# Flexible Foraging of the Hawaiian Hoary Bat on Maui

## An update of the H. T. Harvey & Associates ecological research on Opeapea

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**Kristin Jonasson,**
**and Brad Yuen**

ESRC Meeting
Honolulu, Hawaii
5 March 2020

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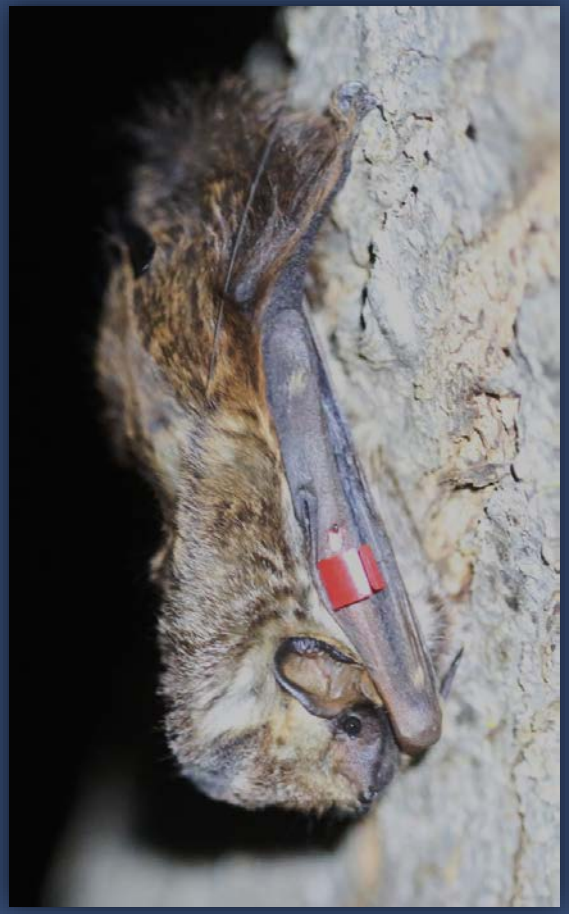
# Strategy for Recovery of the Species

- Which habitats do they use?
- How much land does a bat use?
- What do they eat?



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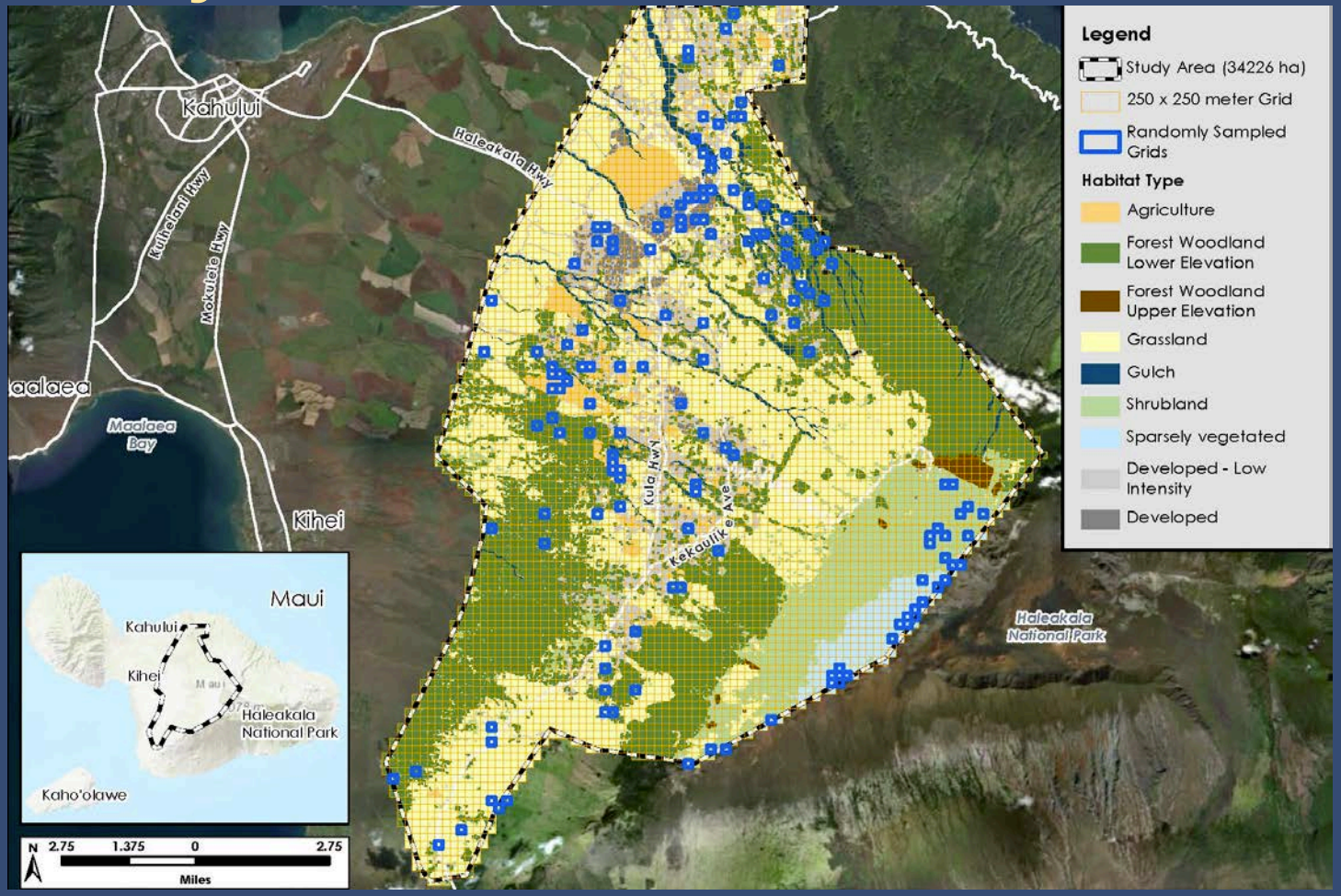
# Study Area & Bat Detector Locations




General Random Tessellation Stratified survey design

# Acoustic Monitoring - Methods


SM4 bat detectors

Bi-monthly

9 habitats

3 nights

5 replicates / month

315 total deployments

35 bat detector sites per each habitat

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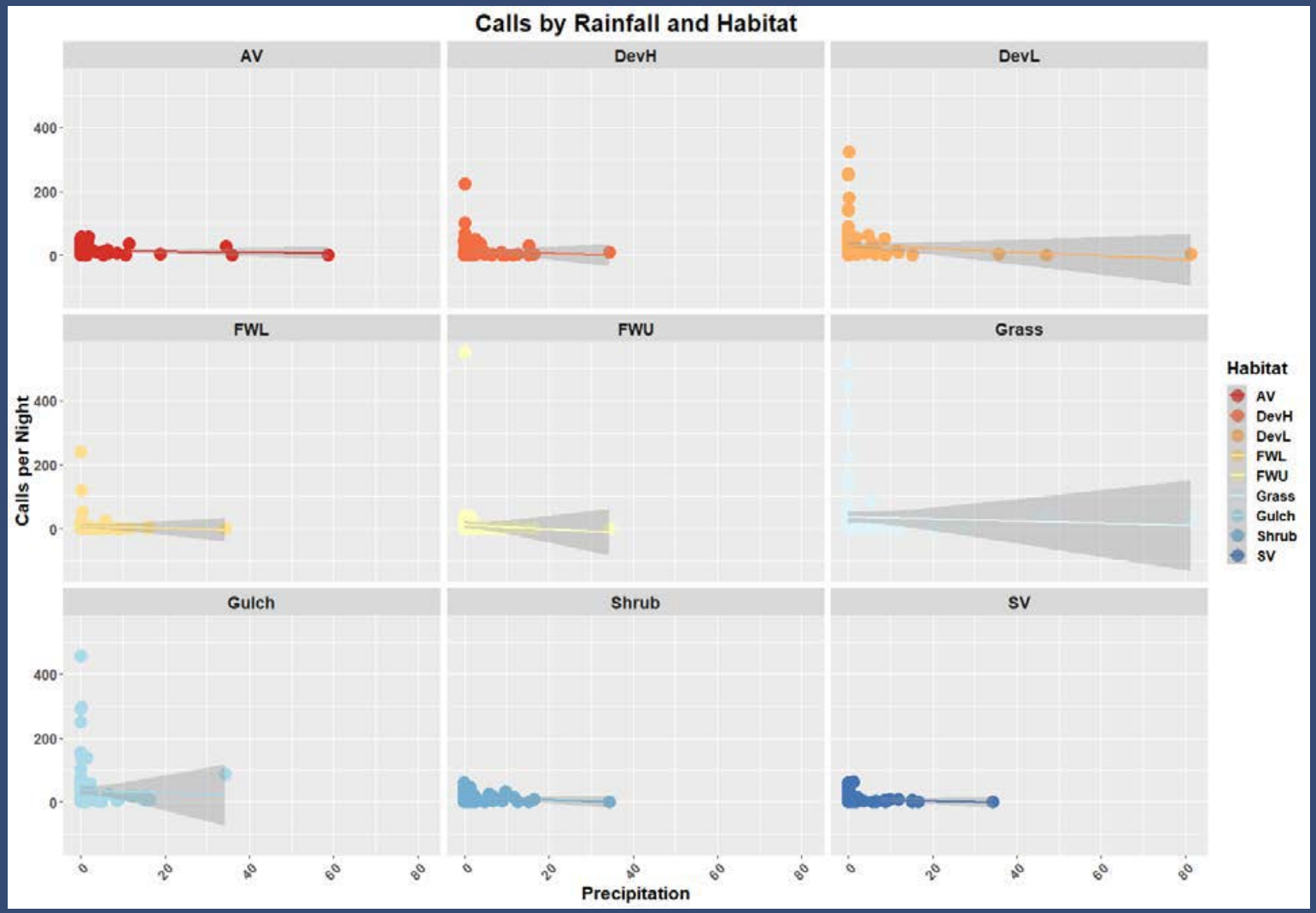
# Relationship between Precipitation and the Nine Habitats in the Study Area.



# Modelling of Acoustic Data - Methods

- **Differences between habitat activity - generalized linear model**
  fit by maximum likelihood with a negative binomial distribution date and site as random factors, and habitat as fixed effect of interest.

- **Tested for differences between months within each habitat, habitats within each month**, using pairwise contrasts with a Tukey adjustment for comparing among estimates

# Methods: Determining Core Use Areas

Mist-netting at “hot spots” of bat activity

Radio-telemetry of foraging bats using triangulation by mobile antennae and fixed stations

Analysis of data to determine core use area (CUA) 50% Kernel and foraging range (FR) 95% kernel. Reanalized data using methods described in Bonaccorso et al. 2015.

