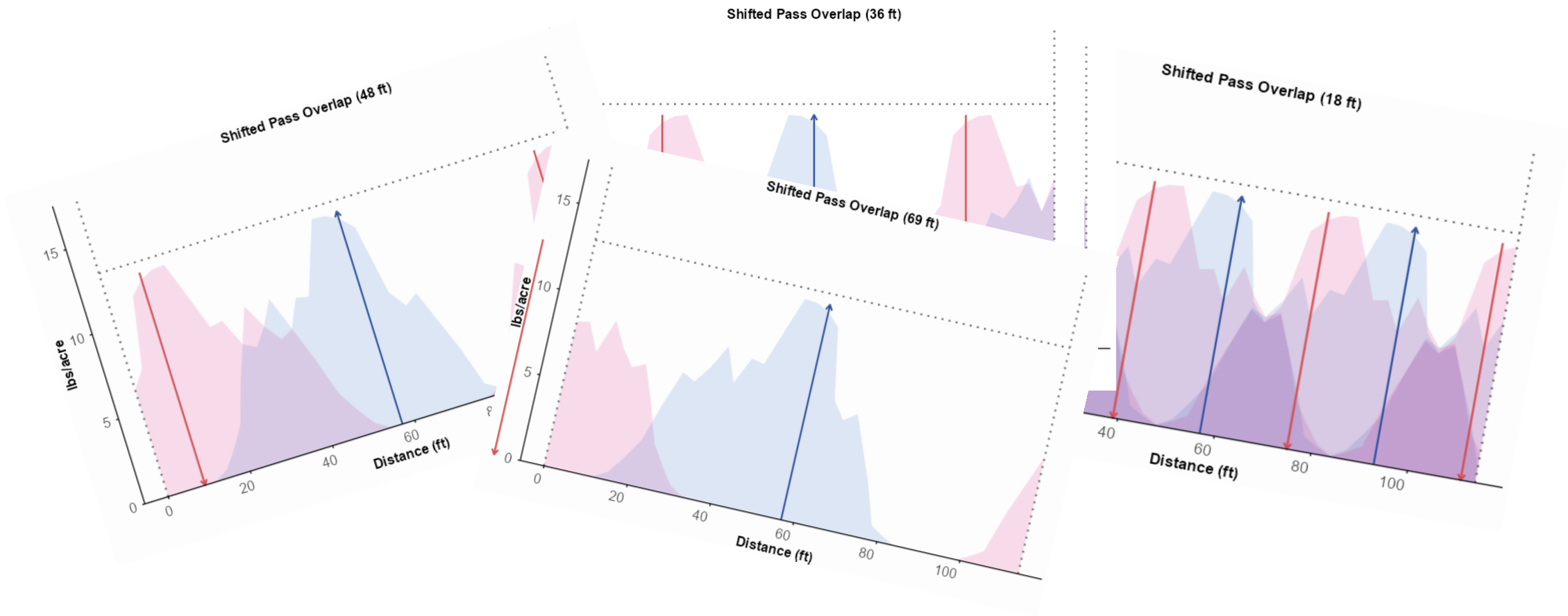
$$\frac{SD}{Mean} \times 100$$

Effective swath is selected based on target rate and *acceptable* uniformity from overlap



10 lb/acre
40% CV

How do you evaluate all the swath widths?

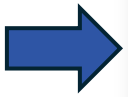


Aerial Swath Analysis Program (ASAP) makes this easy!

```
# AERIAL SWATH ANALYSIS PROGRAM (ASAP)
# Authors: Atom, Olivia, Joseph, Nevaeh, Keira

##### ---- Libraries ---- ####
library(shiny)
library(shinyWidgets)
library(shinyBS)
library(shinyFeedback)
library(shinydashboard)
library(bslib)
library(shinyjs)
library(DT)
library(plotly)
library(tidyverse)
library(readxl)
library(gganimate)
library(gifski)
library(png)
library(viridis)
library(rmarkdown)

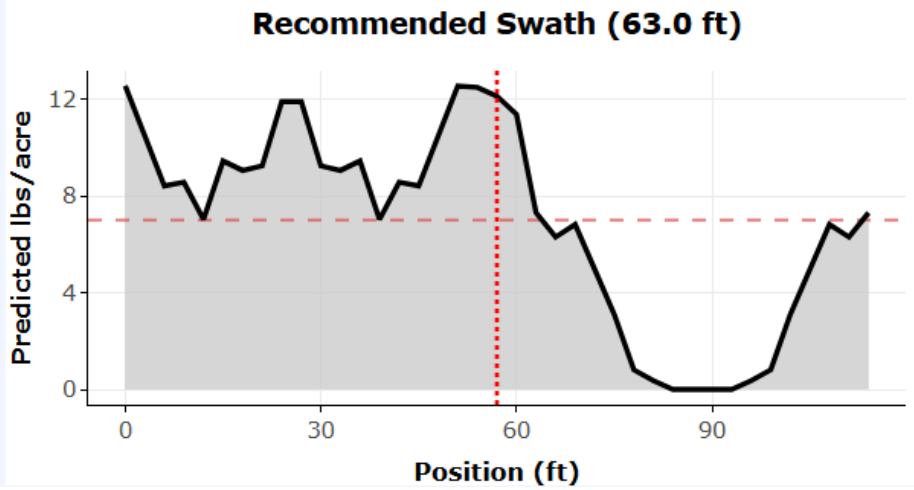
##### ---- Load Modules ---- #####
source("helpers.R") # always load first
source("modules/mod_inputs.R")
source("modules/mod_processed.R")
source("modules/mod_actual.R")
source("modules/mod_predicted.R")
source("modules/mod_summary.R")
```



Recommended Swath

Swath Width	App Rate	CV
63.0 ft	6.89 lbs/acre	59.97%
Absolute Target Error	**Bin Spacing**	**Centerline**
0.11 lbs/acre	3.0 ft	57.0 ft

Recommendation is based on the swath width with the **closest mean application rate to the target**, with **lowest CV** used as the tie-breaker.



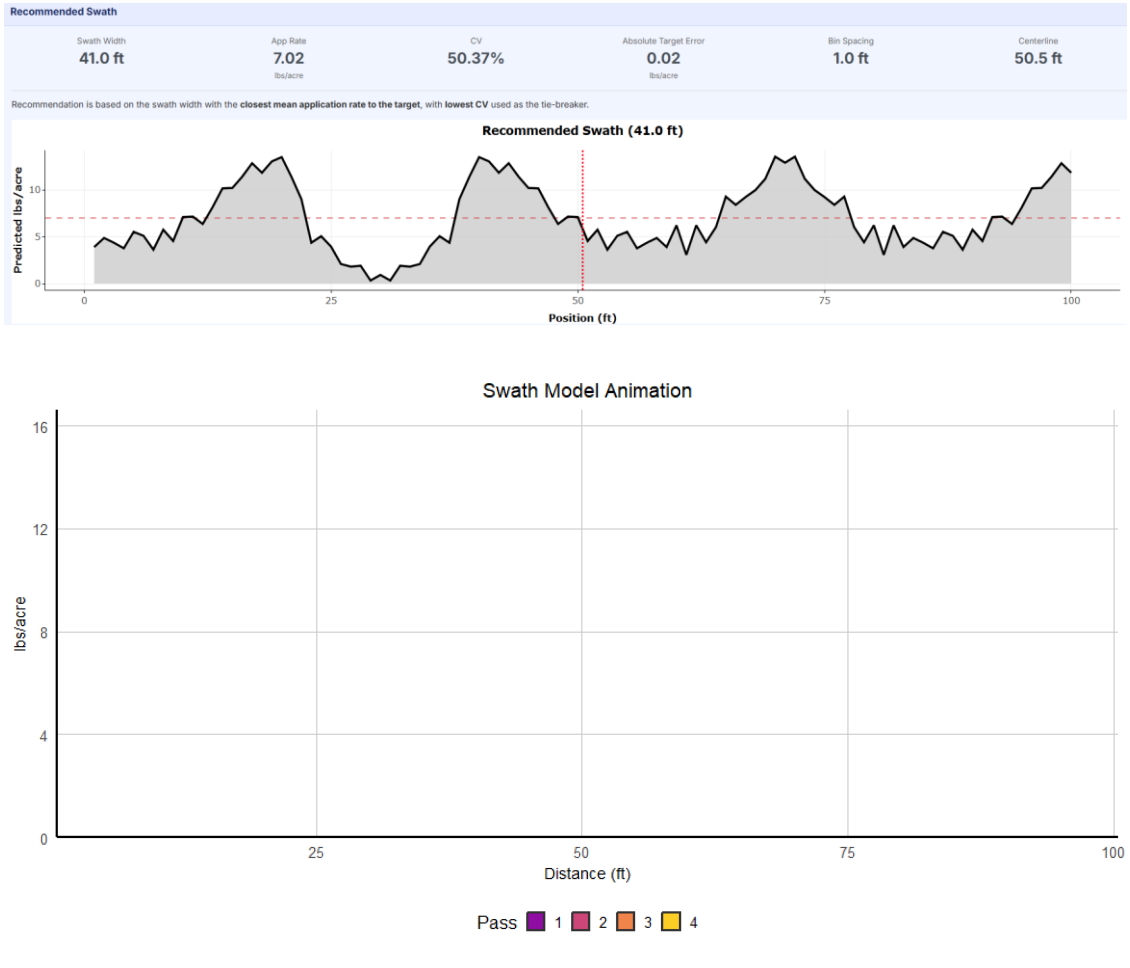
SWATH WIDTH (FT)	APP RATE (LBS/ACRE)	CV (%)	BIN SPACING USED (FT)	ABSOLUTE TARGET ERROR (LBS/ACRE)
63	6.89	59.97	3	0.11
60	7.5	57.01	3	0.5
66	6.38	62.72	3	0.62
69	5.95	66.54	3	1.05
57	8.12	53.66	3	1.12
72	5.56	71.69	3	1.44
54	8.74	50.35	3	1.74
75	5.21	77.47	3	1.79
78	4.95	83.31	3	2.05
51	9.25	47.13	3	2.25

