GIS BASED MODELLING TO PREDICT THE IMPACT OF CLIMATE CHANGE ON MEDFLY POPULATIONS IN CENTRAL AMERICA AND DECISION MAKING SUPPORT FOR PEST MANAGEMENT

Estuardo Lira [1], David Midgarden [2], Pedro Rendon [3], Nicole Parker [1]

Third FAO/IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques

Vienna, Austria, May 25, 2017

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2. USDA-APHIS-IS. Santo Domingo, Dominican Republic. David.G.Midgarden@aphis.usda.gov
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Contents

MEDFLY PROGRAM

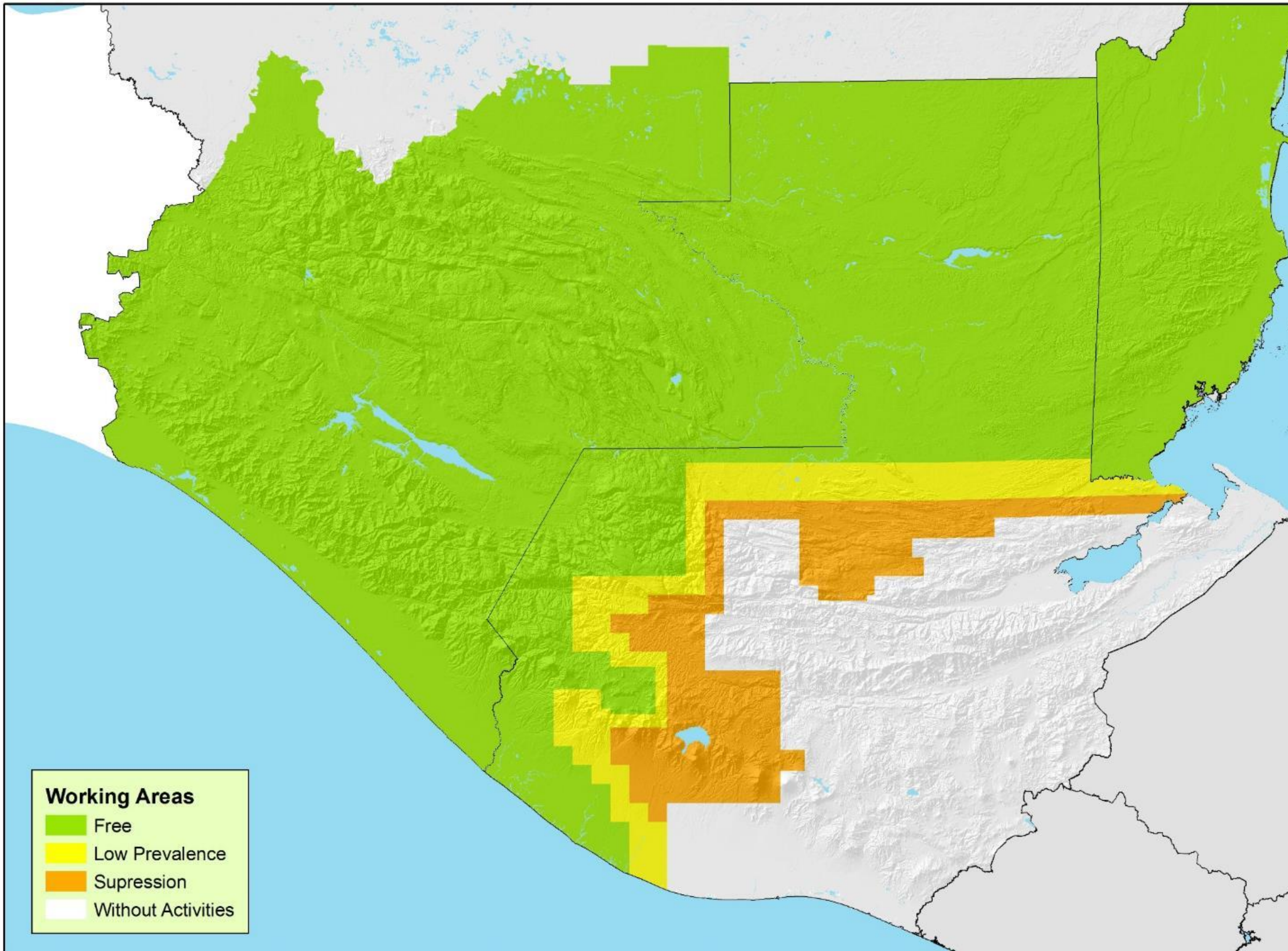
1977 → Guatemala + México + USA + Belize

Protect and Promote the Fruit Production

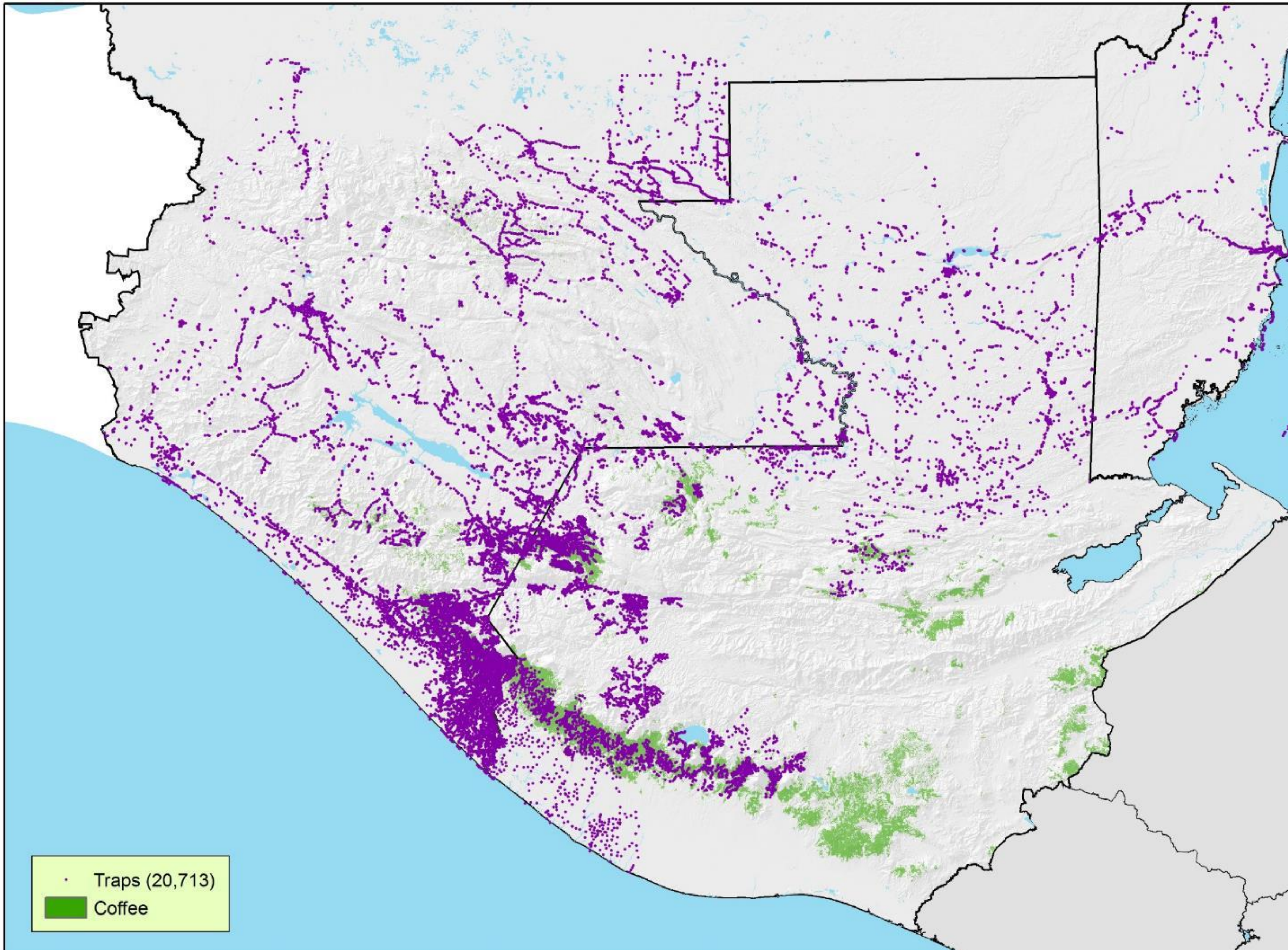
Eradicate the Mediterranean Fruit Fly

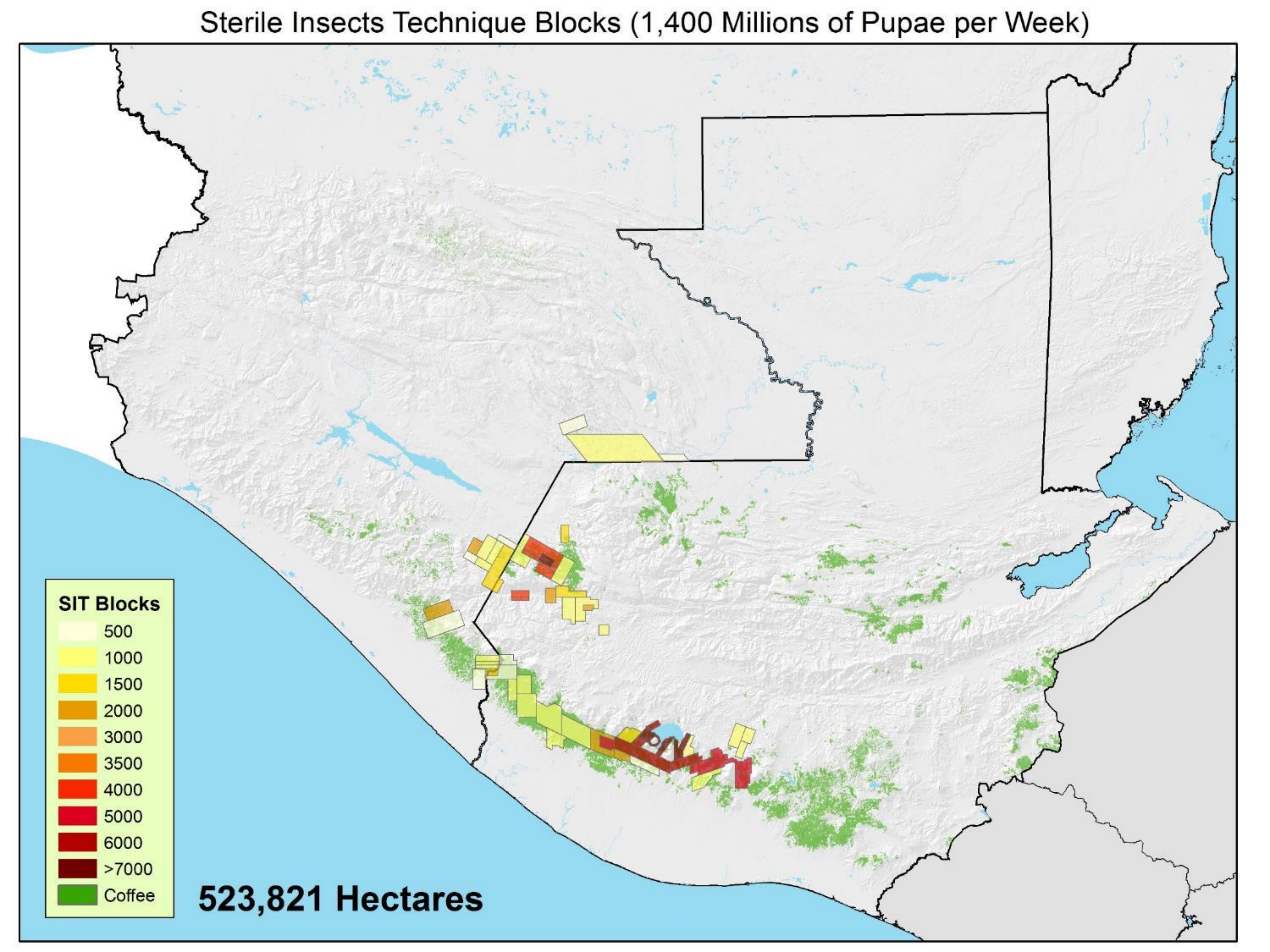
Protect Medfly Free Areas

Current Working Areas

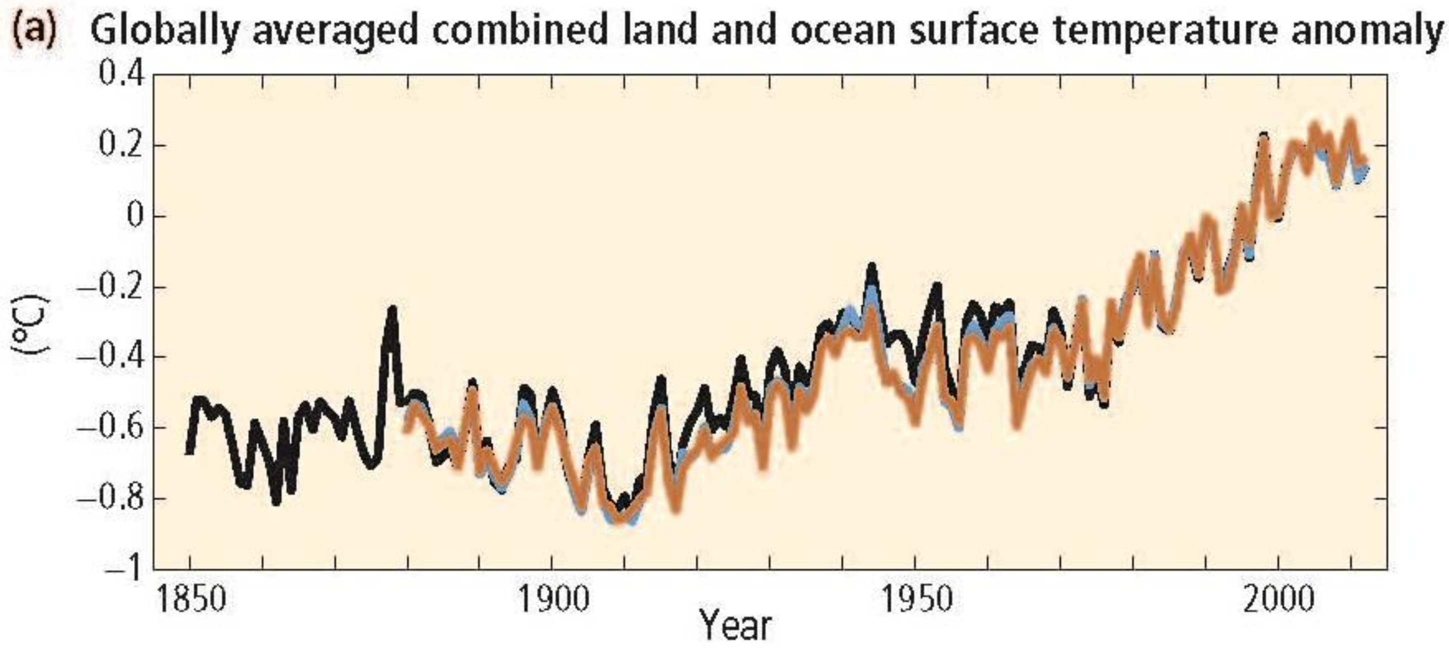


Trapping Network and Coffee Lands

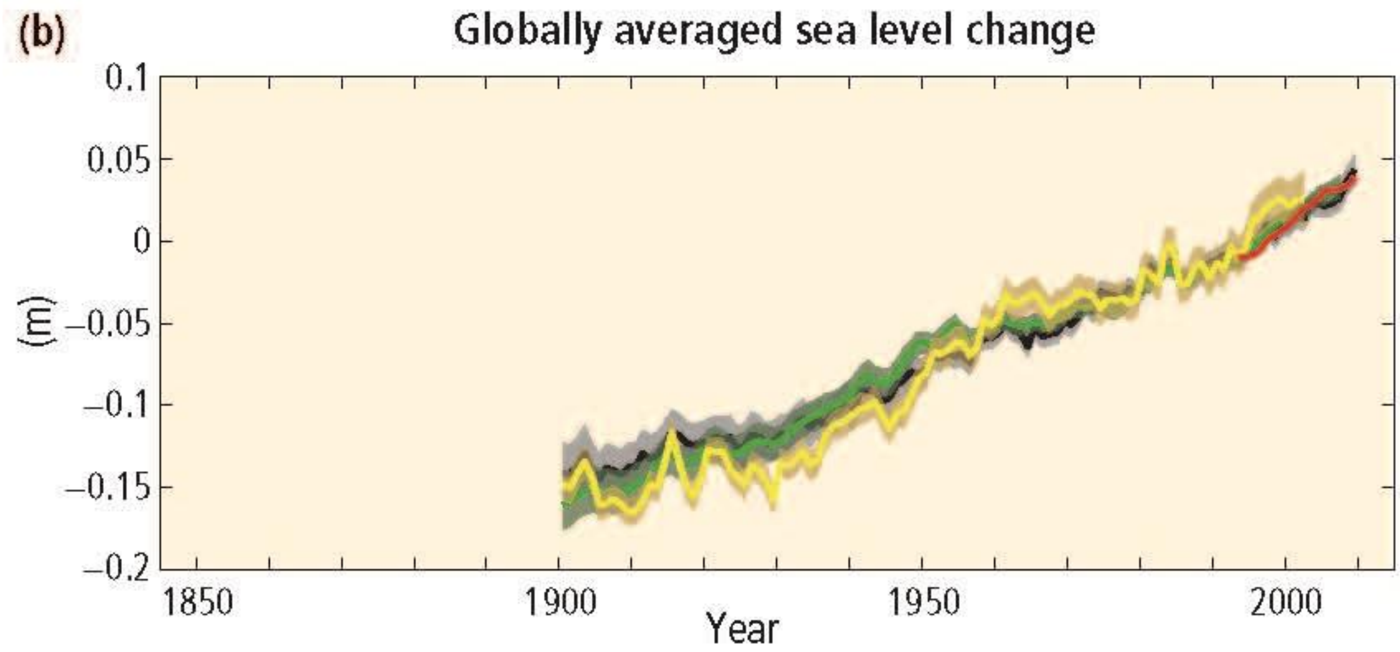



Sterile Insects Technique Blocks (1,400 Millions of Pupae per Week)
SIT Blocks
500
1000
1500
2000
3000
3500
4000
5000
6000
>7000
Coffee
523,821 Hectares

CLIMATE CHANGE



http://www.ipcc.ch
Climate Change 2014
Synthesis Report
Summary for Policymakers



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Climate Change 2014
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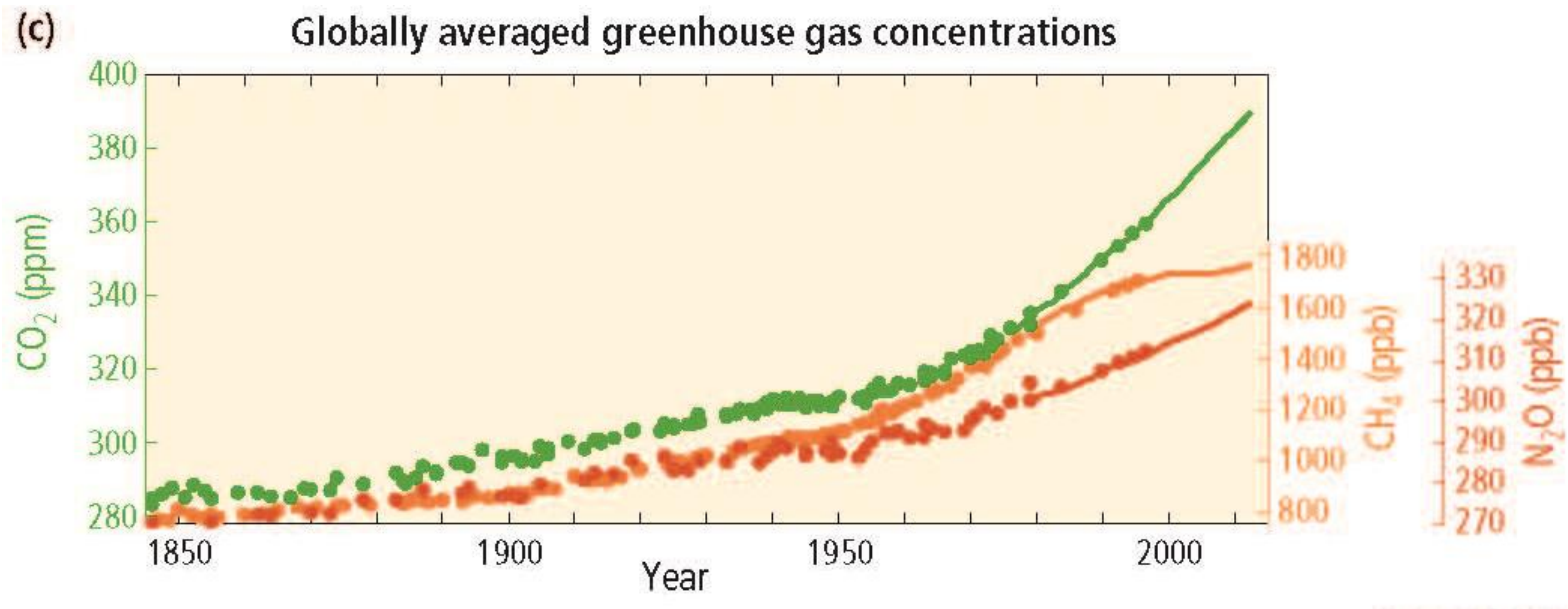
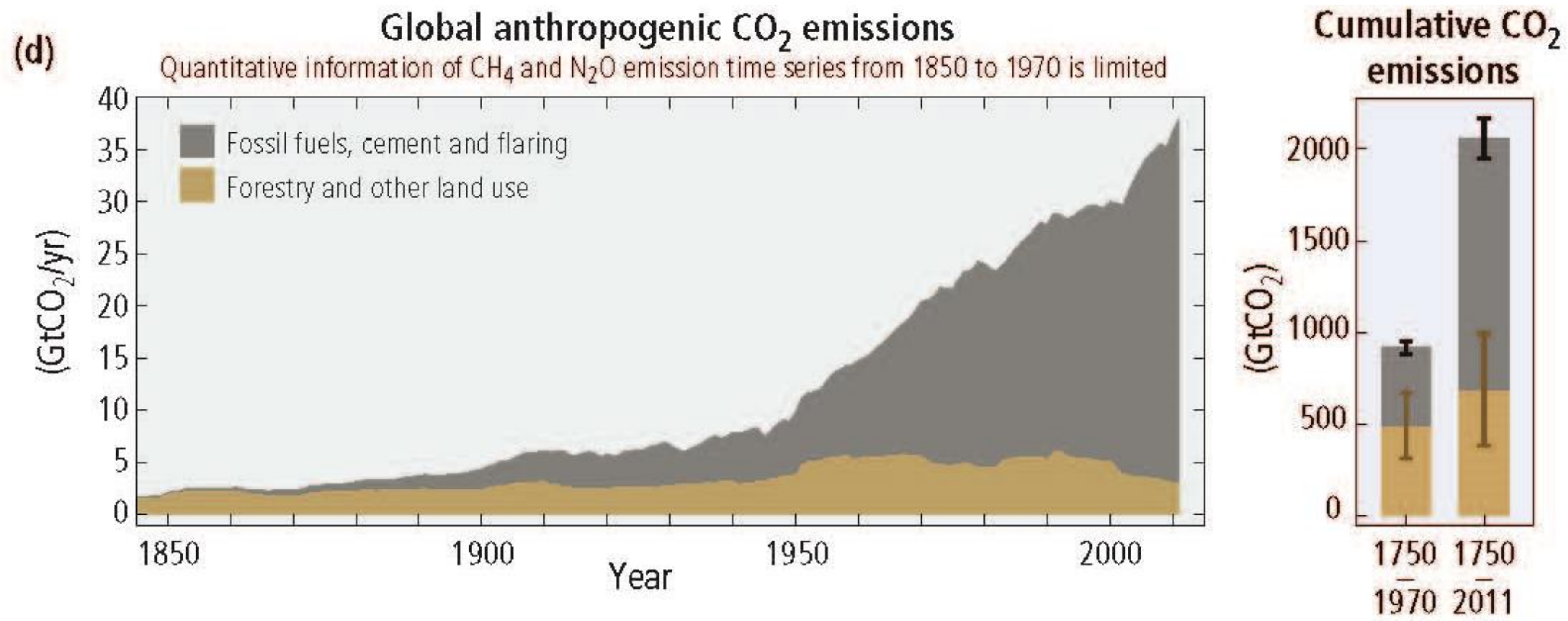


http://www.ipcc.ch
Climate Change 2014
Synthesis Report
Summary for Policymakers



http://www.ipcc.ch
Climate Change 2014
Synthesis Report
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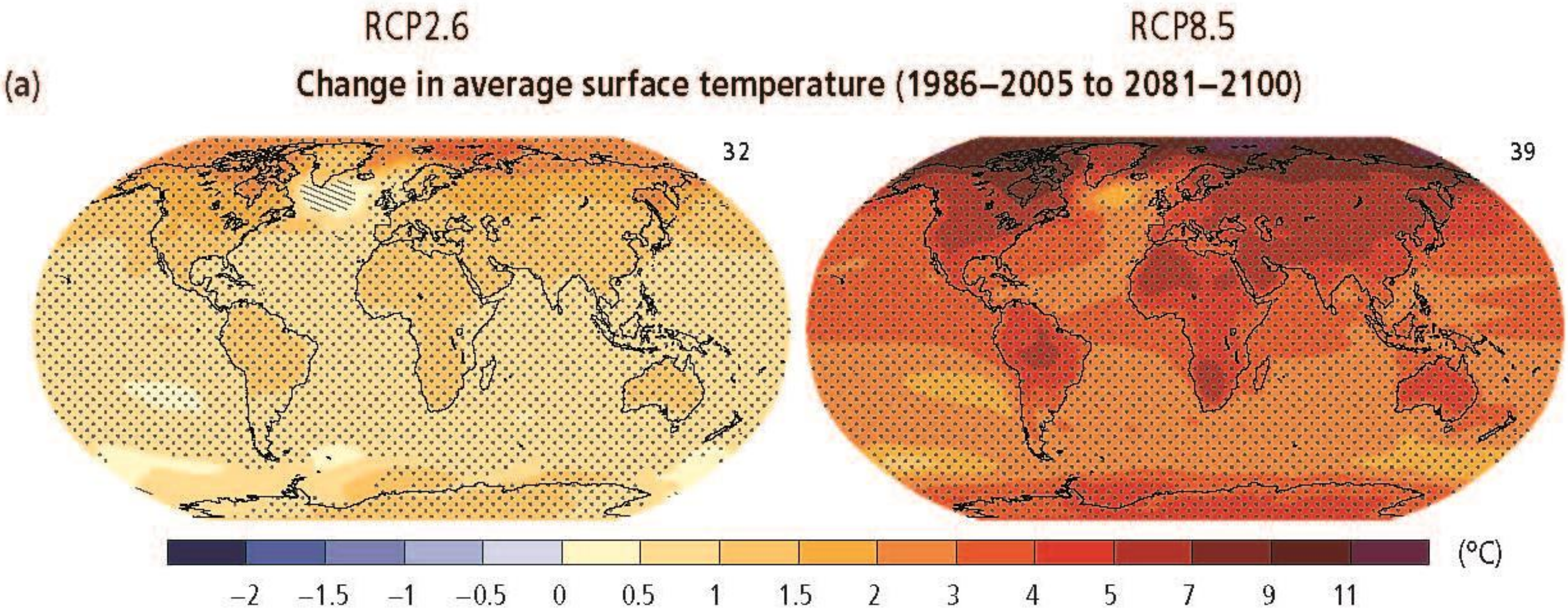