# Prey Availability

Bi-monthly

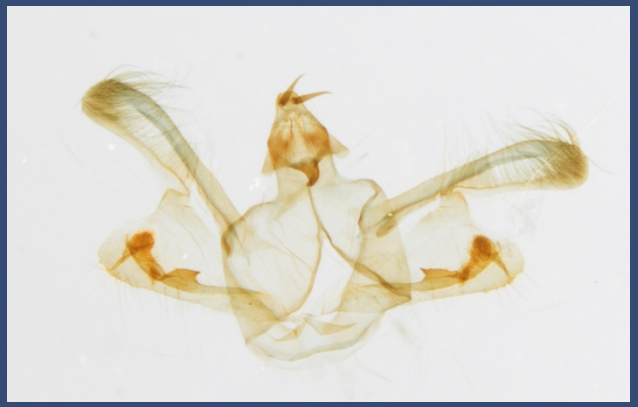
9 habitats

Extraordinary sample set

UV light collection trap

# Identification of Moths from Light Traps

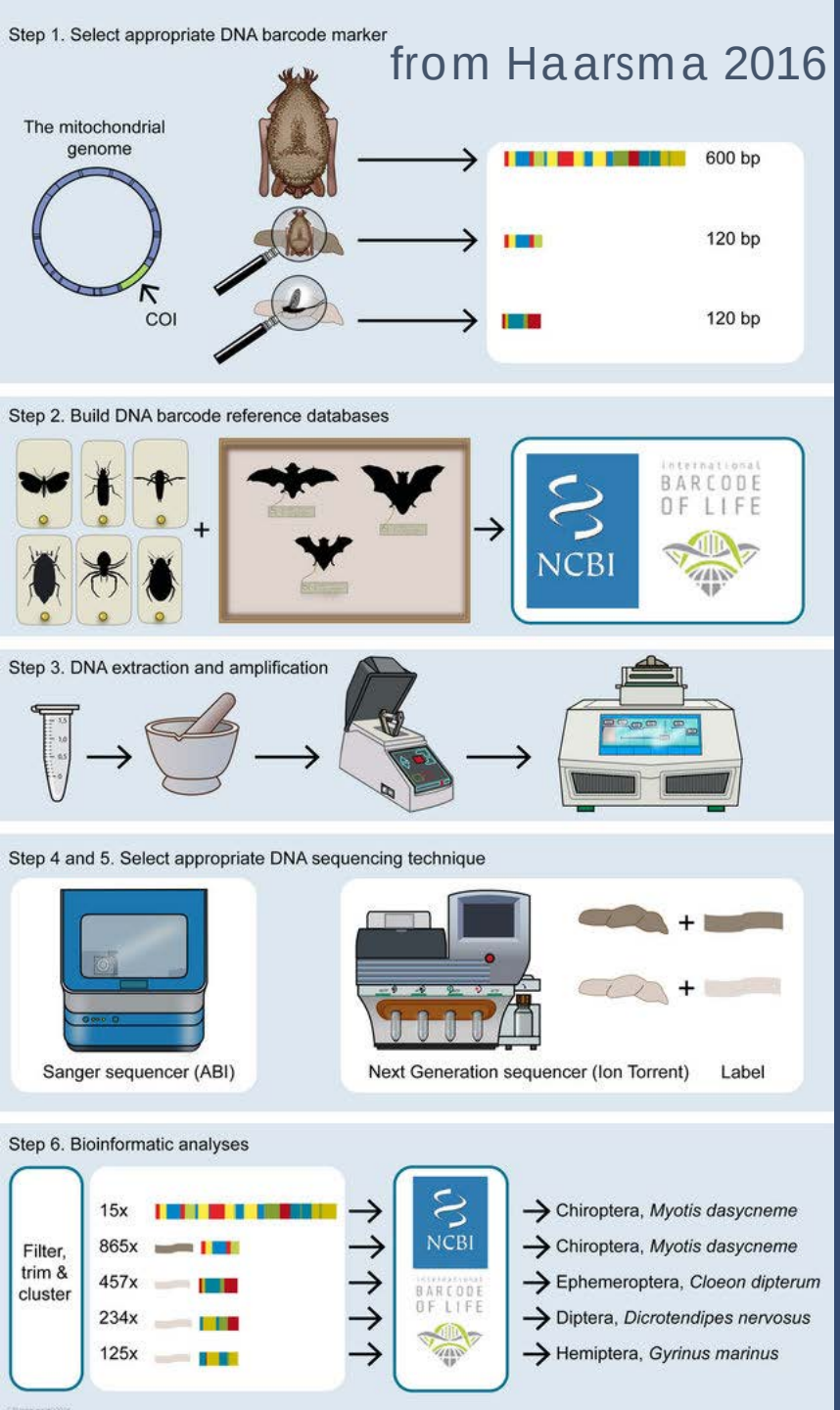
**Moths ID by Matt Medeiros**



**Slide preparations of Male Genitalia of *Darna pallivitta and Macaria abydata* Used to Identify the Species.**

# Modelling of Dry Weights of Insects per Habitat and Month

- **We fit a negative binomial generalized linear model with a log link function** from the MASS package (Venables and Ripley 2002)
- **We used the estimated marginal means** (emmeans) (Searle et al. 1980) function from the emmeans software package in R (Lenth 2009) to generate estimated means for each group
- **We tested for differences between months and habitats using pairwise contrasts with a Tukey adjustment** (Lenth 2009)



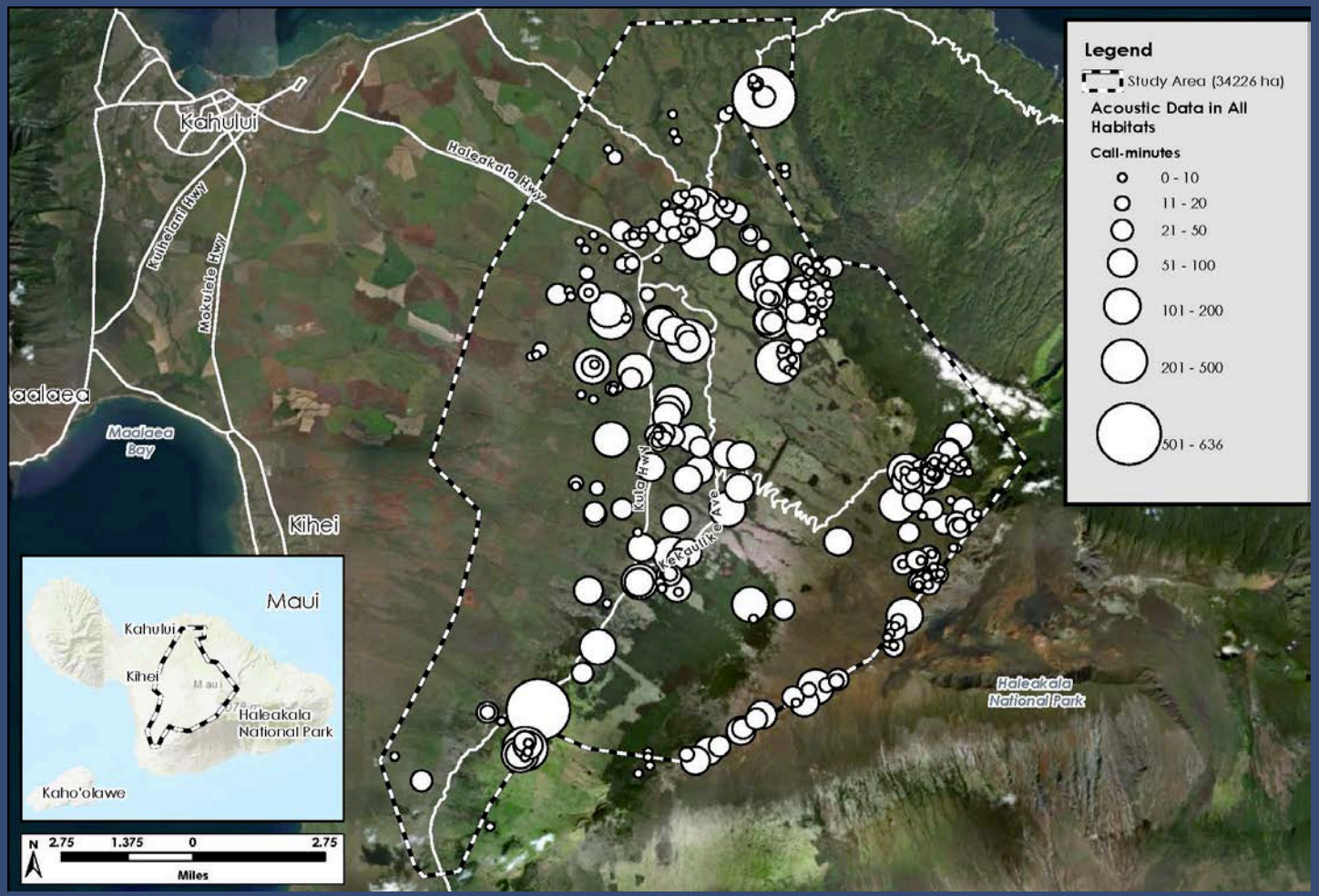

# DNA Extraction, Amplification, Polymerase Chain Reaction, Library Prep and Sequencing

Targeted CO1 region with primers from Zeale et al. (2010)

Targeted the 16s region with primers from Epp et al. (2012)