COLLIER MOSQUITO CONTROL DISTRICT

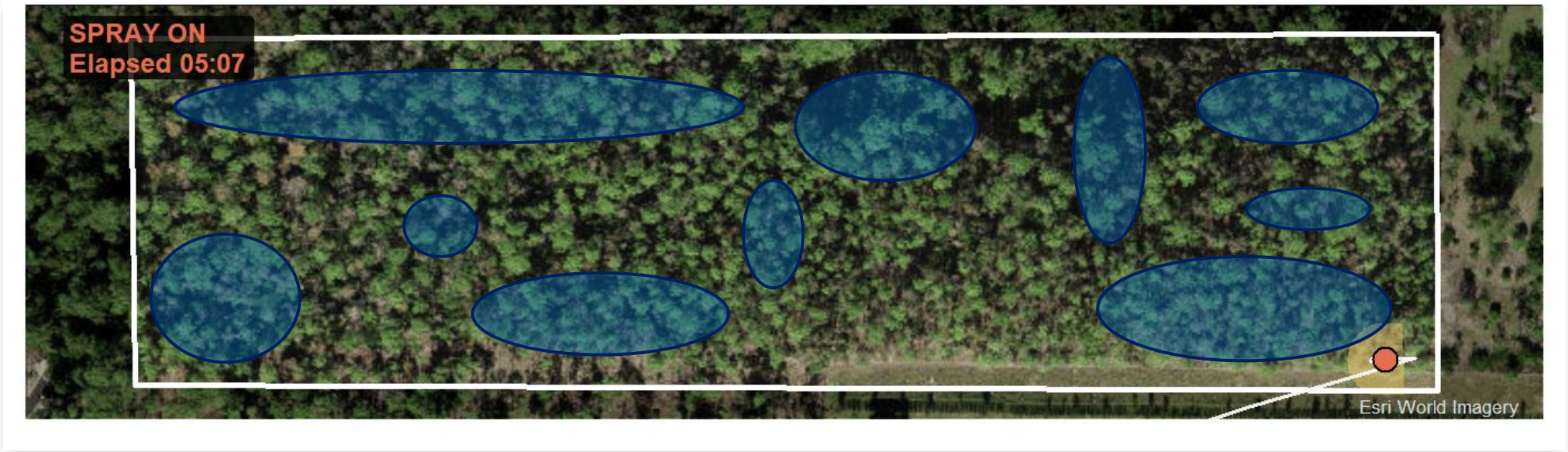
Aerial Swath Analysis Program (ASAP)

- Free, open-source web application for characterizing granular swath
- Applicable for any aerial platform (rotor, UAS, fixed-wing)

ASAP Web Tool

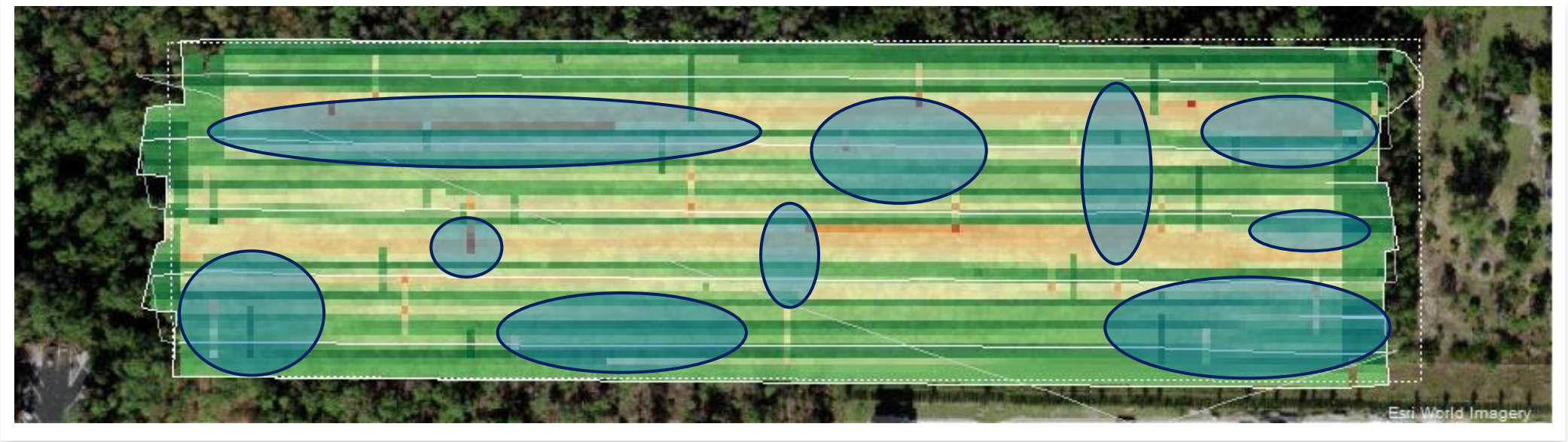


Spotty flooding appears uniformly treated…



Flooded Area

But…there are always under- and over-application regions



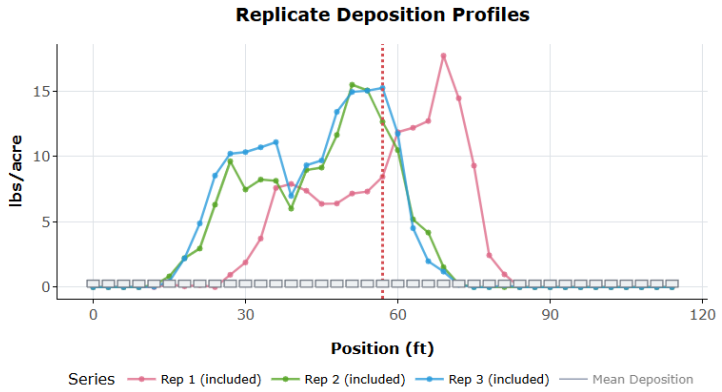
Flooded Area

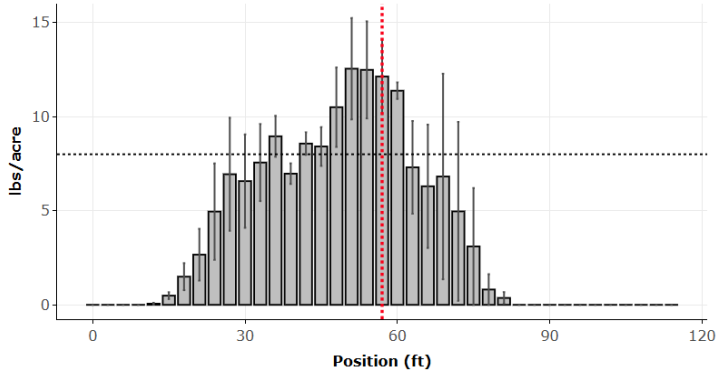
Field conditions and granule uniformity affect field control