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Climate Change 2014
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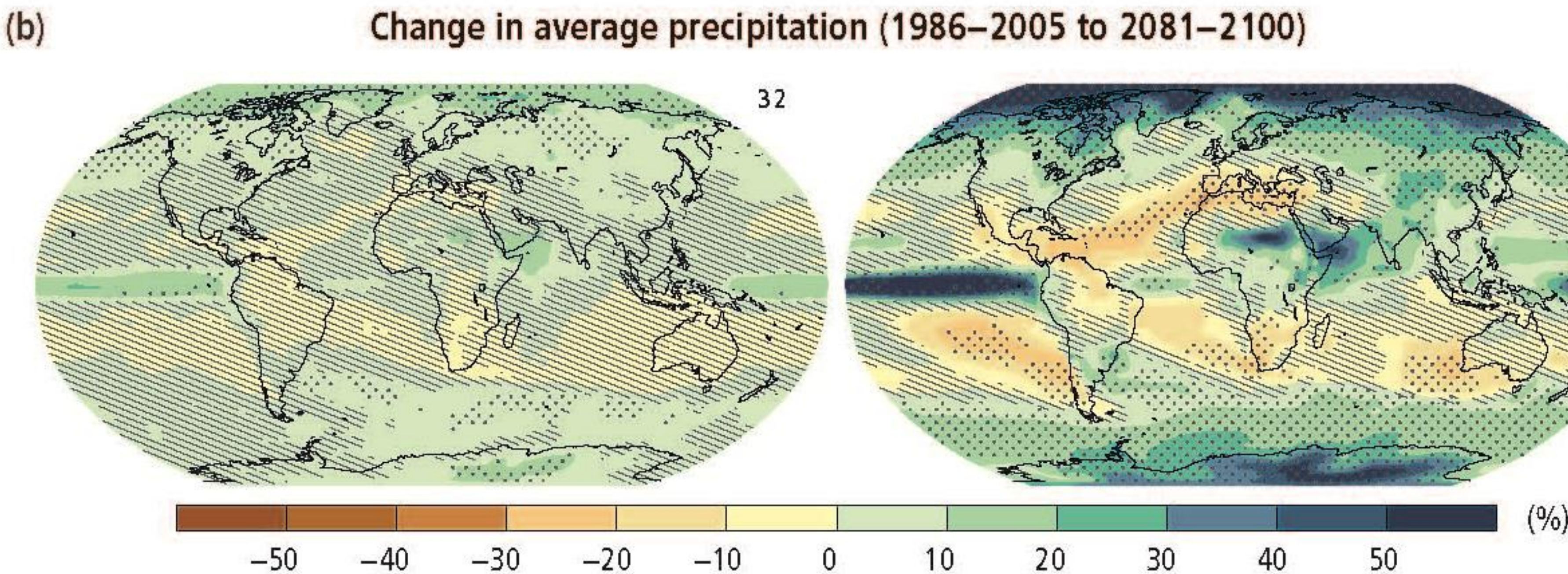
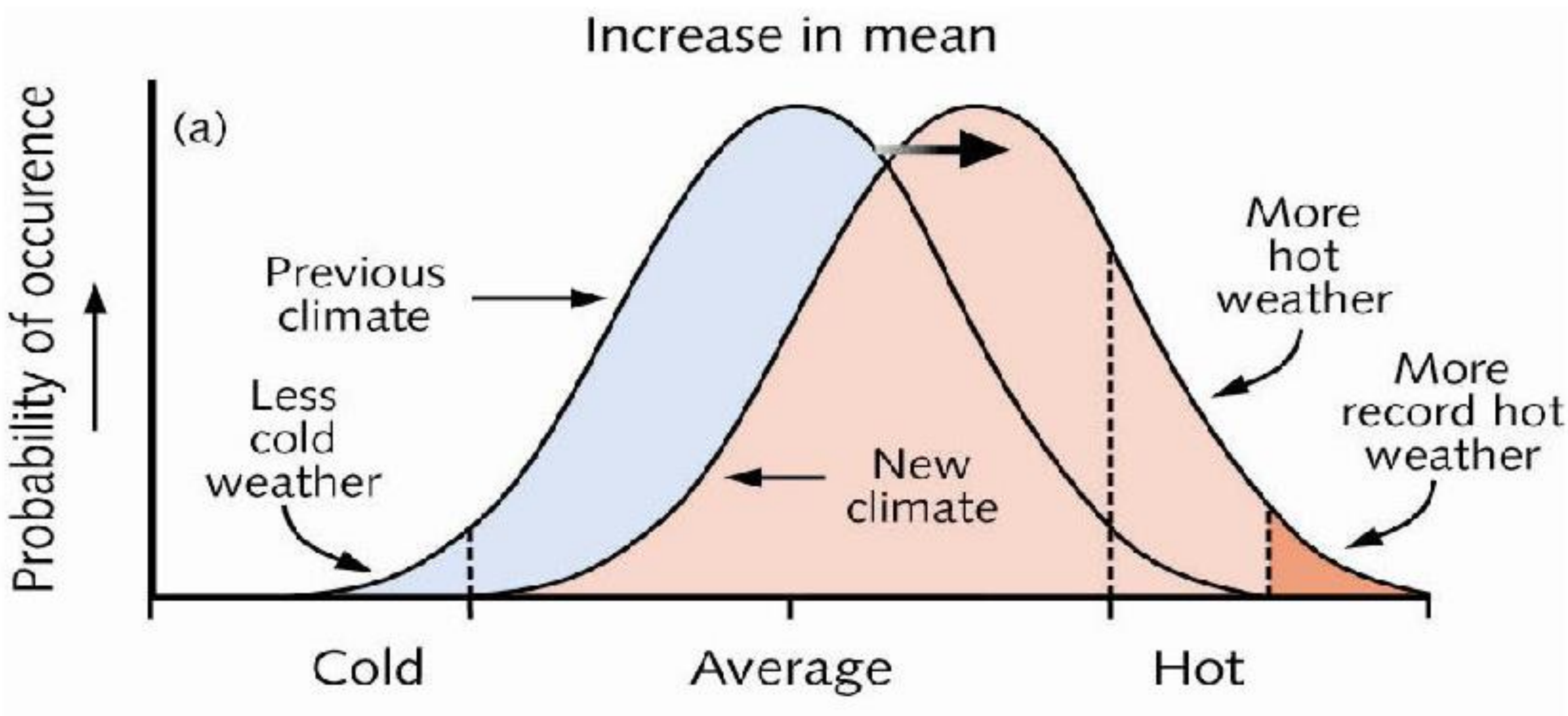
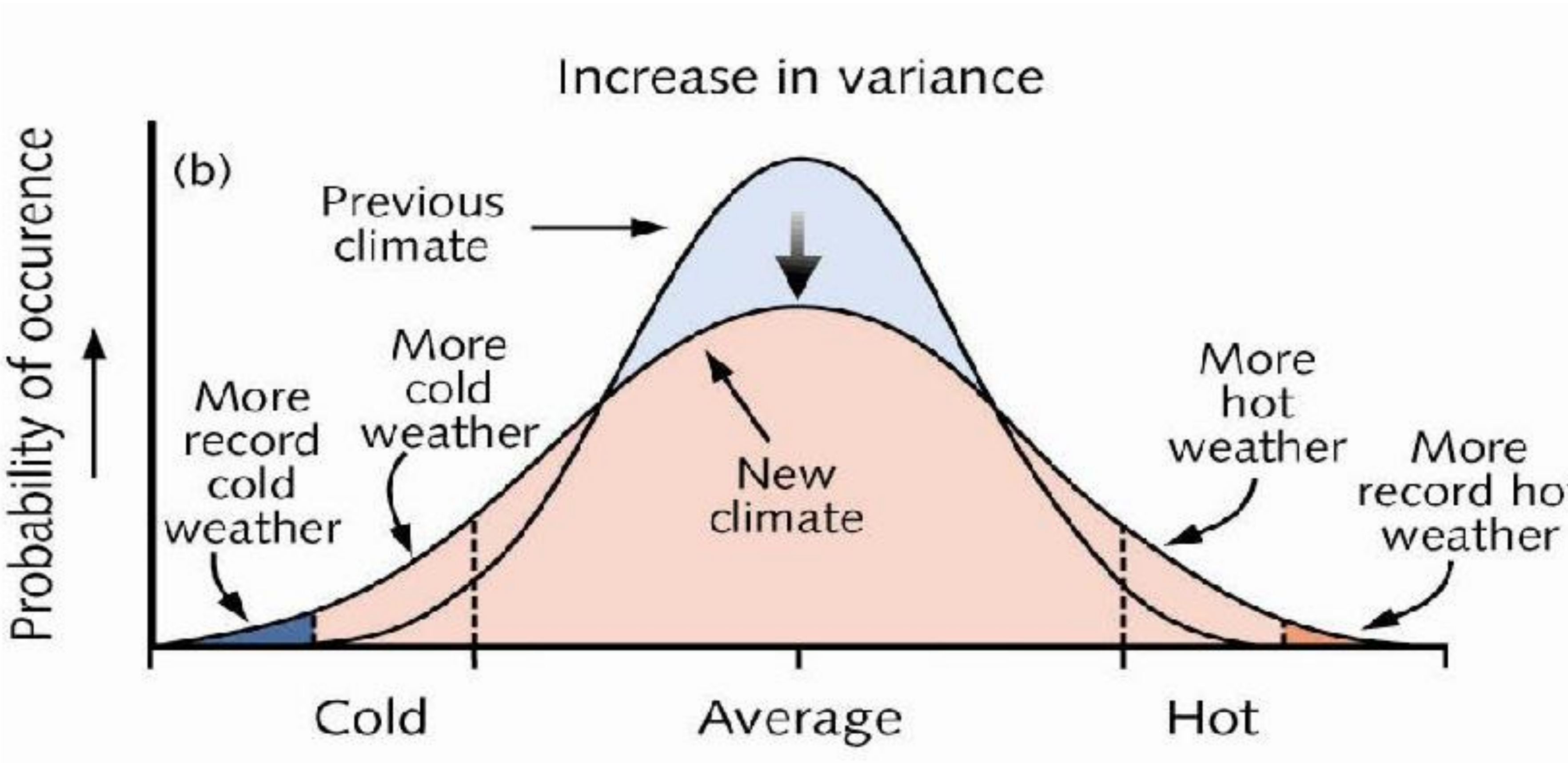


http://www.ipcc.ch
Climate Change 2014
Synthesis Report
Summary for Policymakers

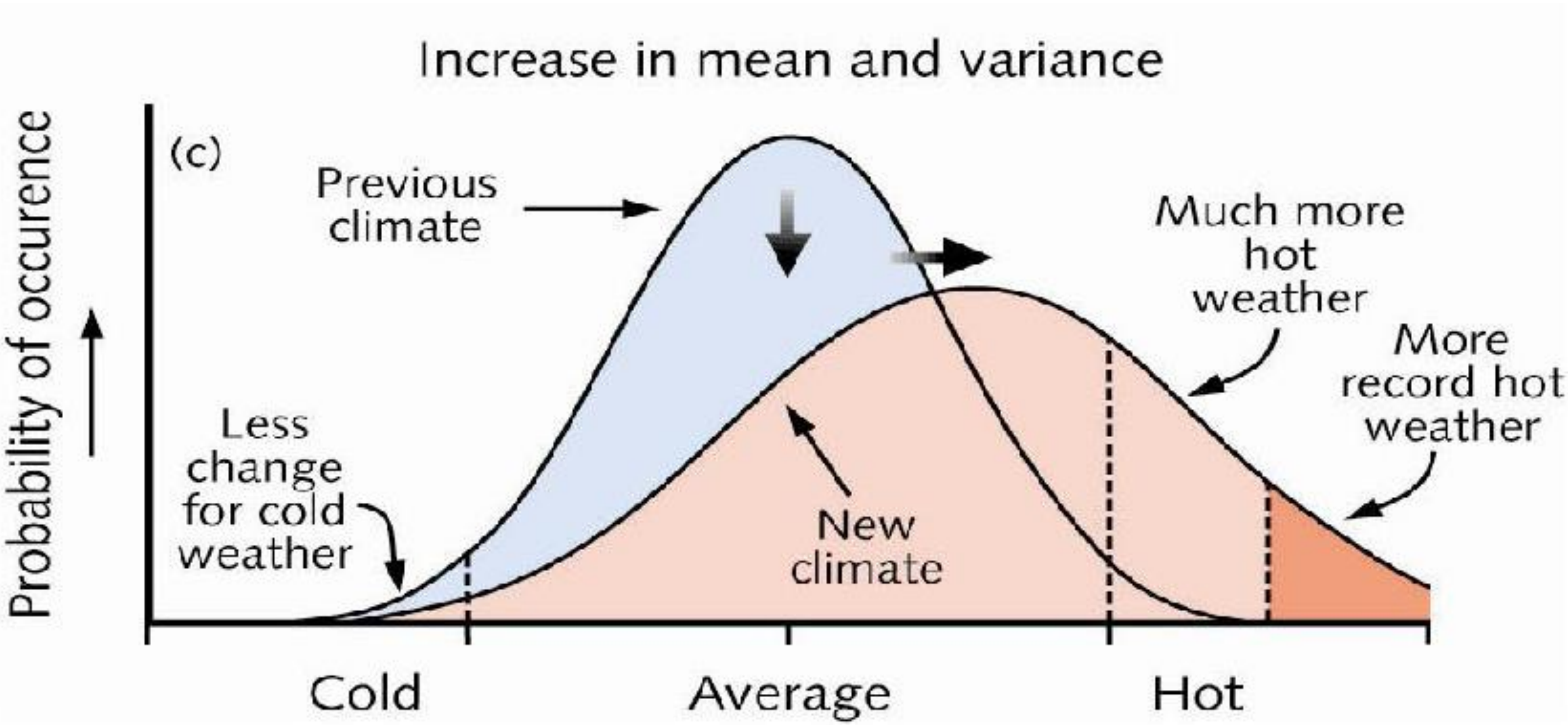
Climate Extremes (Houghton, p.154)



Climate Extremes (Houghton, p.154)



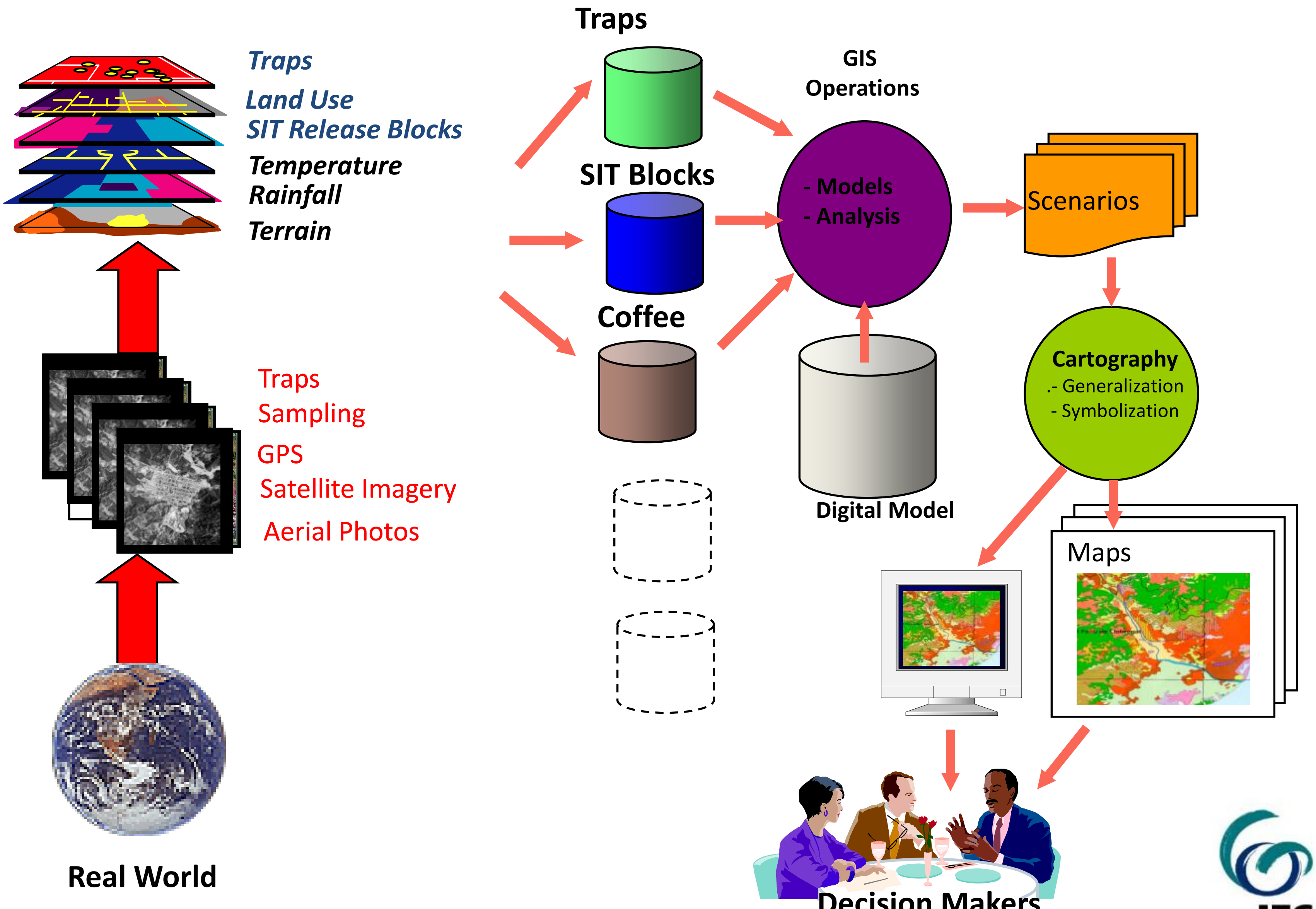
Climate Extremes (Houghton, p.154)



GEOGRAPHIC INFORMATION SYSTEMS

GIS

REAL WORLD can be represented as THEMATIC LAYERS so it can be DESCRIBED and ANALYZED