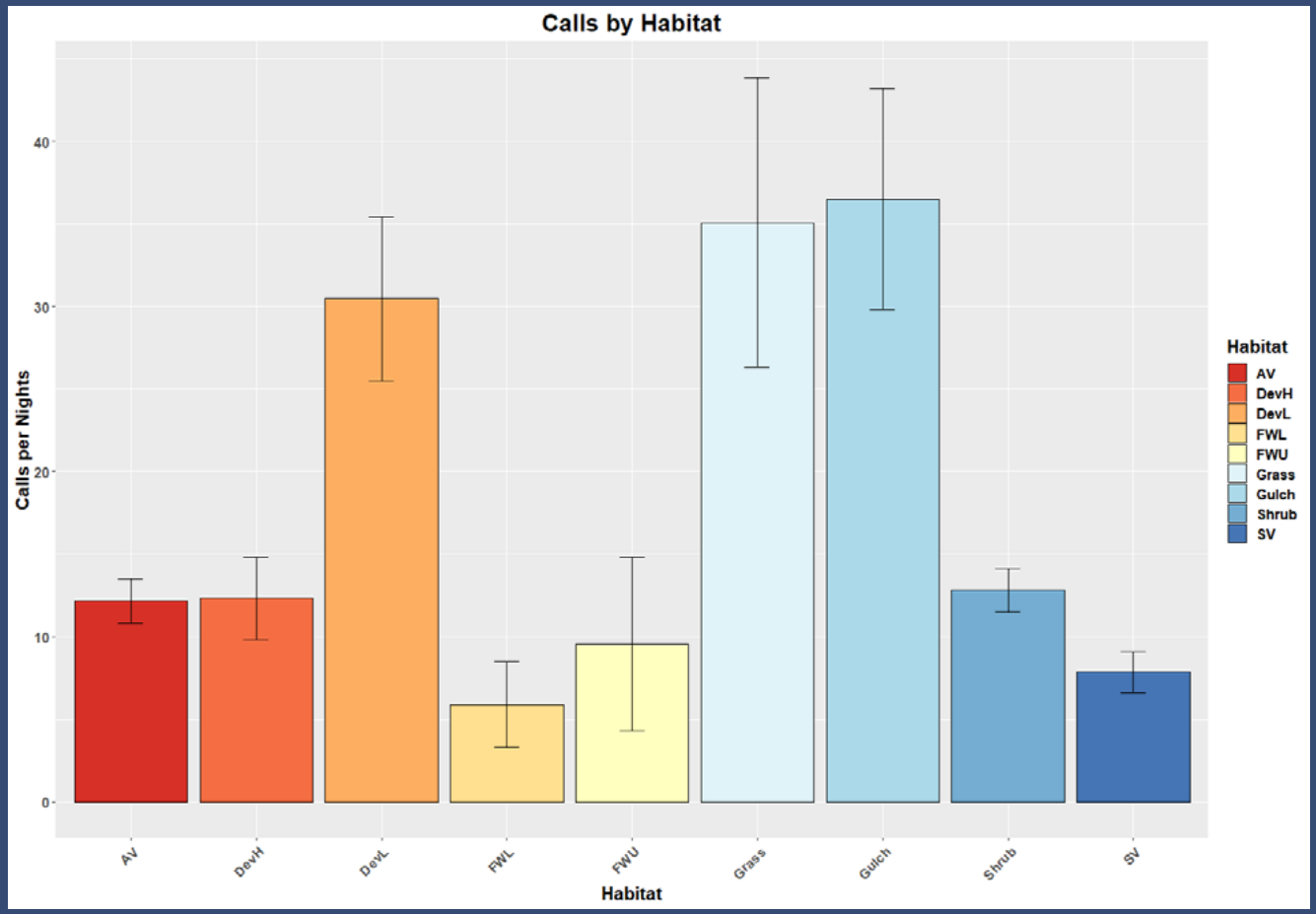
# Results: Acoustic Monitoring

## Habitat Use – All Habitats



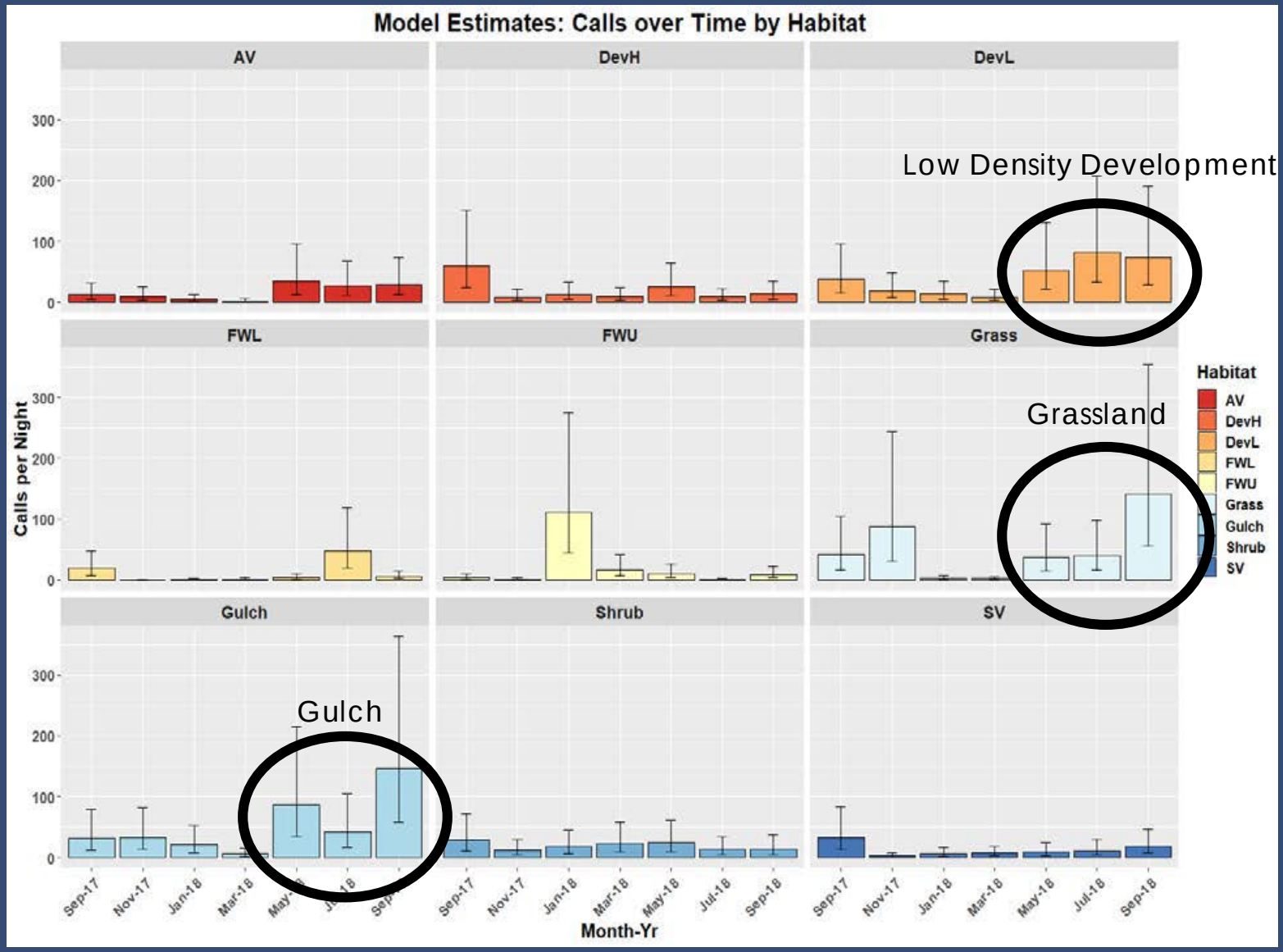
# Results: Acoustic Monitoring

## Calls per Night by Habitat

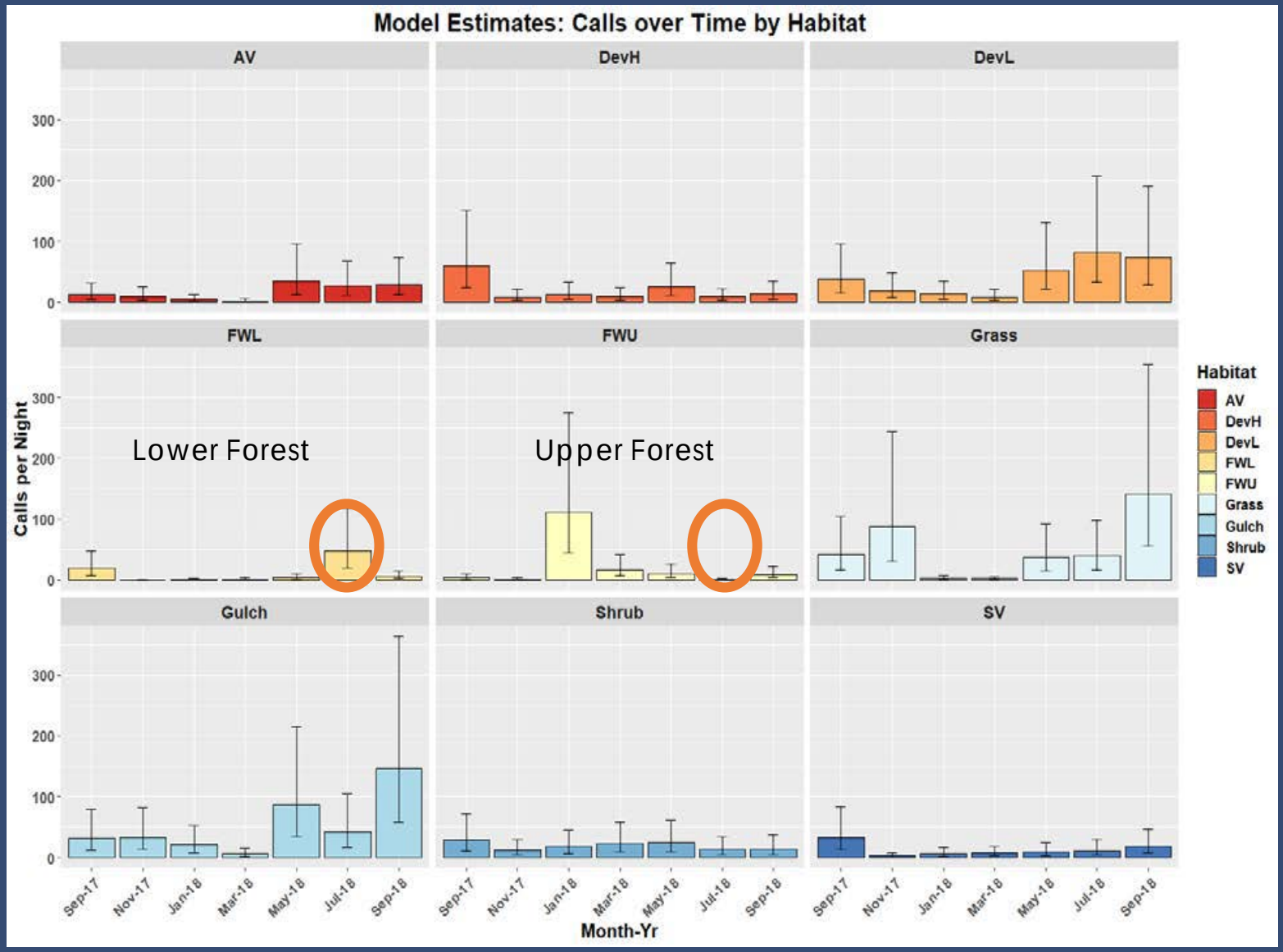



Schlaepfer MA (2018) Do non-native species contribute to biodiversity?

