The use of larvicides to control *Culex spp.* mosquitoes in catch basins

Why a presentation on larvicides?

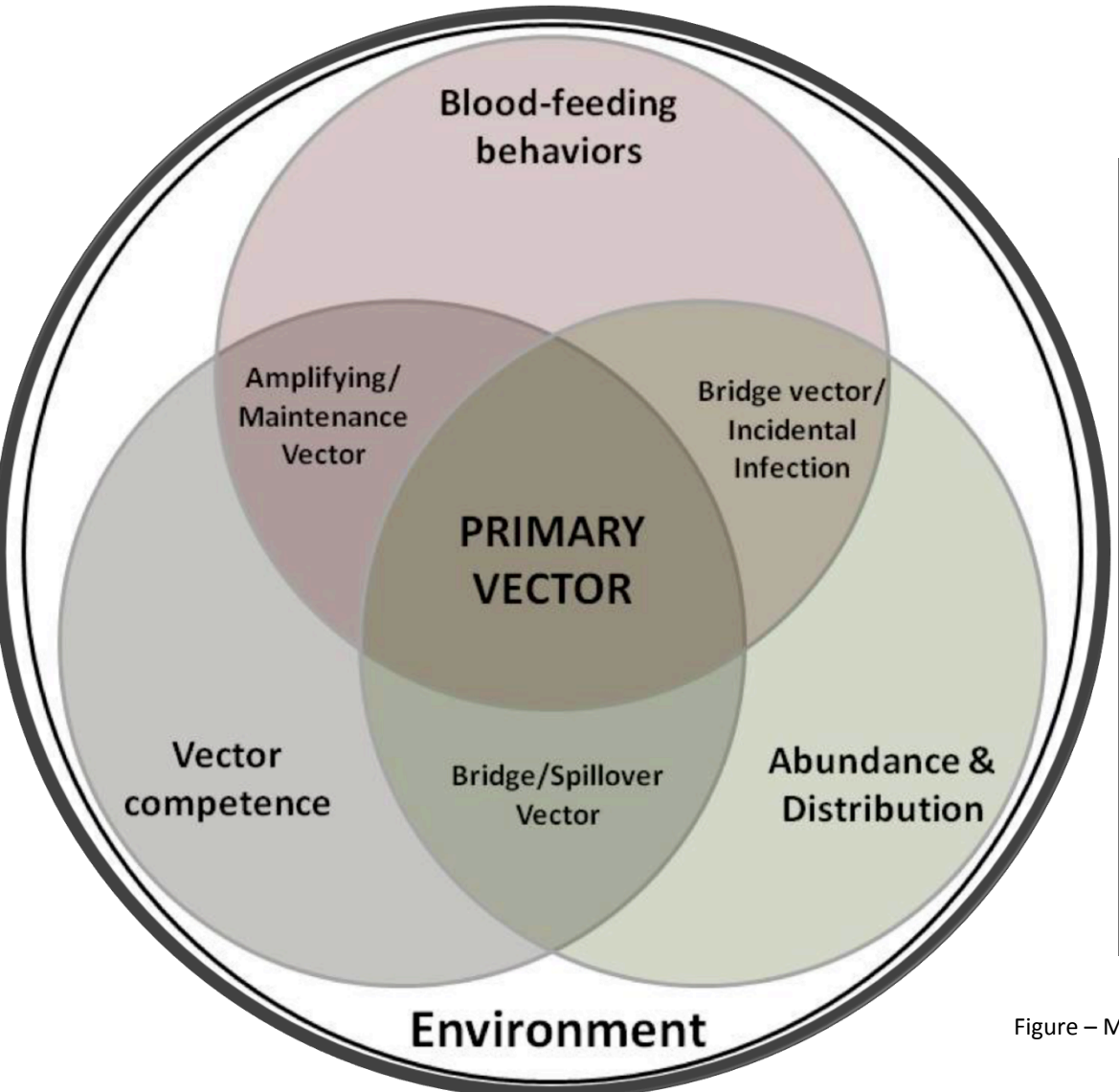
A pilot study related to my dissertation:

The amplification and transmission of West Nile virus in a two vector system: examining the role of secondary vectors

Chapter: Experimental perturbations of *Culex spp.* populations and the effect on WNV transmission

Qualification Exam 4/9/15

Defining primary and secondary vectors



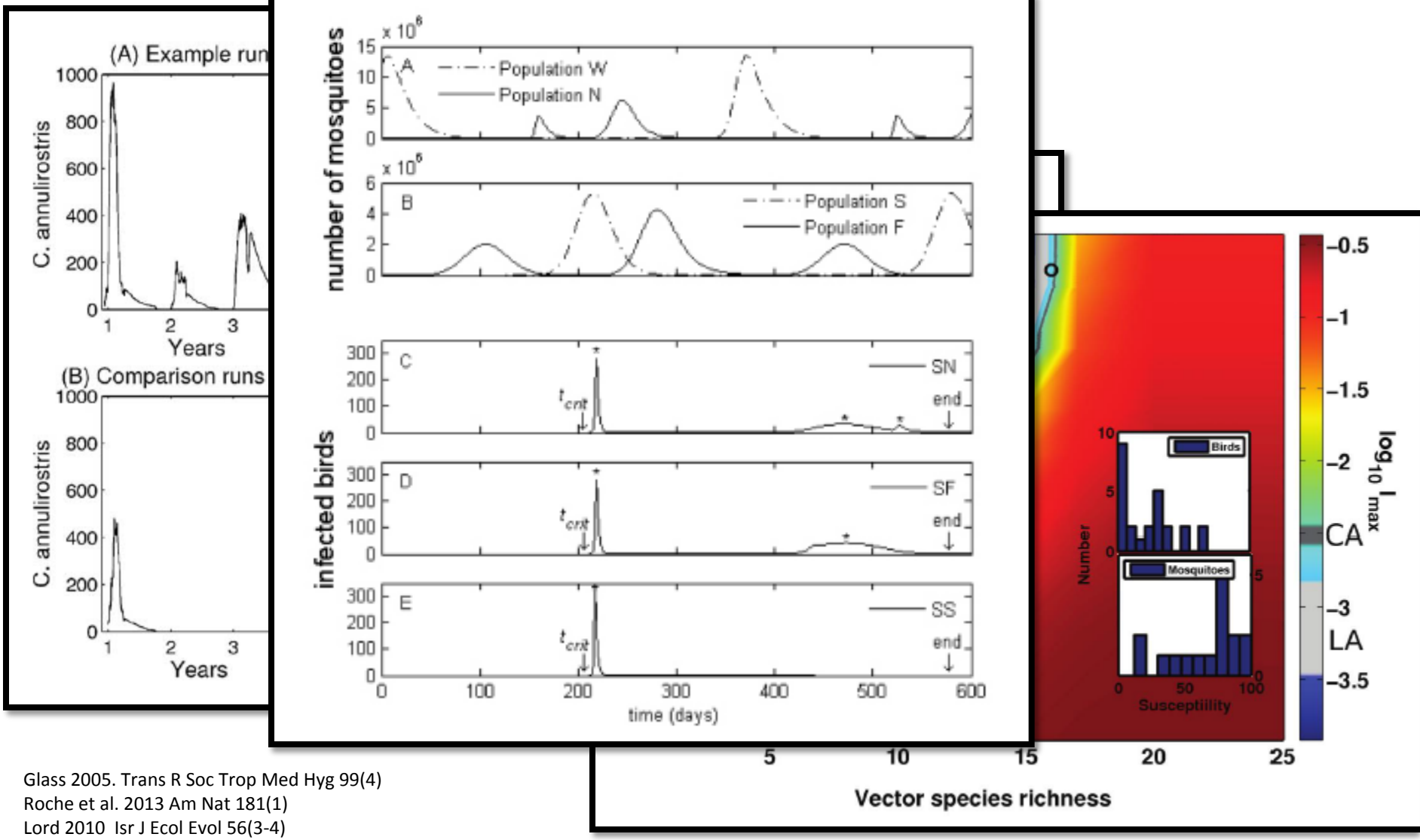
The distinction of a primary vector is often based on epidemiological rather than on ecological characteristics

<u>Public health perspective</u>:
Primary vectors are those that cause the most human morbidity and mortality

<u>Ecological perspective:</u>
Primary vectors are those most responsible for periods of peak transmission