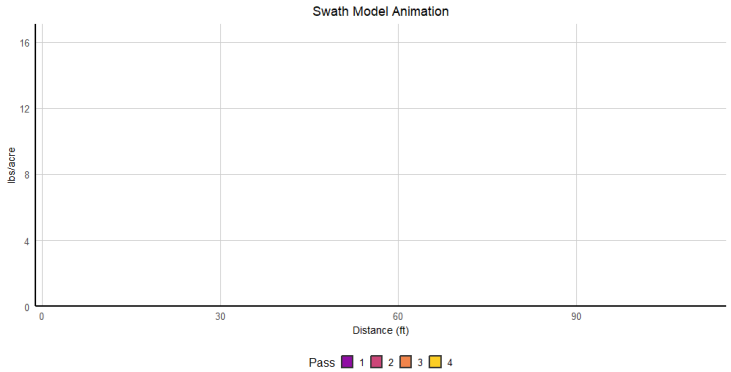


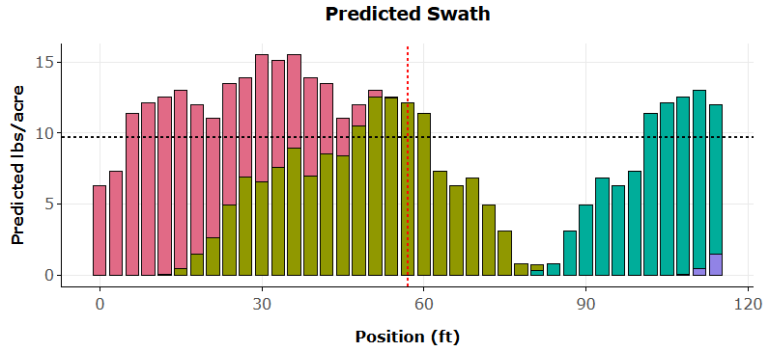


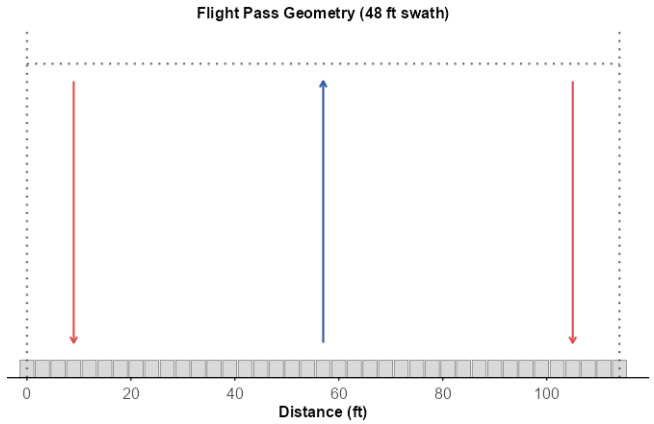
So we have all this information…

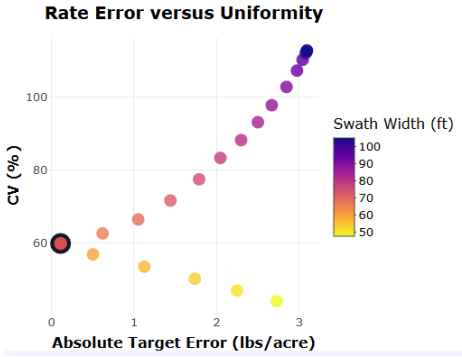












So we have all this information…





If we only have resources to treat 12 locations this week, but 25 locations need it, how do we decide where to treat?







How should we prioritize?

- All these matter, but how is each's relative importance assessed?
- How does surveillance data direct drone operations?
- How do non-mosquito factors weigh decision-making?
- What about the environmental conditions?