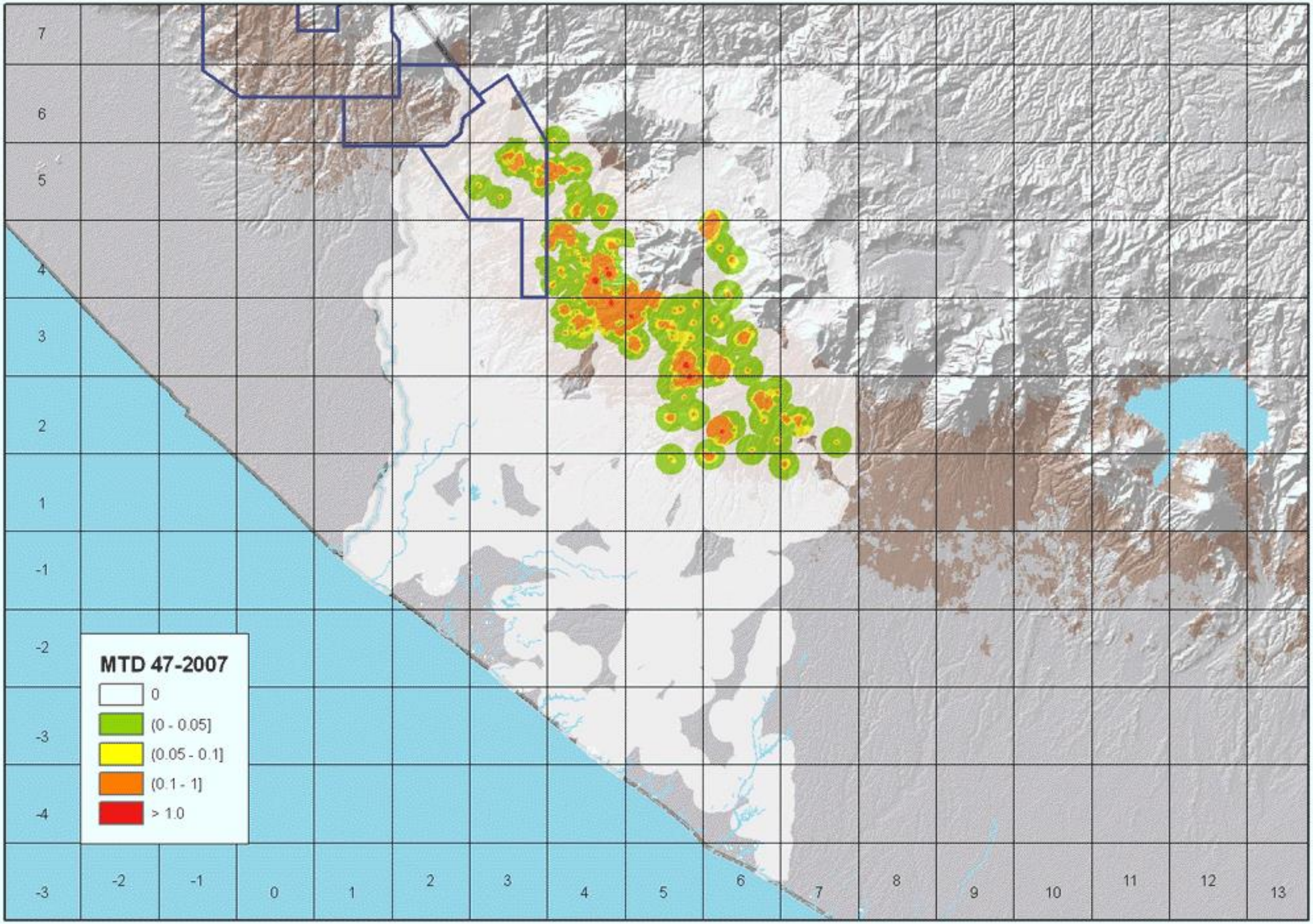


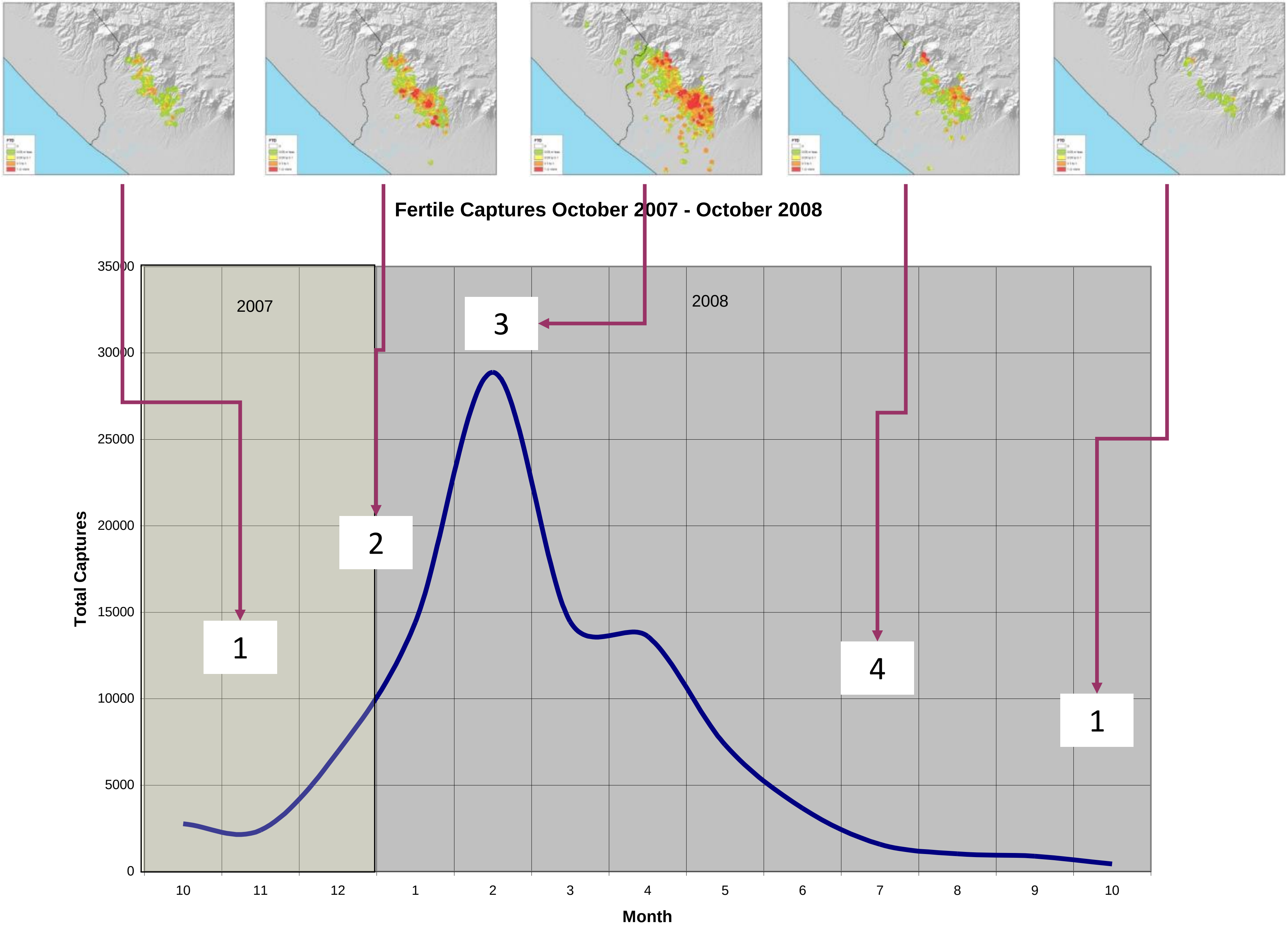
Host + Temperature

MEDFLY ECOLOGY

MEDFLY ECOLOGY CONDITIONS

- Coffee = Main host
- Life Cycle = ~ 28 days (depending on temperature)
  ~ 328 Degree Days
- Temperature Thresholds
  - Minimum ~ 12 C
  - Maximum ~ 28 C
- Soils = > Sandy Soils, < Clay Soils


MTD 47-2007
0
(0 - 0.05]
(0.05 - 0.1]
(0.1 - 1]
> 1.0
7
6
5
4
3
2
1
-1
-2
-3
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13

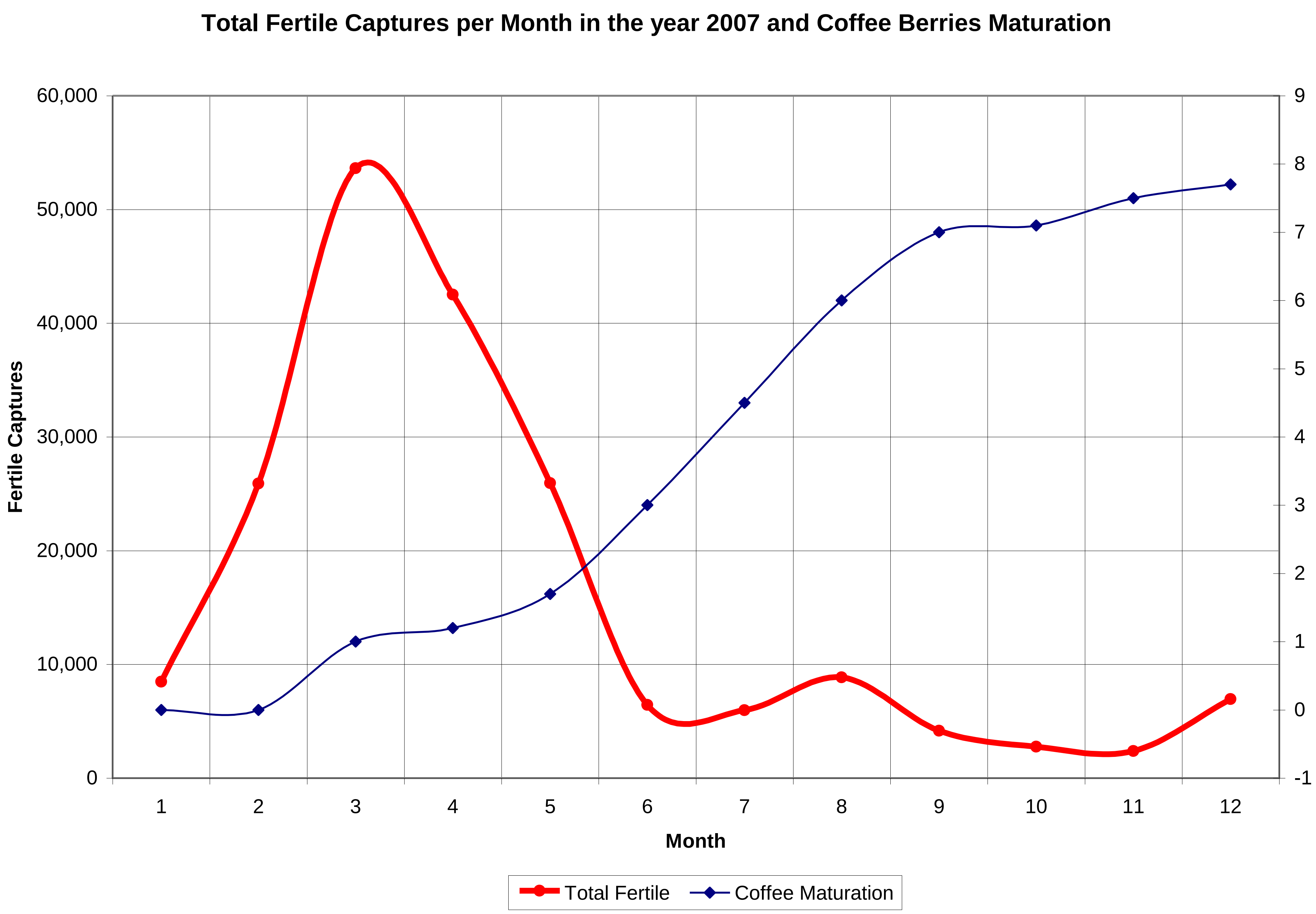


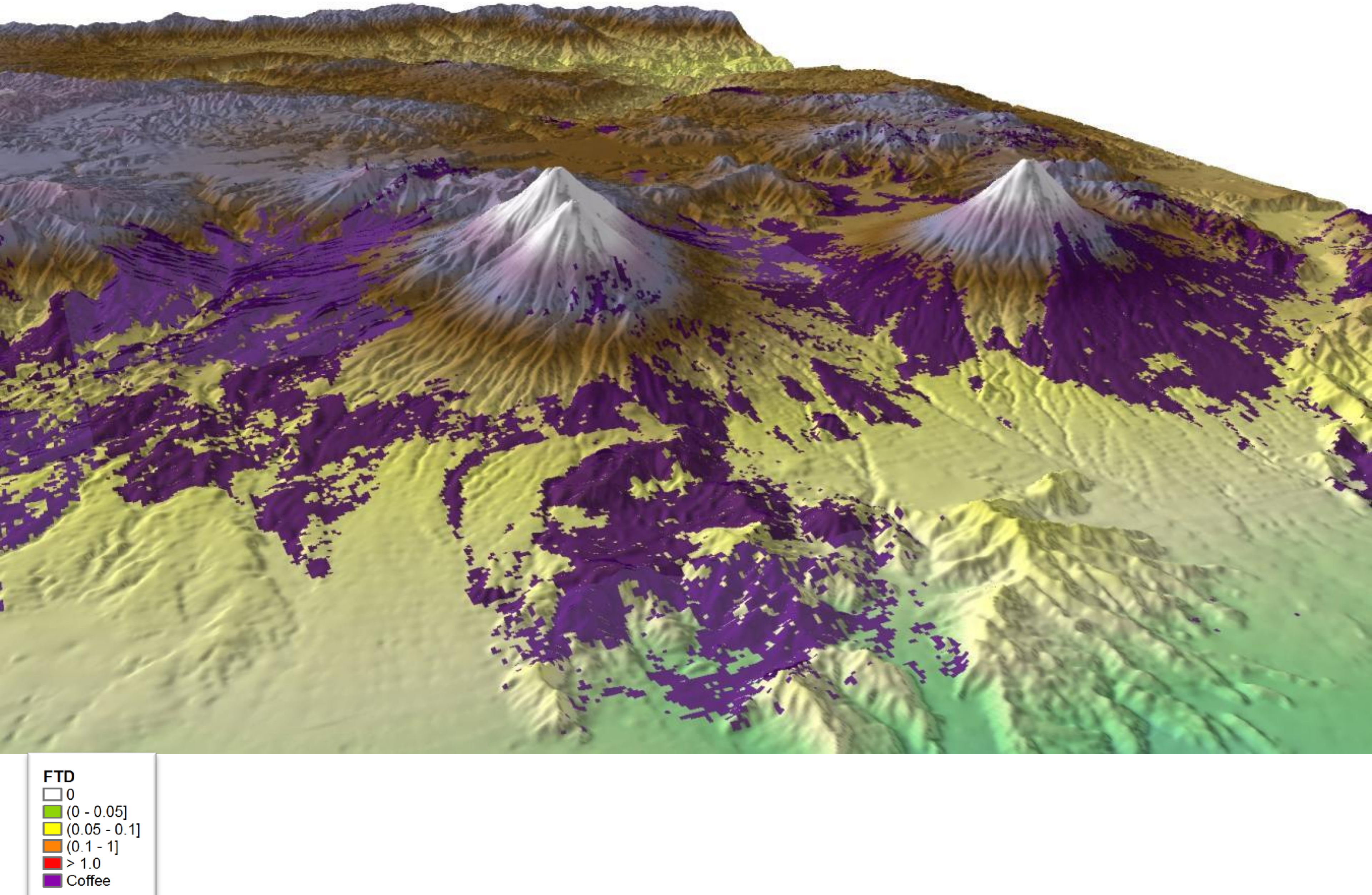
Fertile Captures October 2007 - October 2008
2007
2008
3
2
1
4
1
Total Captures
35000
30000
25000
20000
15000
10000
5000
0
10
11
12
1
2
3
4
5
6
7
8
9
10
Month

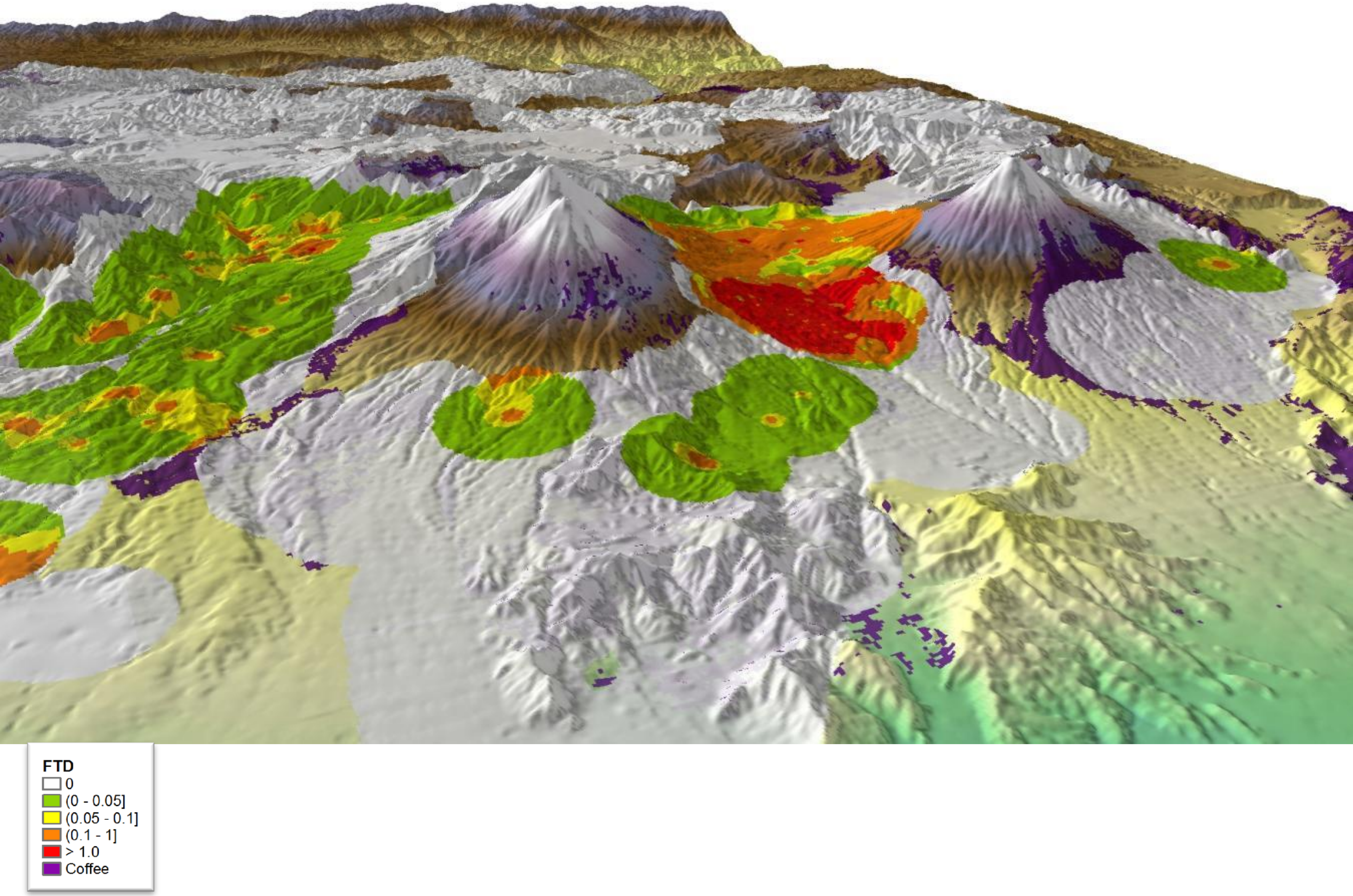
Medfly and Coffee Phenology in Guatemala and Mexico

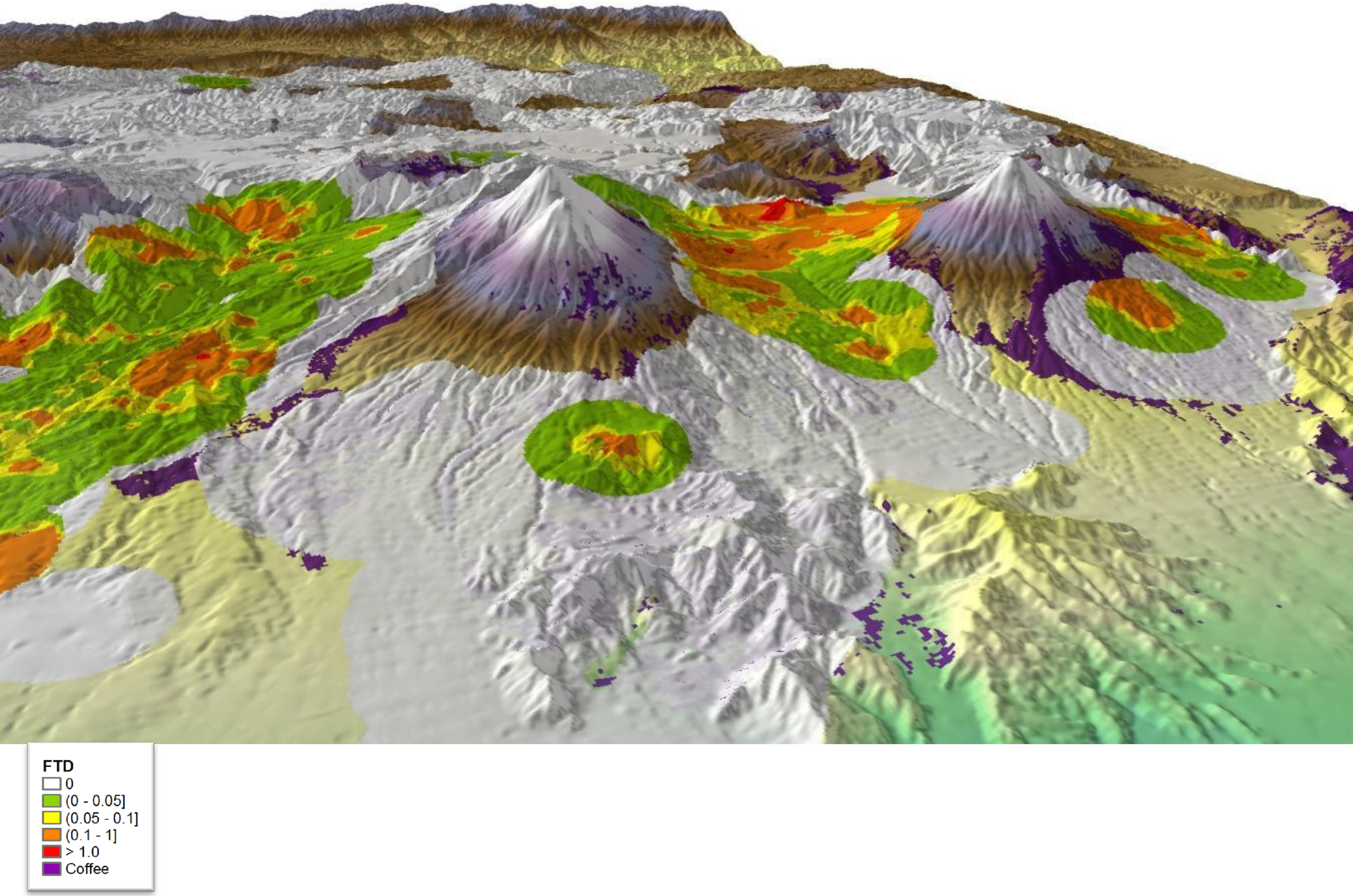
Midgarden, D., Lira, E.

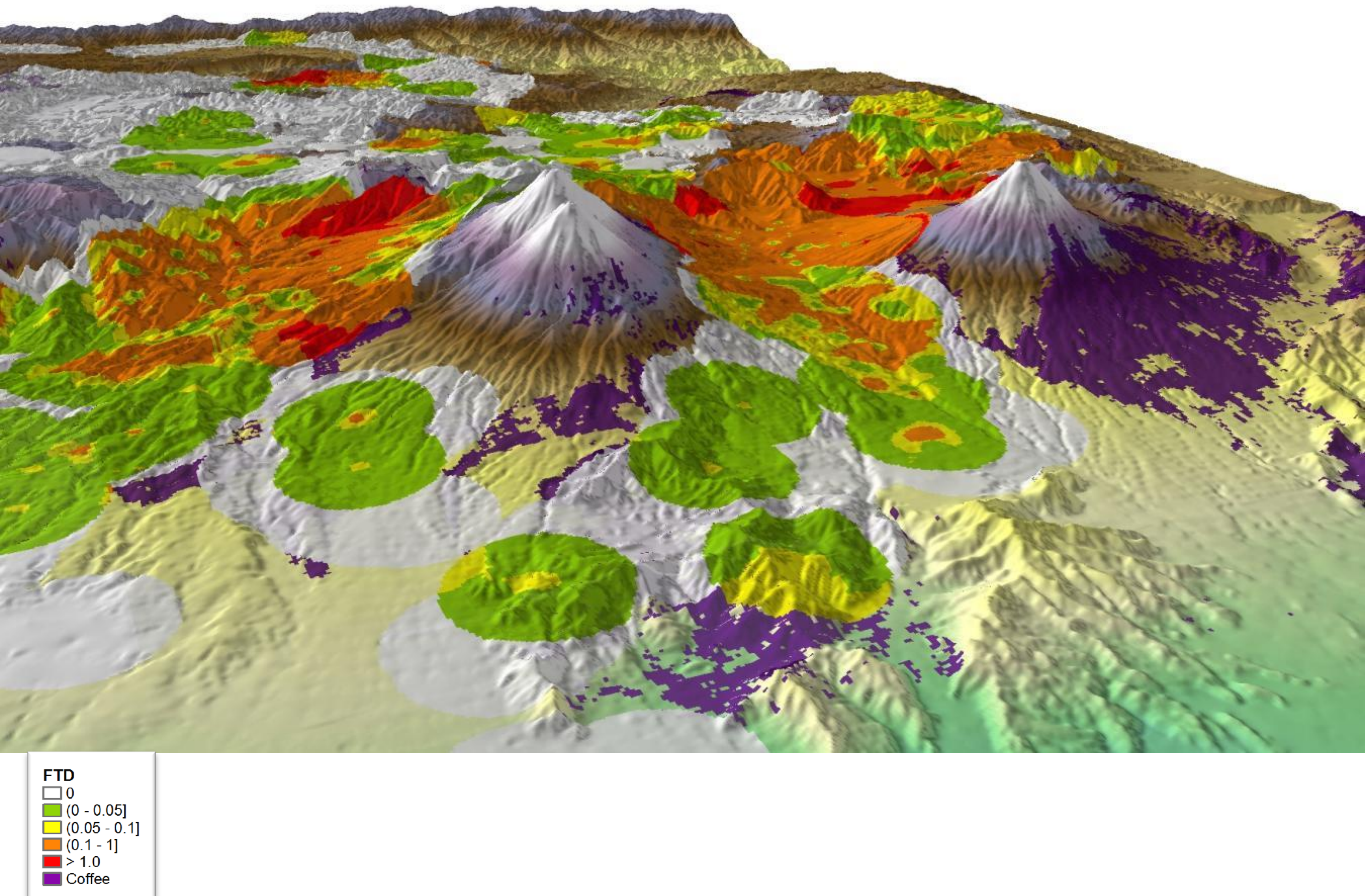
Paper presented 7th International Symposium on Fruit Flies of Economic Importance and 6th Meeting of the Working Group on Fruit Flies of Western Hemisphere. Salvador, BA, Brazil. September 2006.