Figure – McMillan PBEE Qualifying Exam Literature Review

Secondary vectors and vector-borne disease transmission



Glass 2005. Trans R Soc Trop Med Hyg 99(4)
Roche et al. 2013 Am Nat 181(1)
Lord 2010 Isr J Ecol Evol 56(3-4)

The primary and secondary vectors of West Nile Virus

The Big Dawgs

Members of the *Culex pipiens* species complex:

- *Culex pipiens pipiens*
- *Culex quinquefasciatus*
- Hybrids of the two sub-species and potentially the form *molestus*

The Other Guys

Native *Culex* species and perhaps a few non-native *Aedes*:

- *Culex tarsalis*
- *Culex restuans*
- *Culex nigripalpus*
- *Aedes albopictus*
- *Ochlerotatus japonicus*

Moving beyond models: experiments

We know…

- ***Culex spp.*** **commonly breed in road-side catch basins**
- ***Cx. restuans*** **is active in spring/early summer**
- ***Cx. quinquefasciatus*** **dominates field collections during summer months**
- **Difficult to identify *Cx. restuans* and *Cx. quinquefasciatus* from a gravid trap**

Thinking experimentally

- Use catch basins as a unit of intervention
- Apply larvicides during time periods that coincide with each vector species period of greatest activity
- Monitor the effect of the insecticide application at the catch basin level
- Monitor WNV infection in mosquitoes using gravid traps
- Individually vial any *Culex* spp. we cannot identify
- Monitor WNV infection in wild birds

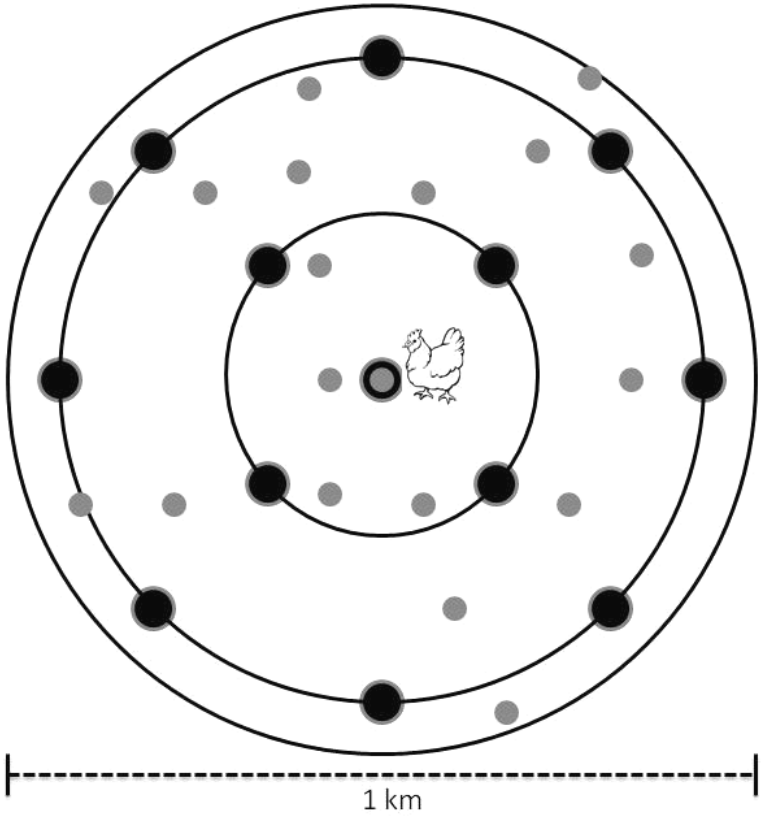
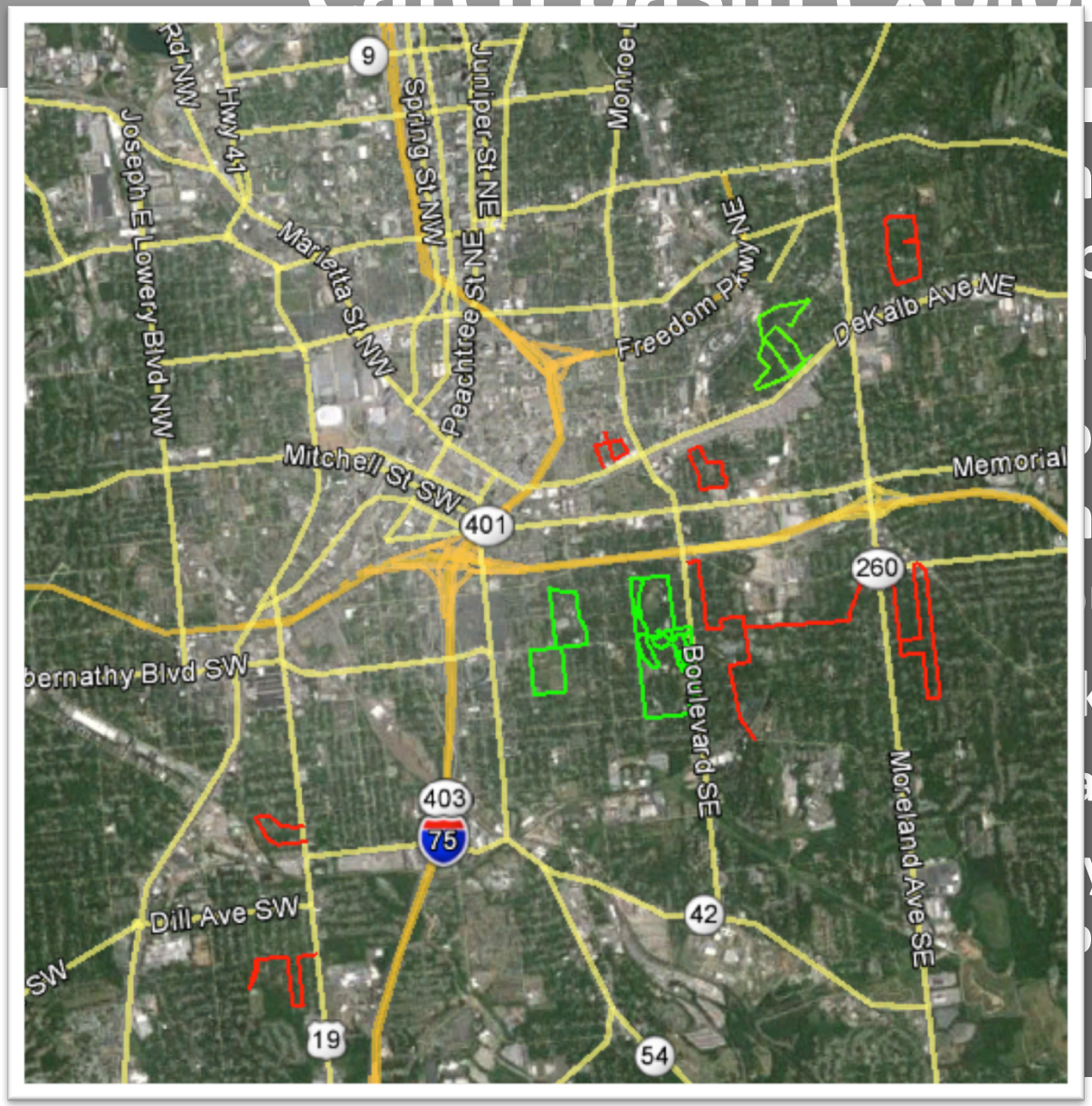


Figure – McMillan PBEE Qualifying Exam Proposal

SUMMER 2015 PILOT STUDY

Catch basin explorations



- …ta, where are *Culex* …breeding in catch …s?
- …red public parks and …borhoods …unding parks
- …ked basins for:
  - …ater
  - …y presence of *Culex* …squitoes