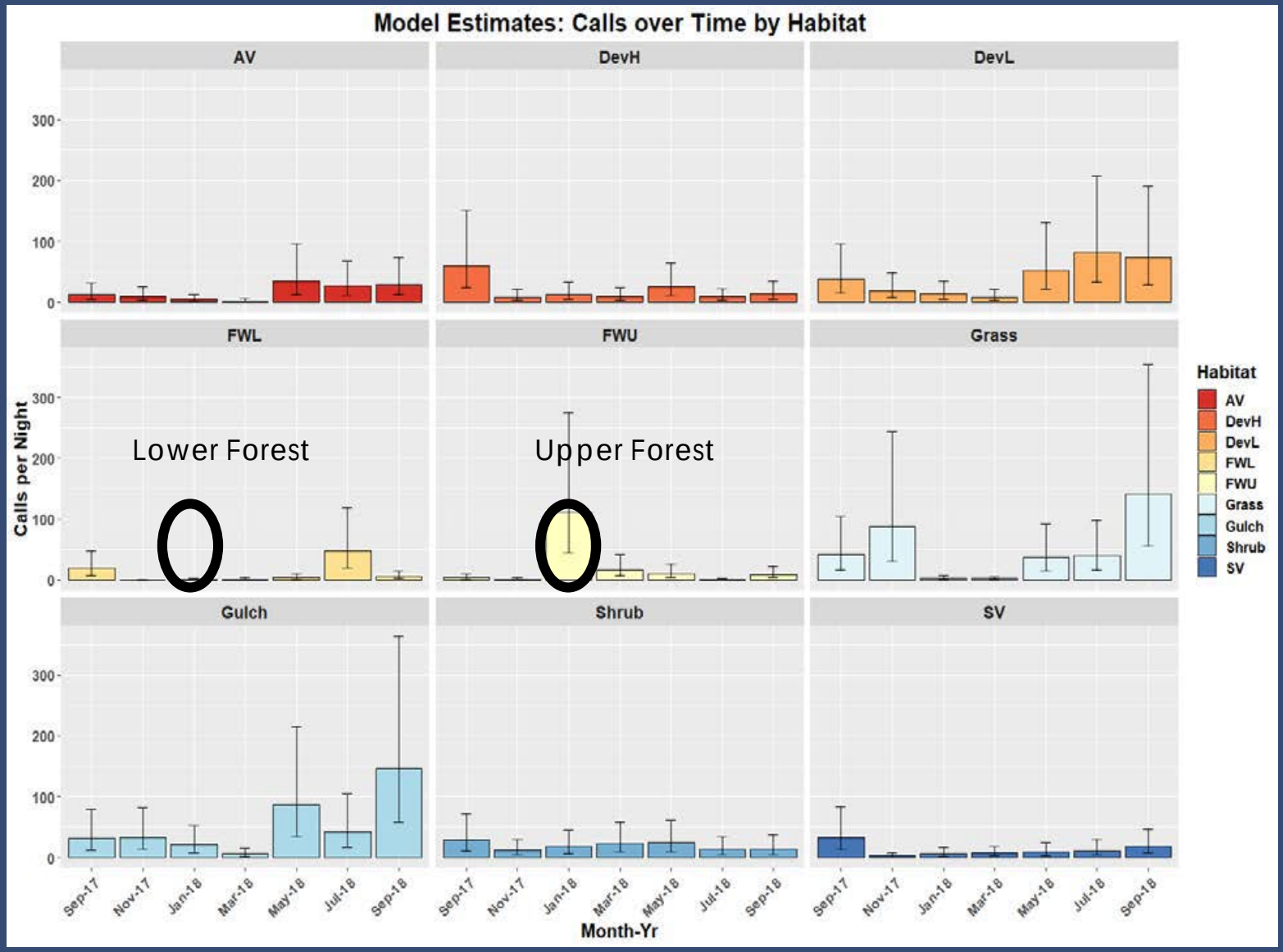
# Calls per Night over Time by Habitat



# Calls per Night by Habitat



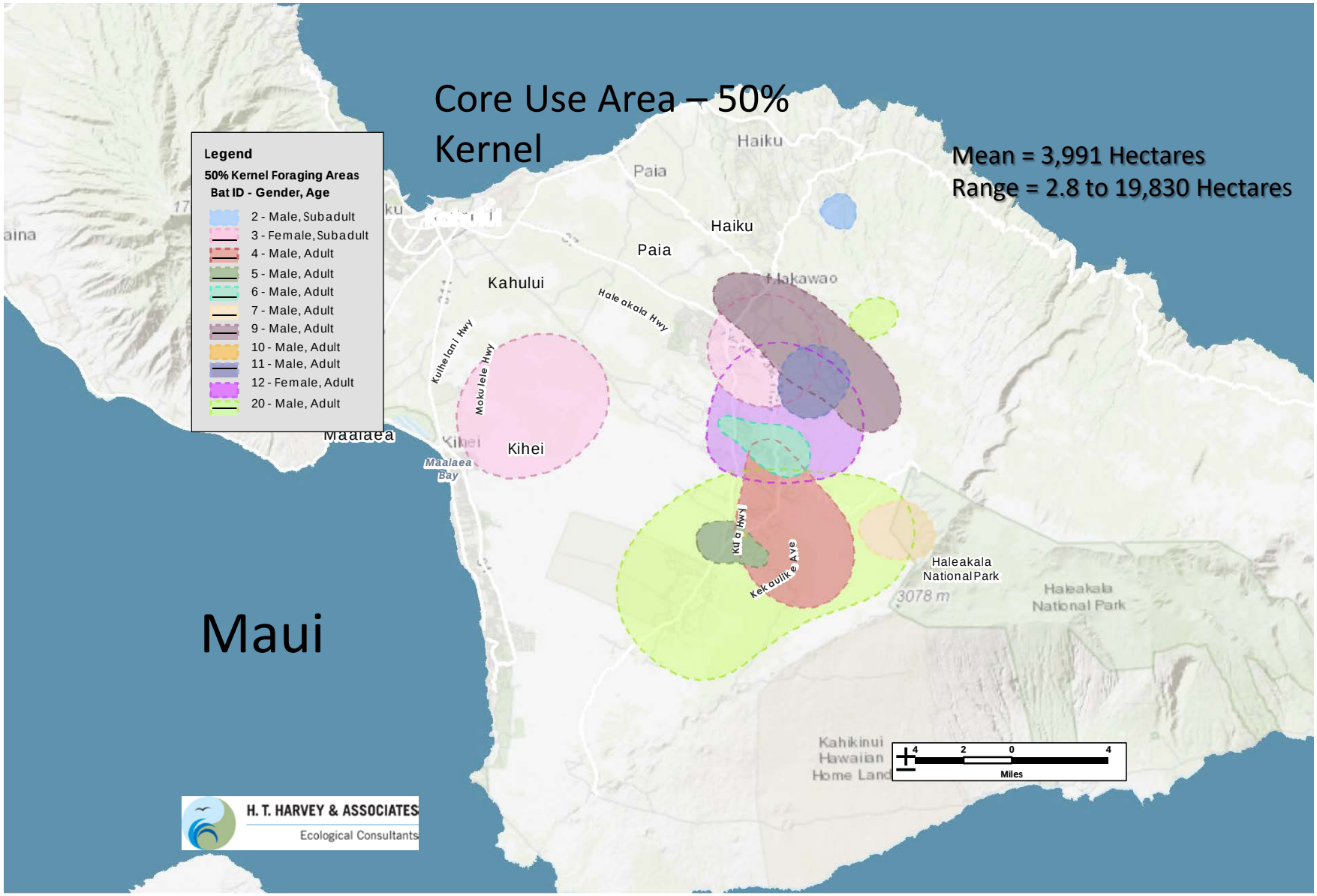
# Calls per Night by Habitat



# Results: Capture and Tracking Success

**20 bats caught;**
**11 ranges mapped**

**Mean number days tracked : 5.3 +/- 1.5**


Core Use Area – 50% Kernel
Mean = 3,991 Hectares
Range = 2.8 to 19,830 Hectares
Legend
50% Kernel Foraging Areas
Bat ID - Gender, Age
2 - Male, Subadult
3 - Female, Subadult
4 - Male, Adult
5 - Male, Adult
6 - Male, Adult
7 - Male, Adult
9 - Male, Adult
10 - Male, Adult
11 - Male, Adult
12 - Female, Adult
20 - Male, Adult
Maui
Haiku
Paia
Kahului
Hale akala Hwy
Kuihelani Hwy
Moku lele Hwy
Kihei
Maalaea Bay
Makawao
Haleakala National Park
3078 m
Kekaulike Ave
Kahikinui Hawaiian Home Land
4 2 0 4
Miles
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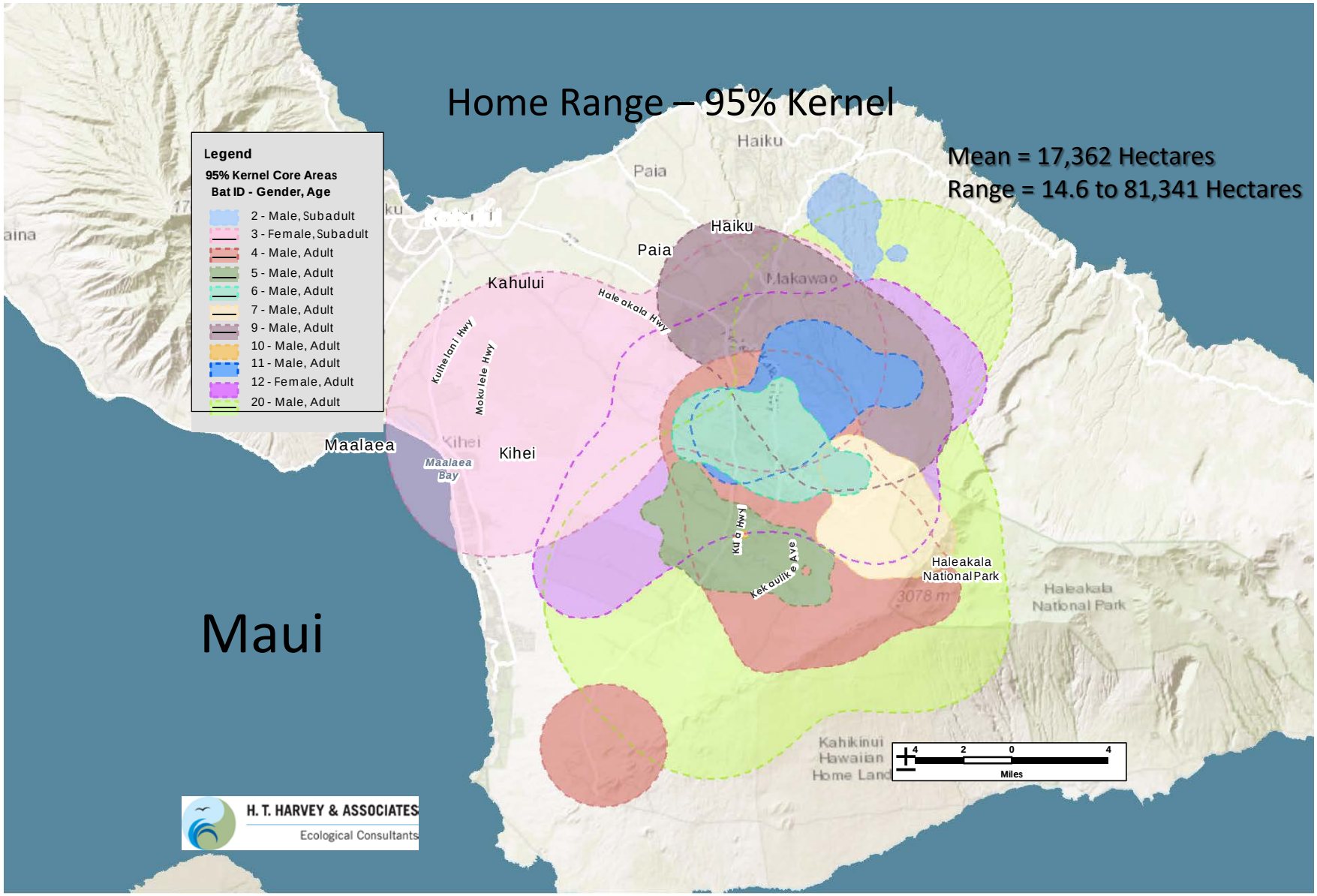
Home Range – 95% Kernel
Mean = 17,362 Hectares
Range = 14.6 to 81,341 Hectares
Legend
95% Kernel Core Areas
Bat ID - Gender, Age
2 - Male, Subadult
3 - Female, Subadult
4 - Male, Adult
5 - Male, Adult
6 - Male, Adult
7 - Male, Adult
9 - Male, Adult
10 - Male, Adult
11 - Male, Adult
12 - Female, Adult
20 - Male, Adult
Haiku
Paia
Kahului
Makawao
Hale akala Hwy
Kuihelani Hwy
Moku lele Hwy
Maalaea
Kihei
Maalaea Bay
Kula Hwy
Kekaulike Ave
Haleakala National Park
3078 m
Kahikinui Hawaiian Home Land
4 2 0 4
Miles
Maui
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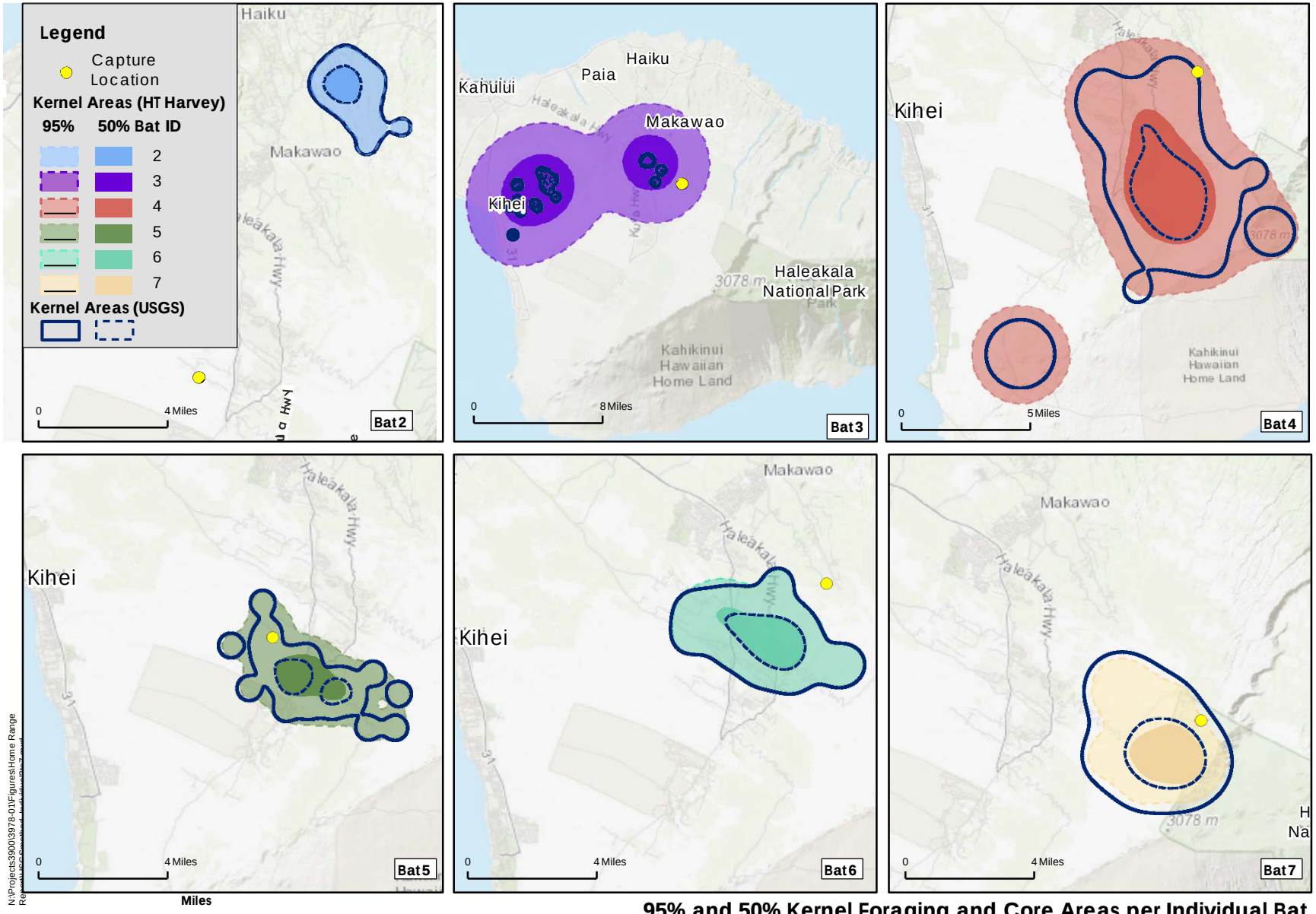


