West Nile Virus

Trends in Human and Mosquito Populations in Fairfax County, Virginia

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Fairfax County Health Department
VMCA Annual Meeting
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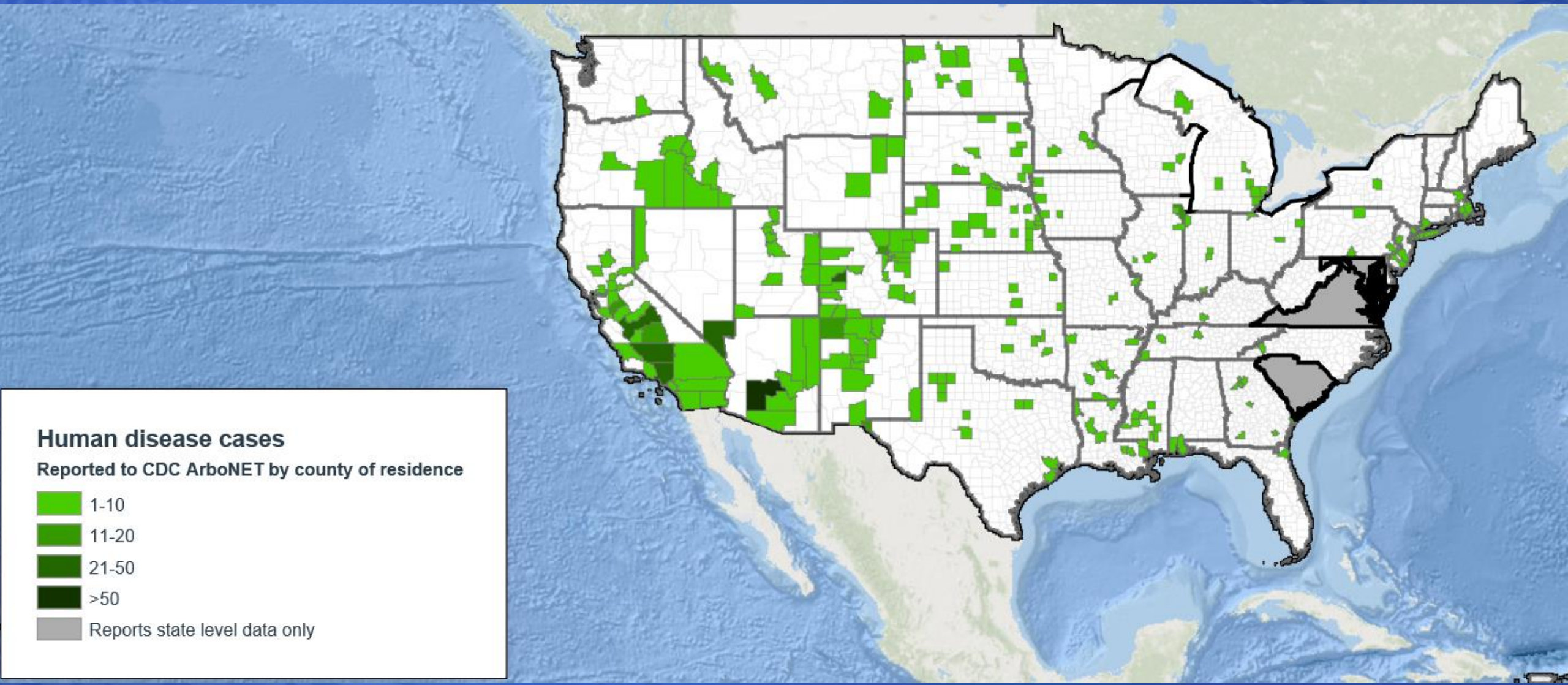
Linking Mosquito and Human WNV Data

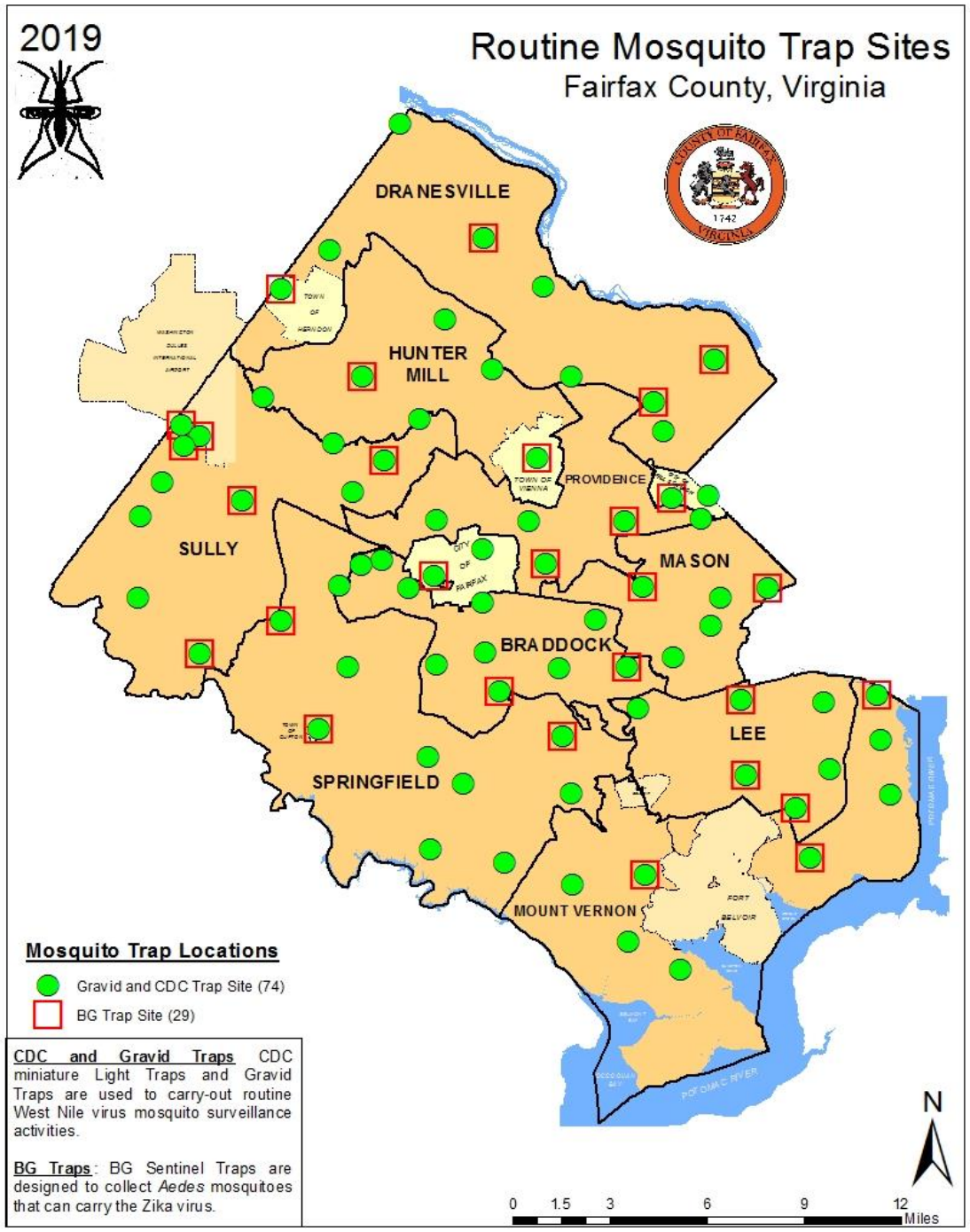
- "Holy Grail" of WNV mosquito surveillance
- The challenges
  - Diagnosed case numbers are low in our area
    small difference between "good" and "bad" years
    - 80% asymptomatic
    - 20% with symptoms (mostly undiagnosed)
    - <1% serious symptoms

Linking Mosquito and Human WNV Data (cont.)