Paired Experimental Design

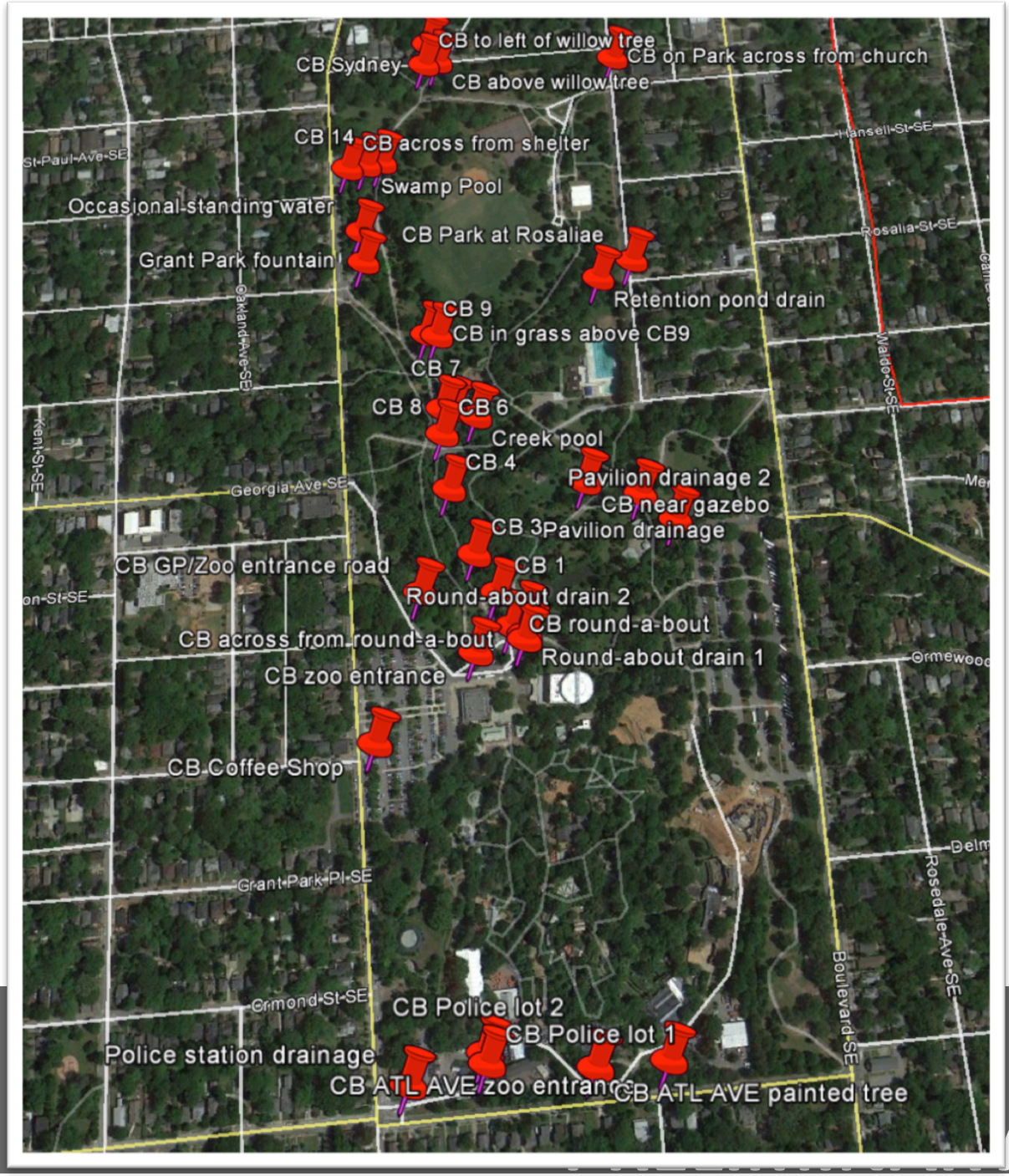
- Sampled two parks (w/ 1 mile of each other)
  - Grant Park (treatment park) – 7 catch basins
  - Phoenix Park (control park) – 10 catch basins
- Catch basin surveillance:
  - 3 dips for egg, larvae, and pupal collections
  - 5 minutes aspiration for adult mosquito collections
  - Measurement of basin water depth
  - Water quality sample for ammonia, nitrate, and phosphate measurements
  - All IV larvae, pupae, and adult identified to species

Larvicide applications

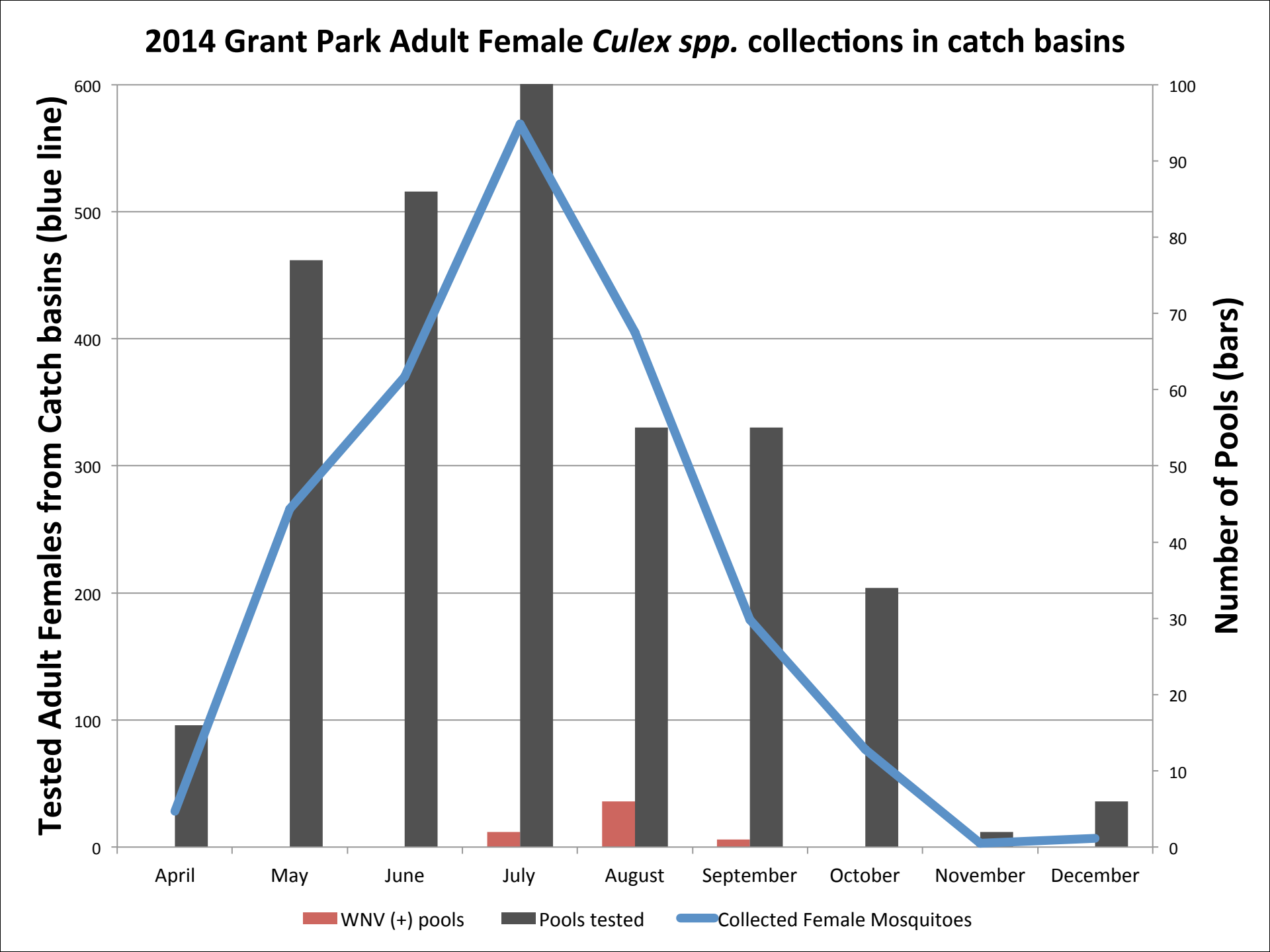
- 36 permanent and semi-permanent water holding containers in Grant Park
- Treat weekly with Summit Chemical's Mosquito Bits and Mosquito Dunks
  - *Bascillus thurenginsis* larvicide
  - Bits (10.96% Bti) – fast acting
  - Dunks (2.96% Bti) – slow release
  - Approx. 3 tablespoons of bits and up to 2 dunks applied per week
- Application period: July 16th – September 9th 2015