**95% and 50% Kernel Foraging and Core Areas per Individual Bat Using HT Harvey and USGS Methodology**

Ecology of the Hawaiian Hoary Bat (3978-01)

March 2020

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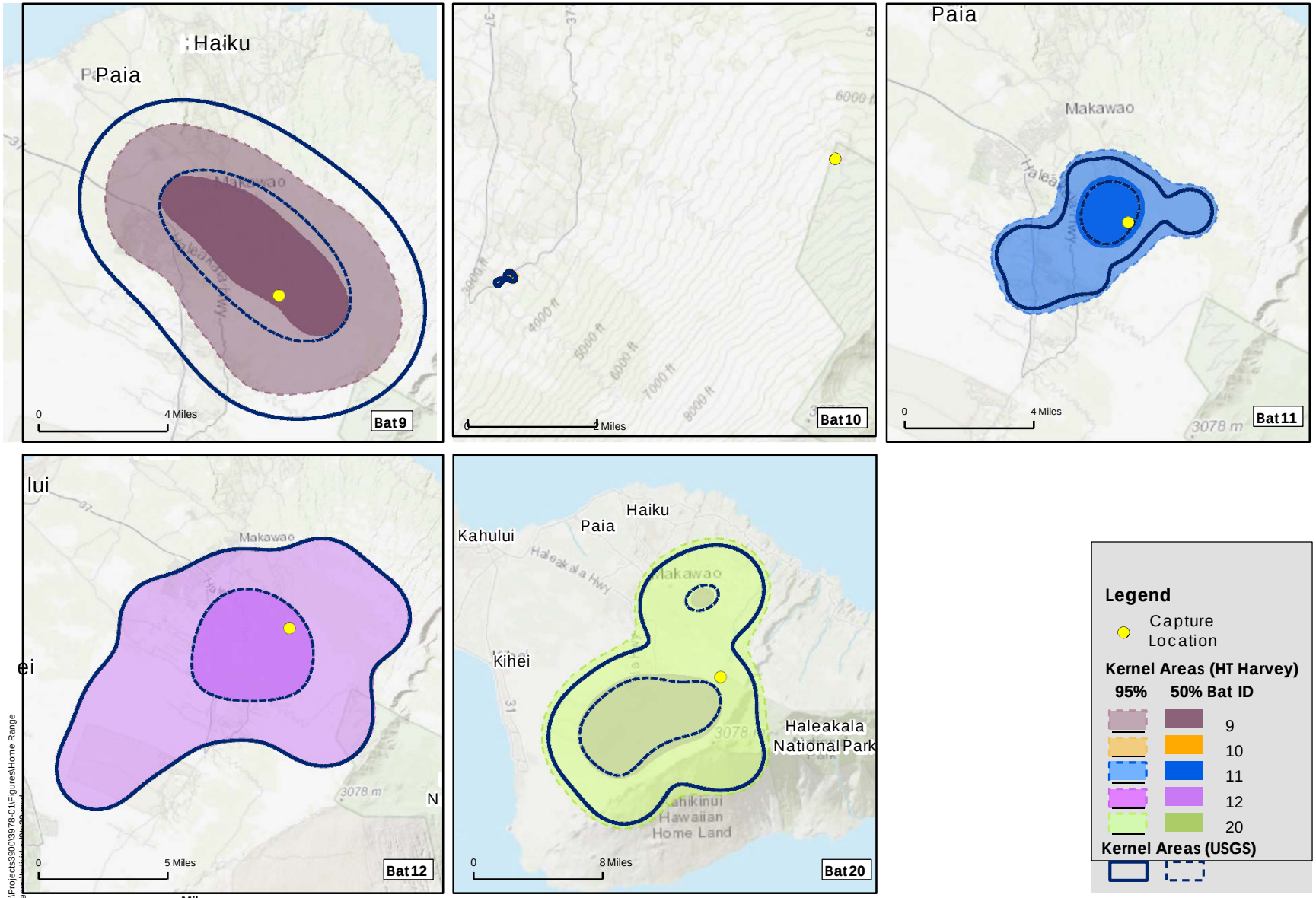


N:\Projects3900\3978-01\Figures\Home Range

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**95% and 50% Kernel Foraging and Core Areas per Individual Bat Using HT Harvey and USGS Methodology**