- Small population size hard to make connections
- Disproportionately affects older adults
- Little data sharing between jurisdictions
  - Which data should be shared?
  - County-level data not shared during season

West Nile Virus 2019





- 74 trap sites
  - Gravid Trap
  - CDC Trap
  - 29 with BG Sentinel Trap
- ~1 trap site per 5-6 square miles

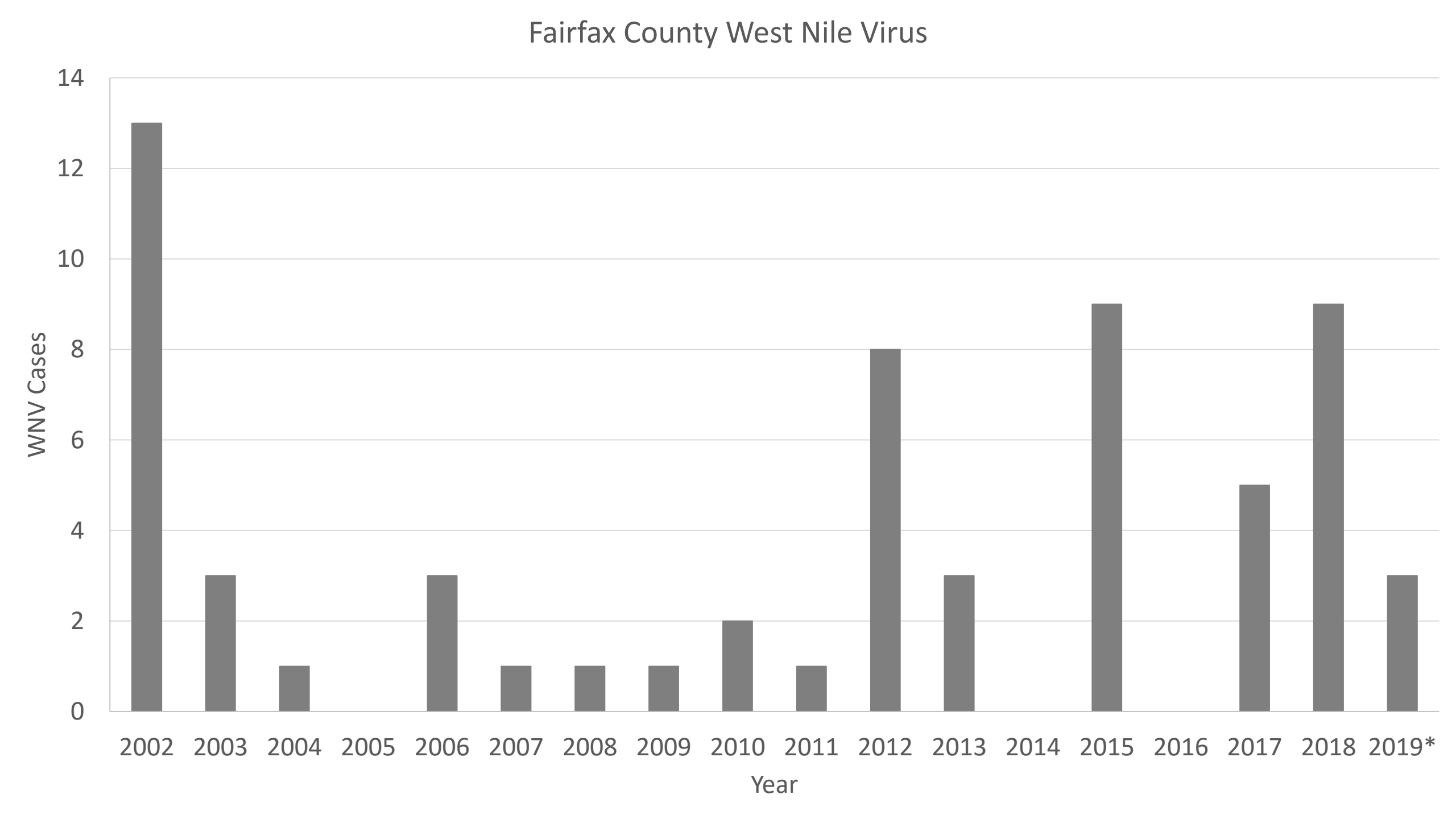
Which trap is best to monitor WNV infection rates in mosquitoes?

Gravid trap

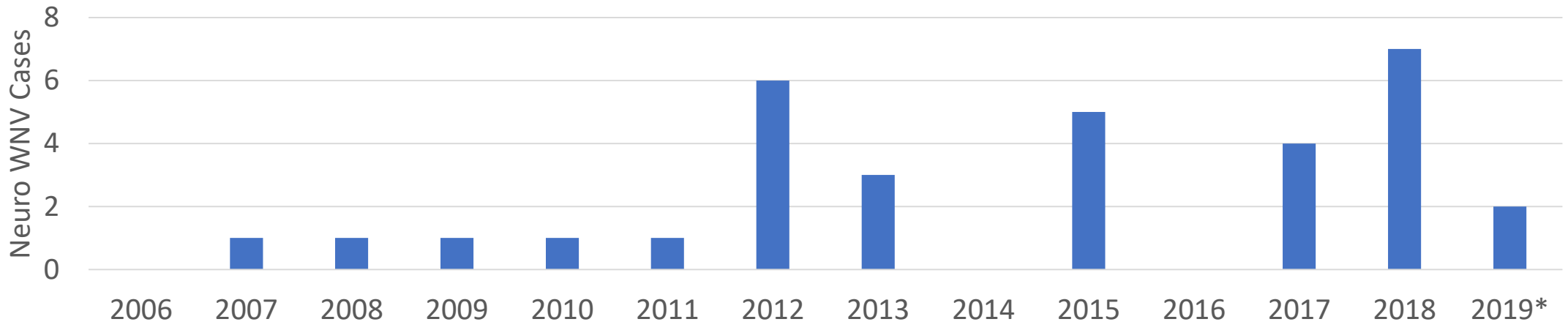
- Large numbers of *Culex* mosquitoes
  - *Culex pipiens* and *Culex restuans* (primary WNV vectors in NoVa)
    - Have already fed on a host
      - That host was likely a bird, where WNV circulates

Terms

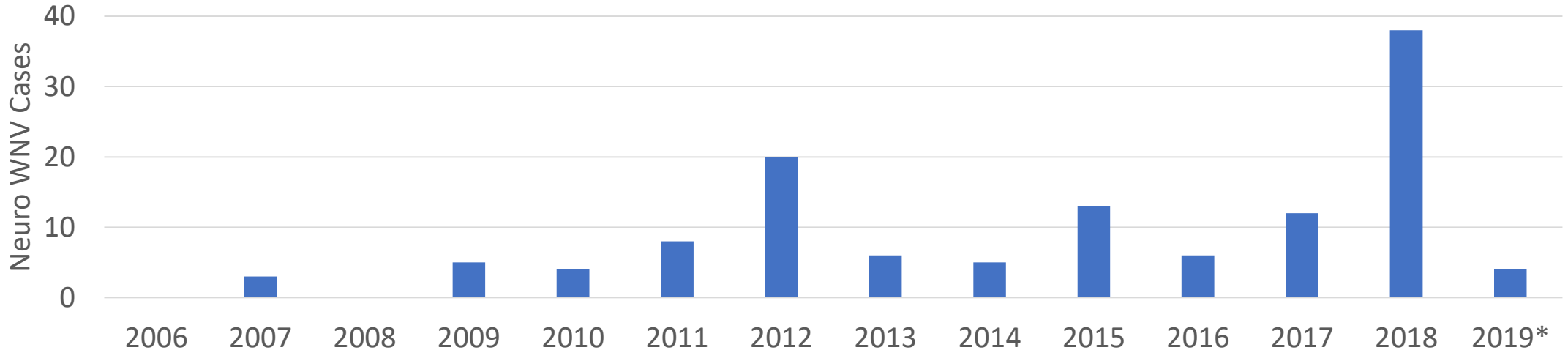
- Epiweek
- *Culex* spp.
- Infection Rate (*Culex*) per thousand
  - MIR - Minimum Infection Rate
  - MLE - Maximum Likelihood Estimate
- Cumulative Infection Rate (weeks 21-40)
- Vector Index
- Neuroinvasive Cases (Neuro)


Fairfax County West Nile Virus
14
12
10
8
6
4
2
0
WNV Cases
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019*
Year