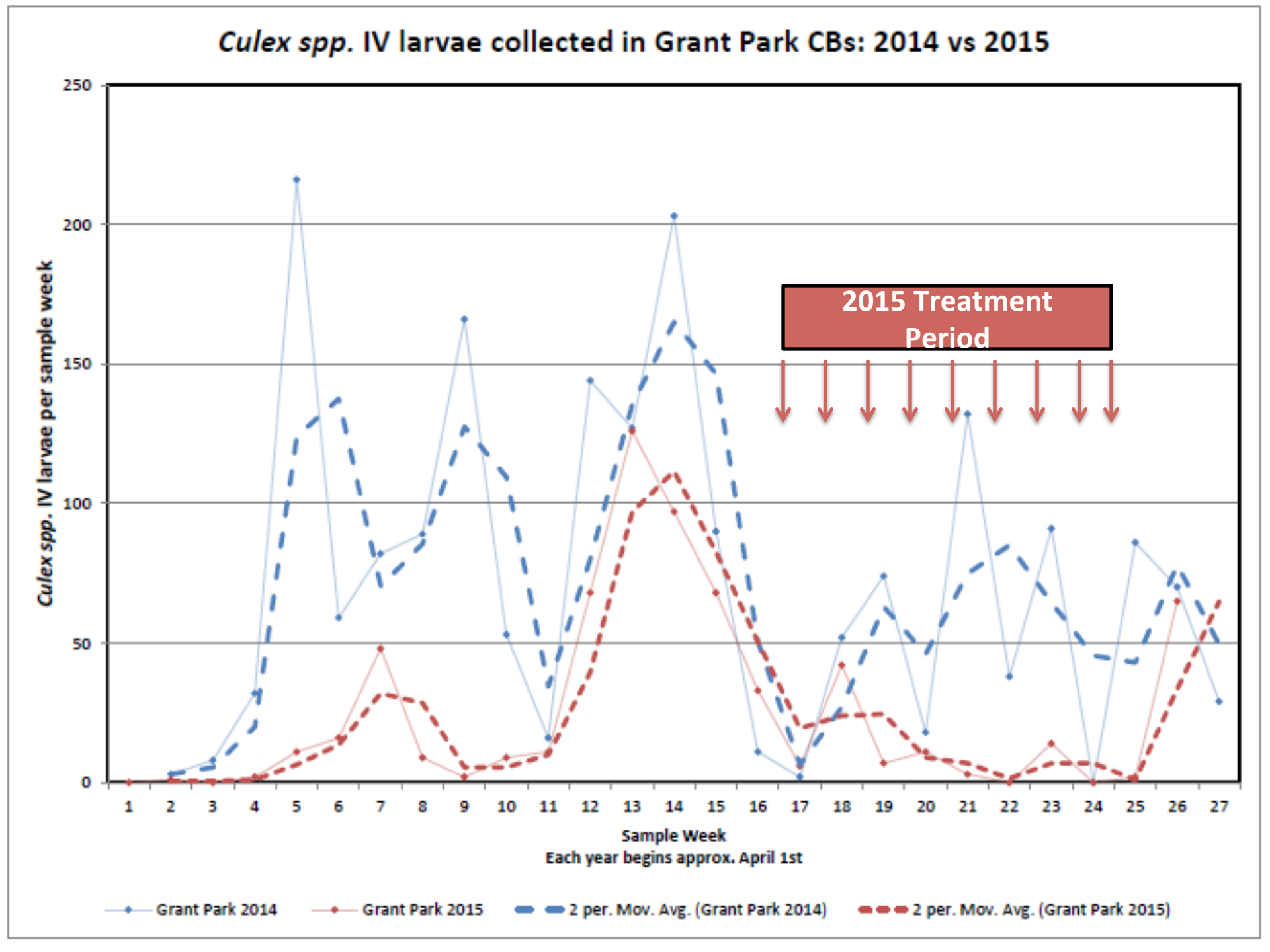
WNV Surveillance

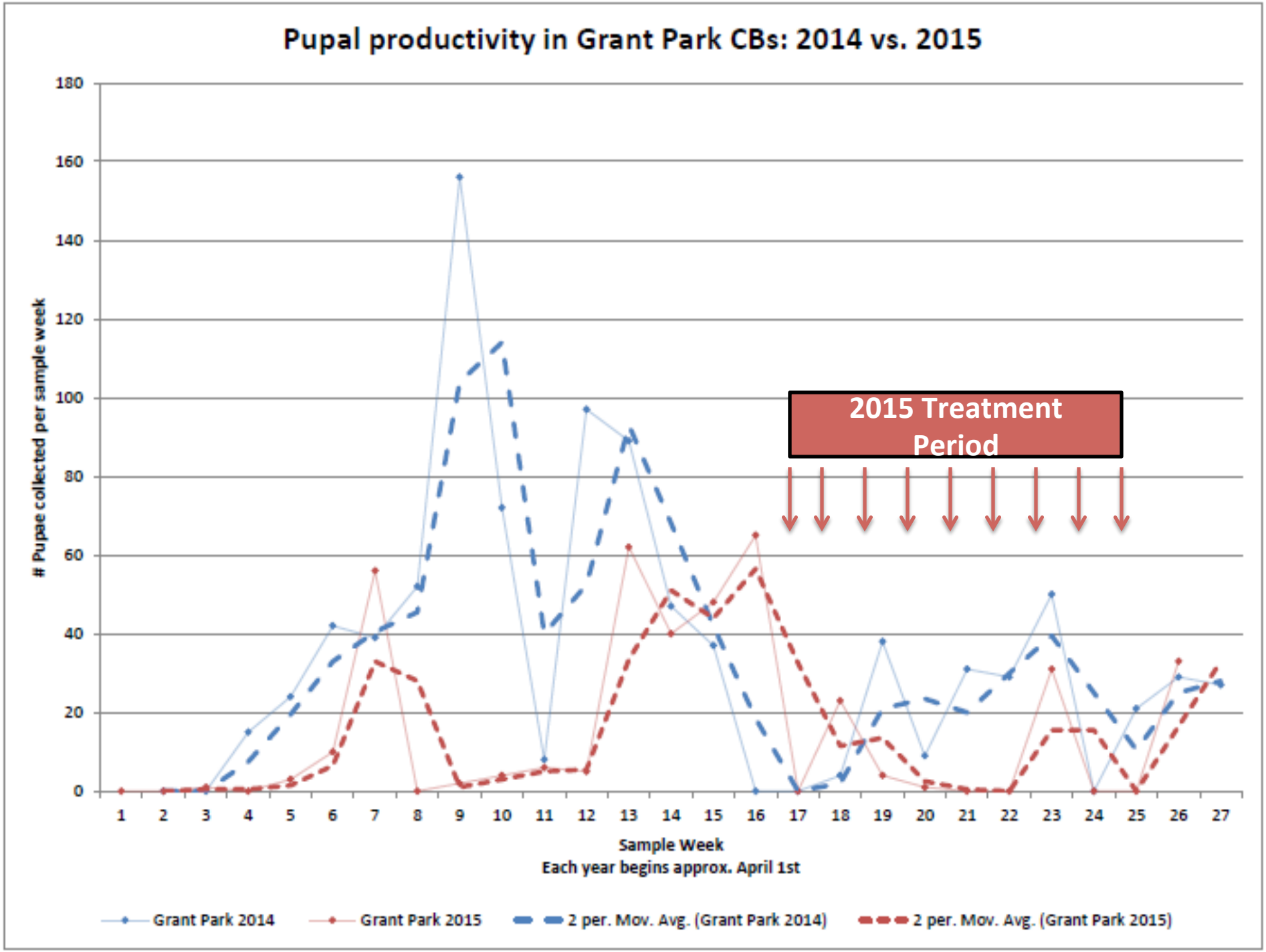
- Gravid trap surveillance
  - Weekly in both parks
- Light trap surveillance in sewers (Grant Park only)
  - Weather permitting
- All adult female mosquitoes pooled by site, collection method, date, and species
  - Unidentified *Culex spp.* pooled individually
  - Bloodfed mosquitoes pooled individually
- Mist netting for wild birds (Grant Park only)
  - Individuals age, sexed, banded
  - Blood sample taken from jugular vein