Total Fertile Captures per Month in the year 2007 and Coffee Berries Maturation
Fertile Captures
60,000
50,000
40,000
30,000
20,000
10,000
0
9
8
7
6
5
4
3
2
1
0
-1
1
2
3
4
5
6
7
8
9
10
11
12
Month
Total Fertile
Coffee Maturation


FTD
0
(0 - 0.05]
(0.05 - 0.1]
(0.1 - 1]
> 1.0
Coffee

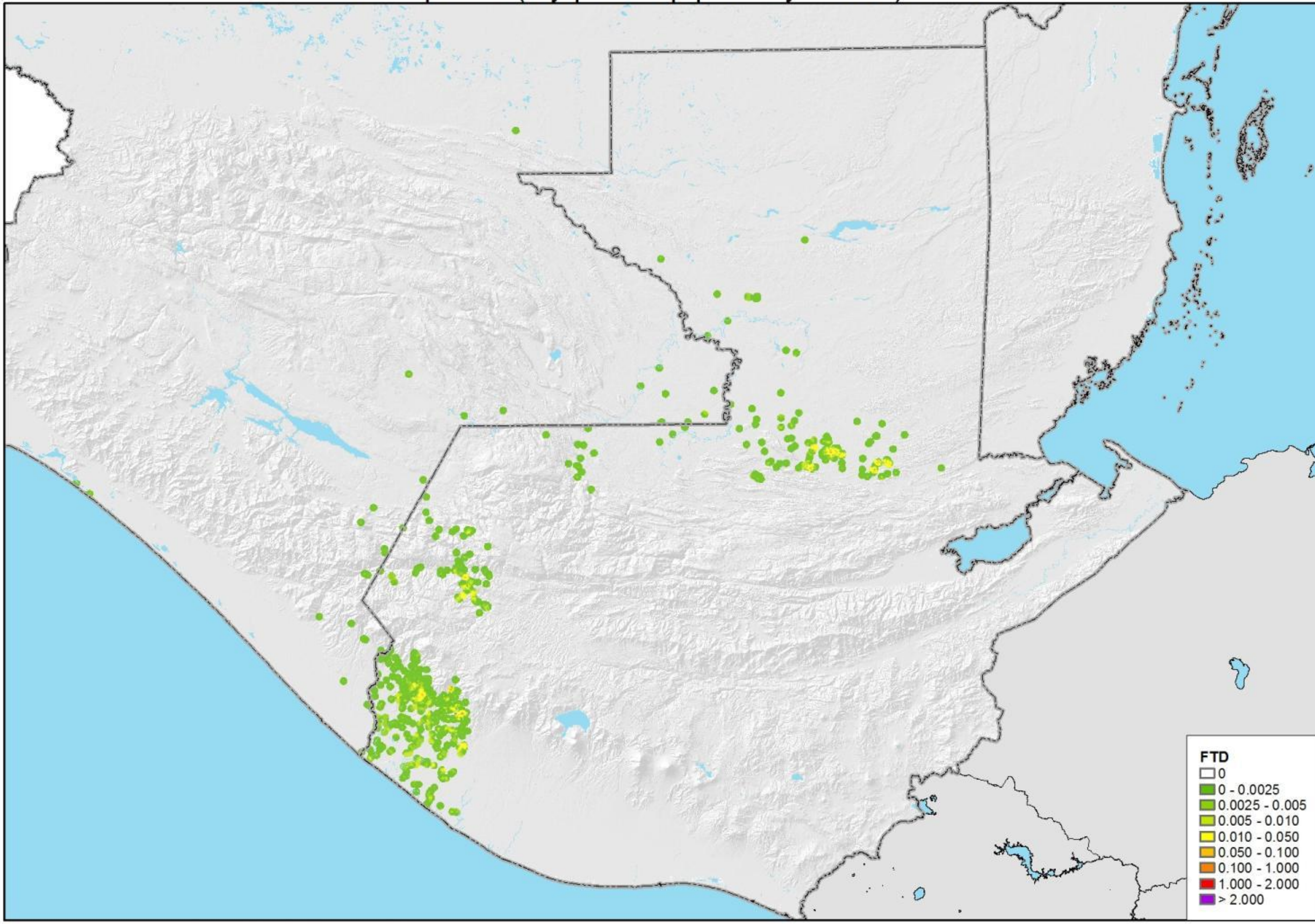

FTD
0
(0 - 0.05]
(0.05 - 0.1]
(0.1 - 1]
> 1.0
Coffee


FTD
0
(0 - 0.05]
(0.05 - 0.1]
(0.1 - 1]
> 1.0
Coffee

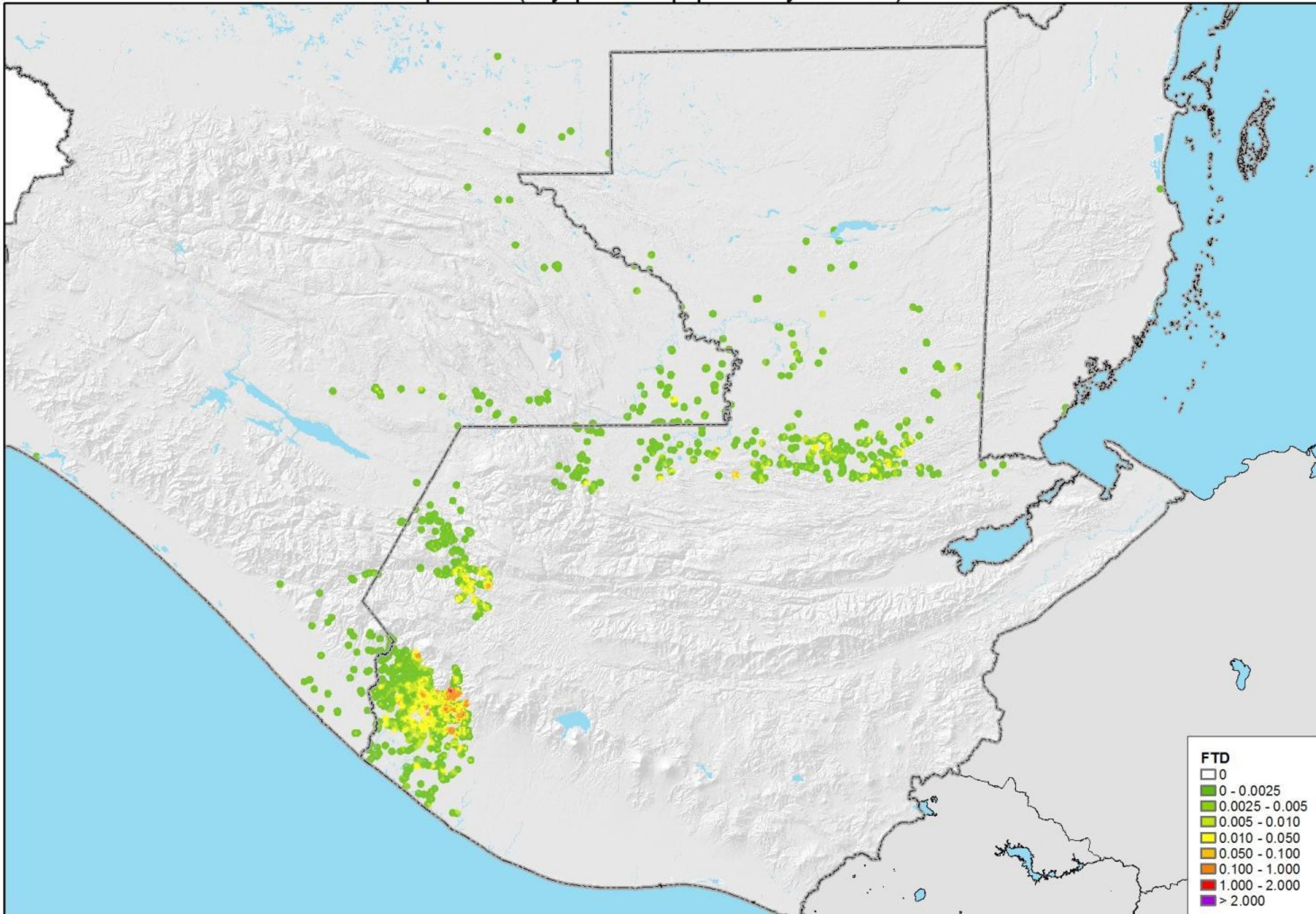

FTD
0
(0 - 0.05]
(0.05 - 0.1]
(0.1 - 1]
> 1.0
Coffee

Captures 2004 to 2016

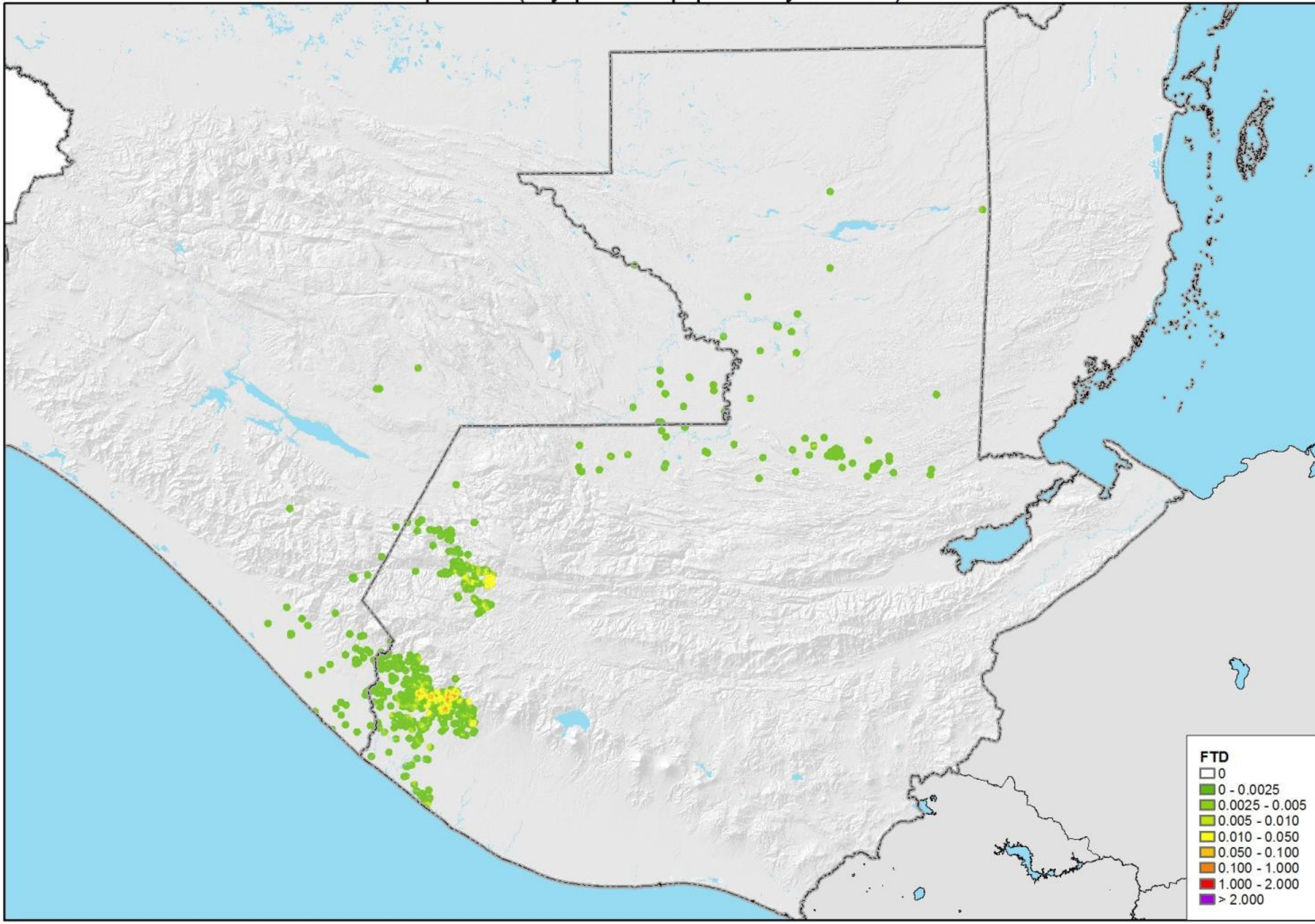
Wild Captures (Fly per Trap per Day - FTD-) in 2004



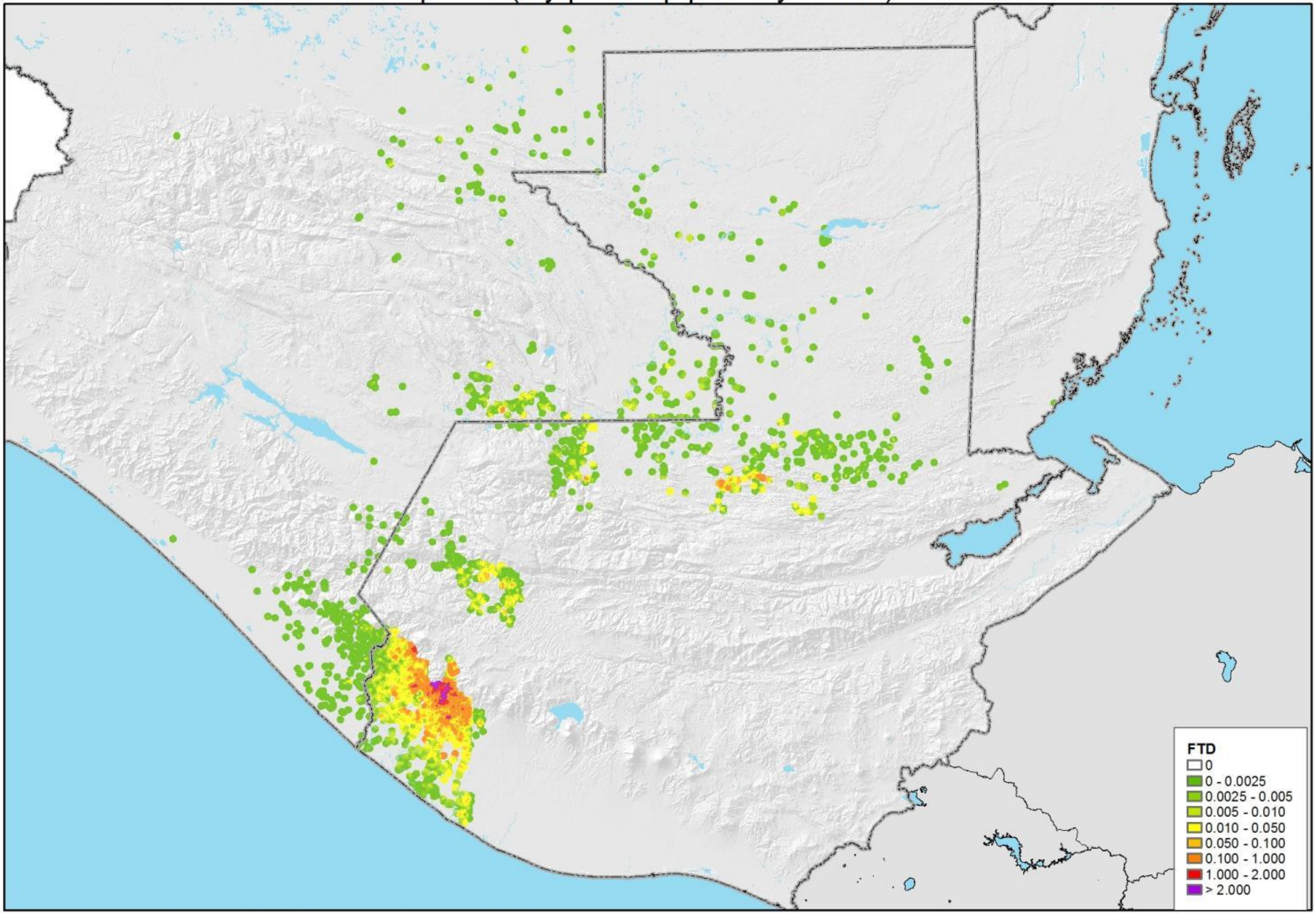
Wild Captures (Fly per Trap per Day - FTD-) in 2005



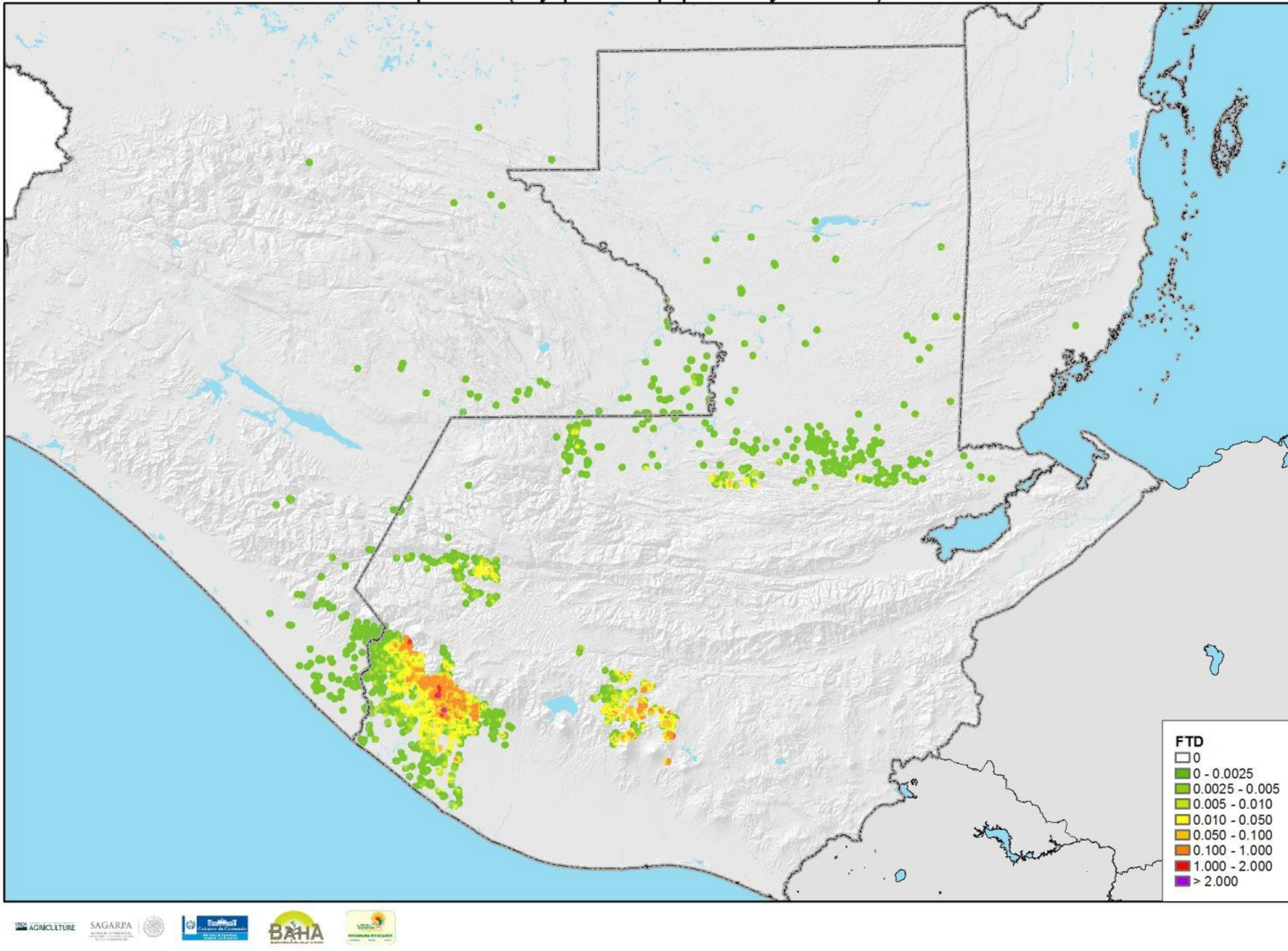
Wild Captures (Fly per Trap per Day - FTD-) in 2006



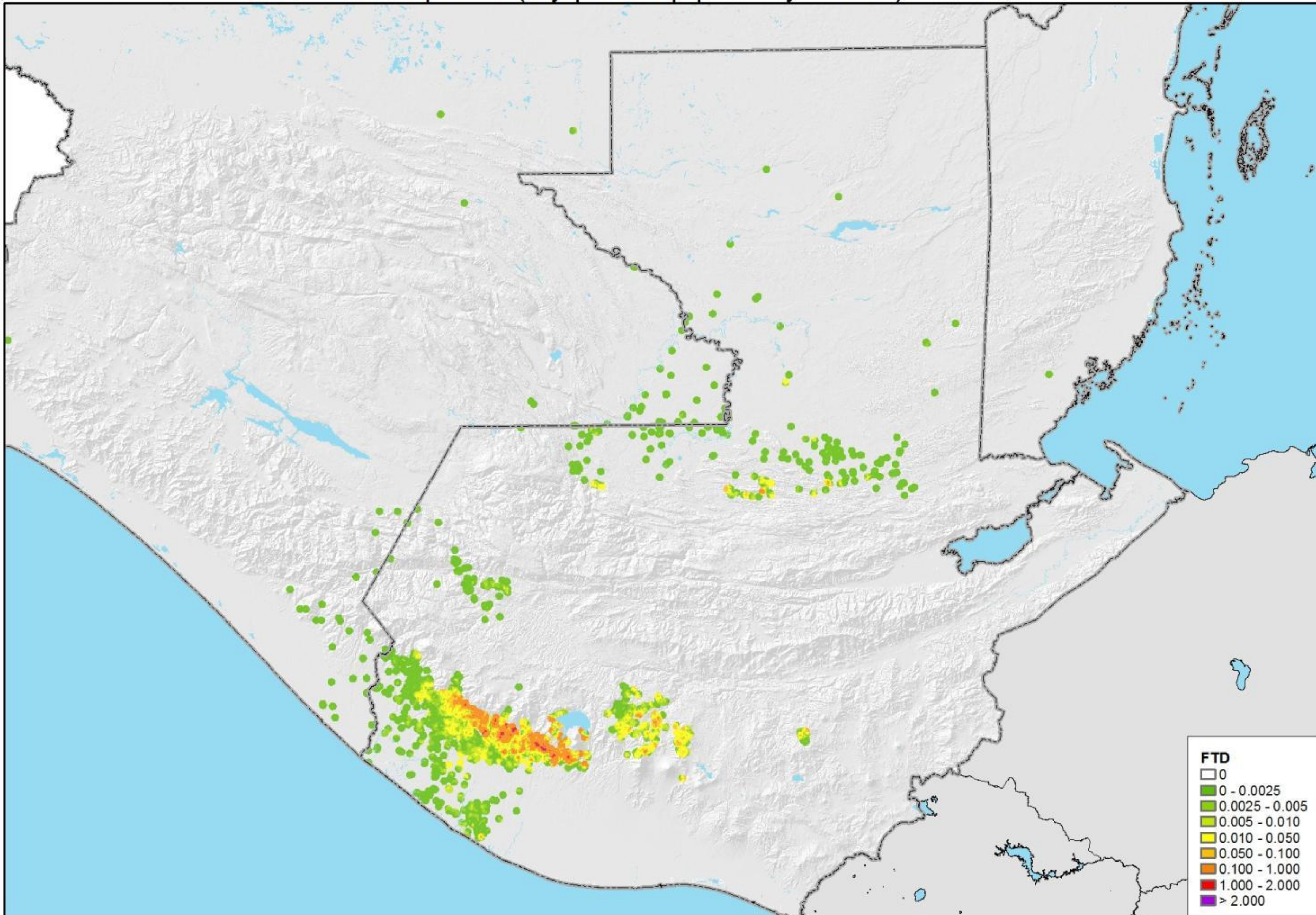
Wild Captures (Fly per Trap per Day - FTD-) in 2007