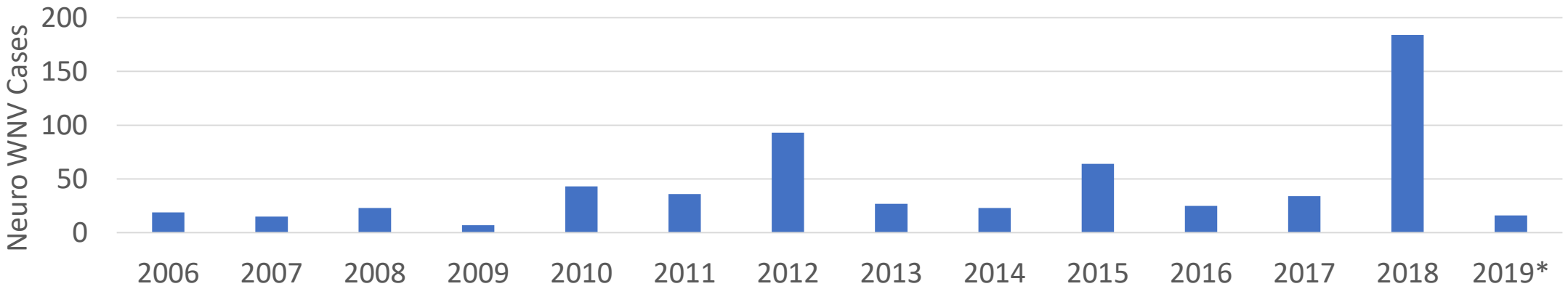
Fairfax

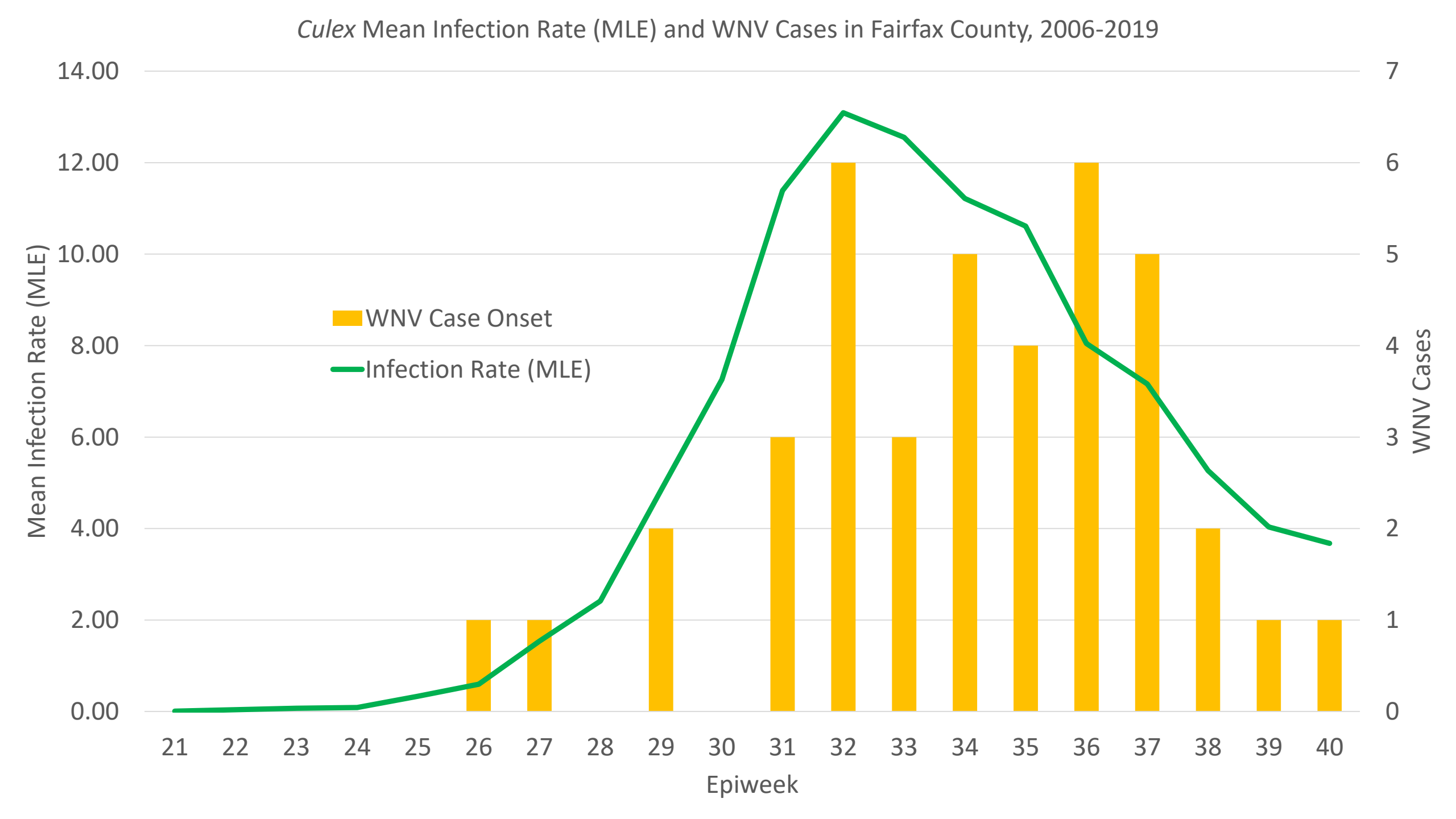


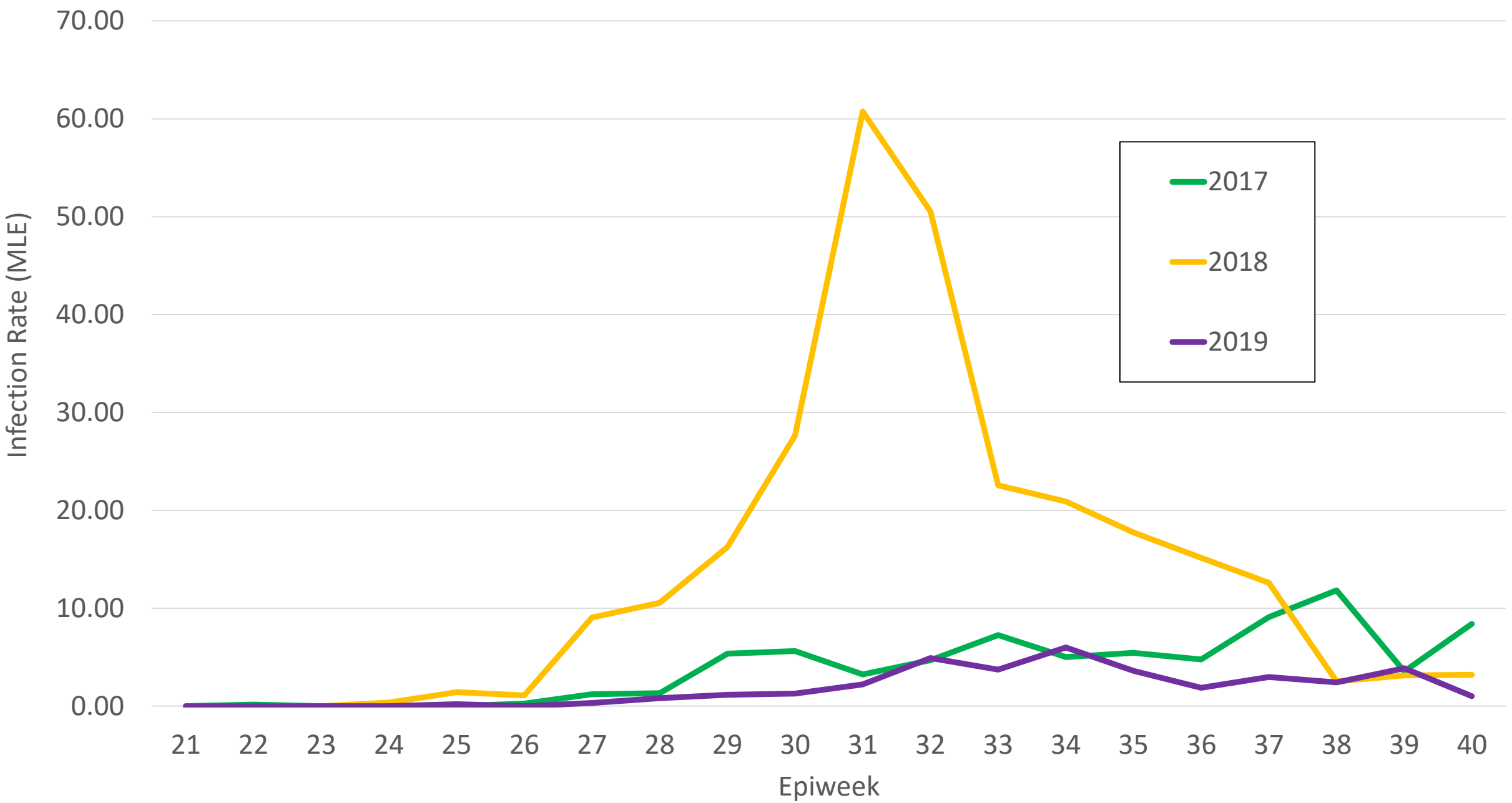
Virginia

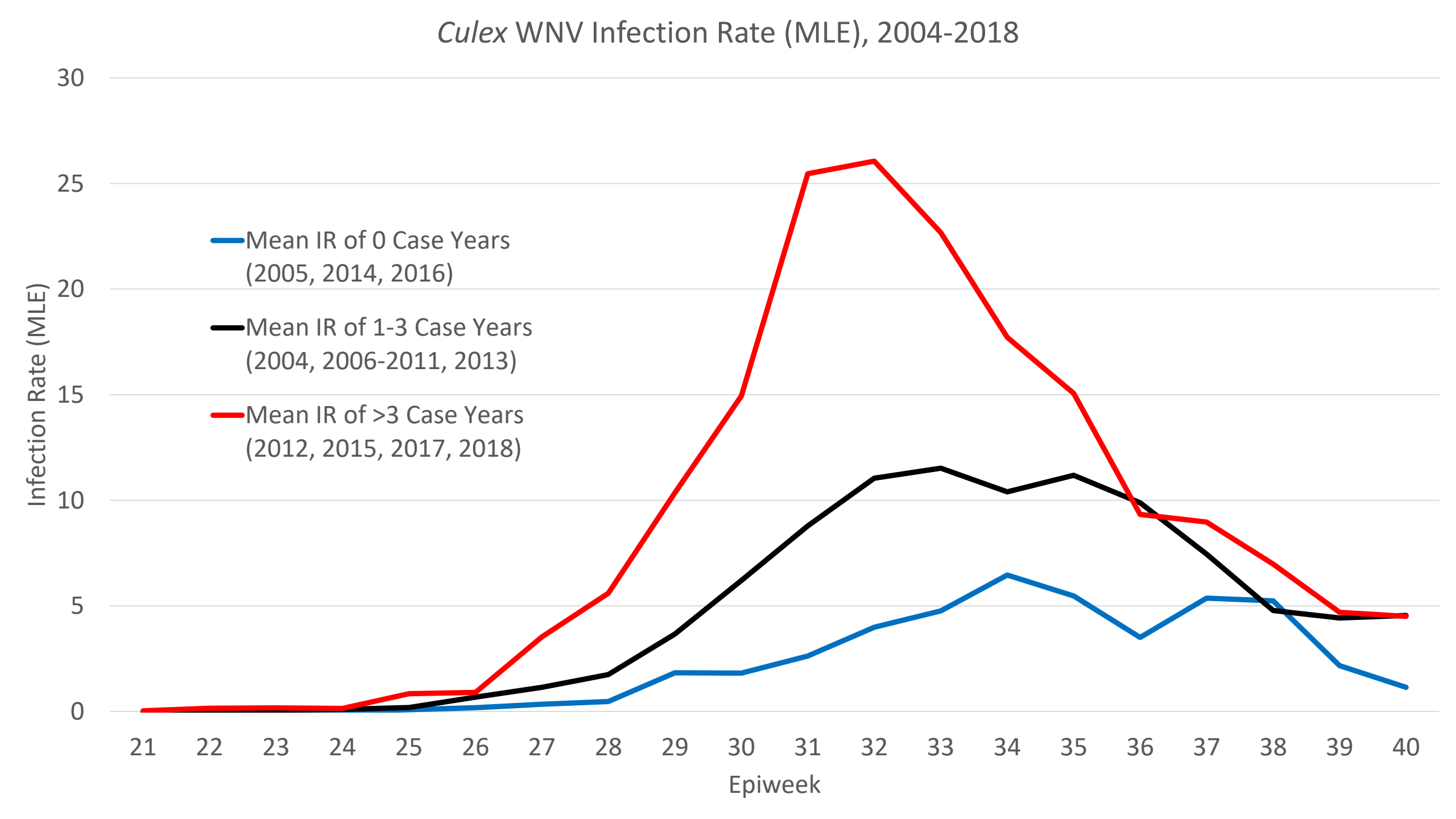


Mid-Atlantic (PA, MD, DE, DC, VA, WV)




Culex Mean Infection Rate (MLE) and WNV Cases in Fairfax County, 2006-2019
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Mean Infection Rate (MLE)