CB to left of willow tree
CB on Park across from church
CB Sydney
CB above willow tree
CB 14
CB across from shelter
Swamp Pool
Occasional standing water
CB Park at Rosaliae
Grant Park fountain
Retention pond drain
CB 9
CB in grass above CB9
CB 7
CB 8
CB 6
Creek pool
CB 4
Pavilion drainage 2
CB near gazebo
CB 3
Pavilion drainage
CB GP/Zoo entrance road
CB 1
Round-about drain 2
CB round-a-bout
CB across from round-a-bout
Round-about drain 1
CB zoo entrance
CB Coffee Shop
CB Police lot 2
CB Police lot 1
Police station drainage
CB ATL AVE zoo entrance
CB ATL AVE painted tree
St Paul Ave SE
Hansell St SE
Rosalia St SE
Oakland Ave SE
Georgia Ave SE
Grant Park Pl SE
Ormond St SE
Rosedale Ave SE
Boulevard SE

Y RESULTS

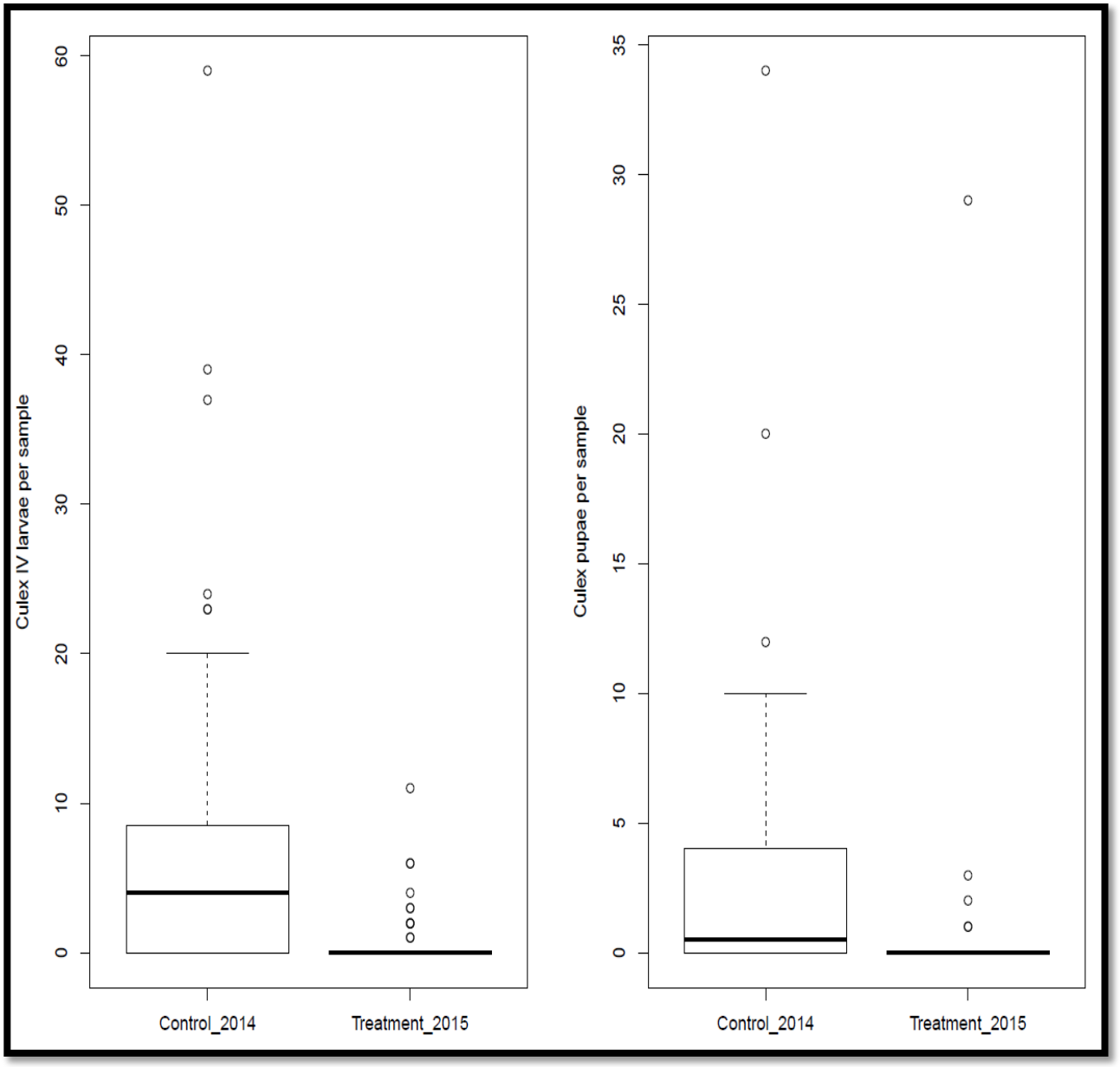

2014 Grant Park Adult Female *Culex spp.* collections in catch basins
Tested Adult Females from Catch basins (blue line)
Number of Pools (bars)
600
500
400
300
200
100
0
100
90
80
70
60
50
40
30
20
10
0
April
May
June
July
August
September
October
November
December
WNV (+) pools
Pools tested
Collected Female Mosquitoes


Culex spp. IV larvae collected in Grant Park CBs: 2014 vs 2015
Culex spp. IV larvae per sample week
250
200
150
100
50
0
2015 Treatment Period
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Sample Week
Each year begins approx. April 1st
Grant Park 2014
Grant Park 2015
2 per. Mov. Avg. (Grant Park 2014)
2 per. Mov. Avg. (Grant Park 2015)


Pupal productivity in Grant Park CBs: 2014 vs. 2015
Pupae collected per sample week
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Sample Week
Each year begins approx. April 1st
2015 Treatment Period
Grant Park 2014
Grant Park 2015
2 per. Mov. Avg. (Grant Park 2014)
2 per. Mov. Avg. (Grant Park 2015)