Wild Captures (Fly per Trap per Day - FTD-) in 2008

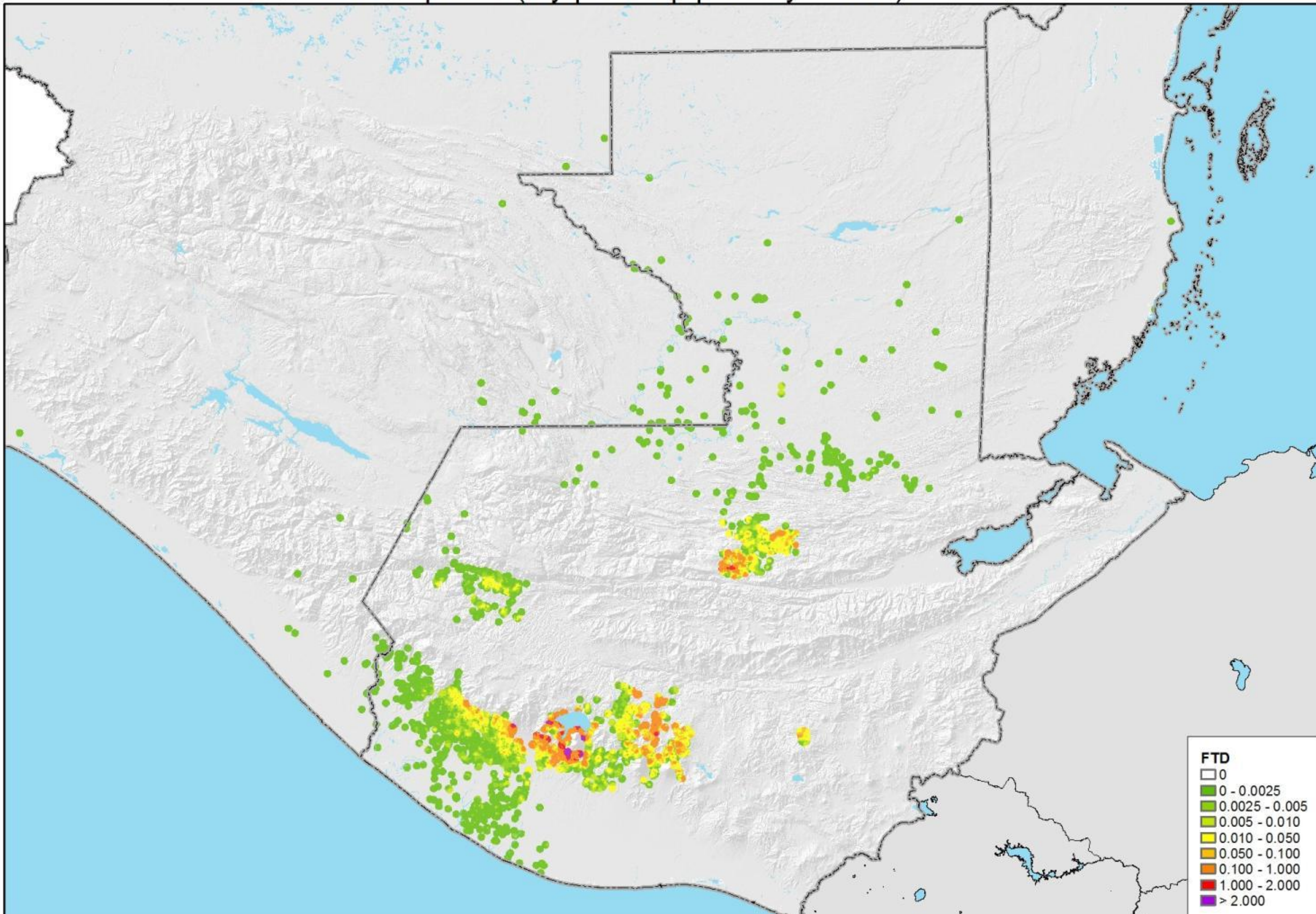


Wild Captures (Fly per Trap per Day - FTD-) in 2009

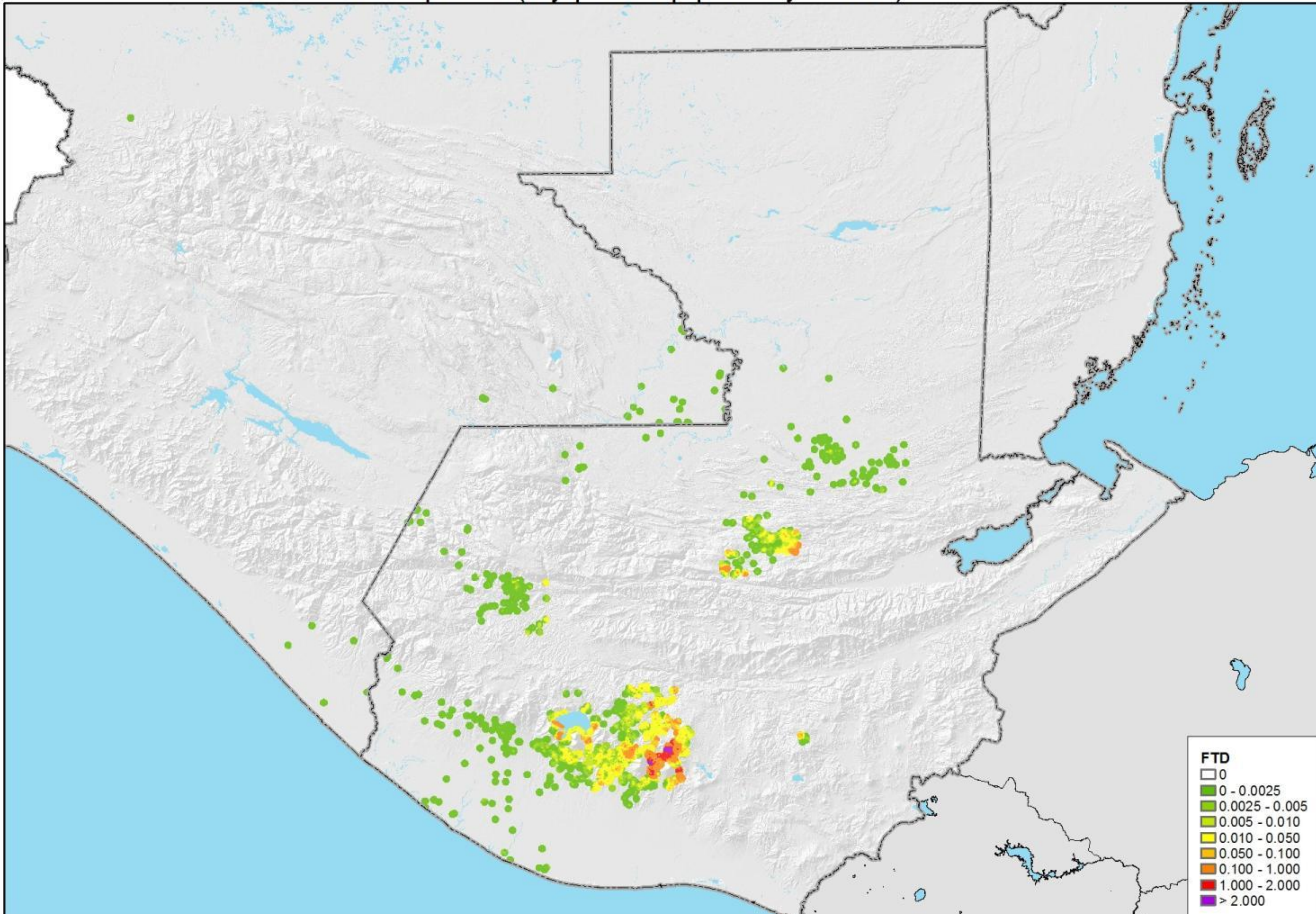


SAGARPA BAHA

Wild Captures (Fly per Trap per Day - FTD-) in 2010

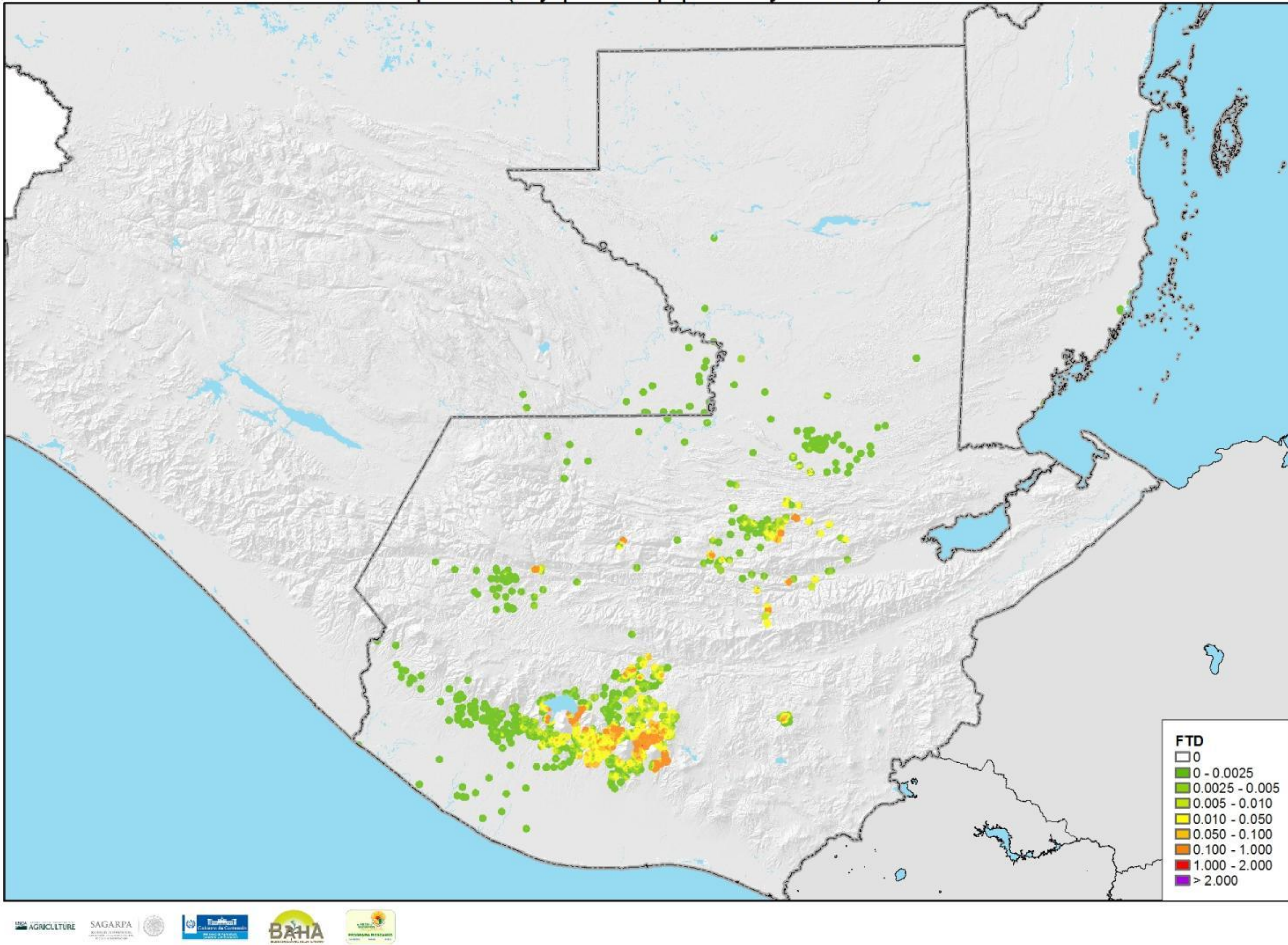


Wild Captures (Fly per Trap per Day - FTD-) in 2011

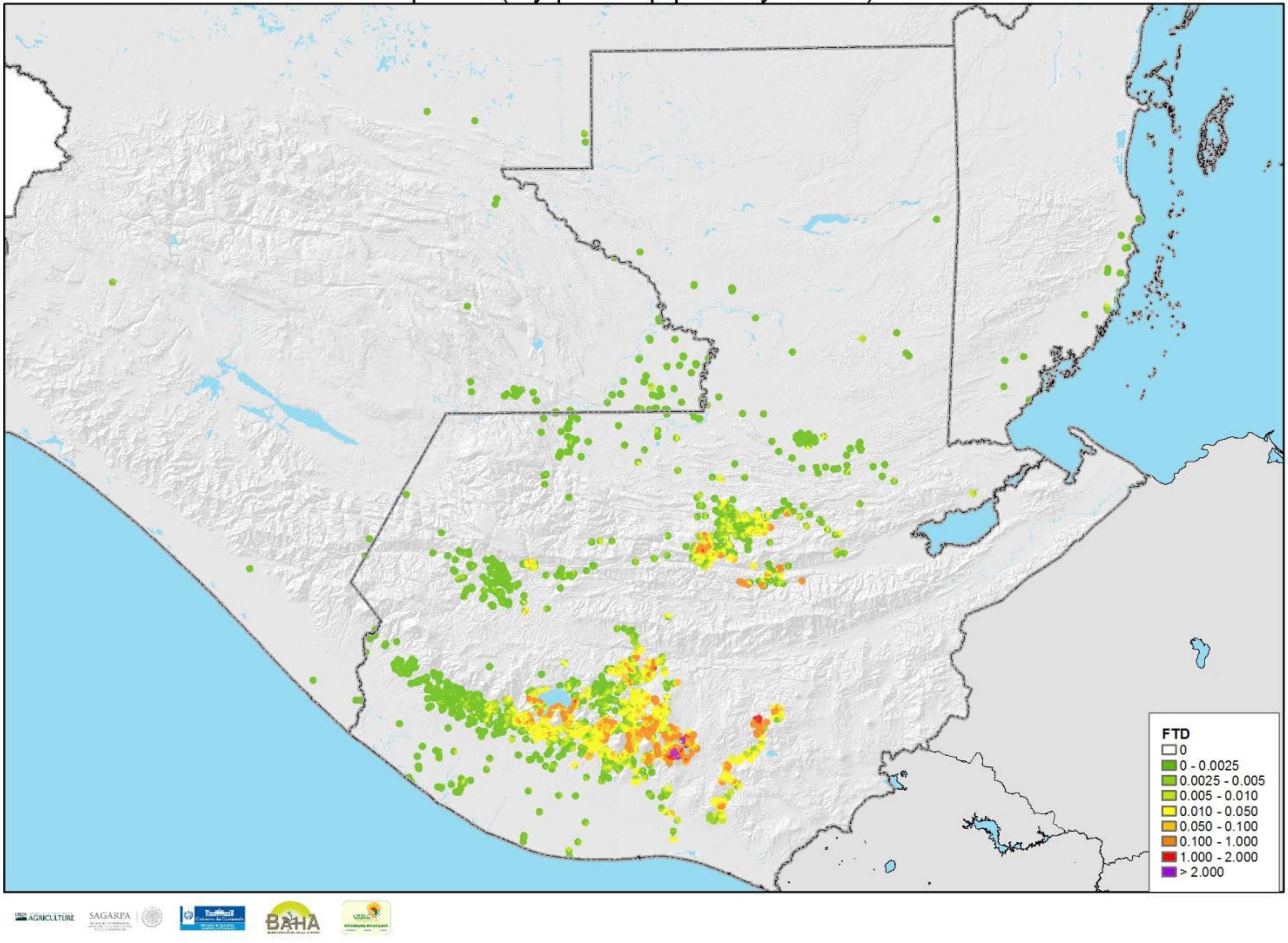


AGRICULTURE SAGARPA BAHA

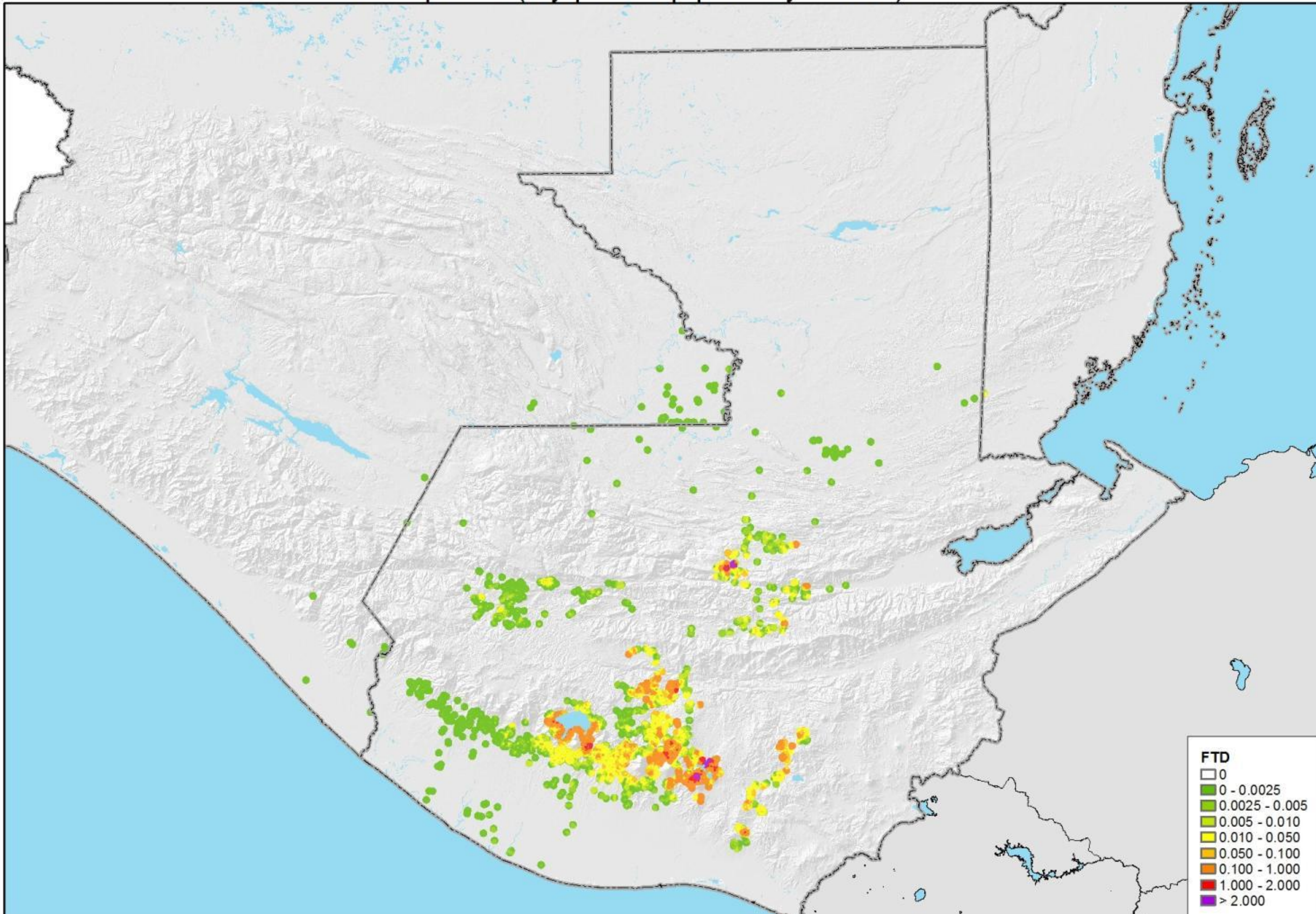
Wild Captures (Fly per Trap per Day - FTD-) in 2012



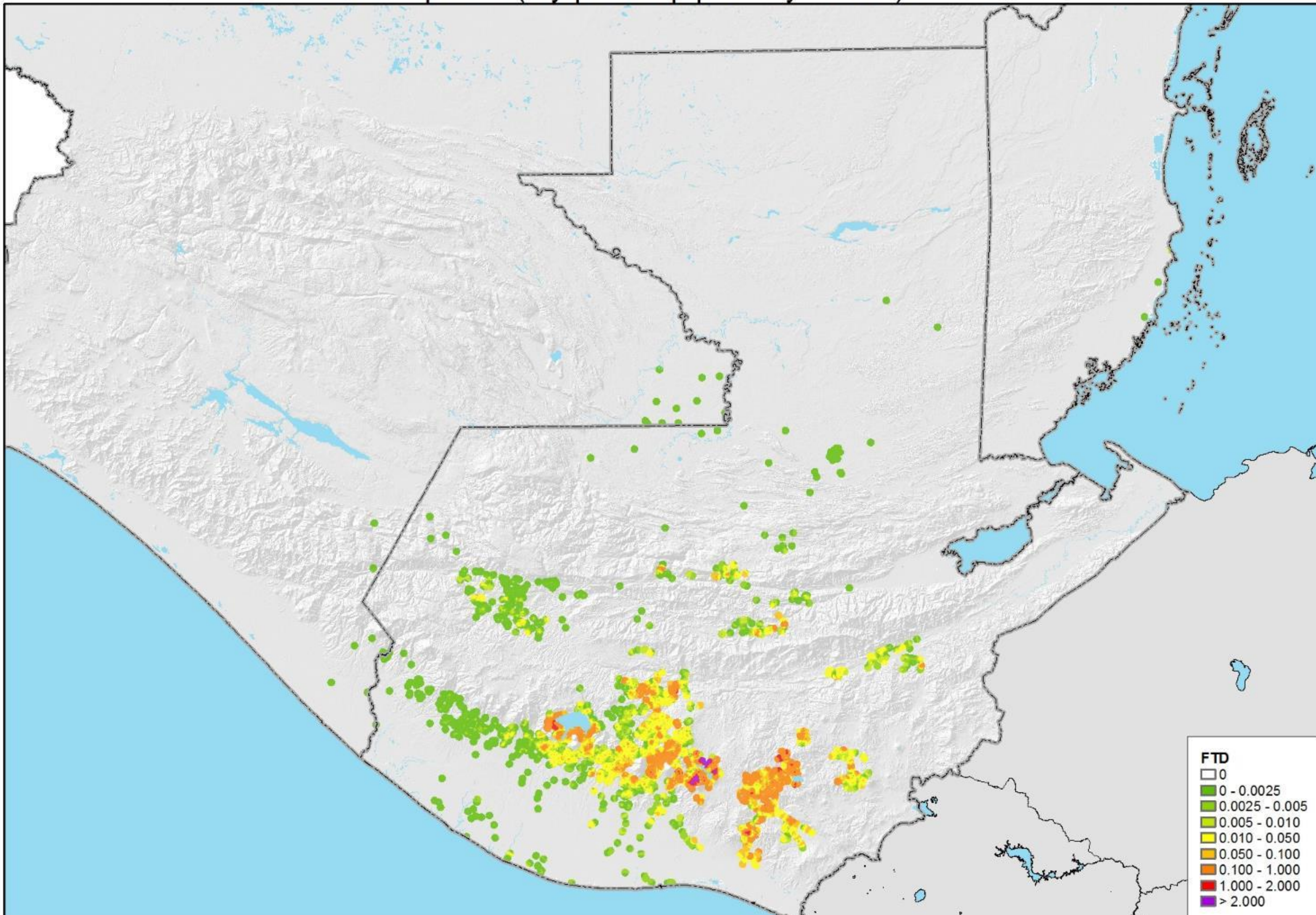
Wild Captures (Fly per Trap per Day - FTD-) in 2013