7
6
5
4
3
2
1
0
WNV Cases
WNV Case Onset
Infection Rate (MLE)
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Epiweek

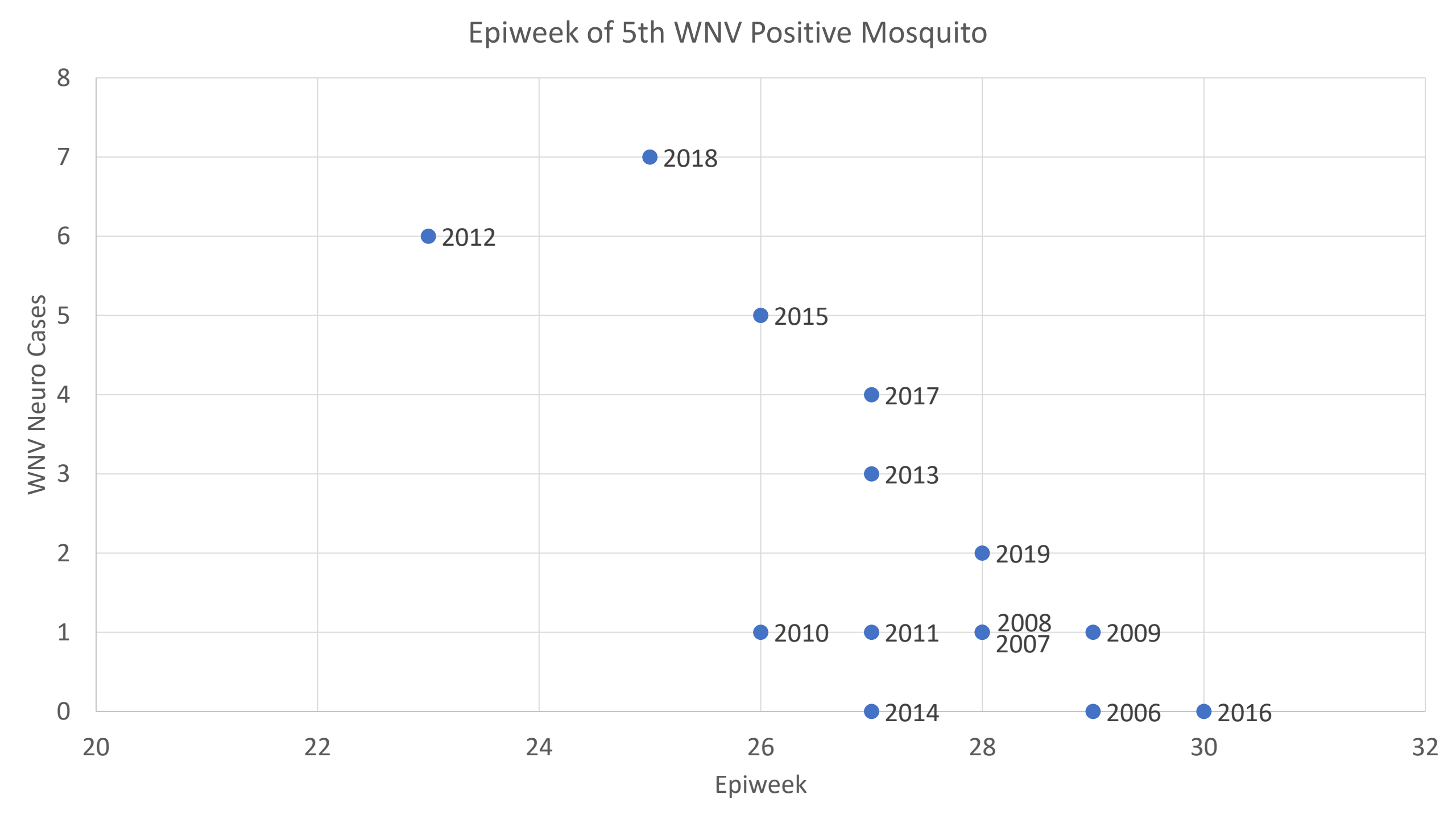

Culex Infection Rate (MLE) in Fairfax County, Virginia
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Infection Rate (MLE)
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Epiweek
2017
2018
2019