***Culex spp.* larvae**

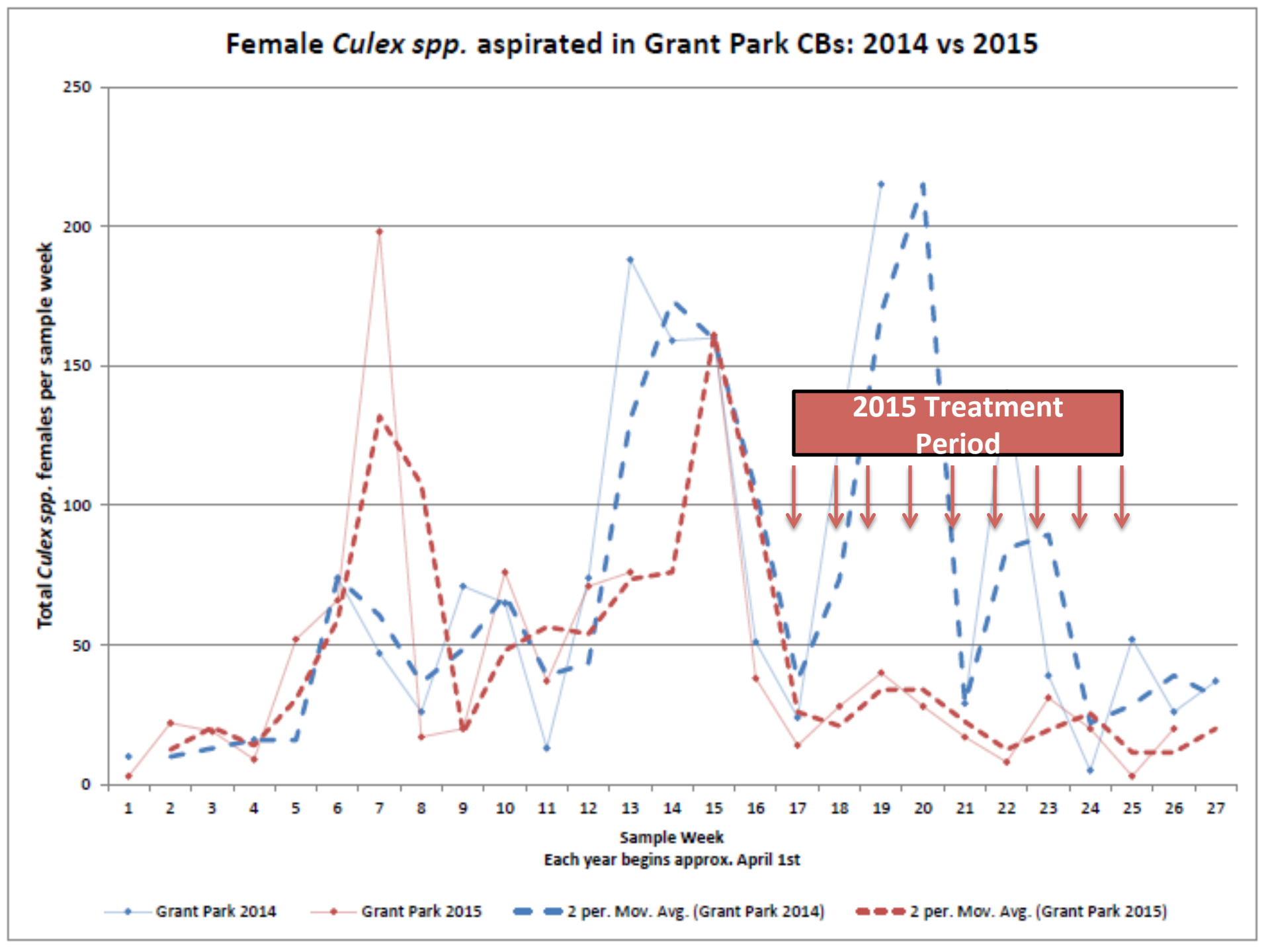
***Culex spp.* pupae**

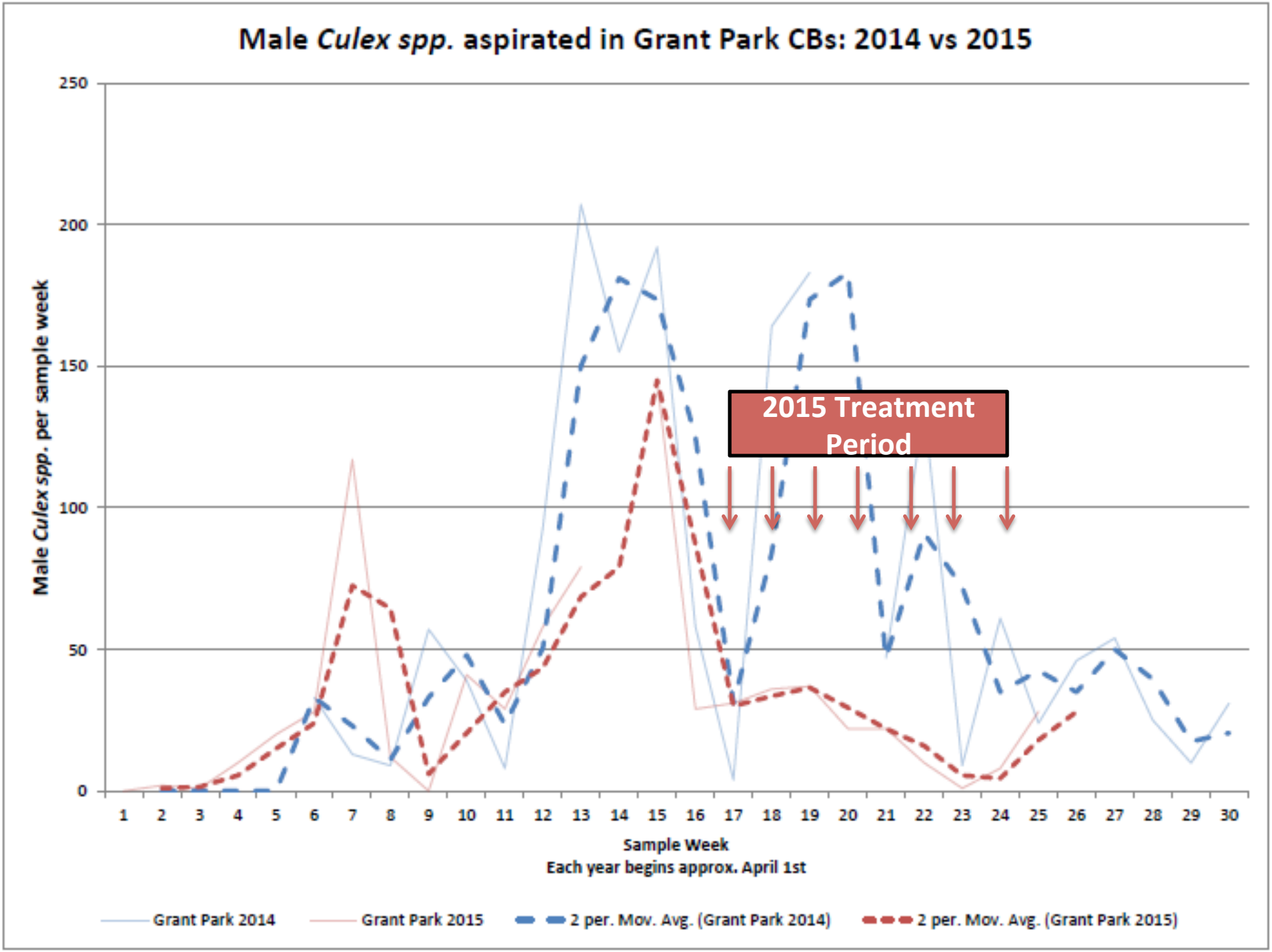


Mann-Whitney U-tests (for non-normal data):

Larvae – significant difference in collections between 2014 and 2015 ($p<0.001$)

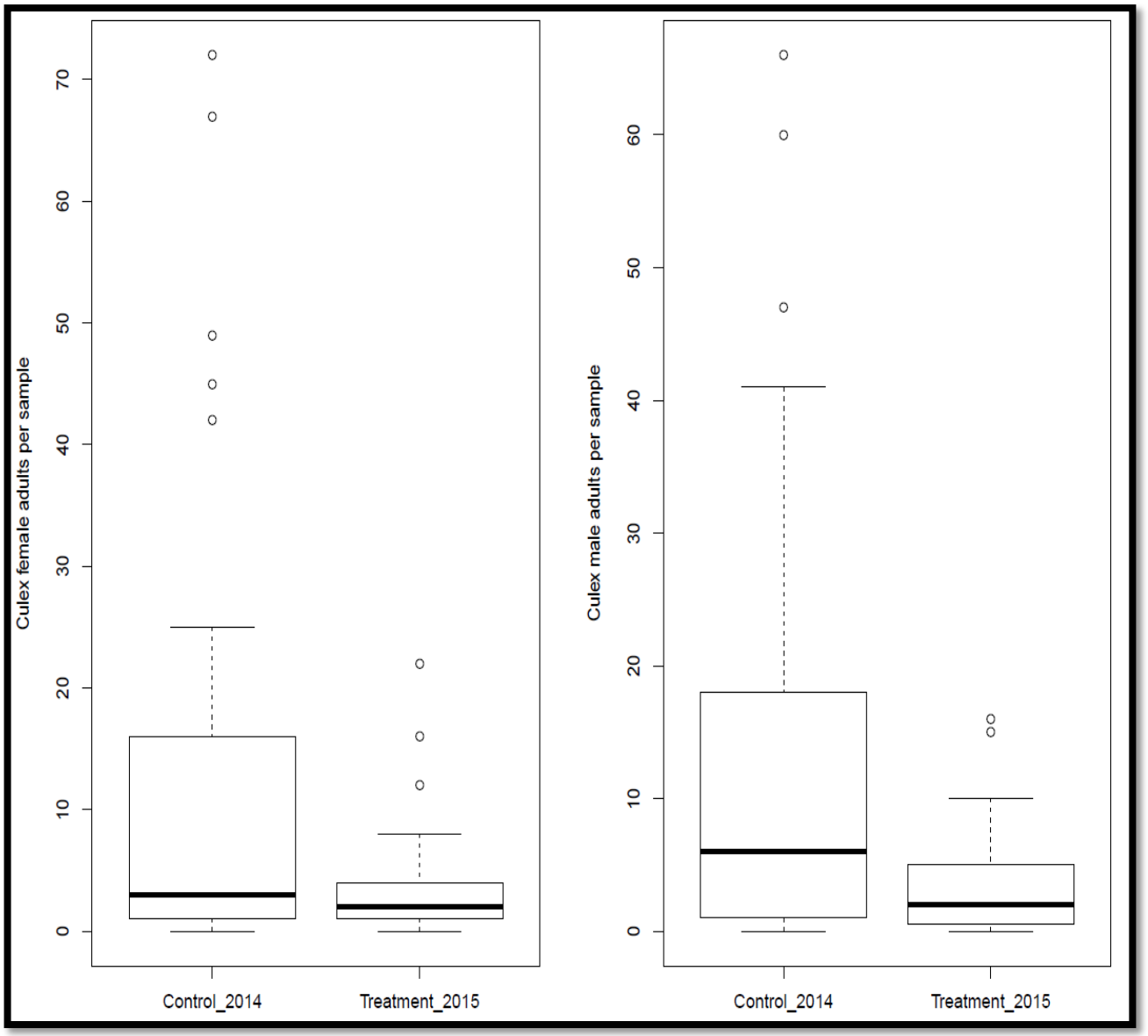
Pupae – significant difference in collections between 2014 and 2015 ($p<0.001$)