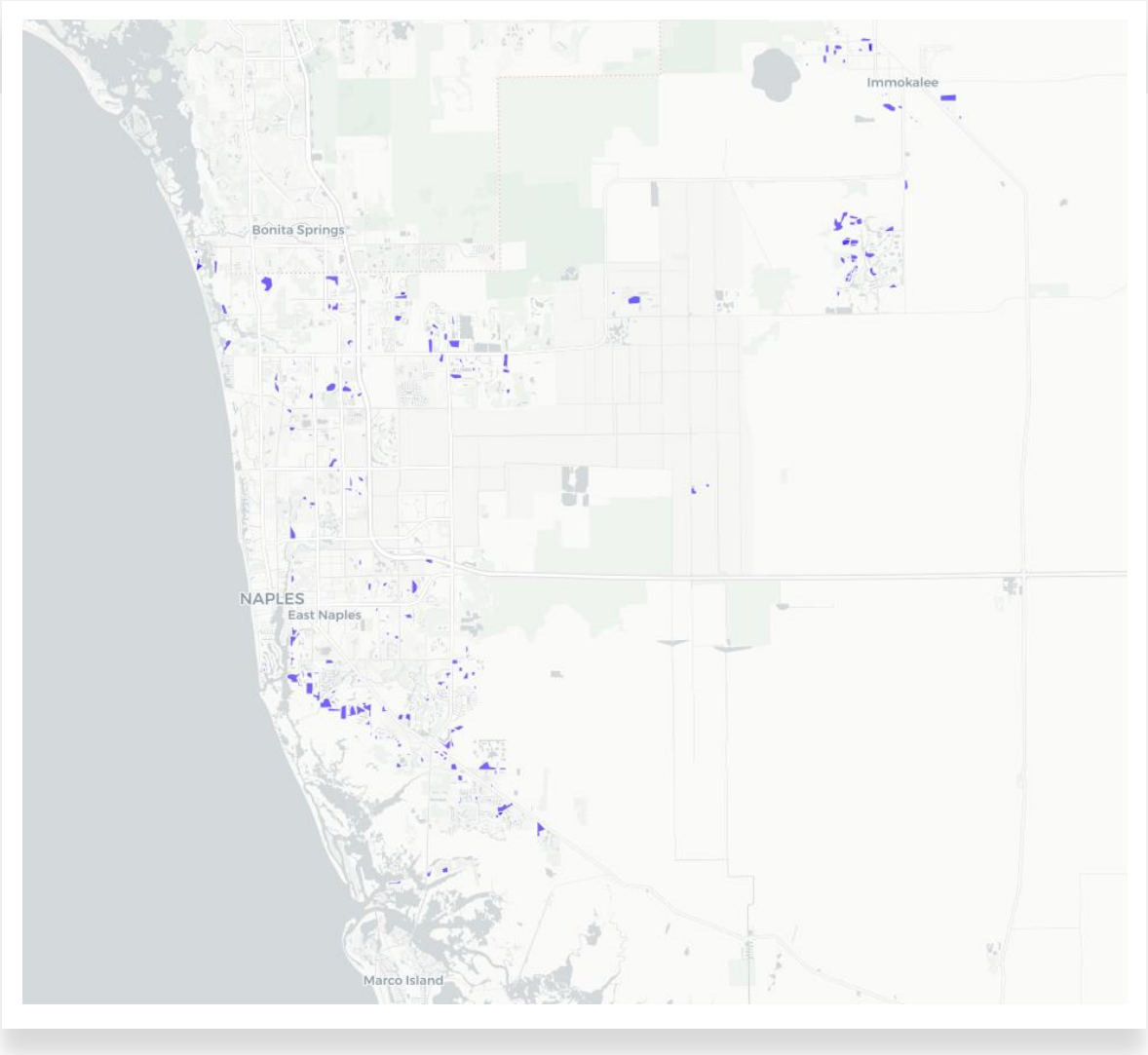




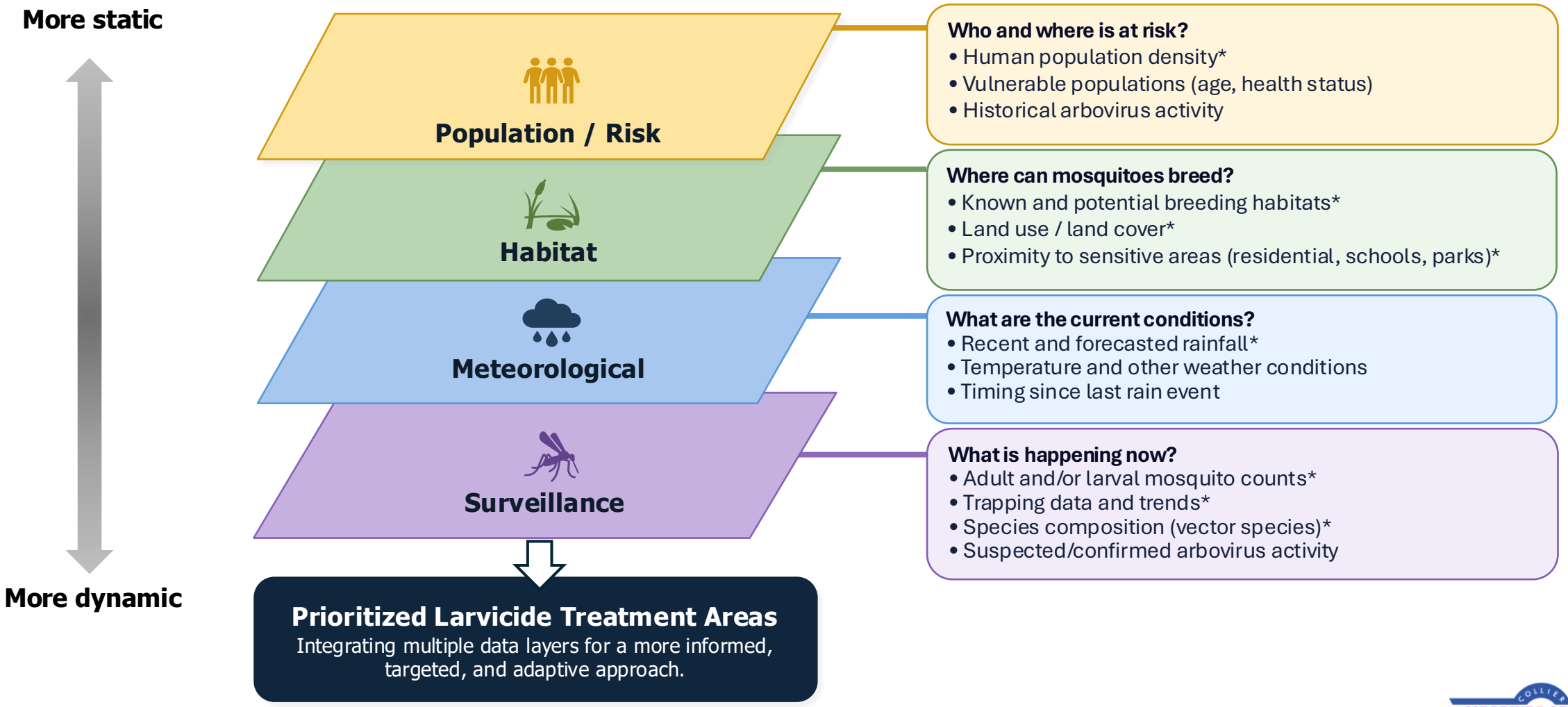


Drone larvicide areas

- 238 unique drone treatment areas
- More potential surveillance and treatment targets than time, staff, or resources to handle.
- **Where will larvicide be most impactful?**
  - **Population Exposure/Risk**
  - **Mosquito Abundance/Species**