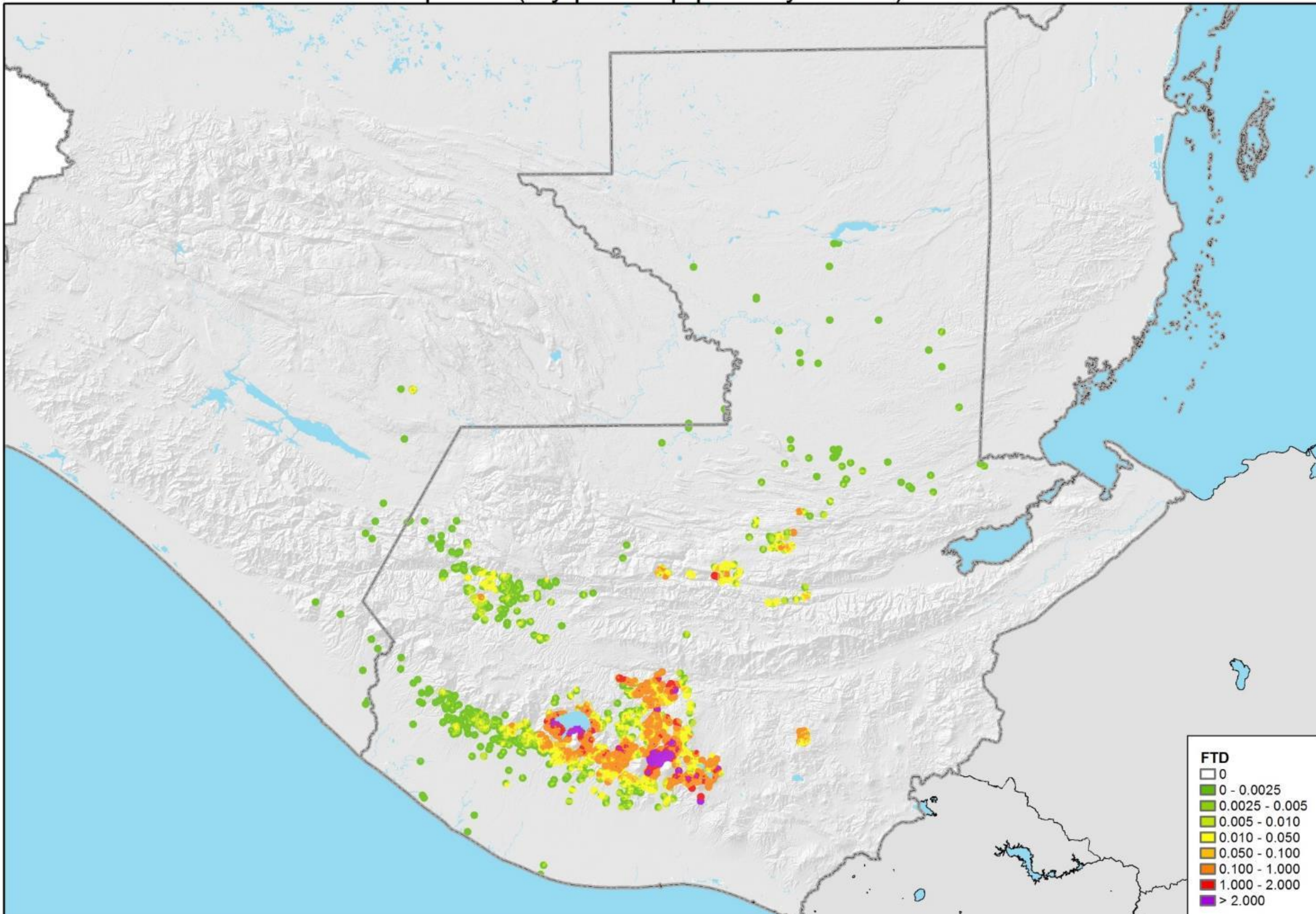
Wild Captures (Fly per Trap per Day - FTD-) in 2014



Wild Captures (Fly per Trap per Day - FTD-) in 2015



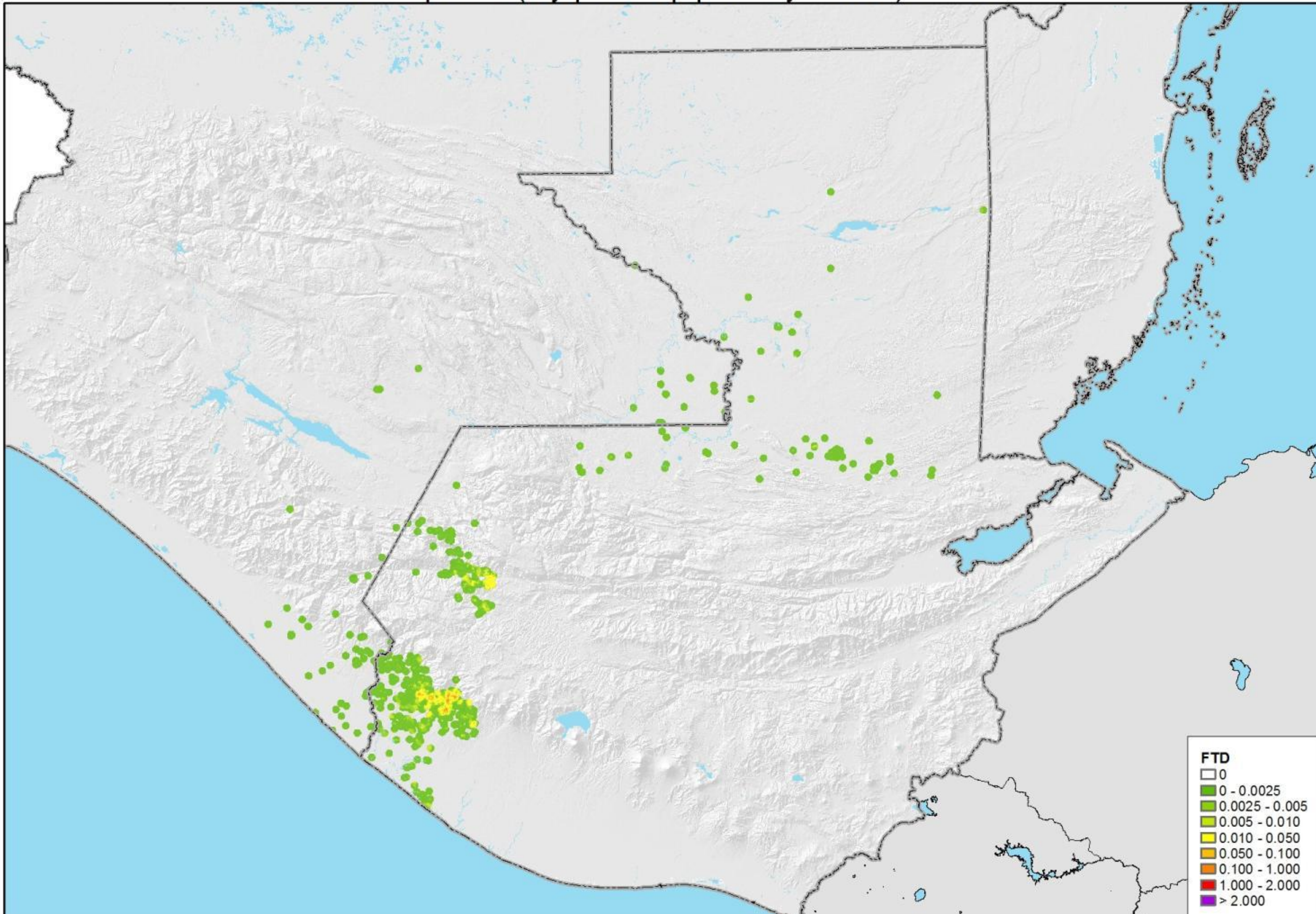
Wild Captures (Fly per Trap per Day - FTD-) in 2016



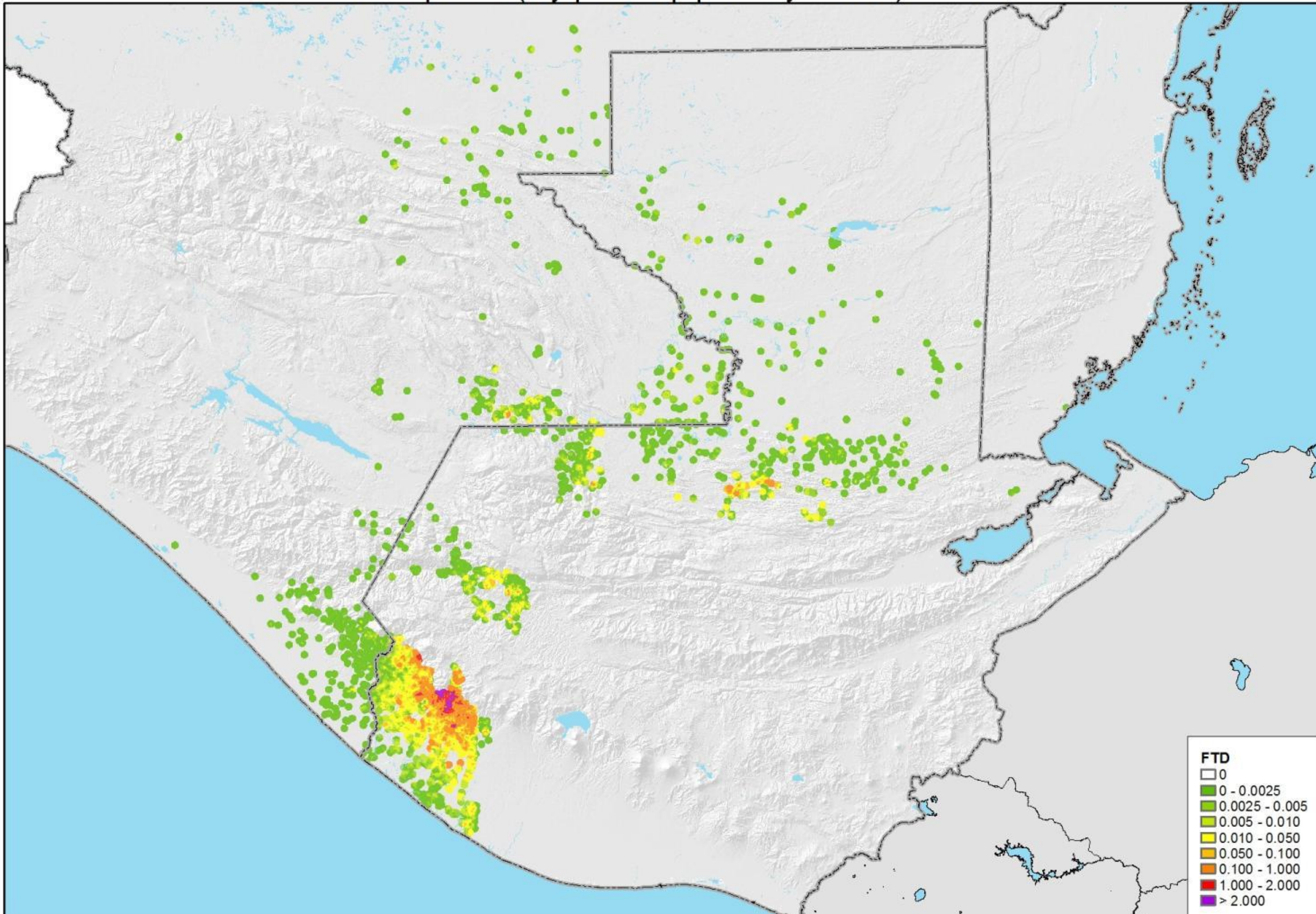
AGRICULTURE SAGARPA MAGA BAHA

GOOD YEARS = FEW CAPTURES
BAD YEARS= LOTS OF CAPTURES

Wild Captures (Fly per Trap per Day - FTD-) in 2006



Wild Captures (Fly per Trap per Day - FTD-) in 2007



AGRICULTURE SAGARPA BAHA

WHY?????

ALLAN AUCLAIR, ET.AL.
MAZATLAN 2008

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David.Enfield@noaa.gov
Assaf Anyamba assaf@gpmail.gsfc.nasa.gov

Using Climate Indices to Predict Medfly Outbreaks in Guatemala and Mexico

USDA APHIS: Alan Auclair, Chinling Chen, William Macheel, Pedro Rendon, Estuardo Lira, David Midgarden, and Roger Magarey

NOAA: David Enfield and *NASA:* Assaf Anyamba

Period of Host Availability (July to December) = Lead-in Year

Year of Interest (January to June)

Fly-Storm Years

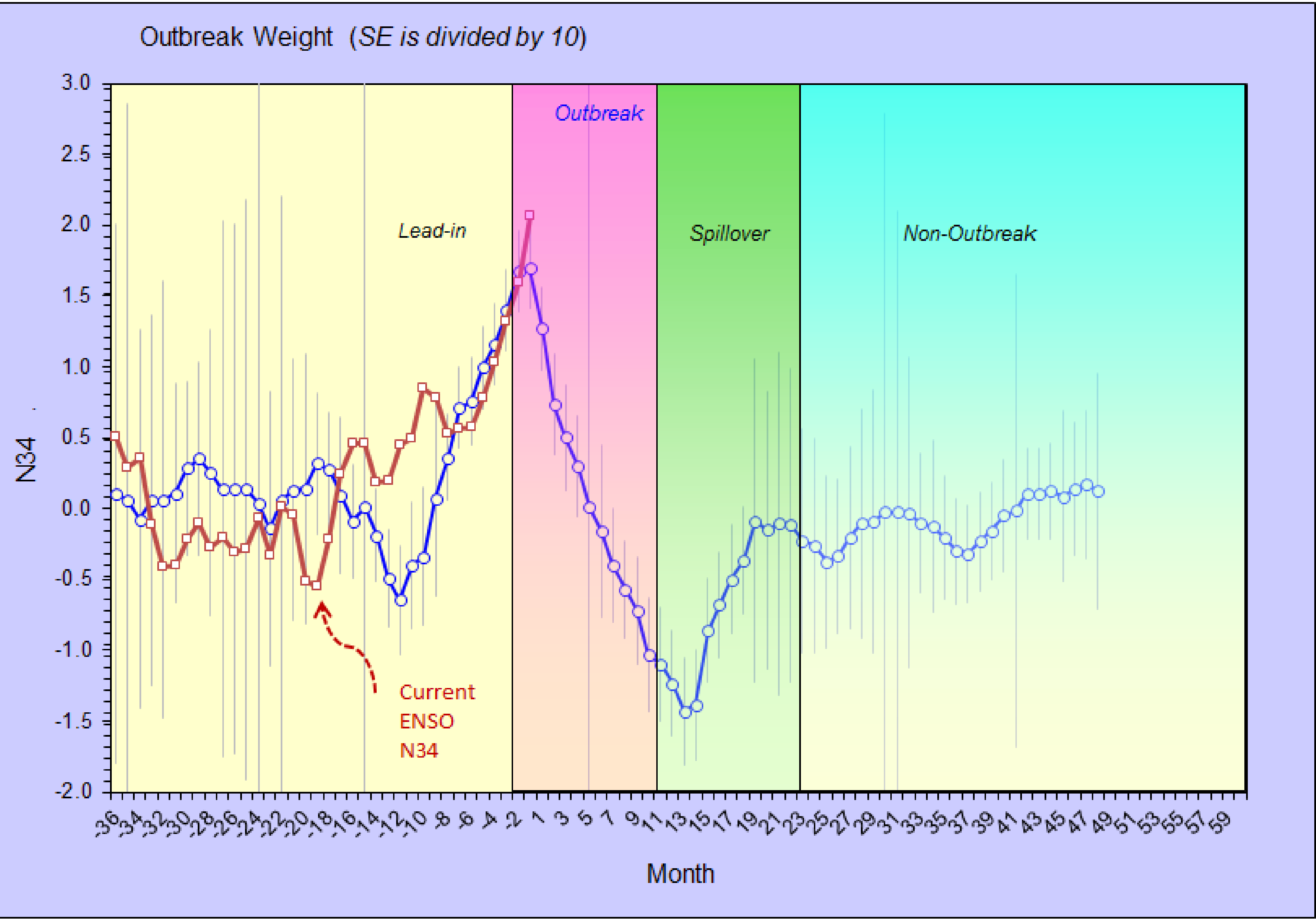
Normal Years

Fly-Storm Year =

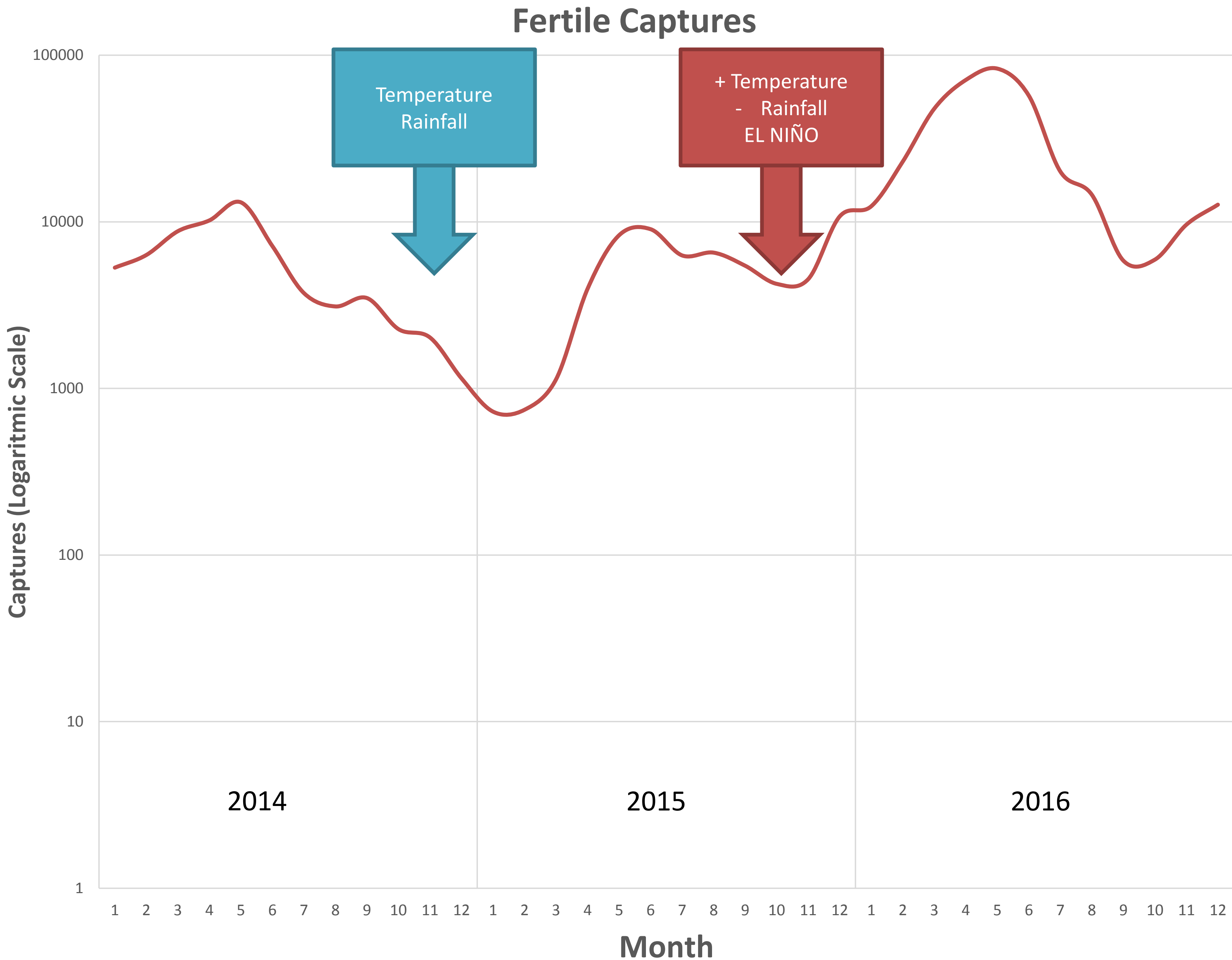
High Temperatures + Less Rainfall

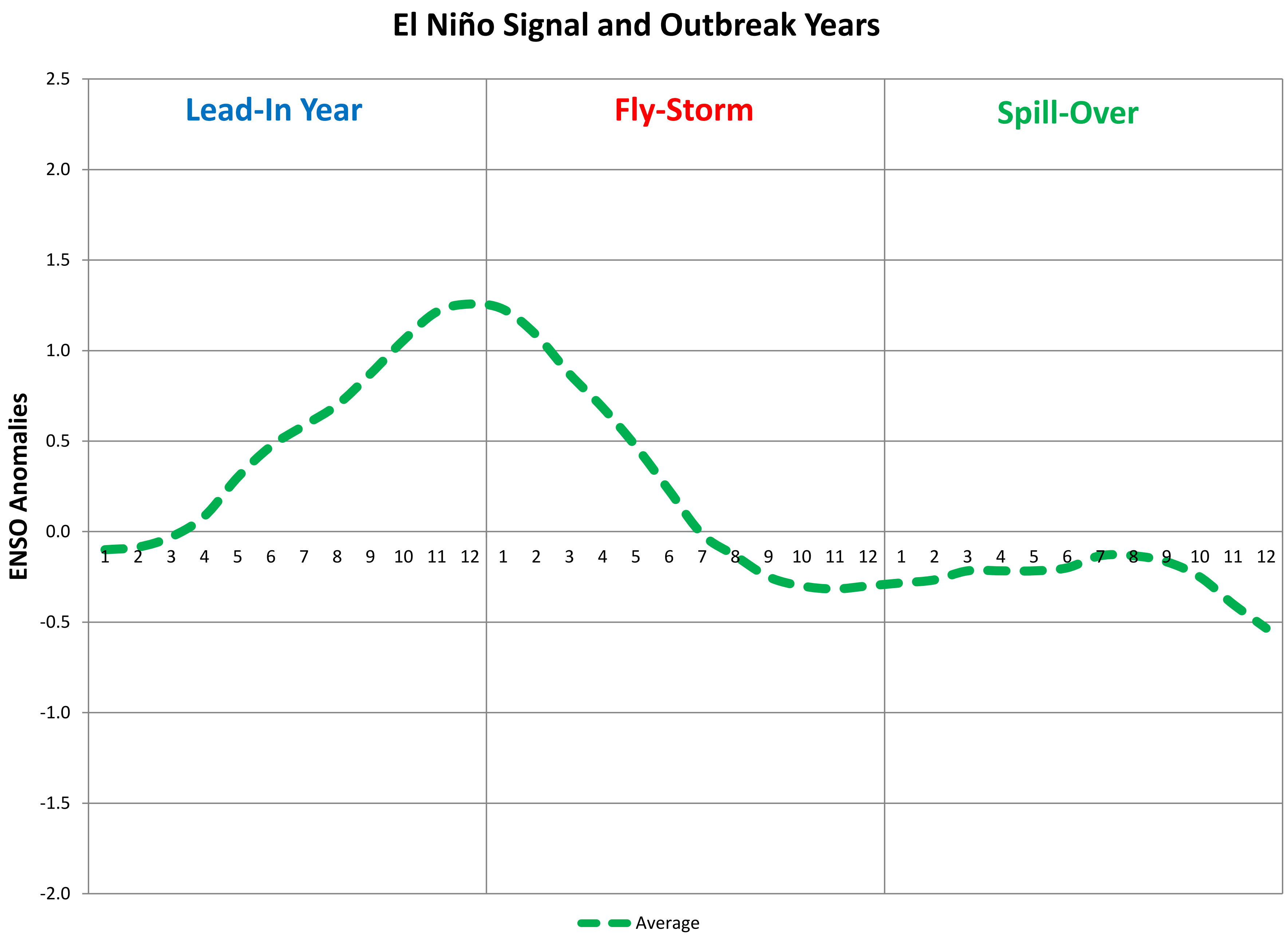
El Niño → High Temperatures + Less Rainfall