Female Culex spp. aspirated in Grant Park CBs: 2014 vs 2015
Total Culex spp. females per sample week
250
200
150
100
50
0
2015 Treatment Period
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Sample Week
Each year begins approx. April 1st
Grant Park 2014
Grant Park 2015
2 per. Mov. Avg. (Grant Park 2014)
2 per. Mov. Avg. (Grant Park 2015)


Male Culex spp. aspirated in Grant Park CBs: 2014 vs 2015
250
200
150
100
50
0
Male Culex spp. per sample week
2015 Treatment Period
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Sample Week
Each year begins approx. April 1st
Grant Park 2014
Grant Park 2015
2 per. Mov. Avg. (Grant Park 2014)
2 per. Mov. Avg. (Grant Park 2015)

***Culex spp.* females**

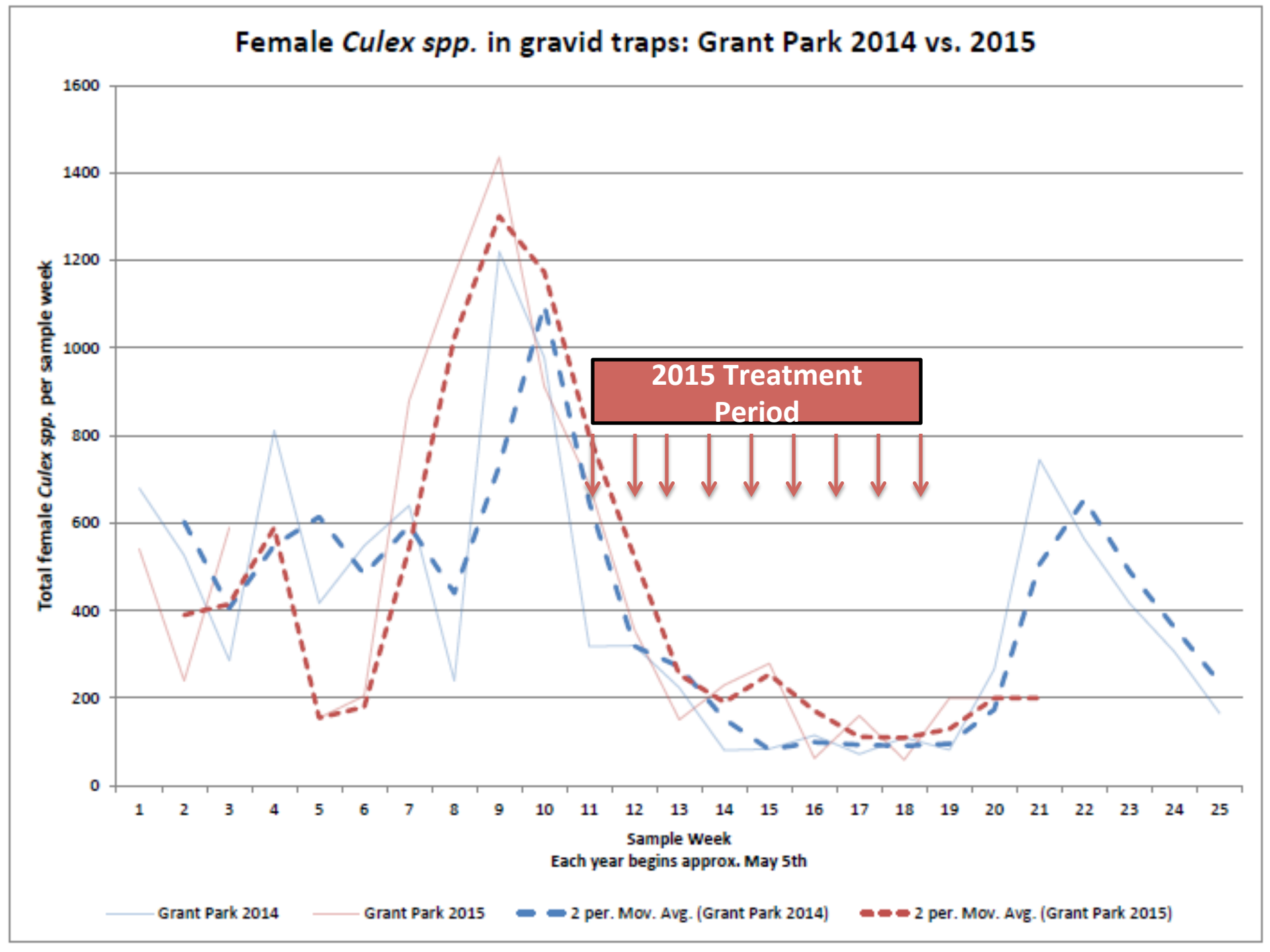
***Culex spp.* males**

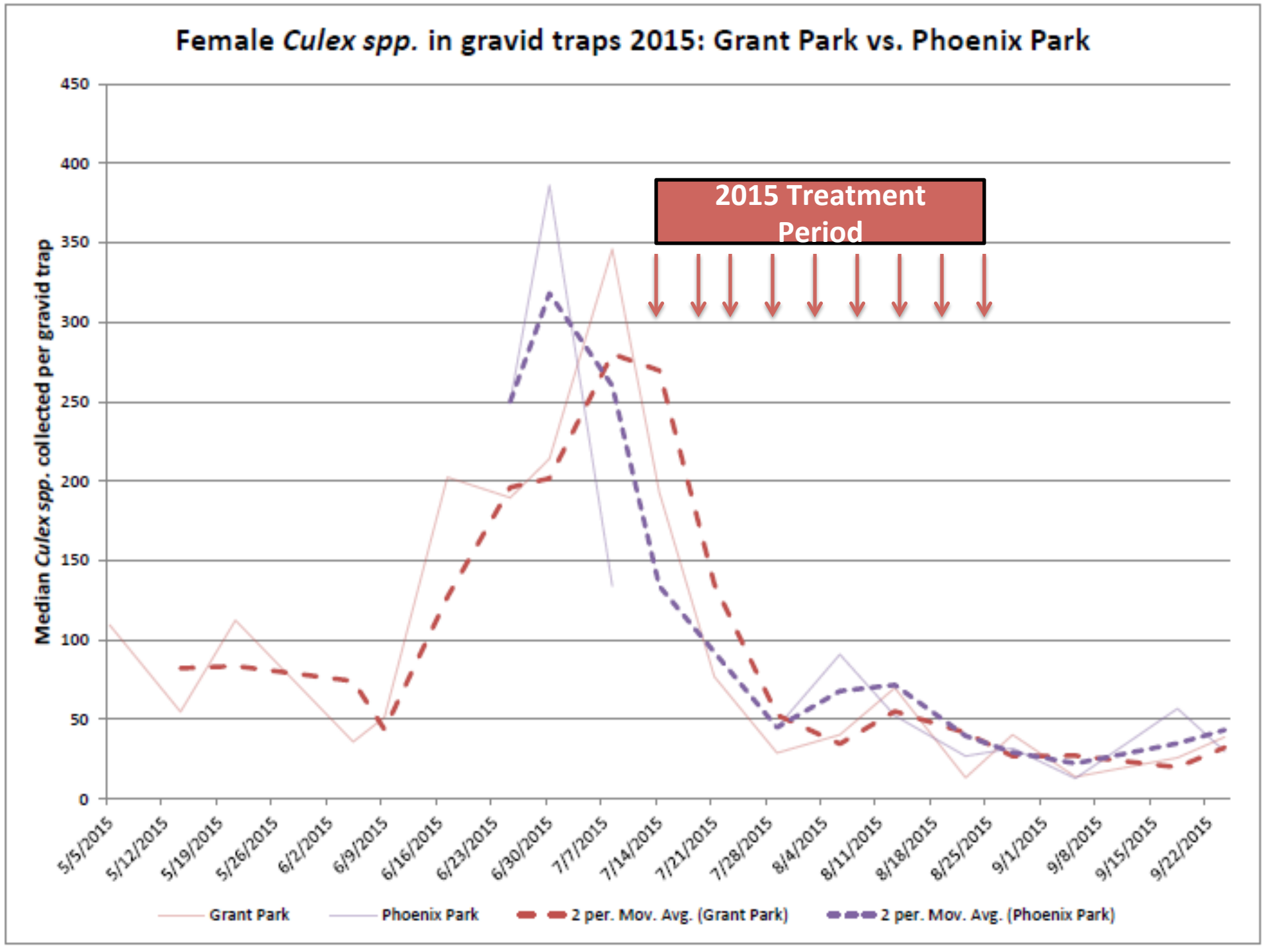


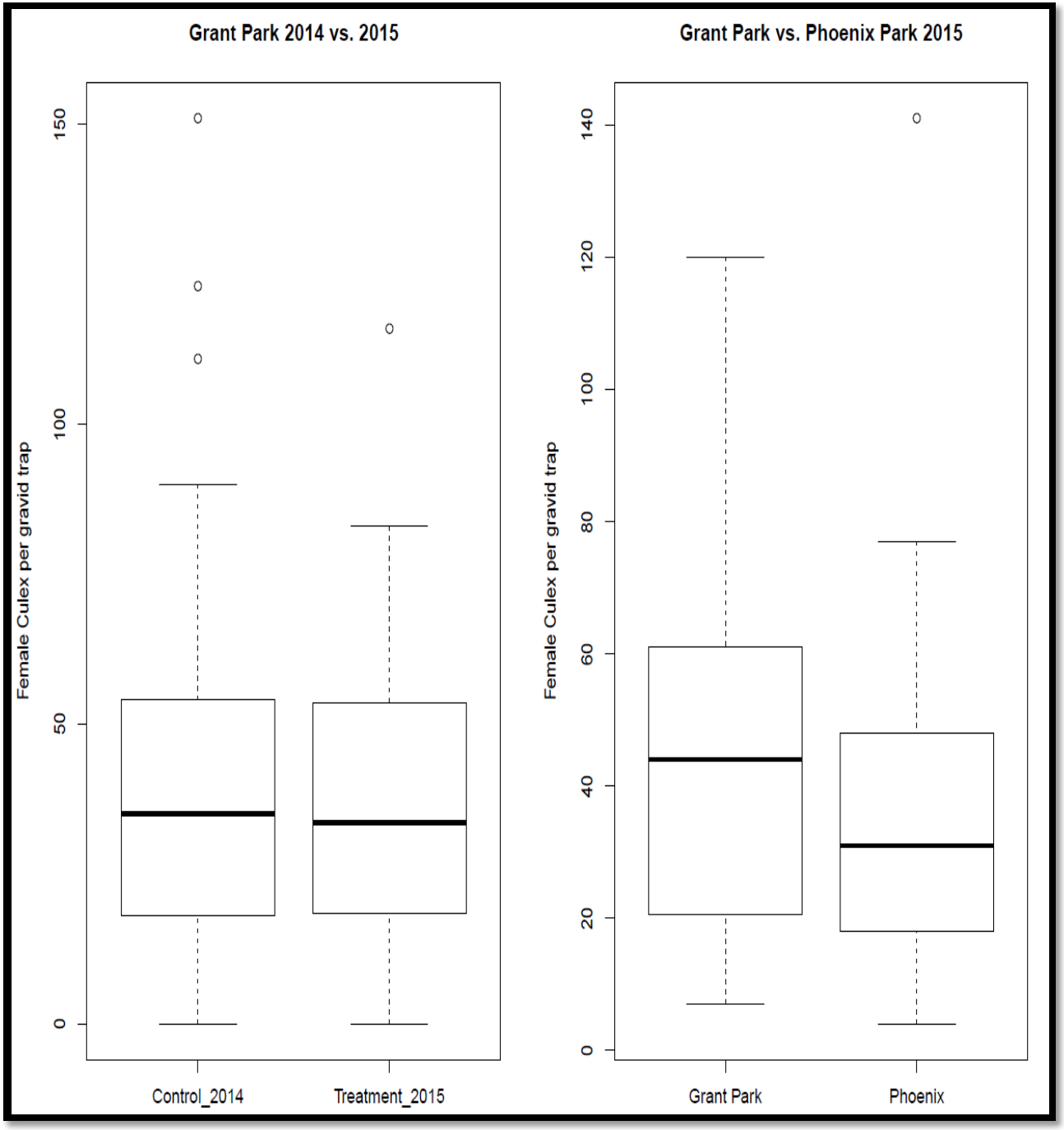
Mann-Whitney U-tests (for non-normal data):

Female adults – non-significant difference in collections between 2014 and 2015 ($p>0.05$)

Male adults – significant difference in collections between 2014 and 2015 ($p<0.01$)


Female Culex spp. in gravid traps: Grant Park 2014 vs. 2015
Total female Culex spp. per sample week
1600
1400
1200
1000
800
600
400
200
0
2015 Treatment Period
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Sample Week
Each year begins approx. May 5th
Grant Park 2014
Grant Park 2015
2 per. Mov. Avg. (Grant Park 2014)
2 per. Mov. Avg. (Grant Park 2015)


Female Culex spp. in gravid traps 2015: Grant Park vs. Phoenix Park
Median Culex spp. collected per gravid trap
450
400
350
300
250
200
150
100
50
0
2015 Treatment Period
5/5/2015
5/12/2015
5/19/2015
5/26/2015
6/2/2015
6/9/2015
6/16/2015
6/23/2015
6/30/2015
7/7/2015
7/14/2015
7/21/2015
7/28/2015
8/4/2015
8/11/2015
8/18/2015
8/25/2015
9/1/2015
9/8/2015
9/15/2015
9/22/2015
Grant Park
Phoenix Park
2 per. Mov. Avg. (Grant Park)
2 per. Mov. Avg. (Phoenix Park)



Mann-Whitney U-tests (for non-normal data):