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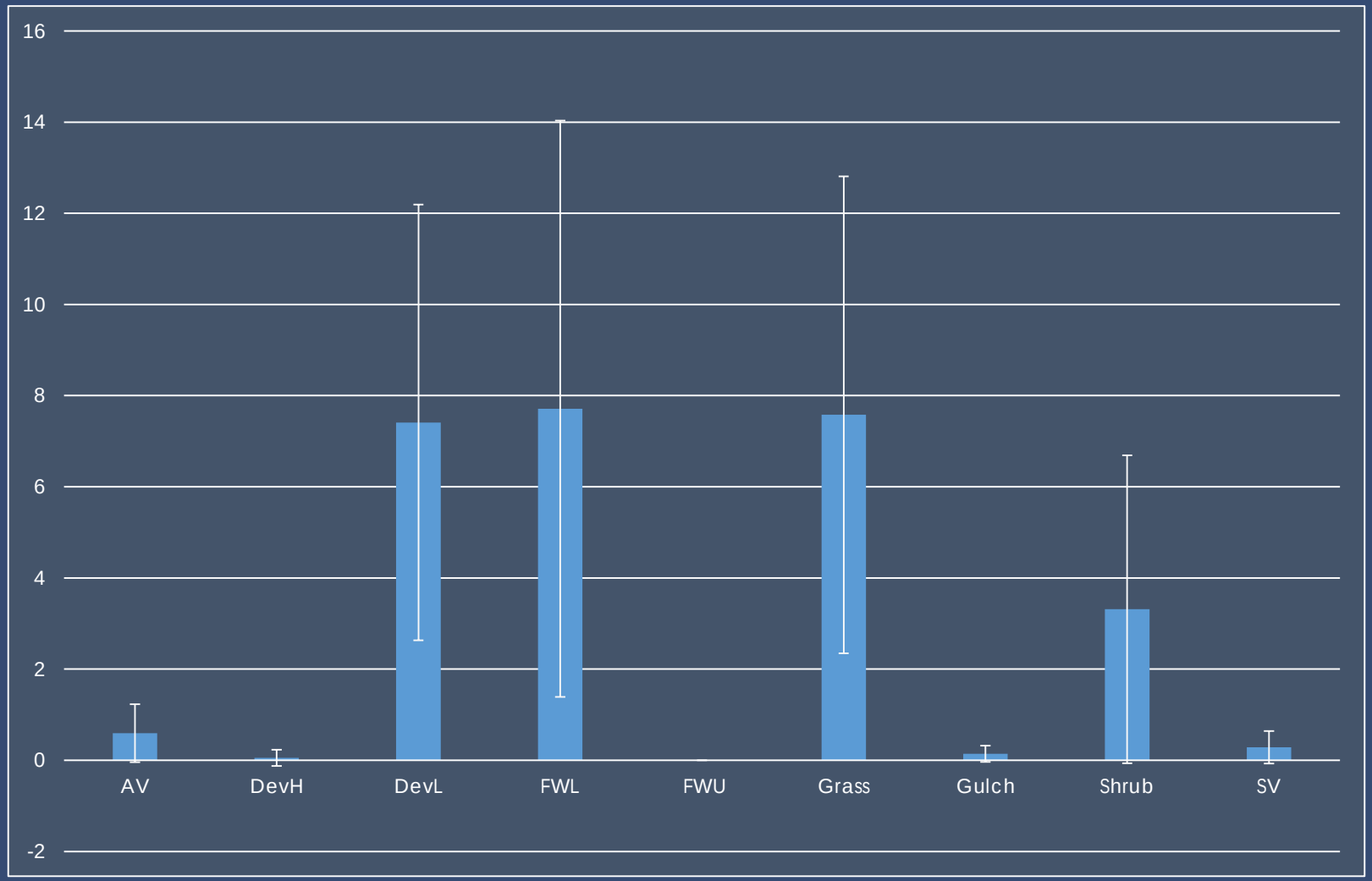
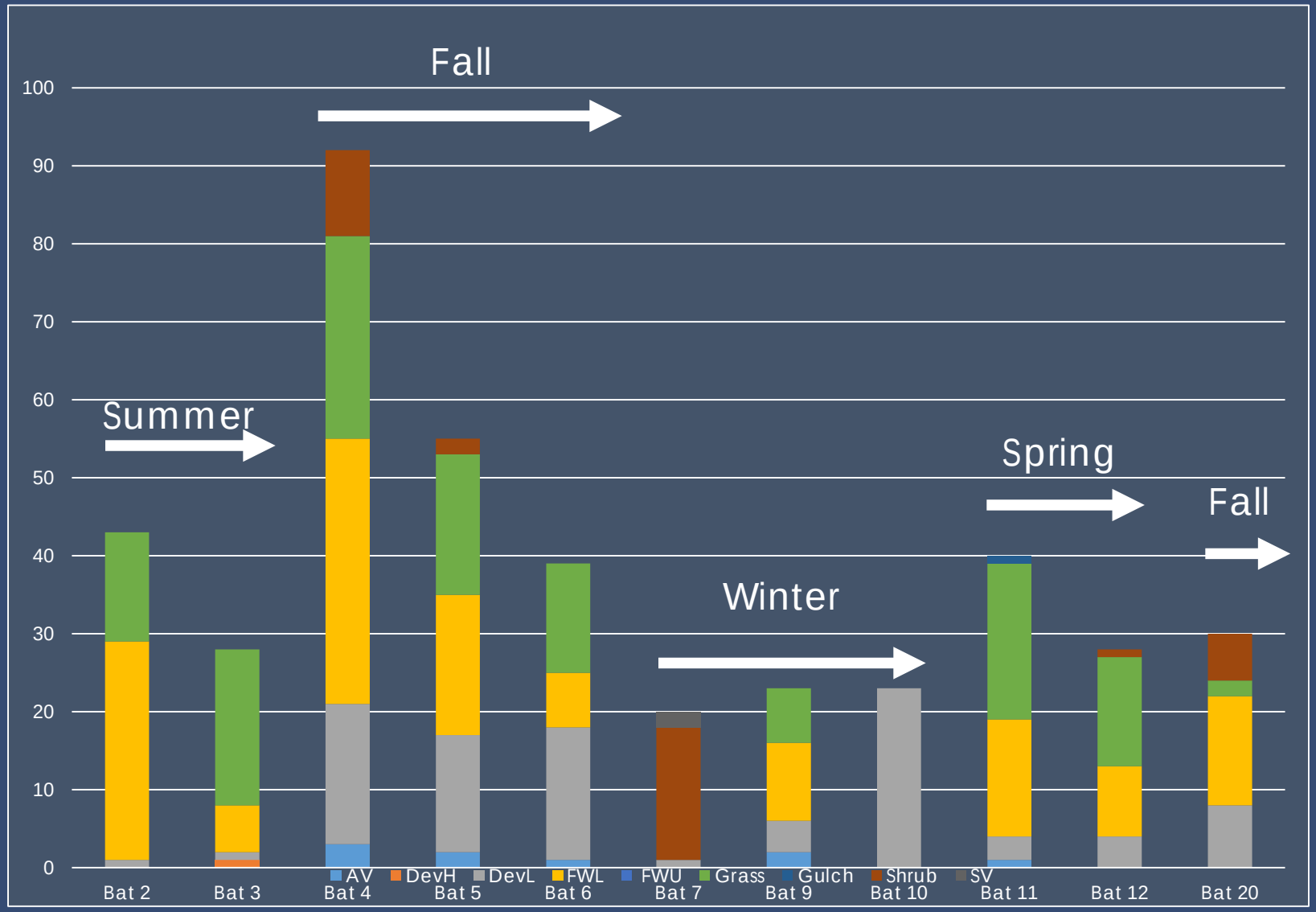
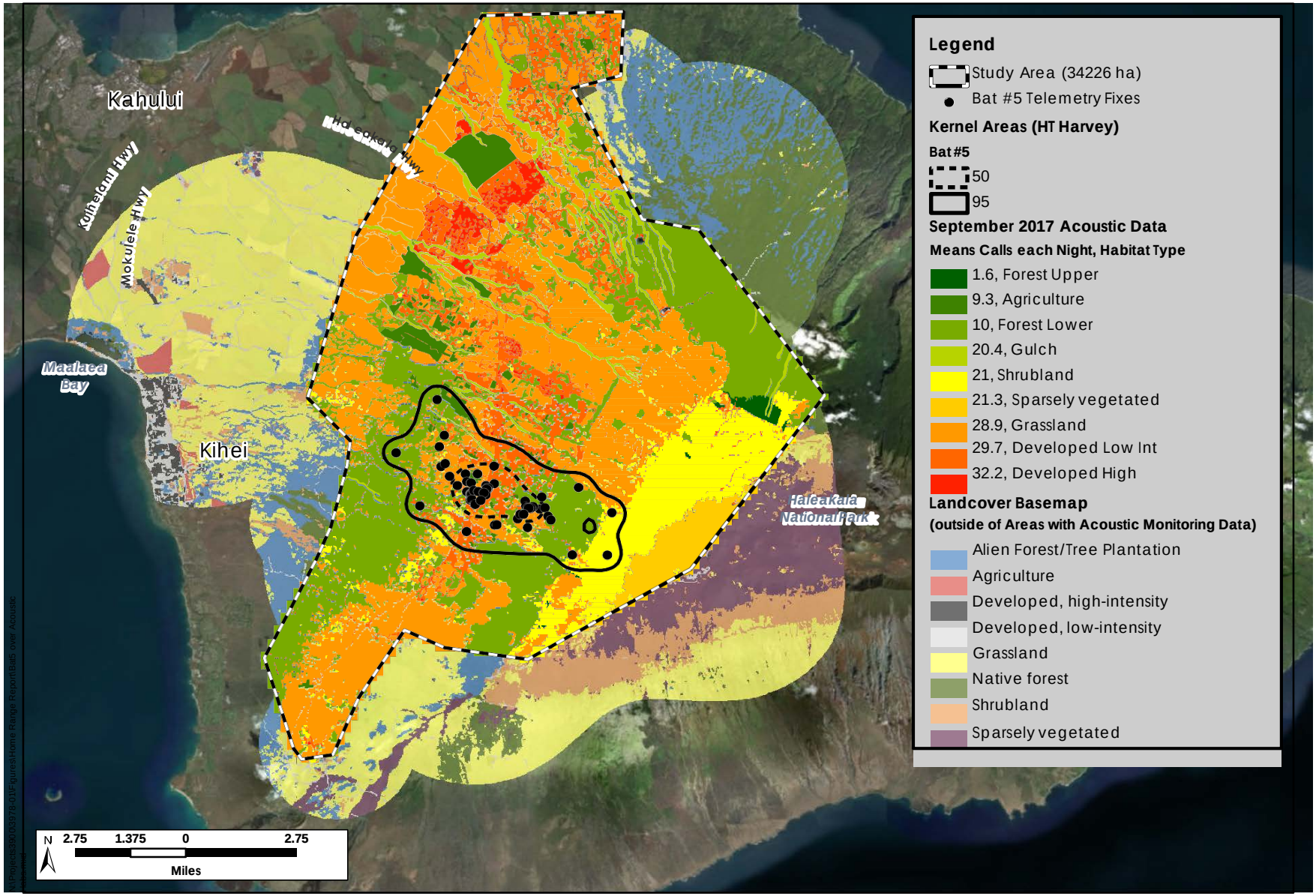
March 2020

# Mean Number of Telemetry Fixes within Habitat Types from Pooled Data from all Bats



# Number of telemetry fixes in habitat types per bat and by season



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**Bat #5 Telemetry Over September 2017 Acoustic Monitoring Data**

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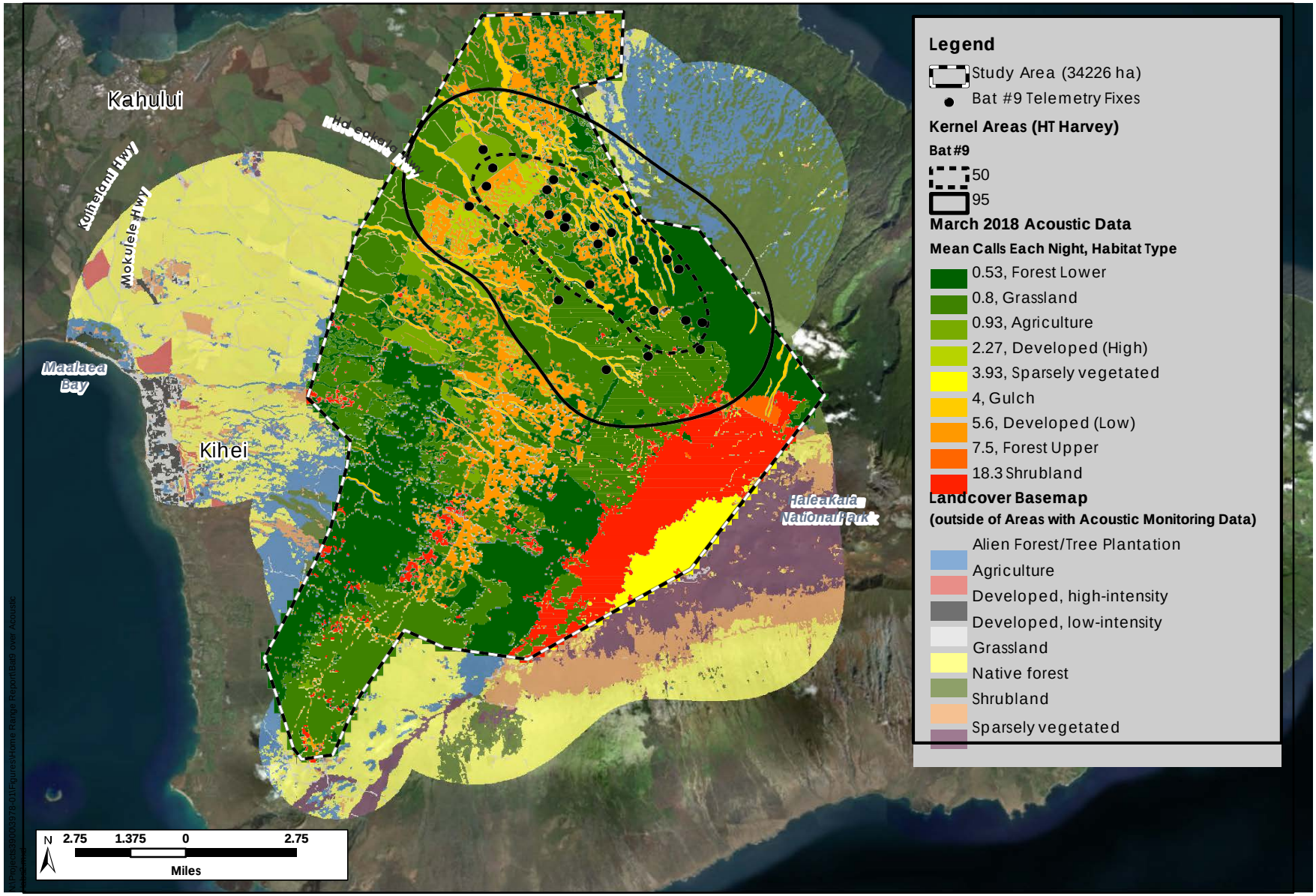