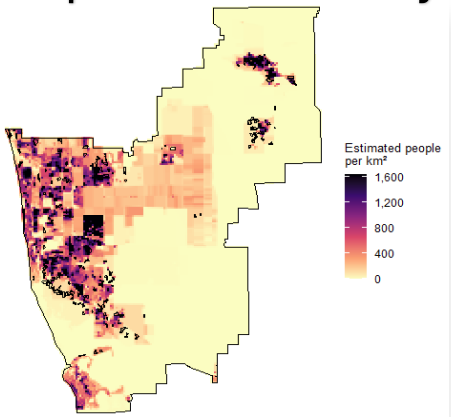


Prioritization Strategy

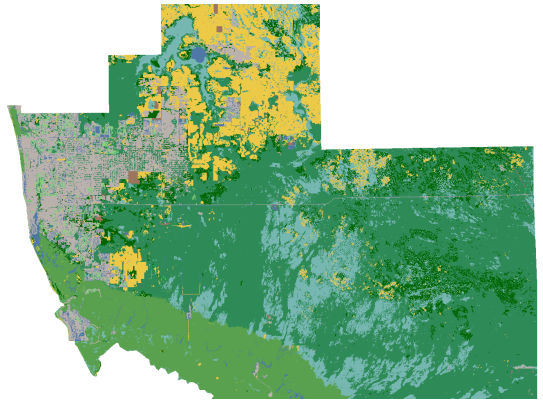


We leverage this data to prioritize UAS activities

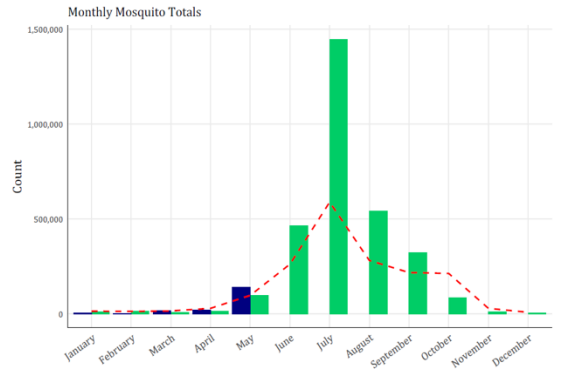
Population Density



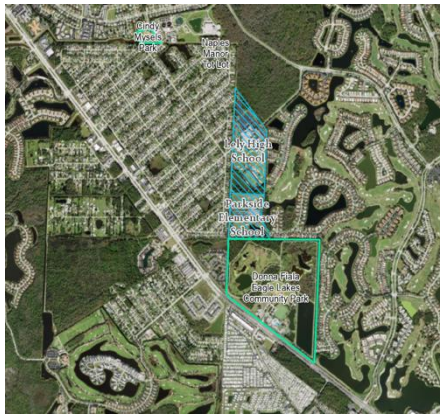
Land-use/cover



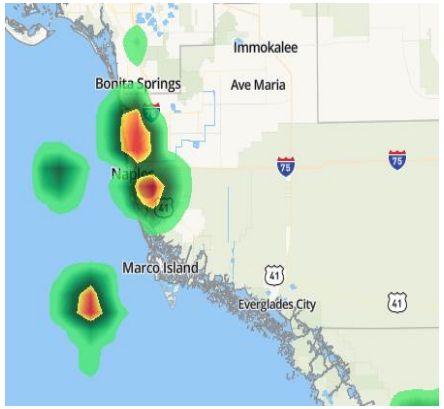
Surveillance Data



Sensitive Areas



Precipitation



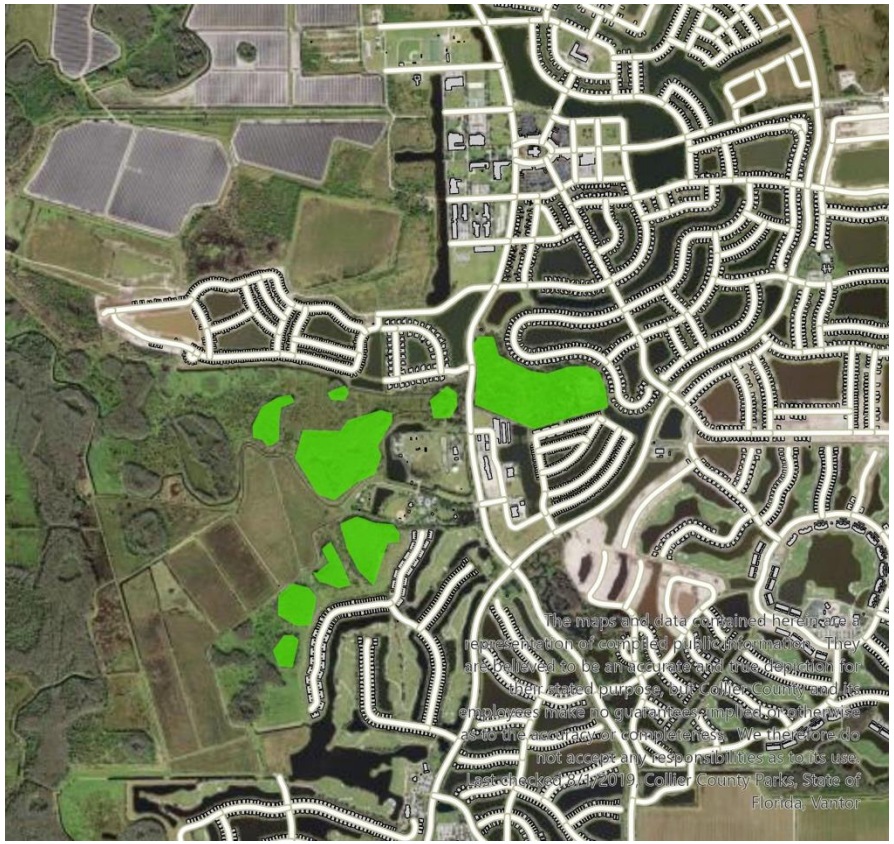
UAS inspections and treatments purposeful and specific

- "Truth" each habitat based on:
  - Population exposure/risk
  - Extent of standing water (or likelihood)
  - Species present
  - Adult vs. larval abundance





How do you relate exposure to habitat geographically?



Review

Flight distance of mosquitoes (Culicidae): A metadata analysis to support the management of barrier zones around rewetted and newly constructed wetlands

Piet F.M. Verdonschot[a,b,*], Anna A. Besse-Lototskaya[a]

[a] Alterra Wageningen UR, Department of Freshwater Ecology, P.O. Box 47, 6700 AA Wageningen, The Netherlands
[b] University of Amsterdam, Institute for Biodiversity and Ecosystem Dynamics (IBED), P.O. Box 94248, 1090 GE Amsterdam, The Netherlands

Where are mosquitoes from this habitat potentially dispersing to?

How do you relate exposure to habitat geographically?



Review

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Where are mosquitoes from this habitat potentially dispersing to?

*Cx. *nigripalpus* mark release recapture (MRR) mean distance 0.85 km (0.5 mile)

Case Study: Immokalee Cypress Strand

IM NLR LCEC - 2/25/25, 6:53 PM
Field Technician: Miguel Rua
Zone IM
5 Minute Count : 250
Field count: 25 in 30 seconds

IM NLR Water Plant - 2/25/25, 7:11 PM
Field Technician: Miguel Rua
Zone IM
5 Minute Count : 42
Field count: 25 in 3 minutes

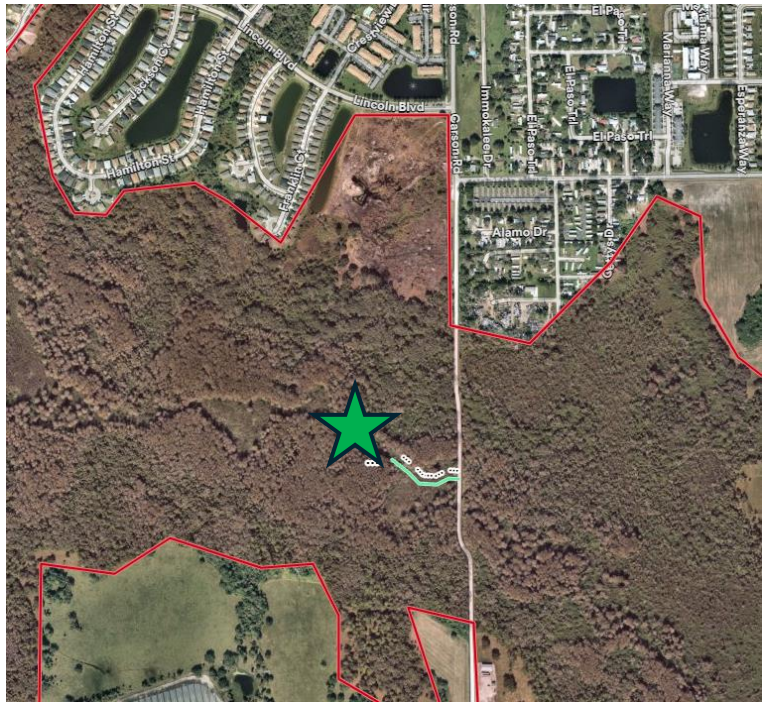


IM NLR LCEC - 3/3/25, 6:55 PM
Field Technician: Miguel Rua
Zone IM
5 Minute Count : 125
Field count: 25 in 1 minute

IM NLR Water Plant - 3/3/25, 7:49 PM
Field Technician: Miguel Rua
Zone IM
5 Minute Count : 25
Field count: 25 in 5 minutes