Grant Park: non-significant difference in collections between 2014 and 2015 ($p>0.8$)

Summer 2015 paired EXP: non-significant difference in collections between Grant Park and Phoenix ($p>0.25$)

Bird data Summer 2015

Species	# Blood Samples
American Robin	18
Brown Thrasher	6
Brown-headed Cowbird	1
Carolina Wren	6
Common Grackle	2
Downy Woodpecker	1
Eastern Bluebird	5
Eastern Phoebe	1
Eastern Towhee	3
Gray Catbird	10
Gray-cheeked Thrush	1
Northern Cardinal	6
Northern Mockingbird	5
Red-eyed Vireo	1
Song Sparrow	2
Swainson's Thrush	5
Yellow-breasted Chat	1

- Blood samples from Grant Park ONLY
- 17 species sampled
- 76 total samples (as of 10/8/15)
- Success Rate: 63.7%
- 25 individuals bleeding not attempted

The data to come…

- WNV infection data for:
  - All mosquito pools
  - All avian samples
- Mosquito species identification for:
  - Sub-sample of individual *Culex spp.* pools
- Blood source identification for blood feds
  - Species identification for *Culex spp.* blood feds
- Models that control for:
  - Weather (temperature/ precipitation)
  - Time-lags
    - Insecticide application
    - Extreme weather events

Future Directions and Questions

Given the research question, are larvicides the most appropriate control tool?

- At the catch basins level: residual spraying vs. larvicide vs. BOTH

How large is the above ground *Culex spp.* populations?

- Why are 2014 and 2015 gravid trap collections almost identical?

How large is the underground *Culex spp.* population?

- Are above ground and catch basin interventions impacting below ground populations?

Acknowledgments

- Advisor and mentor: Gonzalo Vazquez Prokopec
- Qualification Committee members: Tom Gillespie, Nicole Gerardo, Lance Waller, Levi Moran
- Uriel Kitron, Daniel Mead and all undergraduate, graduate, post graduate members and collaborators of the Prokopec/Kitron Lab
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THANK YOU & QUESTIONS?