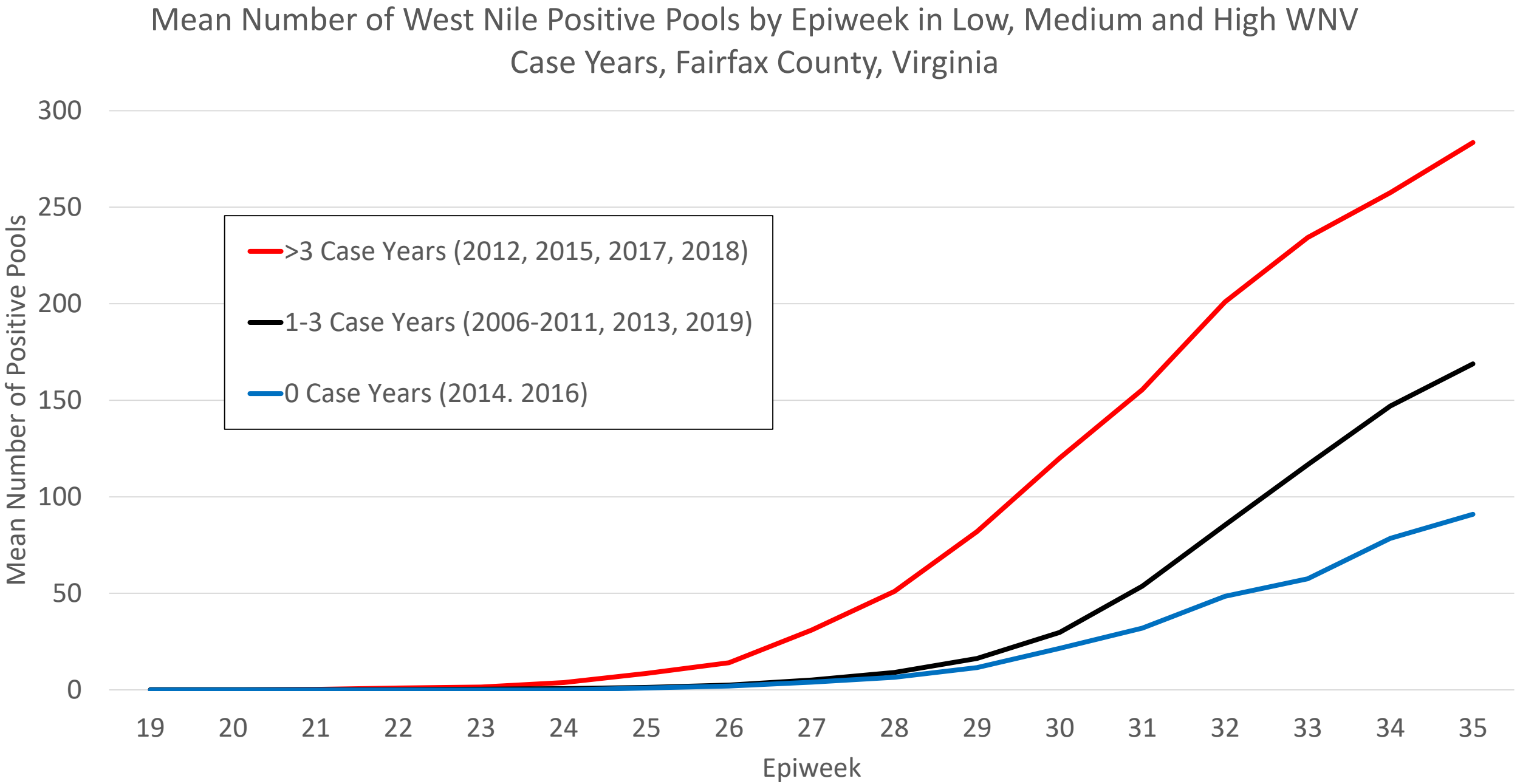

Culex WNV Infection Rate (MLE), 2004-2018
Infection Rate (MLE)
30
25
20
15
10
5
0
Mean IR of 0 Case Years
(2005, 2014, 2016)
Mean IR of 1-3 Case Years
(2004, 2006-2011, 2013)
Mean IR of >3 Case Years
(2012, 2015, 2017, 2018)
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Epiweek

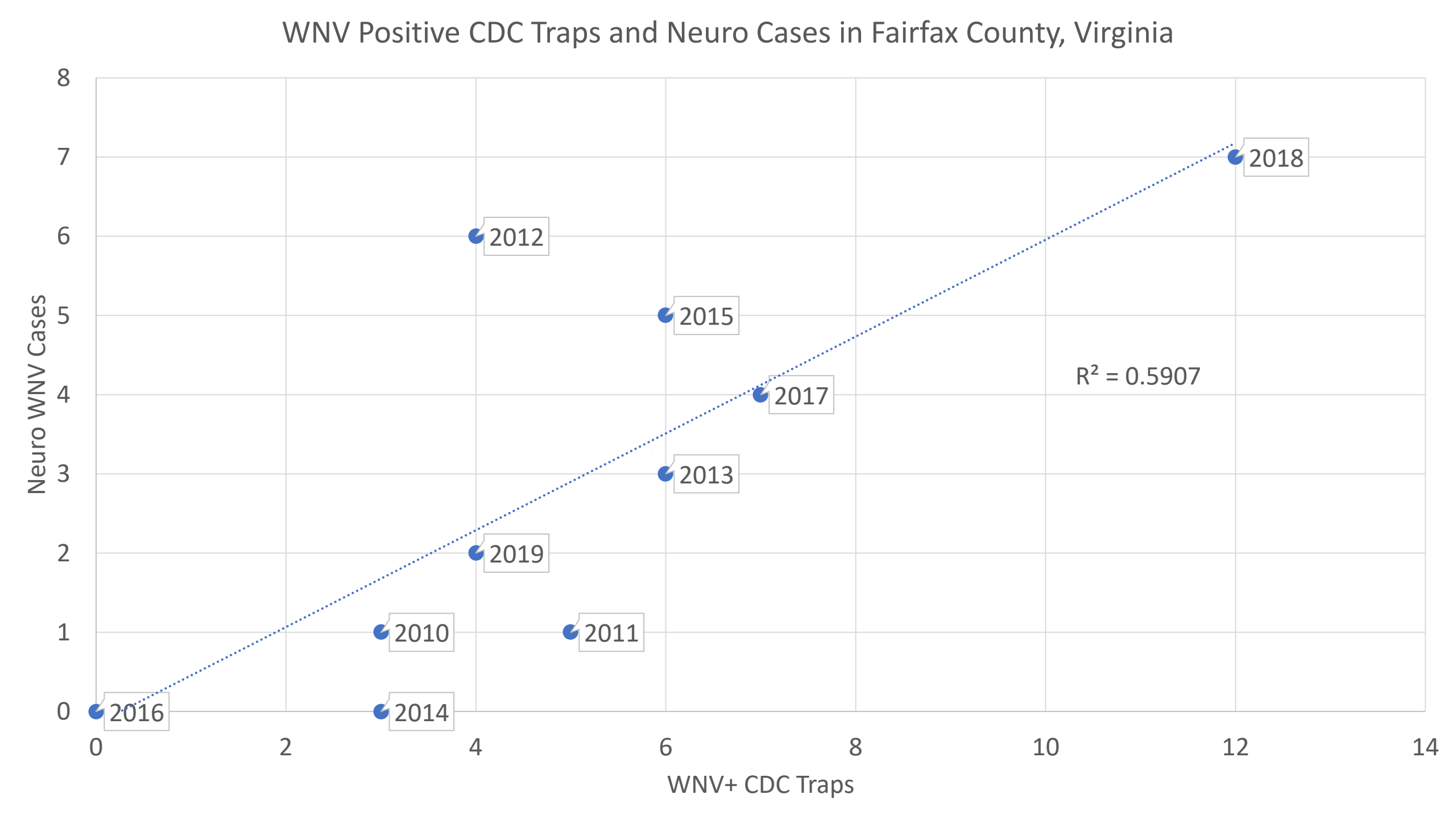
Thresholds

When should we respond?