Cast Study: Immokalee Cypress Strand

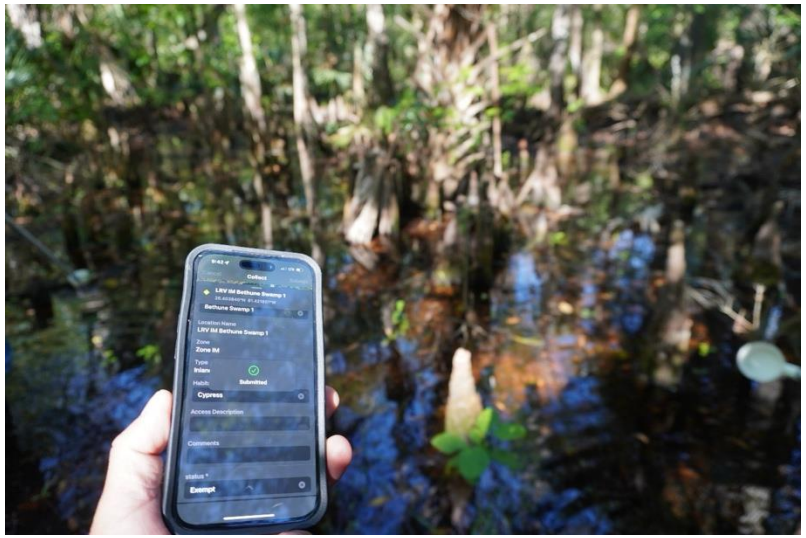








Cast Study: Immokalee Cypress Strand

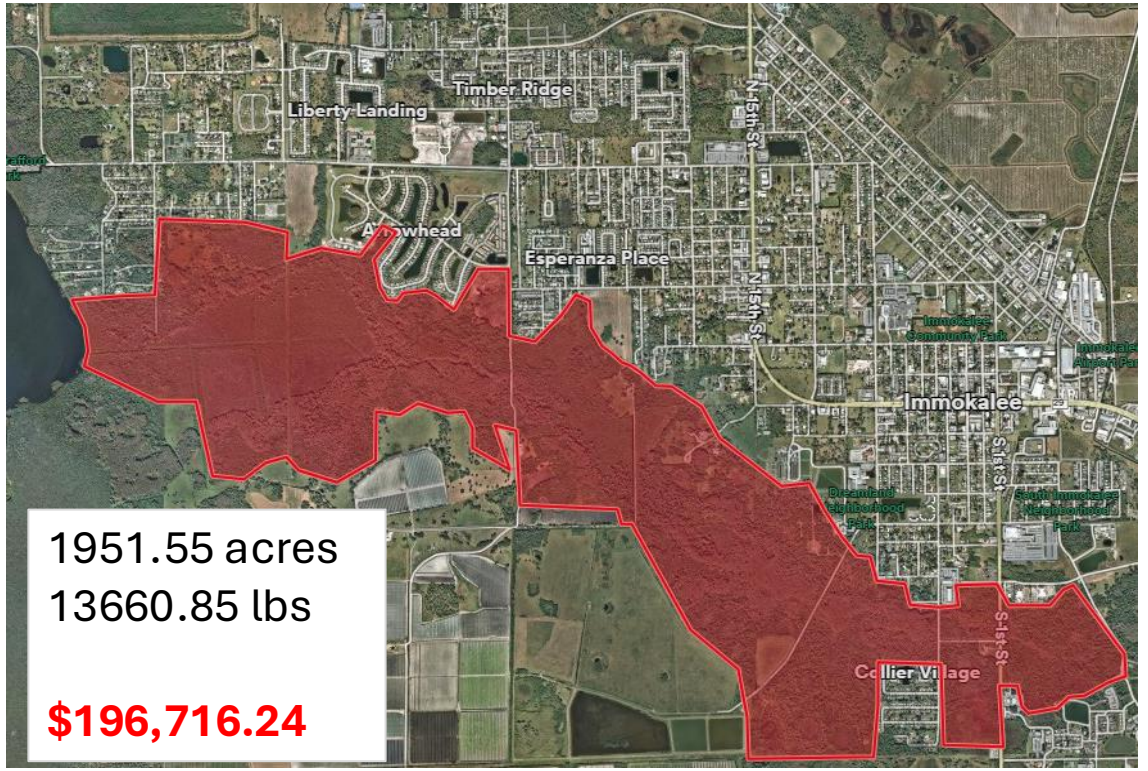




Cast Study: Immokalee Cypress Strand







Cast Study: Immokalee Cypress Strand





336 acres
2361 lbs

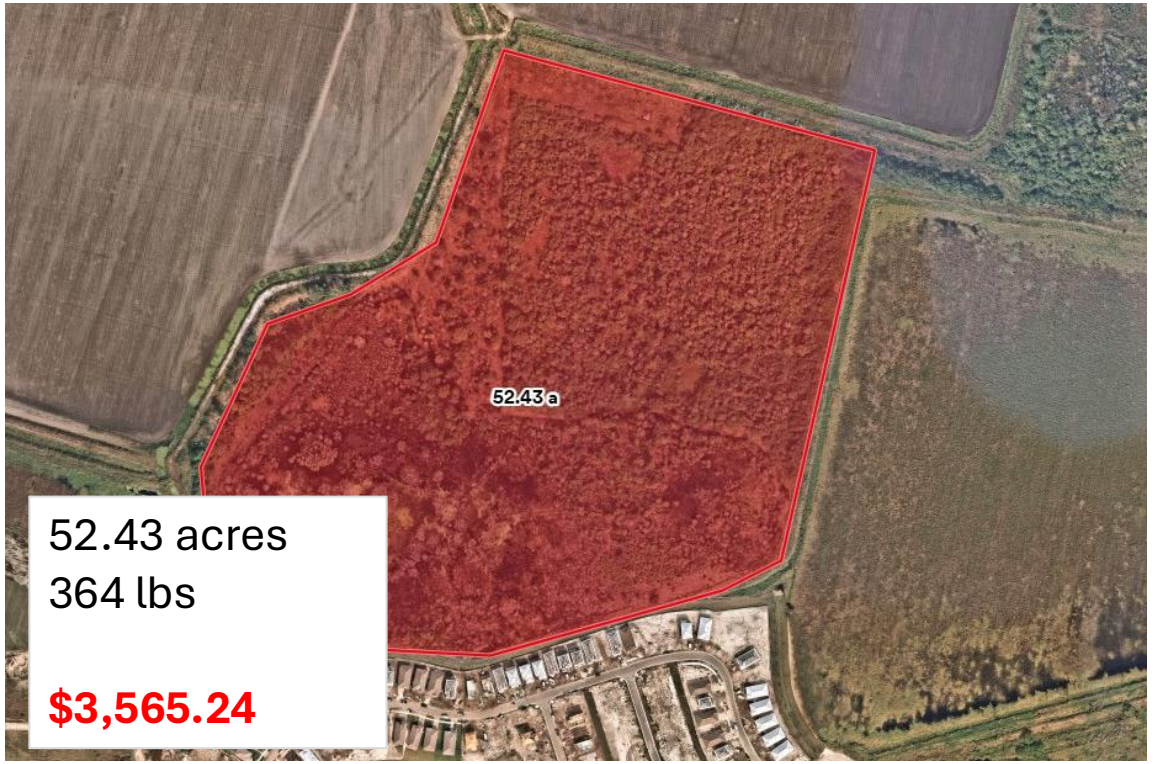
$48,499.20



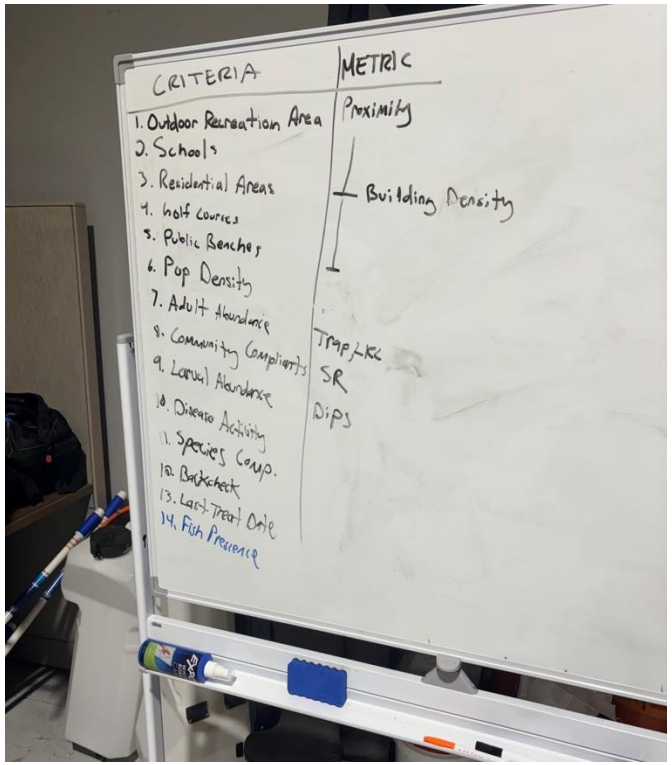


Cast Study: Silverwood





Formalizing the process…

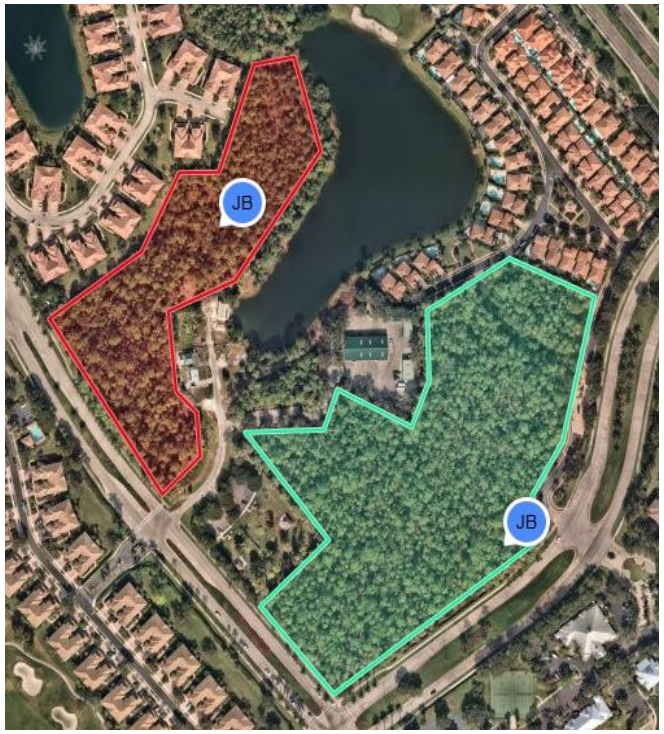



```
# determine land use of drone blocks
landuse["landuse_area"]  = st_area(landuse$geometry)

land_intersect <- st_intersection(dronepolys, landuse) %>%
  mutate(int_area= st_area(geom),
         # proprtion of intersection actually in land use block
         landuse_wt = int_area/landuse_area,
        # area of each landuse per drone block
         lu_prop = landuse_wt*poly_ar) %>%
  st_drop_geometry() %>%
  group_by(polygonName) %>%
  # # choose highest area of land use
  slice_max(lu_prop, n=1) %>%
  ungroup() %>%
  select(c(GlobalID, General_LU))