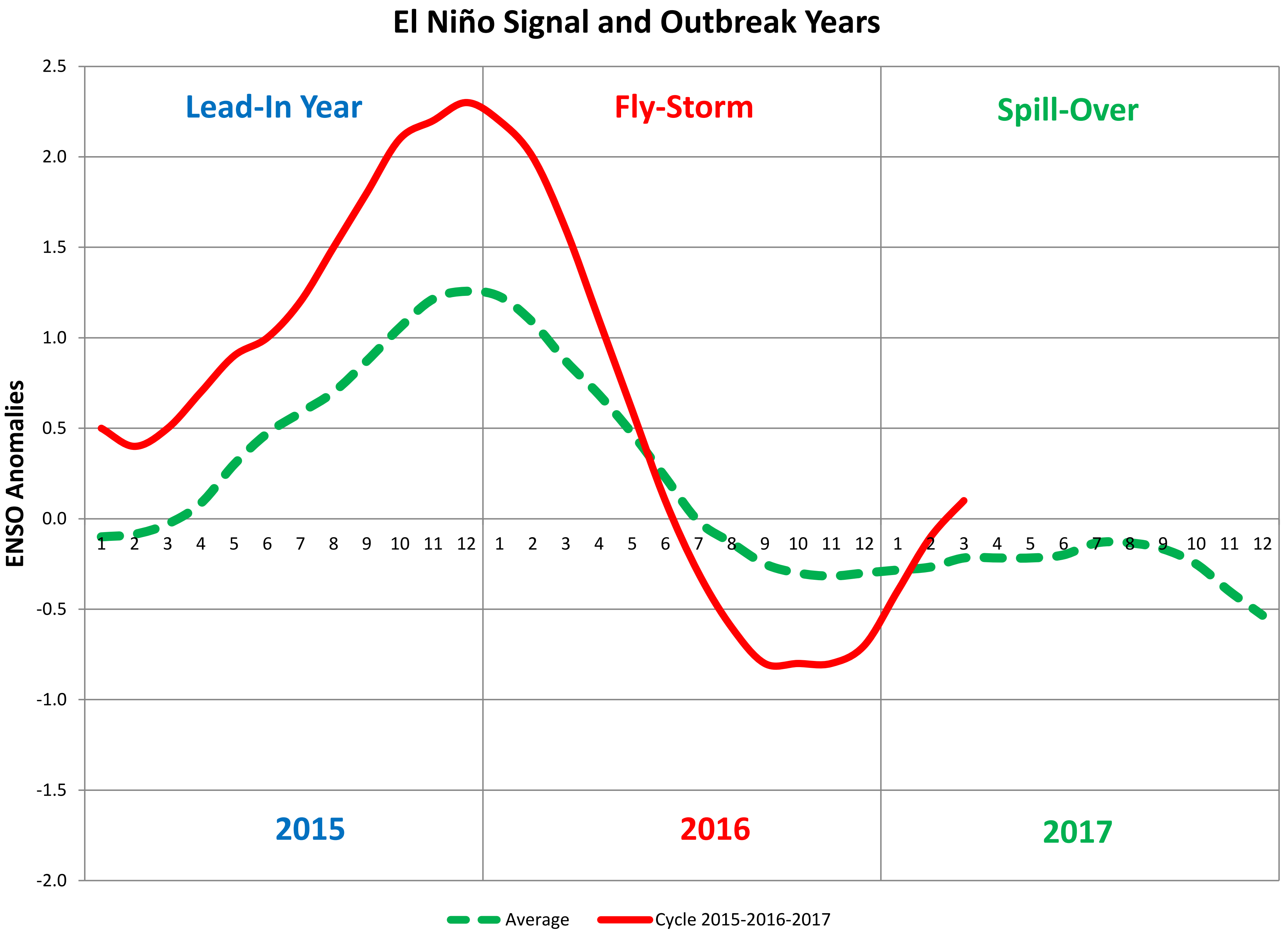
El Niño Lead-in Year → Fly Storm Years



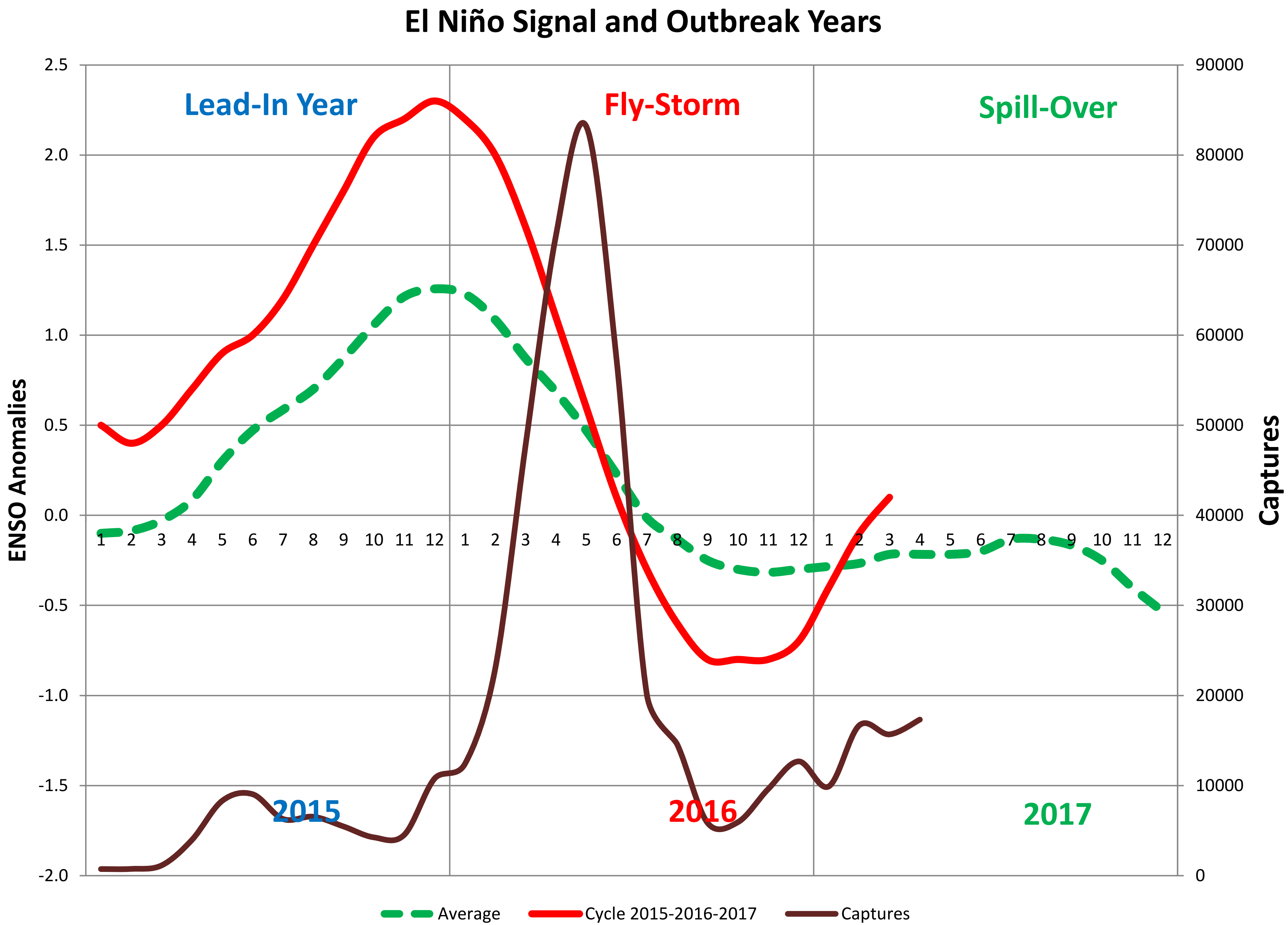
Outbreak Weight (SE is divided by 10)
Lead-in
Outbreak
Spillover
Non-Outbreak
Current
ENSO
N34
N34
Month


Fertile Captures
100000
10000
1000
100
10
1
Captures (Logaritmic Scale)
Temperature
Rainfall
+ Temperature
- Rainfall
EL NIÑO
2014
2015
2016
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Month

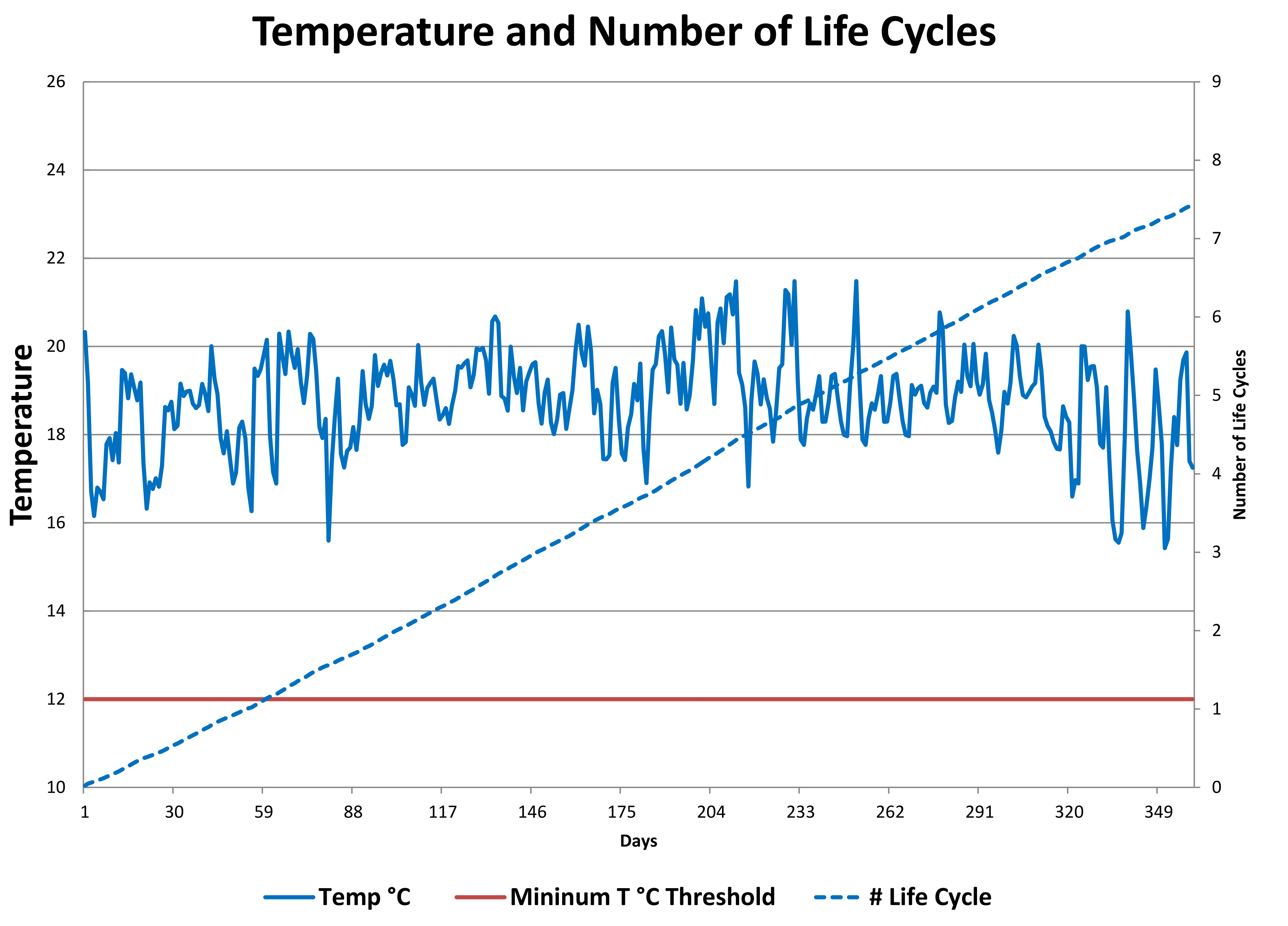

El Niño Signal and Outbreak Years
ENSO Anomalies
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Lead-In Year
Fly-Storm
Spill-Over
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Average

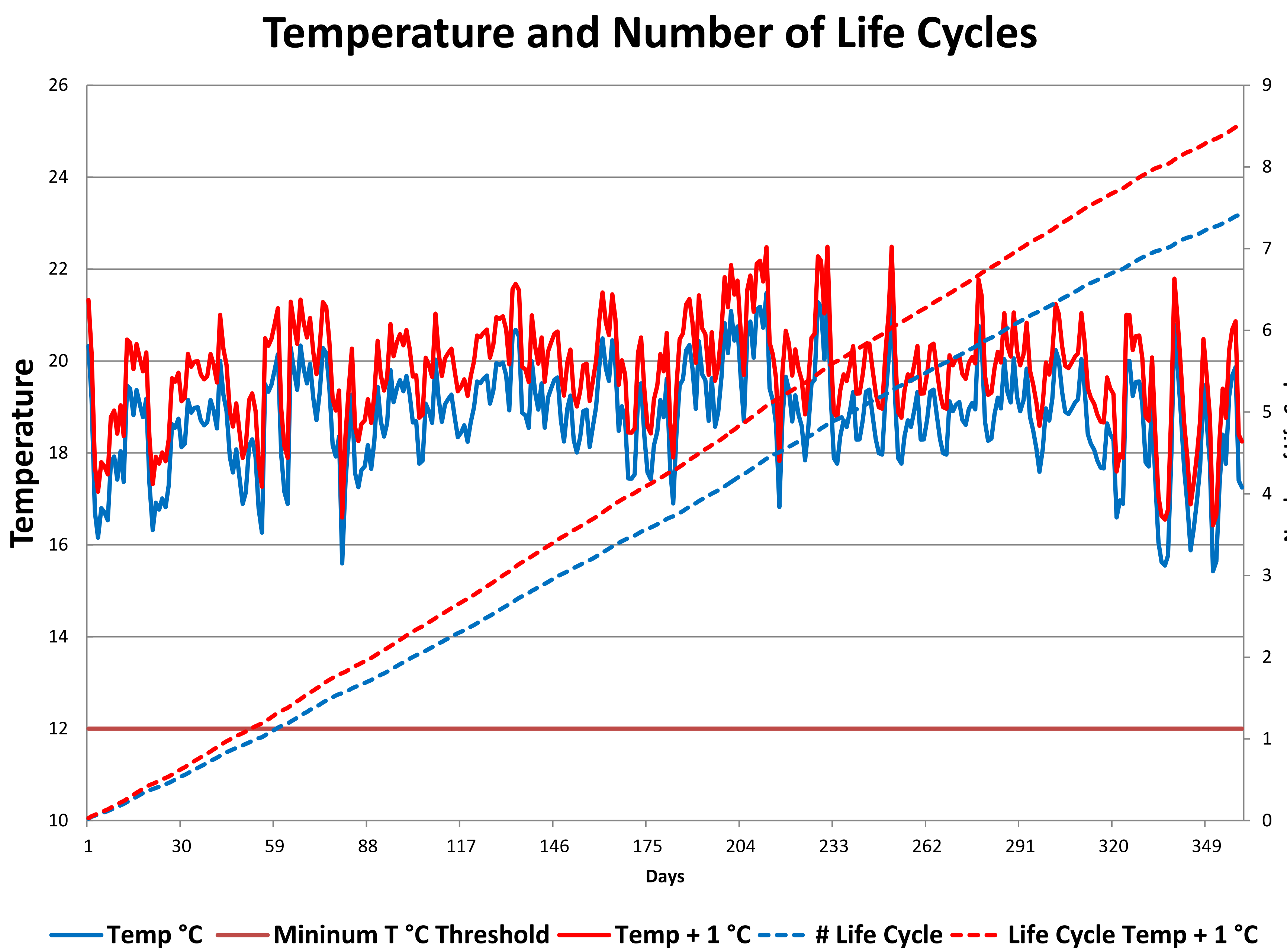


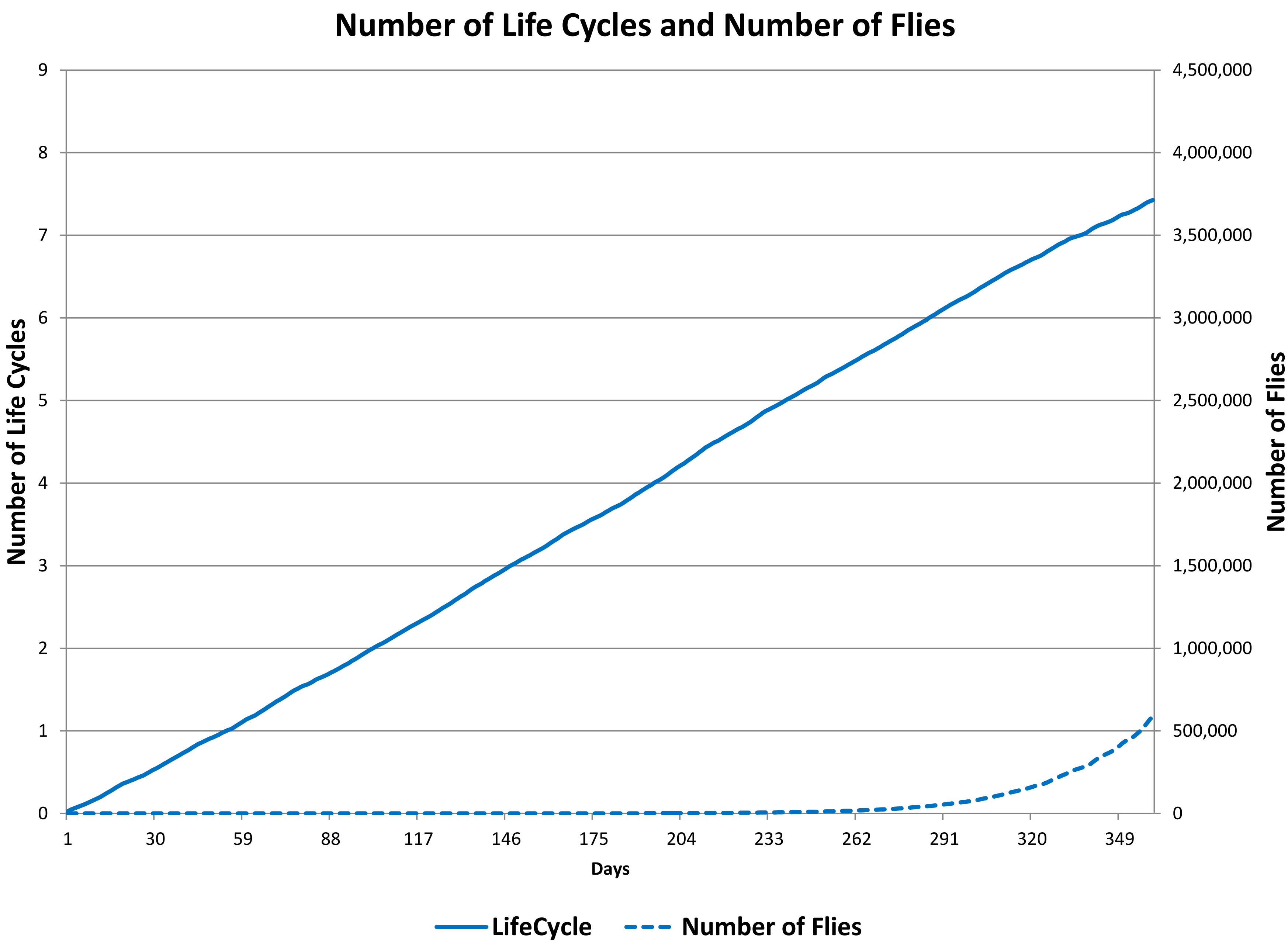
El Niño Signal and Outbreak Years
ENSO Anomalies
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Lead-In Year
Fly-Storm
Spill-Over
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2015
2016
2017
Average
Cycle 2015-2016-2017


El Niño Signal and Outbreak Years
Lead-In Year
Fly-Storm
Spill-Over
2015
2016
2017
ENSO Anomalies
Captures
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Average
Cycle 2015-2016-2017
Captures

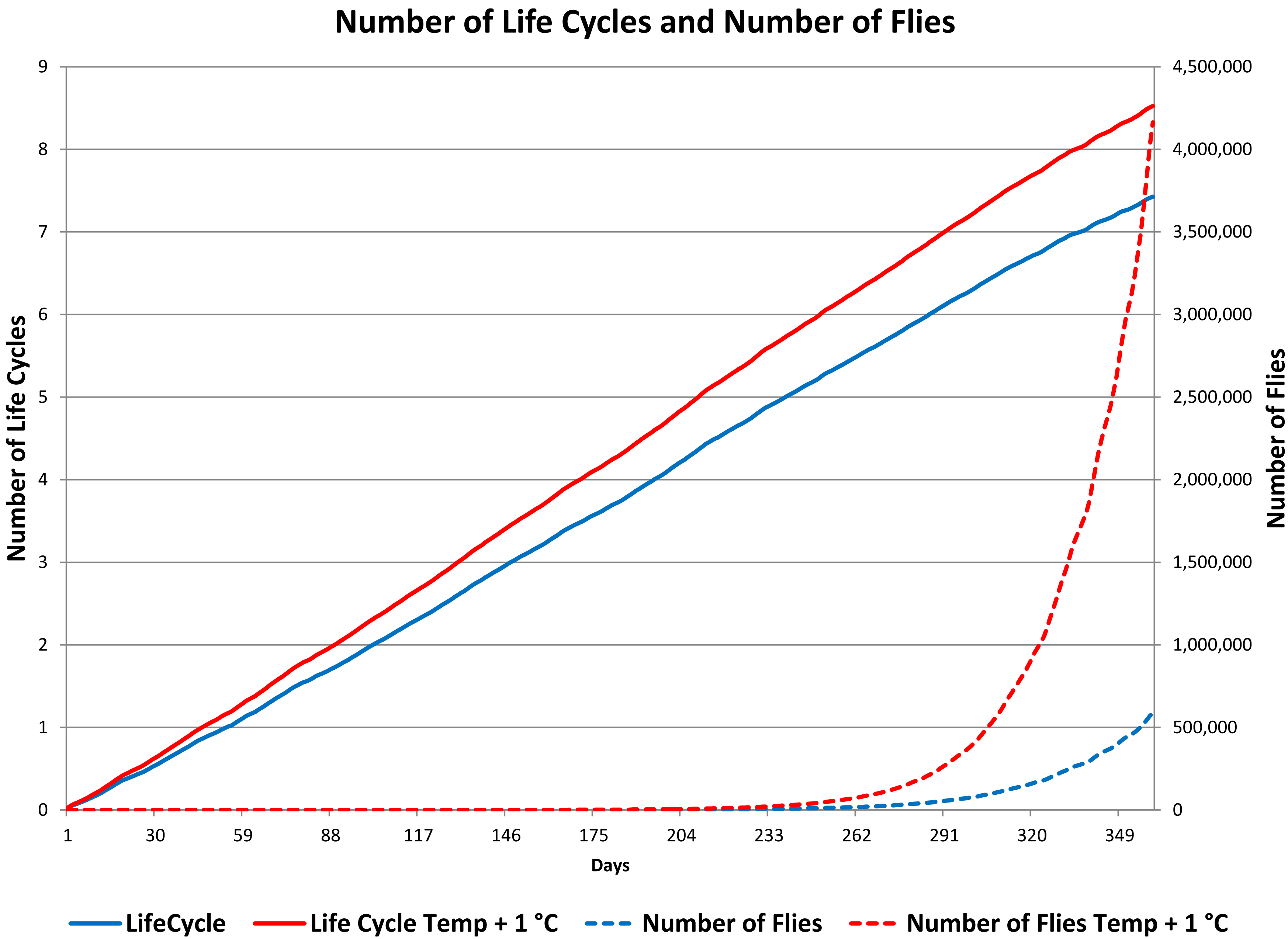
MEDFLY AND TEMPERATURE


Temperature and Number of Life Cycles
Temperature
26
24
22
20
18
16
14
12
10
Number of Life Cycles
9
8
7
6
5
4
3
2
1
0
1
30
59
88
117
146
175
204
233
262
291
320
349
Days
Temp °C
Mininum T °C Threshold
Life Cycle


Temperature and Number of Life Cycles
Temperature
Number of Life Cycles
Days
26
24
22
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
0
1
30
59
88
117
146
175
204
233
262
291
320
349
Temp °C
Mininum T °C Threshold
Temp + 1 °C
Life Cycle
Life Cycle Temp + 1 °C

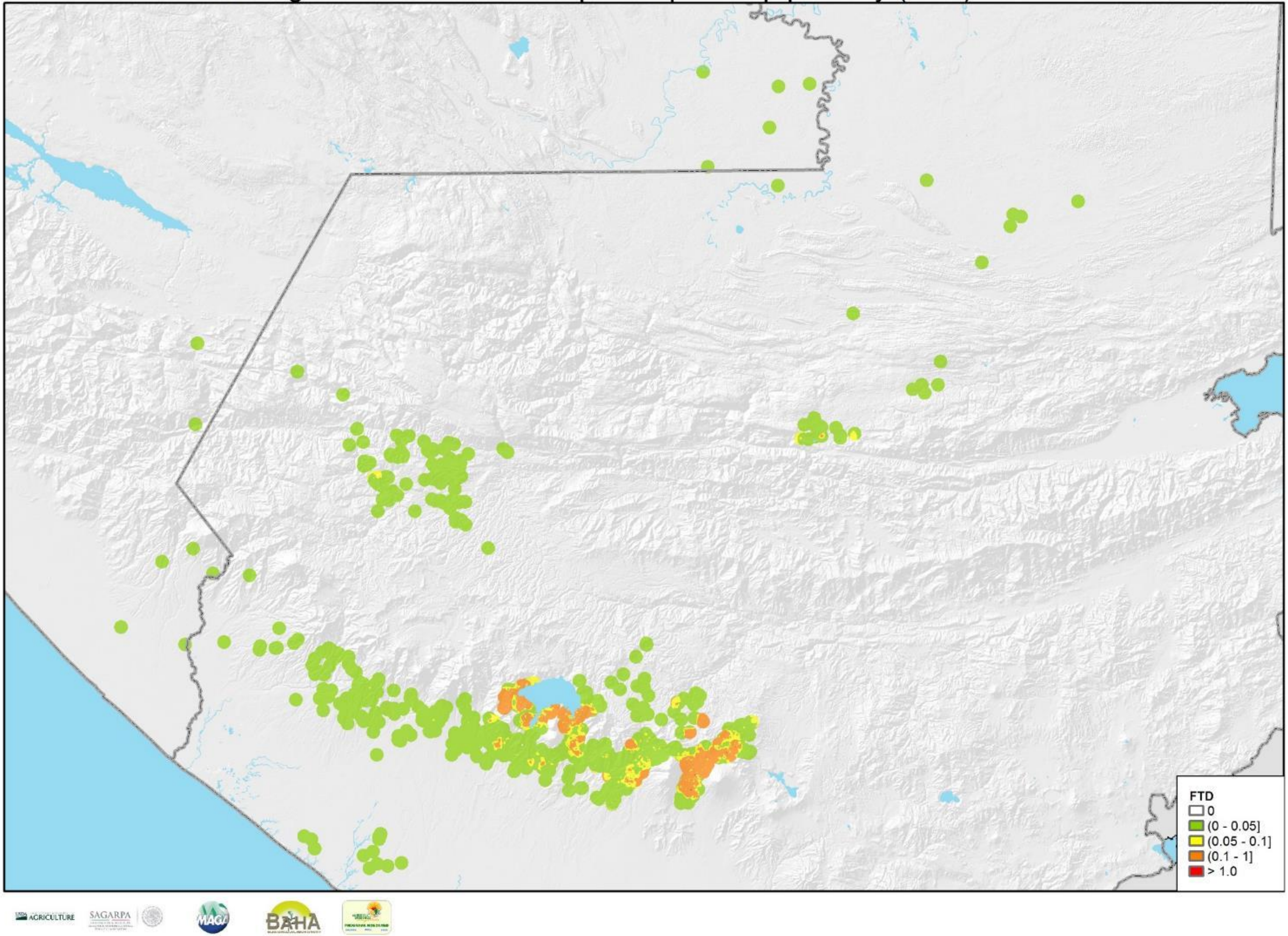


Number of Life Cycles and Number of Flies
Number of Life Cycles
Number of Flies
Days
9
8
7
6
5
4
3
2
1
0
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1
30
59
88
117
146
175
204
233
262
291
320
349
LifeCycle
Number of Flies