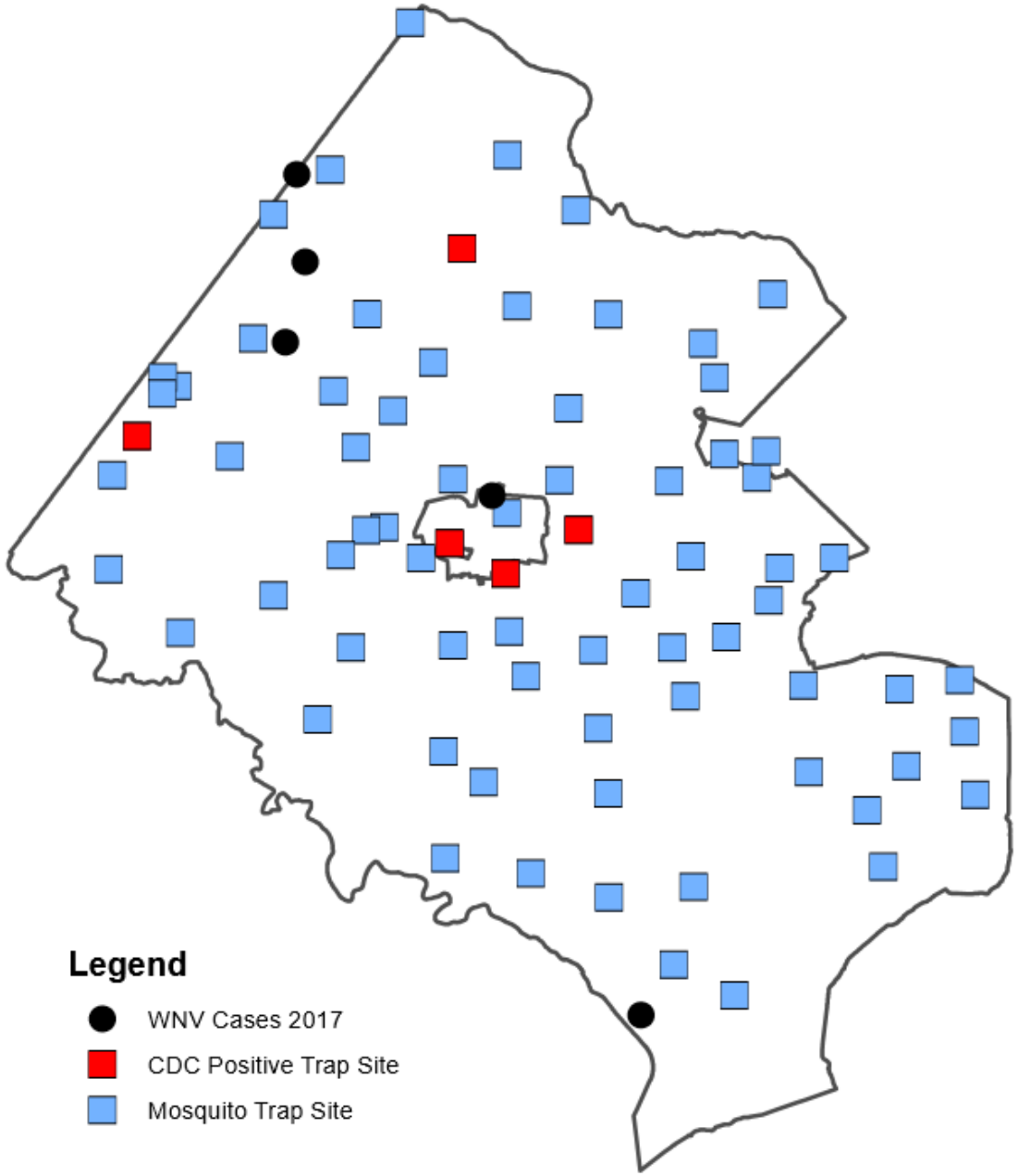
- Early season indicators
- Host-seeking trap positives
- Bridge vector positives
- High Infection Rate
- High *Culex* abundance
- High Vector Index


Epiweek of 5th WNV Positive Mosquito
WNV Neuro Cases
Epiweek
0
1
2
3
4
5
6
7
8
20
22
24
26
28
30
32
2018
2012
2015
2017
2013
2019
2010
2011
2008
2007
2009
2014
2006
2016

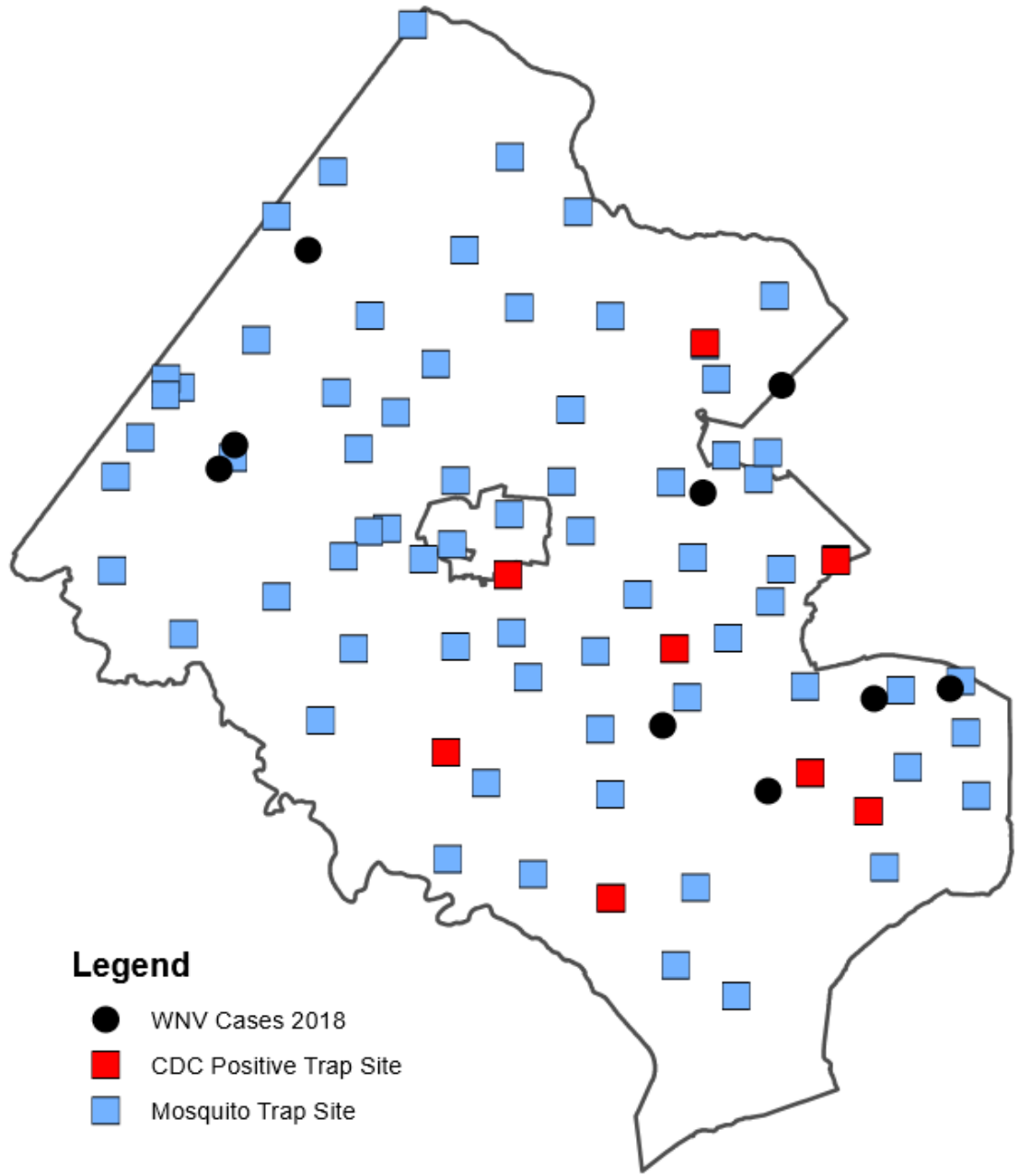

Mean Number of West Nile Positive Pools by Epiweek in Low, Medium and High WNV Case Years, Fairfax County, Virginia
300
250
200
150
100
50
0
Mean Number of Positive Pools
>3 Case Years (2012, 2015, 2017, 2018)
1-3 Case Years (2006-2011, 2013, 2019)
0 Case Years (2014. 2016)
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
Epiweek