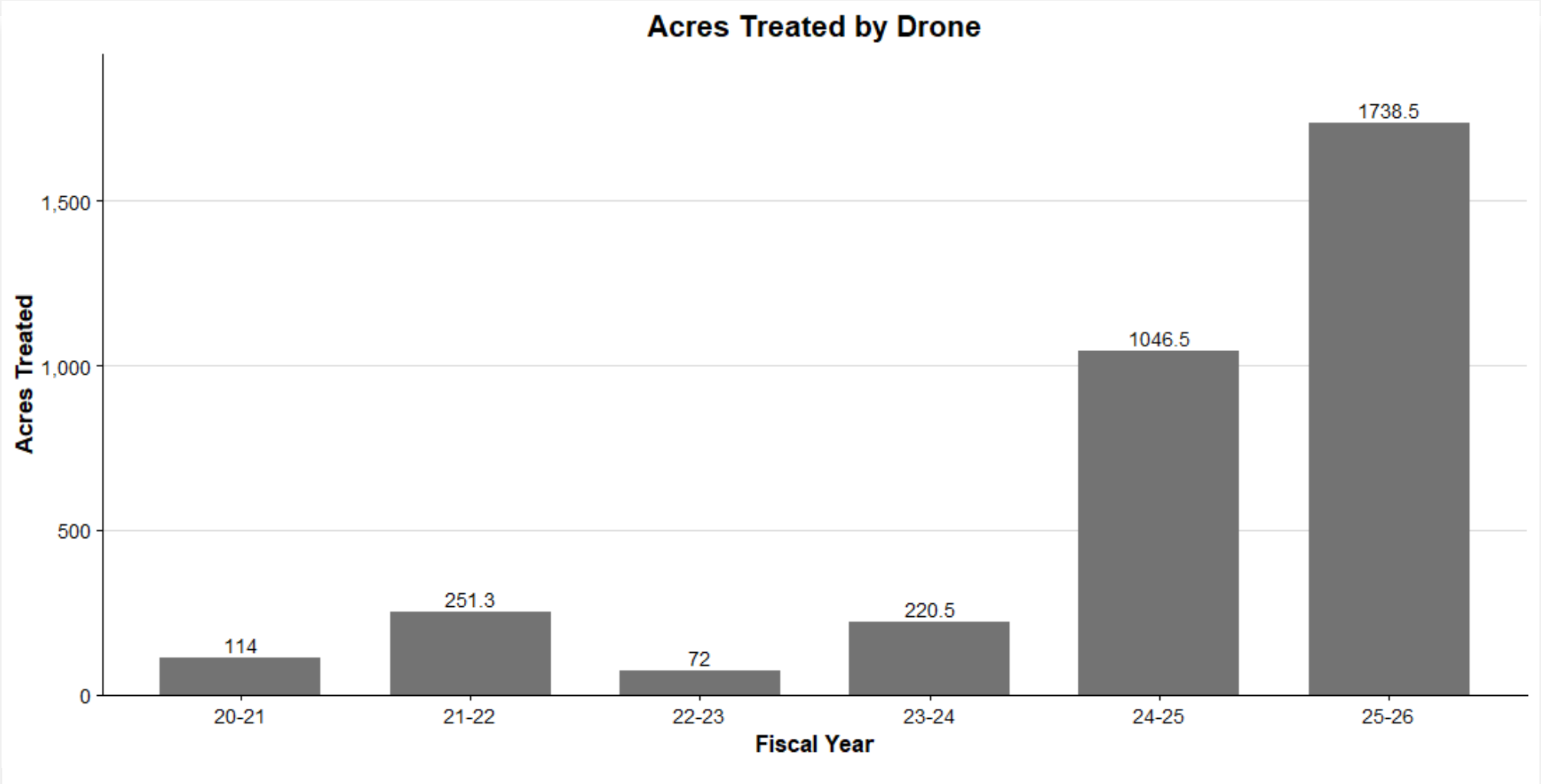
# join back to drone polys
dronepolys <- dronepolys %>%
  left_join(land_intersect, by="GlobalID")

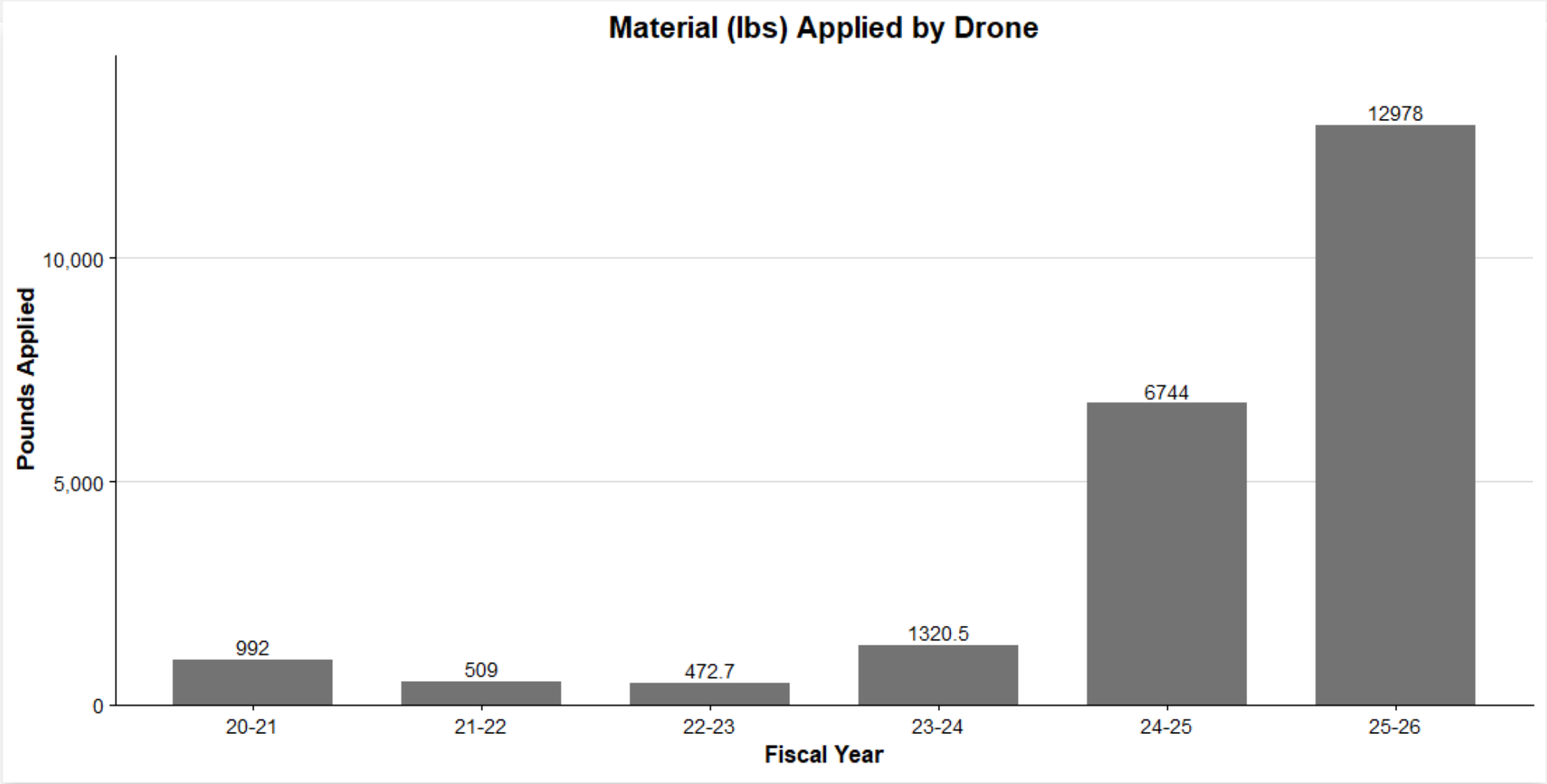
# categorize land use values for relative mosquito flight ranges
#habitats <- unique(dronepolys$LANDUSE_D)
habitats <- unique(dronepolys$General_LU)
weak <- c("Residential High Density", "Institutional", "Resident
medium_s <- c("Pasture", "Agricultural Other", "Rangeland", "Tre
              "Barren, Spoil", "Parks, Recreation, Golf", "Resid
medium_l <- c("Freshwater Marsh, Wet Prairie", "Wetland Forest",
              "Freshwater", "Wetland Other")
strong <- c("Mangrove, Saltwater Marsh", "Saltwater")
# weak fliers - urban habitats?
# weak <- c("Fixed Single Family Units", "Commercial and Service
#           "Parks and Zoos", "Institutional", "Tree Nurseries",
# # short medium range - anopholes habitats?
# medium_s <- c("Improved Pastures", "Woodland Pastures", "Pine
#               "Upland Shrub and Brushland", "Upland Mixed Coni
```