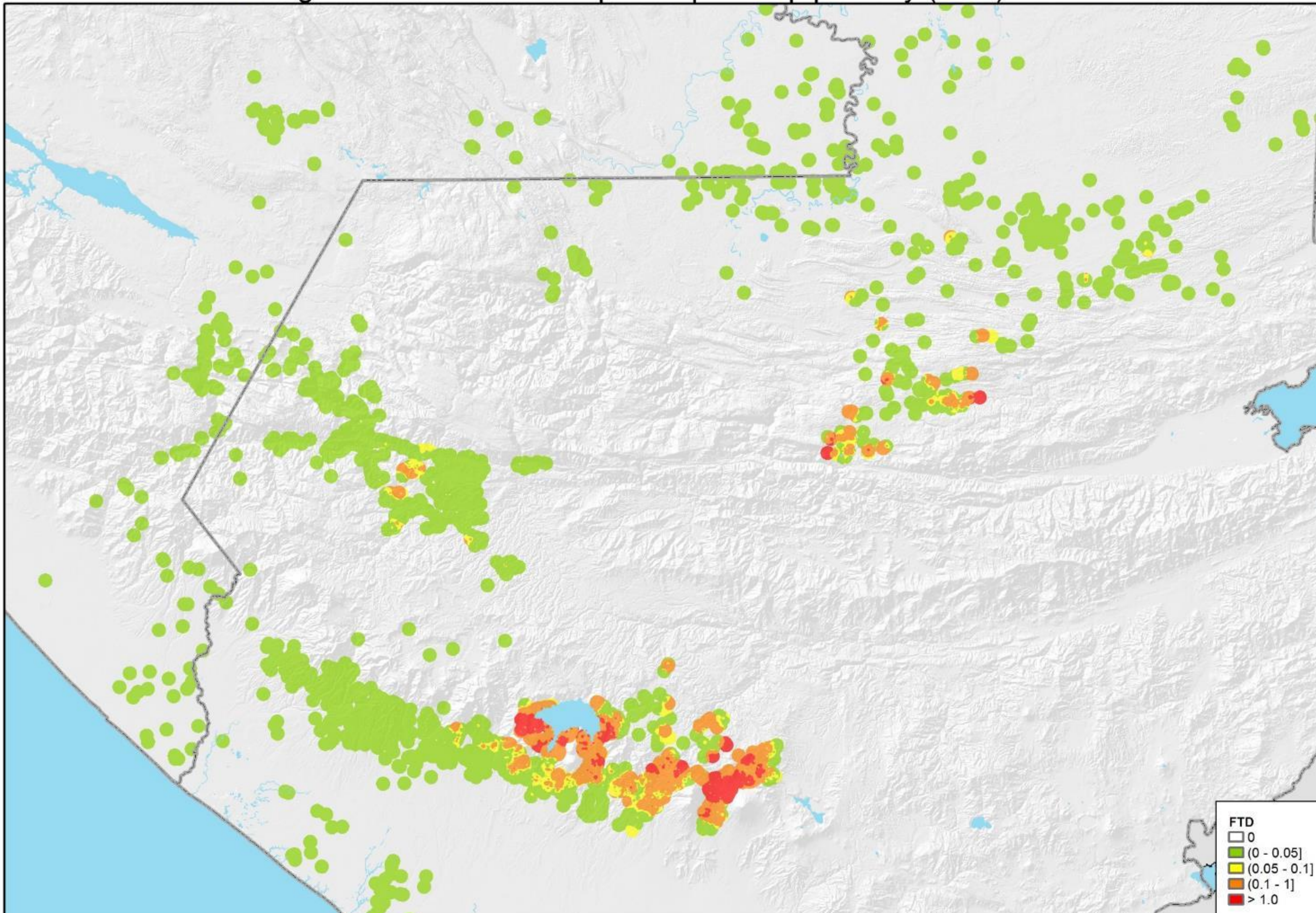


Number of Life Cycles and Number of Flies
Number of Life Cycles
Number of Flies
Days
0
1
2
3
4
5
6
7
8
9
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
4,000,000
4,500,000
1
30
59
88
117
146
175
204
233
262
291
320
349
LifeCycle
Life Cycle Temp + 1 °C
Number of Flies
Number of Flies Temp + 1 °C

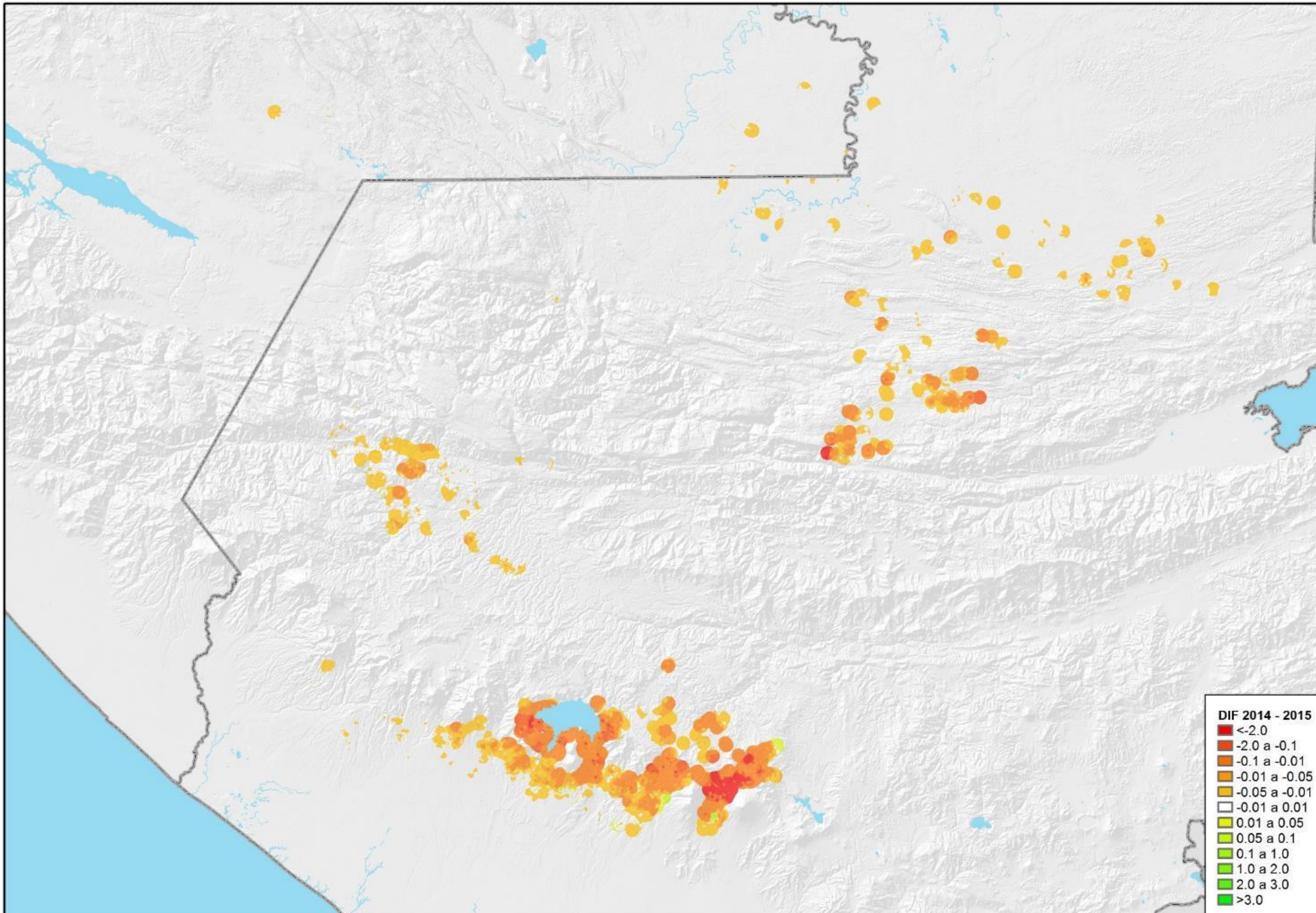
Average Number of Flies Captured per Trap per Day (FTD) in 2015



Average Number of Flies Captured per Trap per Day (FTD) in 2016



Difference in Average Number of Flies Captured per Trap per Day (FTD) between 2015 and 2016



DIF = FTD2014 - FTD2015

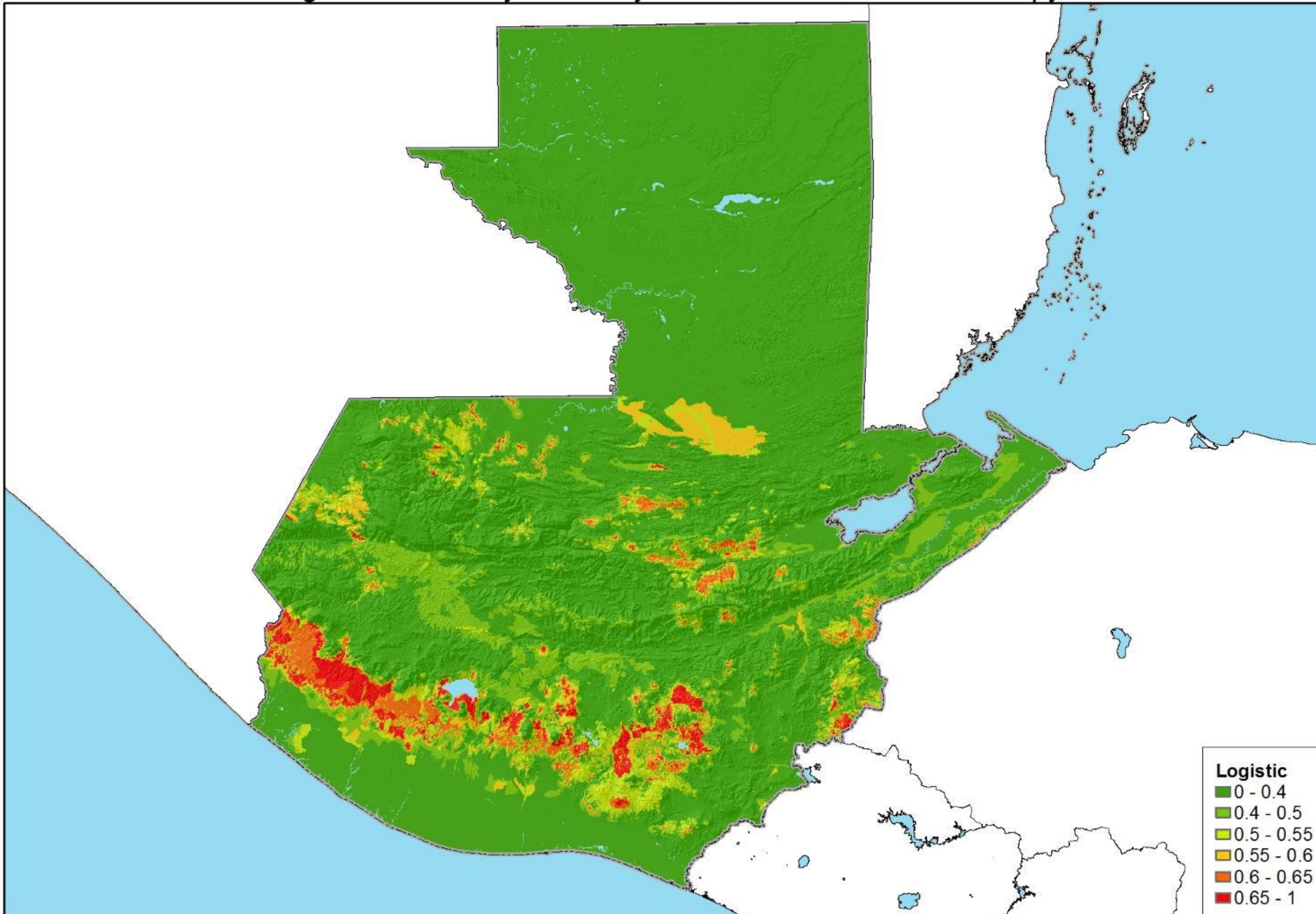
Negative values indicate a higher FTD in 2015
Positive values indicate a higher FTD in 2014

PREDICTION MODELS

Modelling Distribution of Medfly

- Dataset: 17,014 traps.
- Time Frame: 2004 – 2015
- Response Variable: Maximum number of flies captured in one trap in one week.
  - This number represent the maximum level of infestation in one site.
- Explanatory Variables:
  - Distance to Coffee → Close to main host
  - Temperature → Life cycle.
  - Soil Texture → Clay to sandy – Larvae/Pupae Stage
- MaxEnt
- Model with increased temperature

Logistic Probability of Medfly Occurrence: Maximun Entropy



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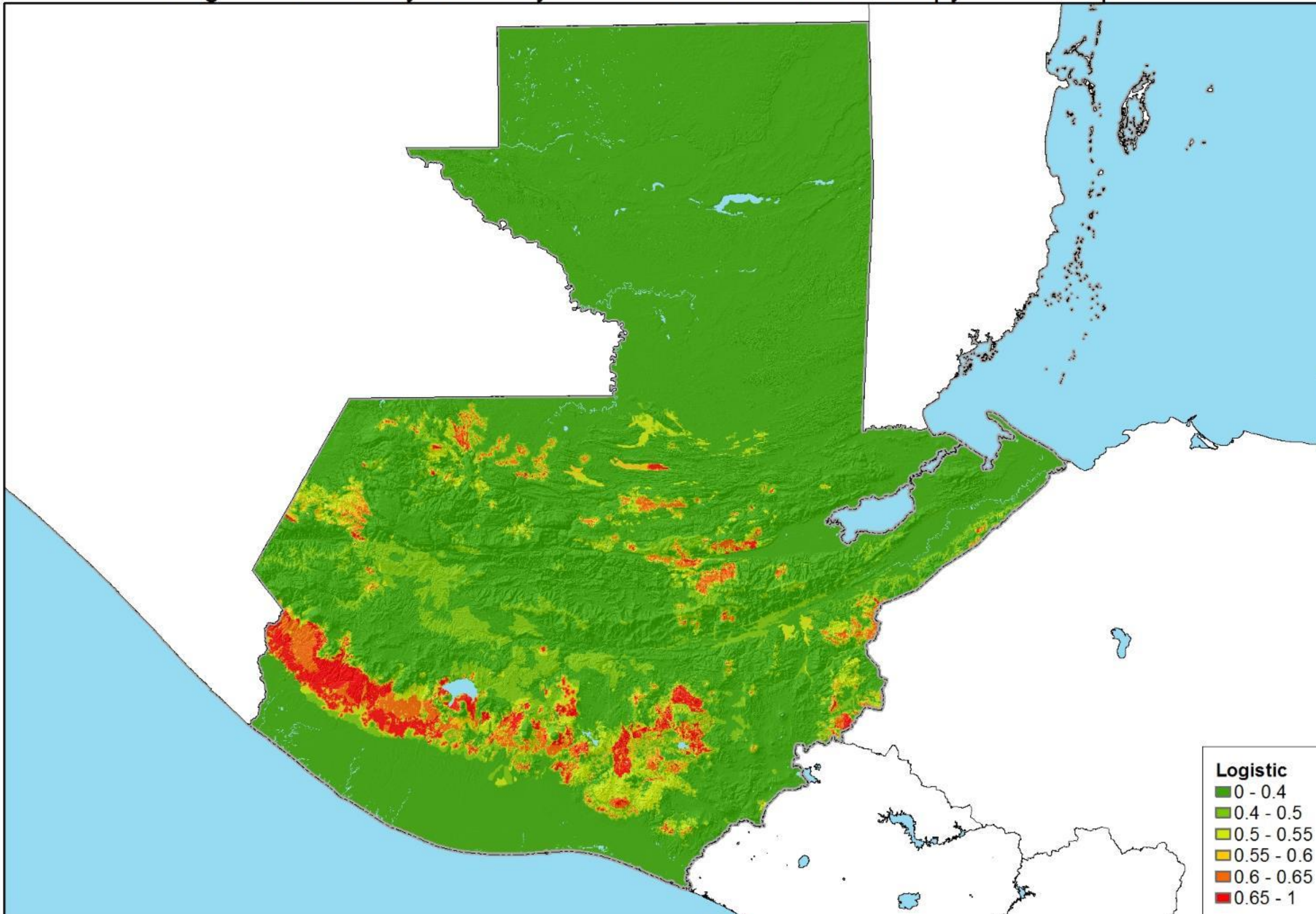
Logistic Probability of Medfly Occurrence: Maximun Entropy and Temp +1



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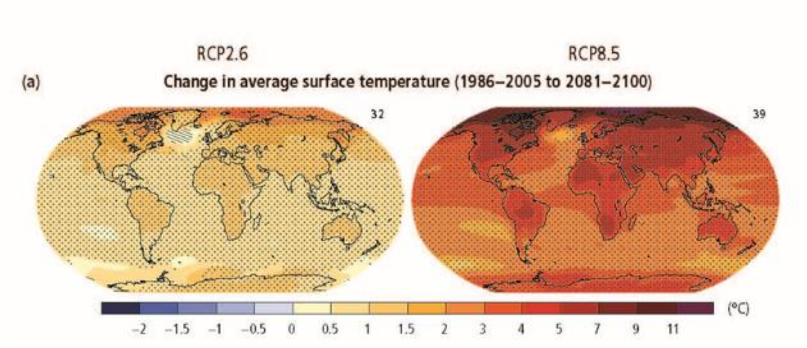
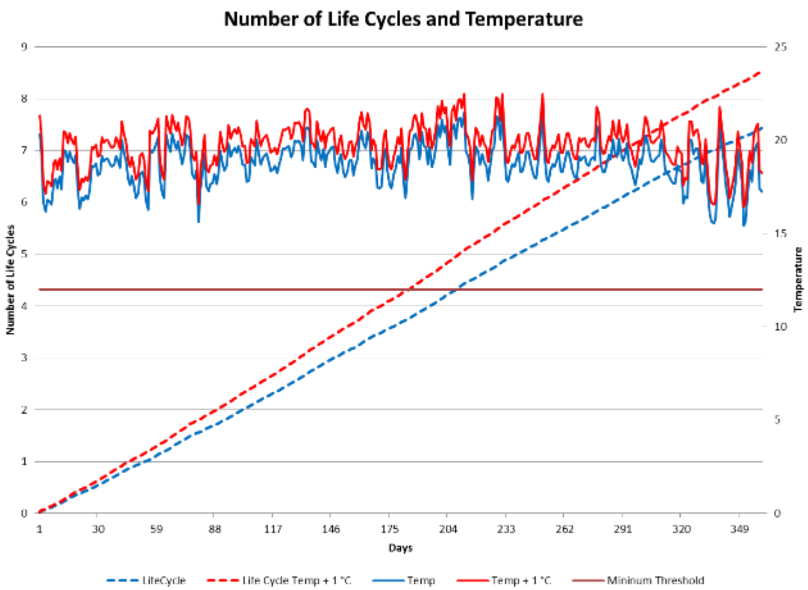
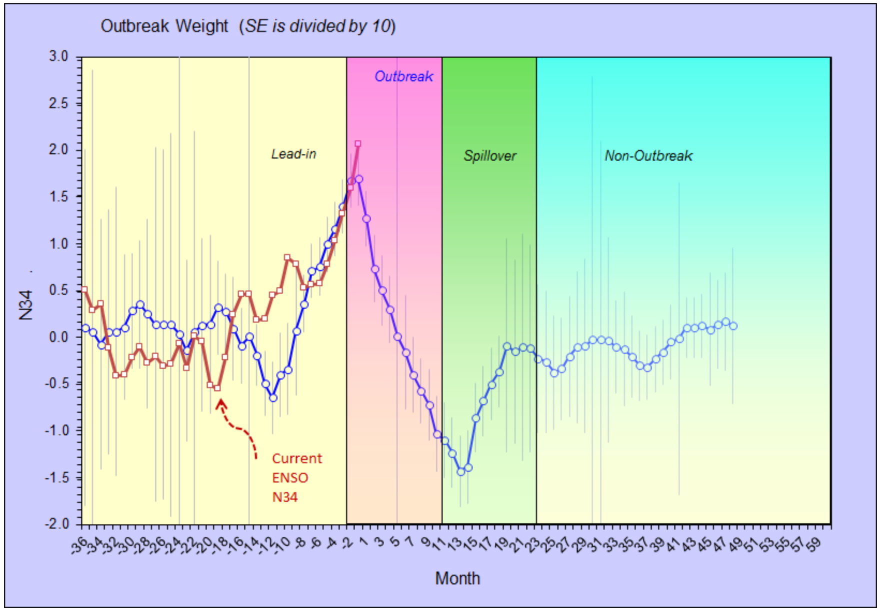
CONCLUSIONS



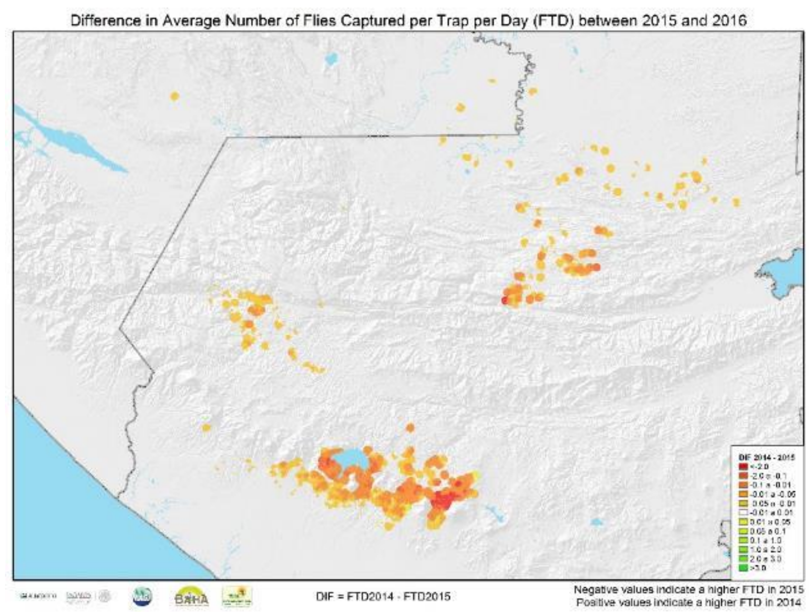
Climate Change Models ➔ Increase of Temperature



Increase of Temperature ➔ More Medfly Populations



El Niño Signal = Good predictor of Medfly in our region



Prediction = Early Warning for Pest Management

GIS BASED MODELLING TO PREDICT THE IMPACT OF CLIMATE CHANGE ON MEDFLY POPULATIONS IN CENTRAL AMERICA AND DECISION MAKING SUPPORT FOR PEST MANAGEMENT

Estuardo Lira [1], David Midgarden [2], Pedro Rendon [3], Nicole Parker [1]

Third FAO/IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques

Vienna, Austria, May 25, 2017

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