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**Bat #9 Telemetry Over March 2018 Acoustic Monitoring Data**

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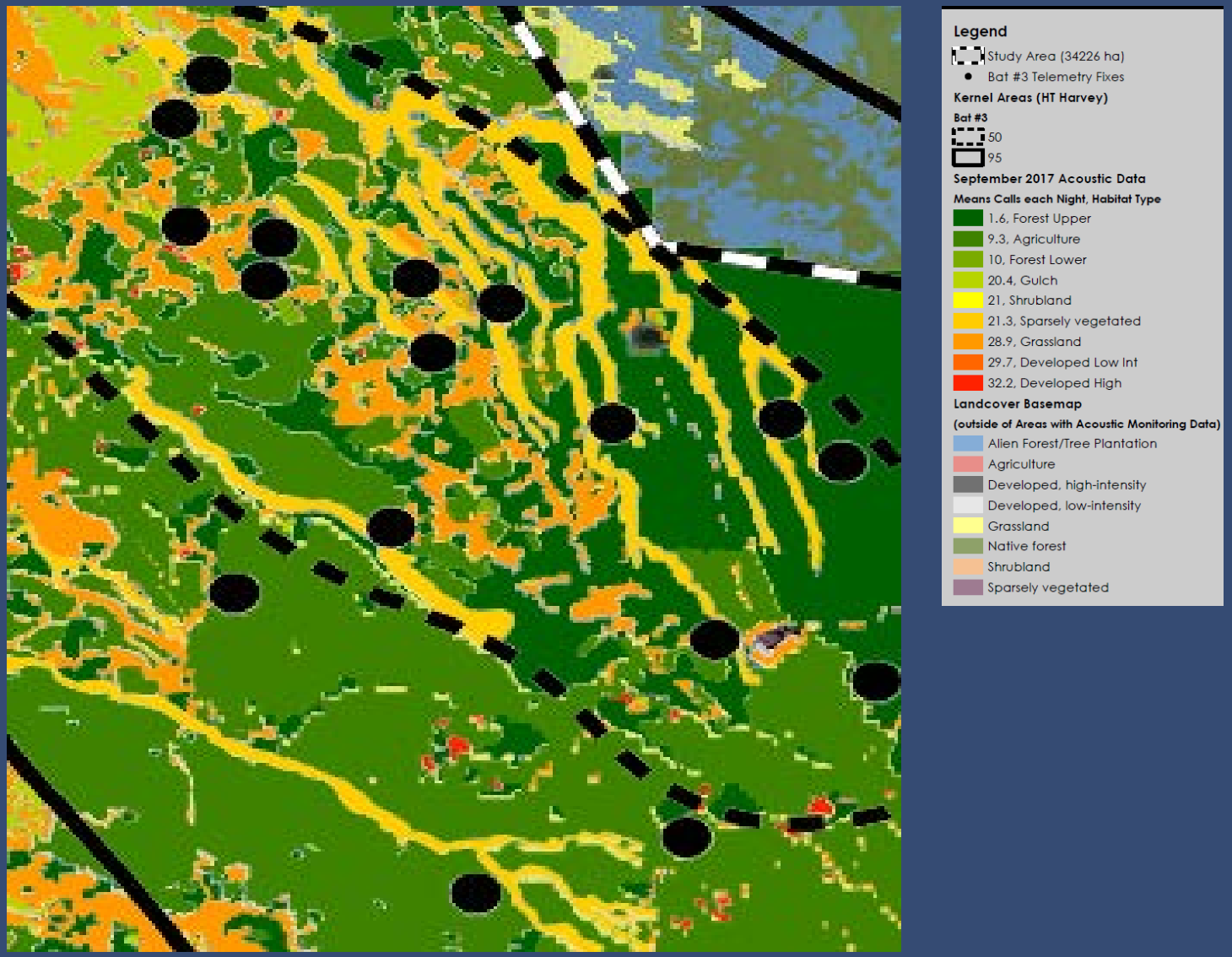
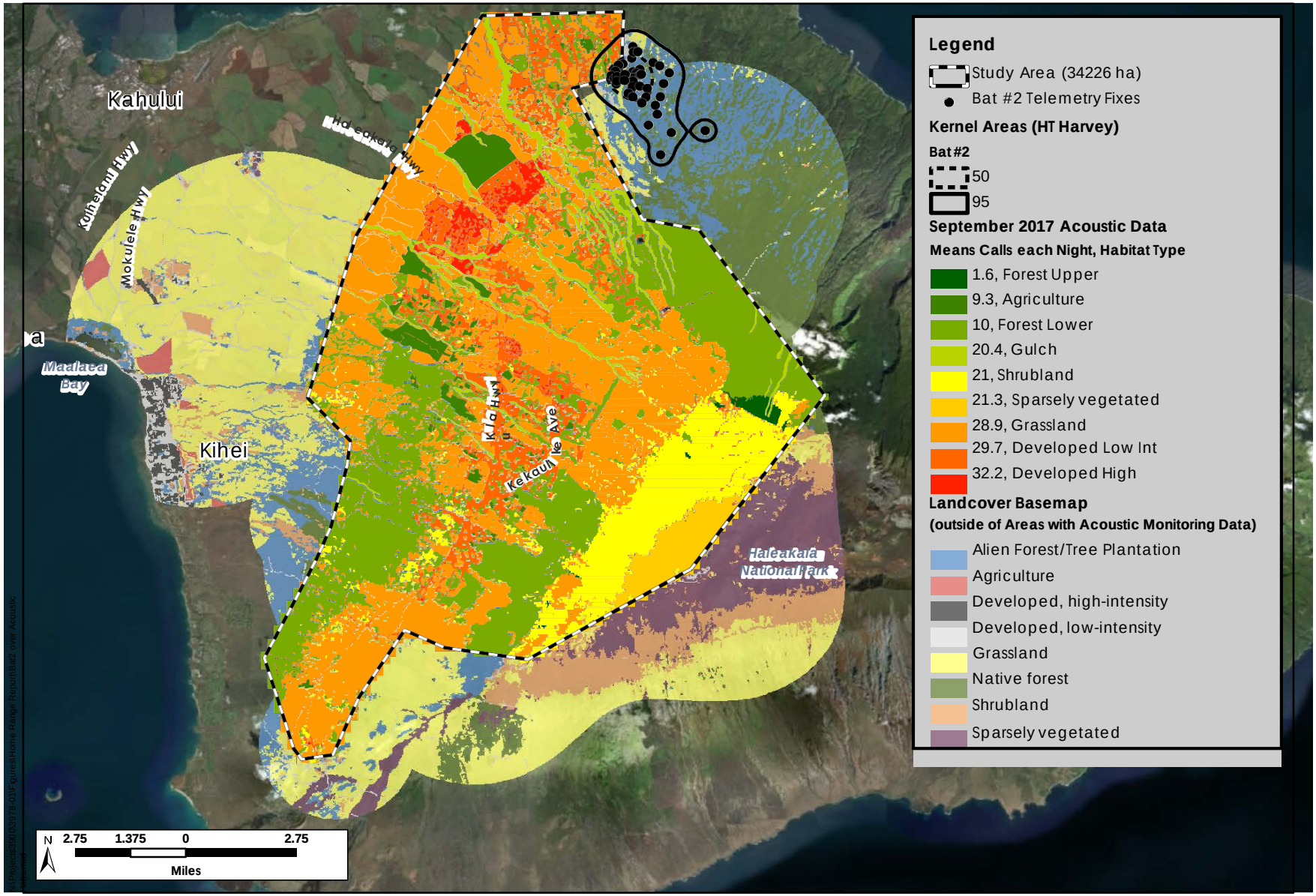
# Detail of Bat 9 Fixes over Habitat Types



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**Bat #2 Telemetry Over July 2017 Acoustic Monitoring Data**

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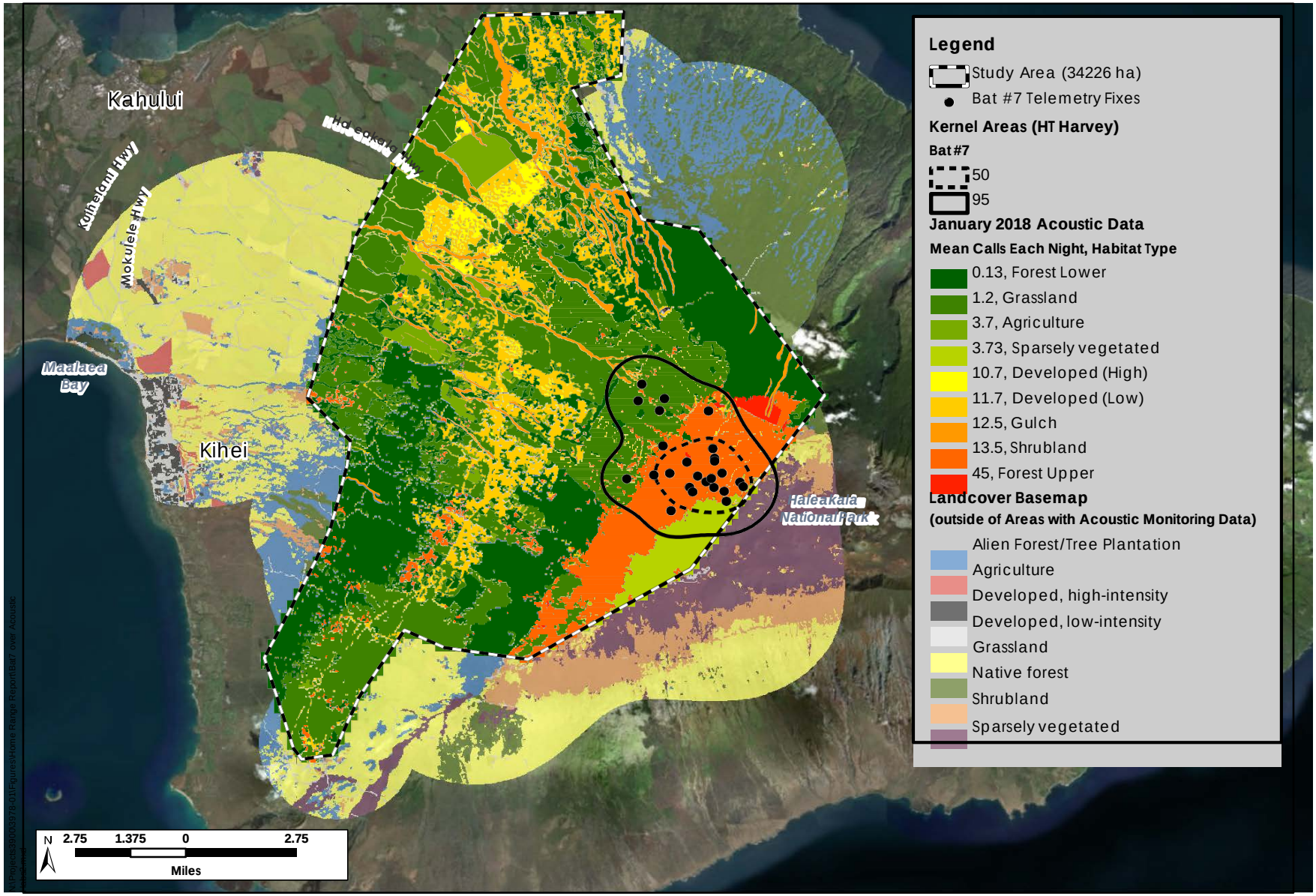