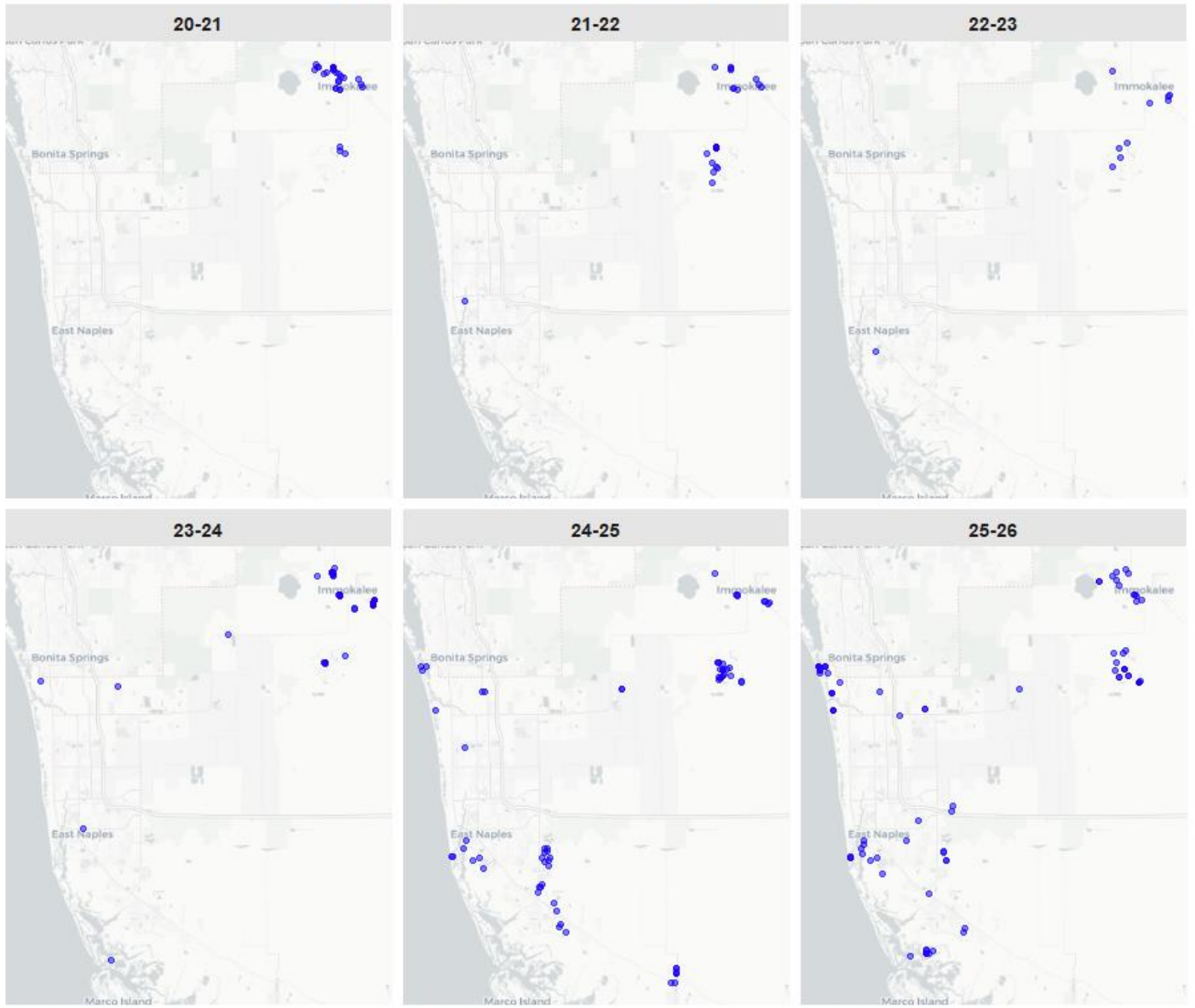
Why does this matter?

- Make our lives easier
- Better service and impact
- Allocate resources better (save money)
- Justify treatment


Acres Treated by Drone
Acres Treated
1,500
1,000
500
0
114
251.3
72
220.5
1046.5
1738.5
20-21
21-22
22-23
23-24
24-25
25-26
Fiscal Year


Material (lbs) Applied by Drone
Pounds Applied
10,000
5,000
0
992
509
472.7
1320.5
6744
12978
20-21
21-22
22-23
23-24
24-25
25-26
Fiscal Year

Drone Treatment Locations by Fiscal Year



Drone “Dipping”

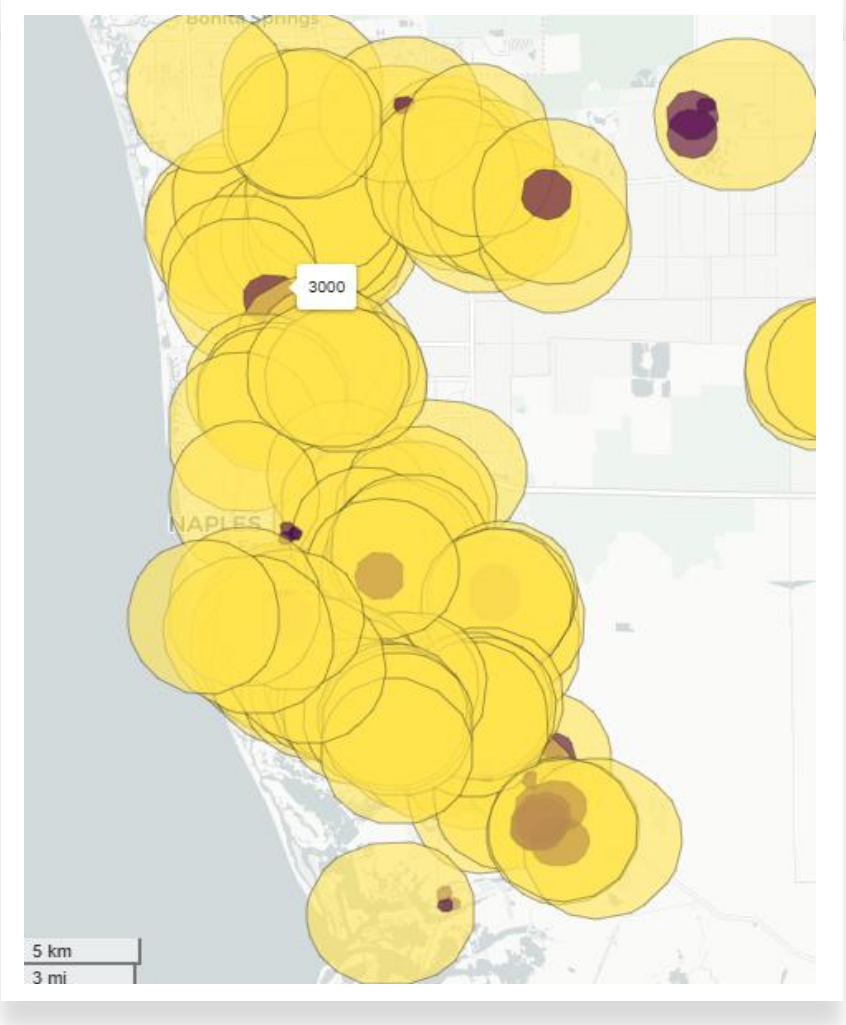


Drone “Dipping”



Looking Ahead

- Formalize surveillance and treatment prioritization criteria
- Develop *suggestive* model for selecting drone treatment areas
- Integrate historical, static, and dynamic data for monthly drone "hit list"



Questions?