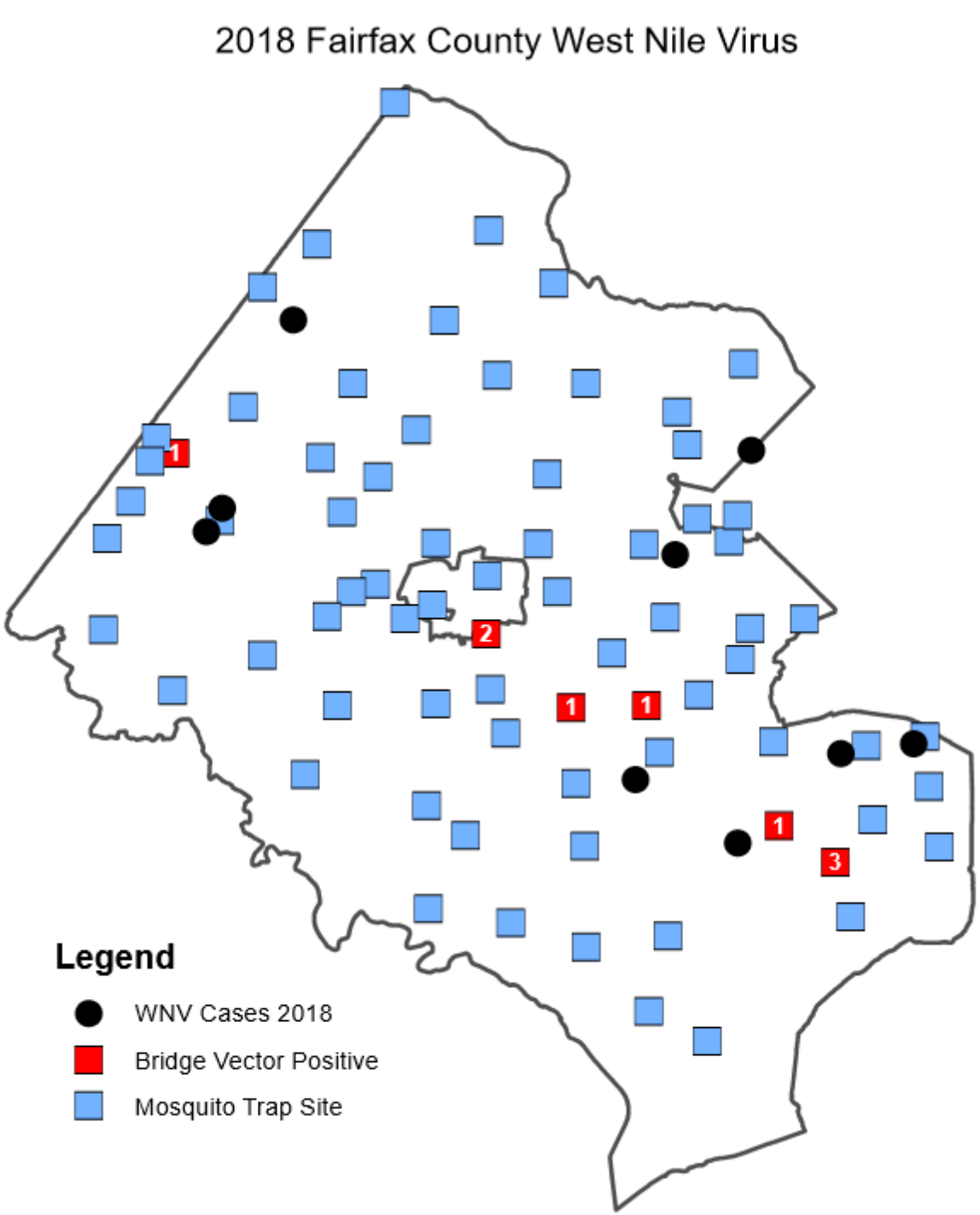

WNV Positive CDC Traps and Neuro Cases in Fairfax County, Virginia
Neuro WNV Cases
WNV+ CDC Traps
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
2016
2014
2010
2011
2019
2013
2015
2012
2017
2018
R² = 0.5907