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**Bat #7 Telemetry Over January 2018 Acoustic Monitoring Data**

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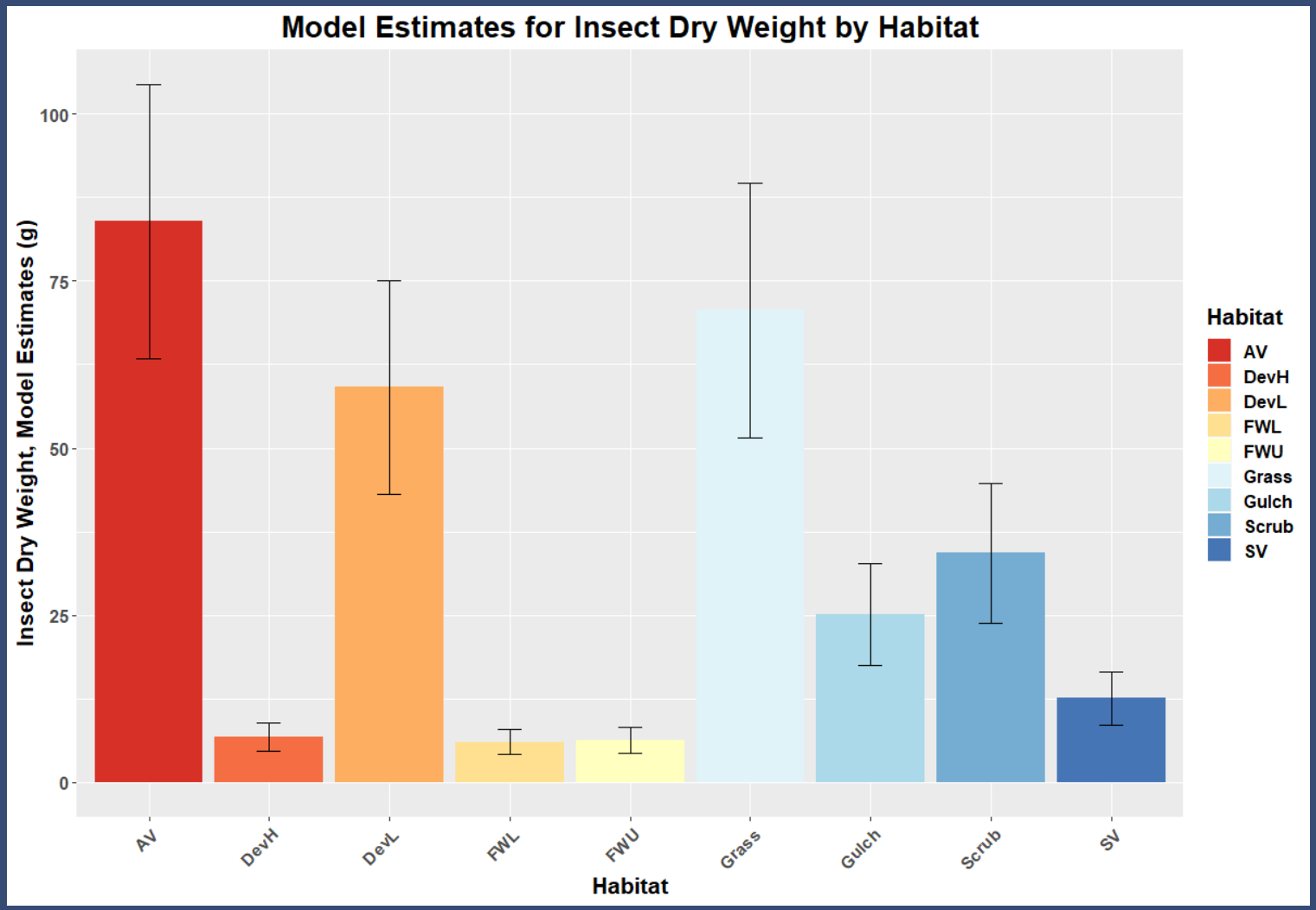
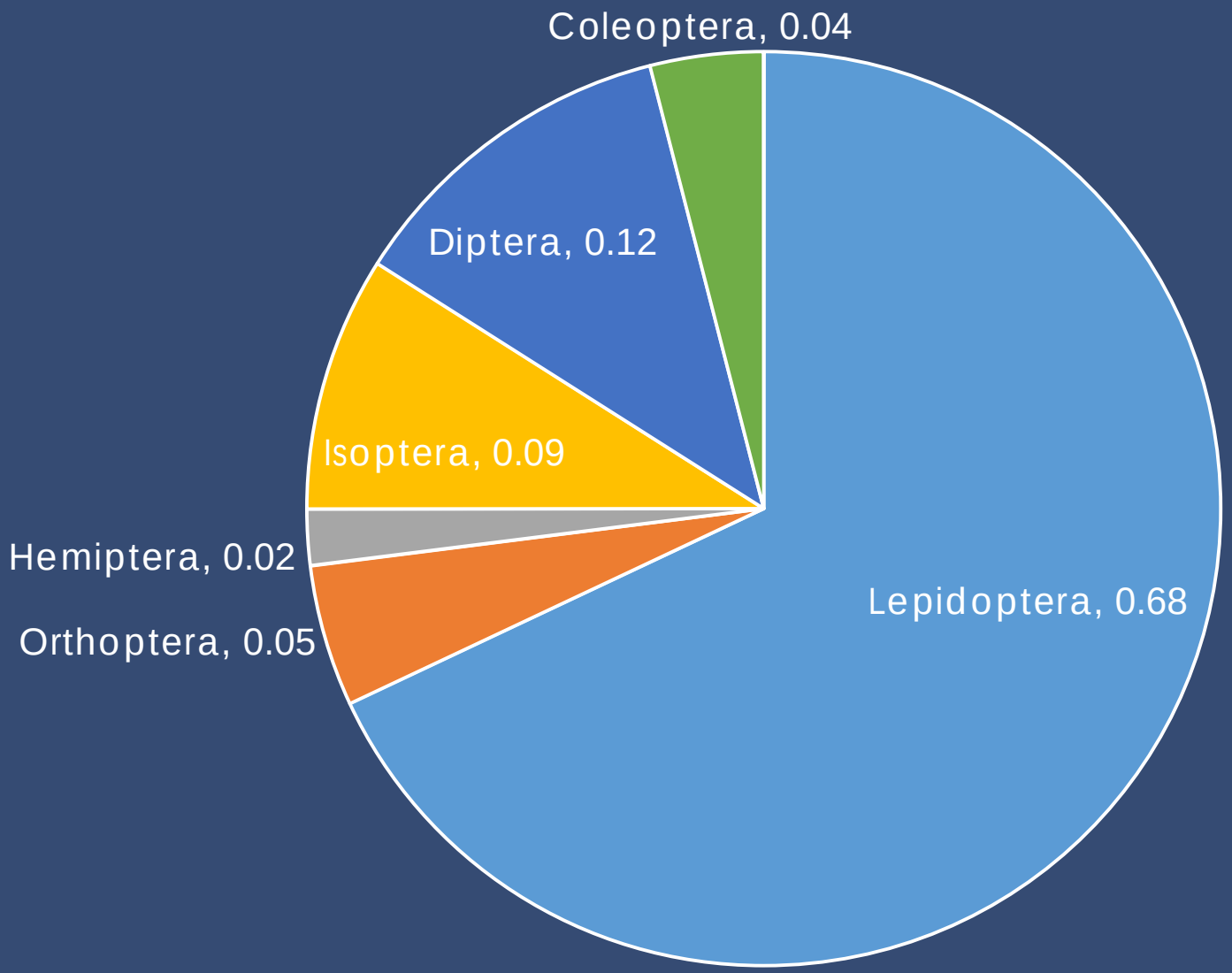
# Model Estimates for Insect Dry Weight by Habitat



# Percentage of Prey Items Based on Number of Sequences Detected by Order for 11 Bats



# Important prey species in ~ ½ of guano samples


*Herpetogramma licarsisalis*
Tropical grass webworm


*Peridroma saucia*
Variegated cutworm moth


*Athetis thoracica*
Athetis moth

# Summary

**Bats from Maui vs. Hawaii used very different habitats!**

- Mostly in Gulches, Low density developed and Grasslands
- Most forests on Maui are non-native that have few insects and are not productive

**Maui Bats' core use areas were highly variable in size, and averaged many times the size of the Hawaii bats' core use areas**

**Bats moved up and down elevation gradient year round. Bats tended to forage in lower altitudes in Summer, Fall, and Spring, and in higher altitudes in Winter**

**Bats ate primarily moths and very few beetles. They ate native and non-native insects and appeared somewhat selective**

**Bats of each season used very similar habitats except for during winter when each of 3 bats used different habitats**

# Discussion

- Bats should be managed on an Island by Island basis. Different habitats and different CUA sizes

- CUA sizes may not be as important as the quality of the habitat.
- Bats foraged in patchy habitats so conservation efforts may not necessarily need be contiguous.
- We advocate enhancing or improving habitat as opposed to the purchase of a specific amount of forest as mitigation for take.

# Mahalo!


Frank Bonaccorso and Corinna Pinzari, Native Nursery, Kama'ole Ranch, 'Ulupalakua Ranch, Haleakala Ranch, Maui Nui Farms, Maui Bees, Ali'i Kula Lavender Farm Deb Bauer, Bazie Brandt, Danny and Jenta Brictson, Kelly Bryce, Monroe Bryce, Andrea Buckman, Keahi Bustamente, Lois Campbell, Terry Chang, Mark Damon, Kerri Fay, Dominic Gambino, Geoff Haines, Joseph Imhoff, Hadley Luis, Debra Lordan, Mary Jane Gapero, Linsey Manuel, Wisa Miller, Molly O'Grady, Evan Ryan, Zach Pezzillo, Michelle Smith, Andrei Stanescu, Ruth-Marie Stecker, Monte Tudor-long, Doc Vitale, Heather Wade, Ian Wade, John Wilson, Jamie Woodburn, Bonnie Young Terry Zinn and many more.

# Questions?