2017 Fairfax County West Nile Virus



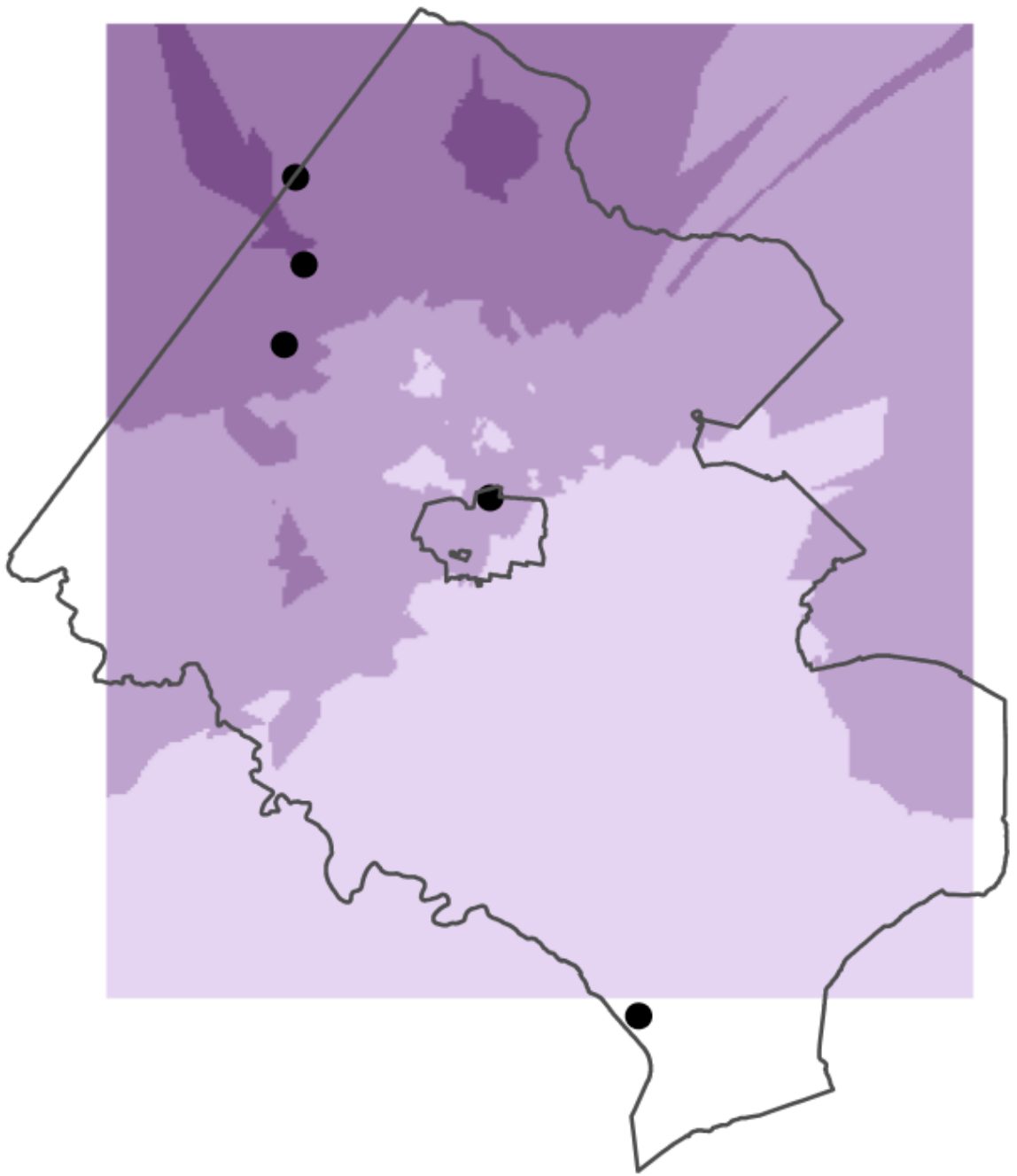
2018 Fairfax County West Nile Virus



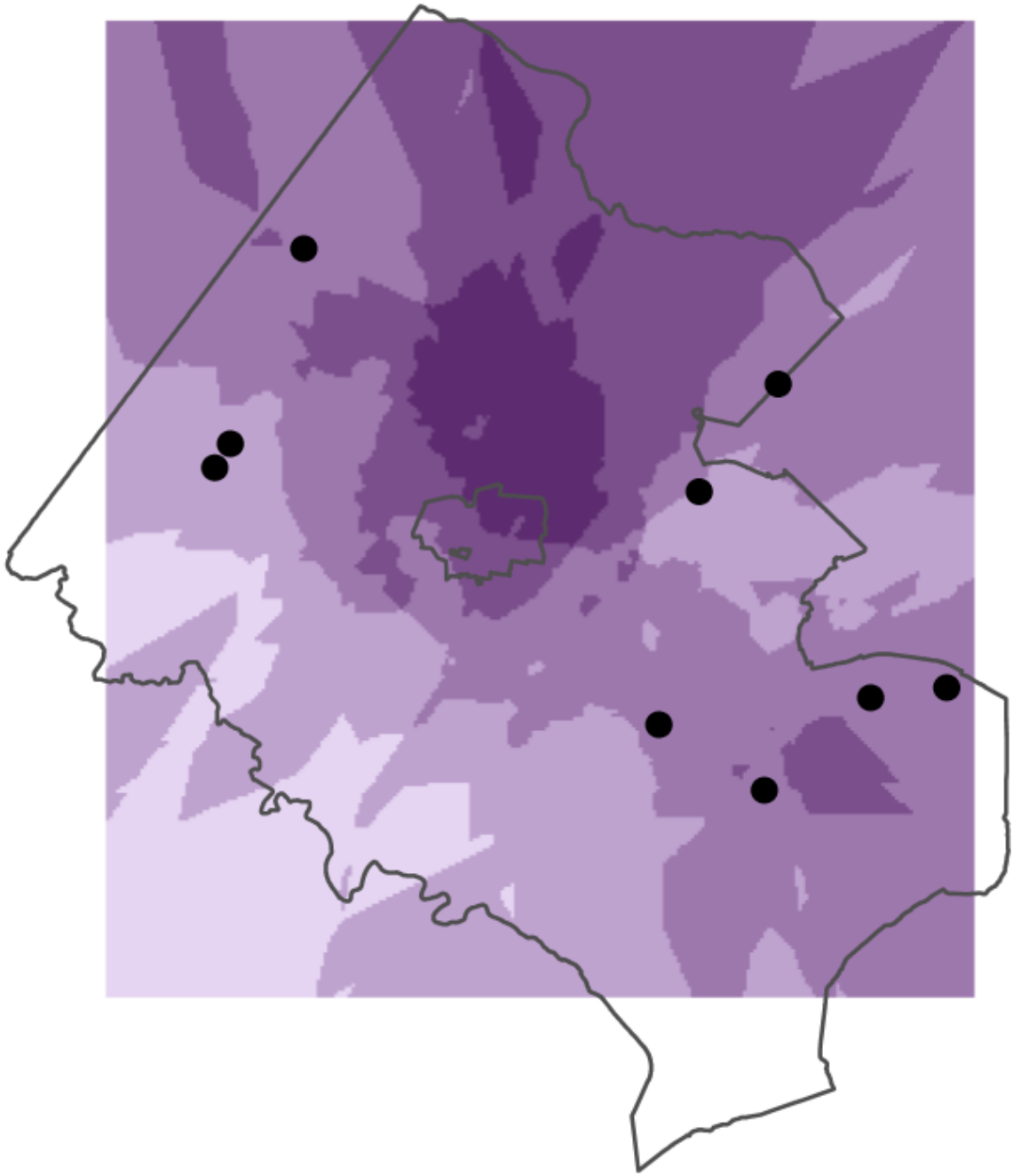


Aedes albopictus
Aedes japonicus
Aedes vexans
Culex erraticus
Culex salinarius

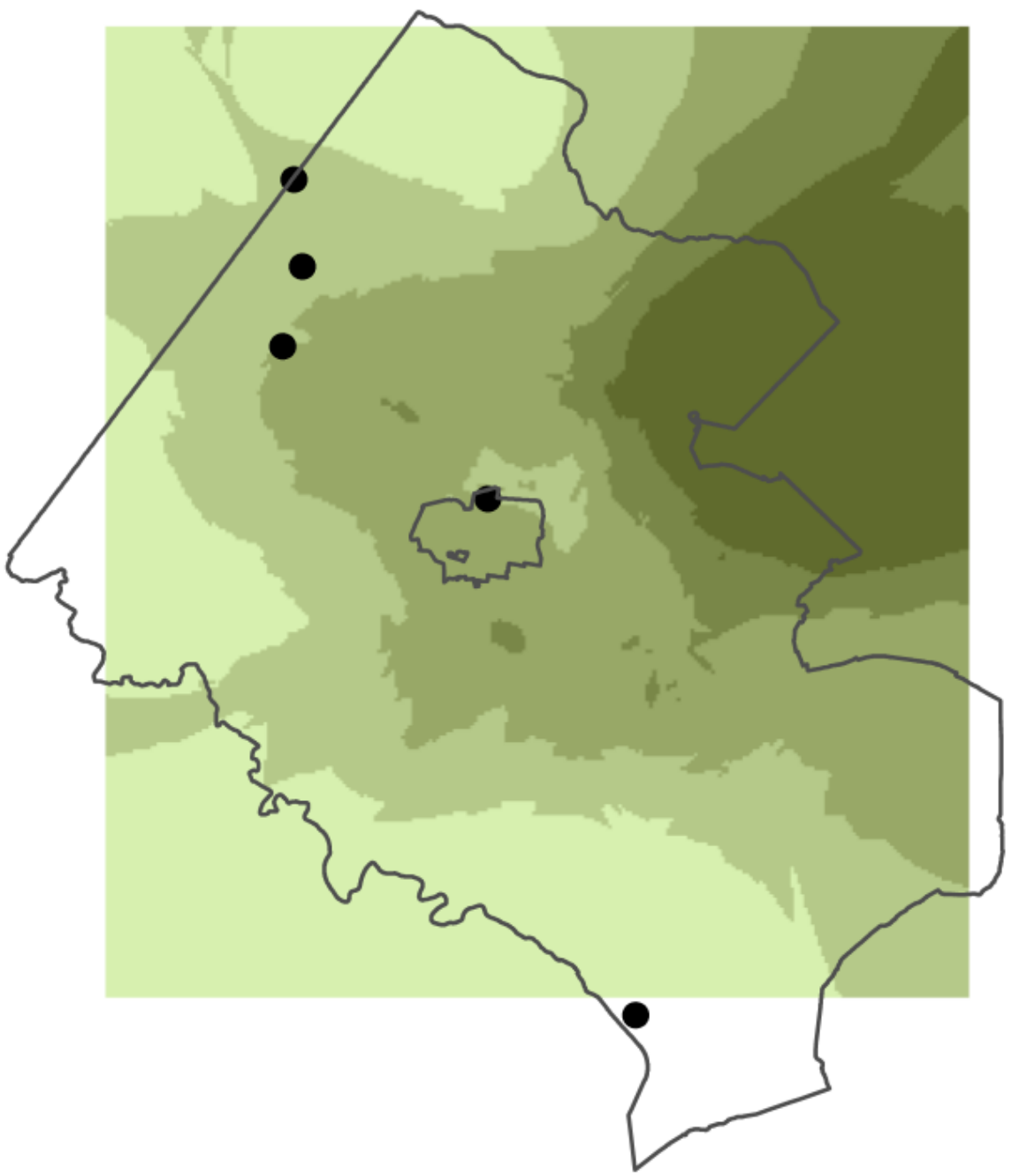
2017 Infection Rate and WNV Cases



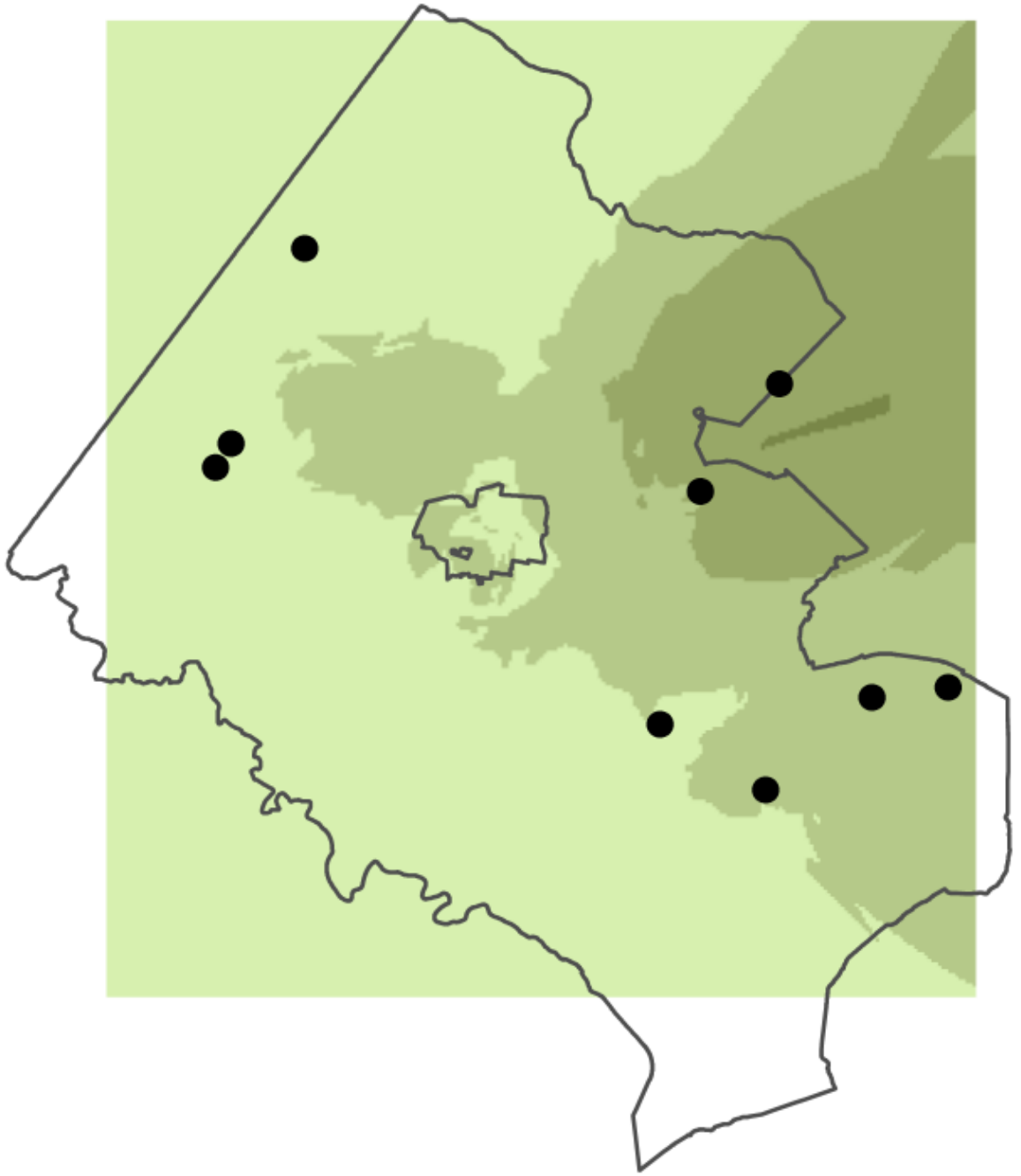
2018 Infection Rate and WNV Cases



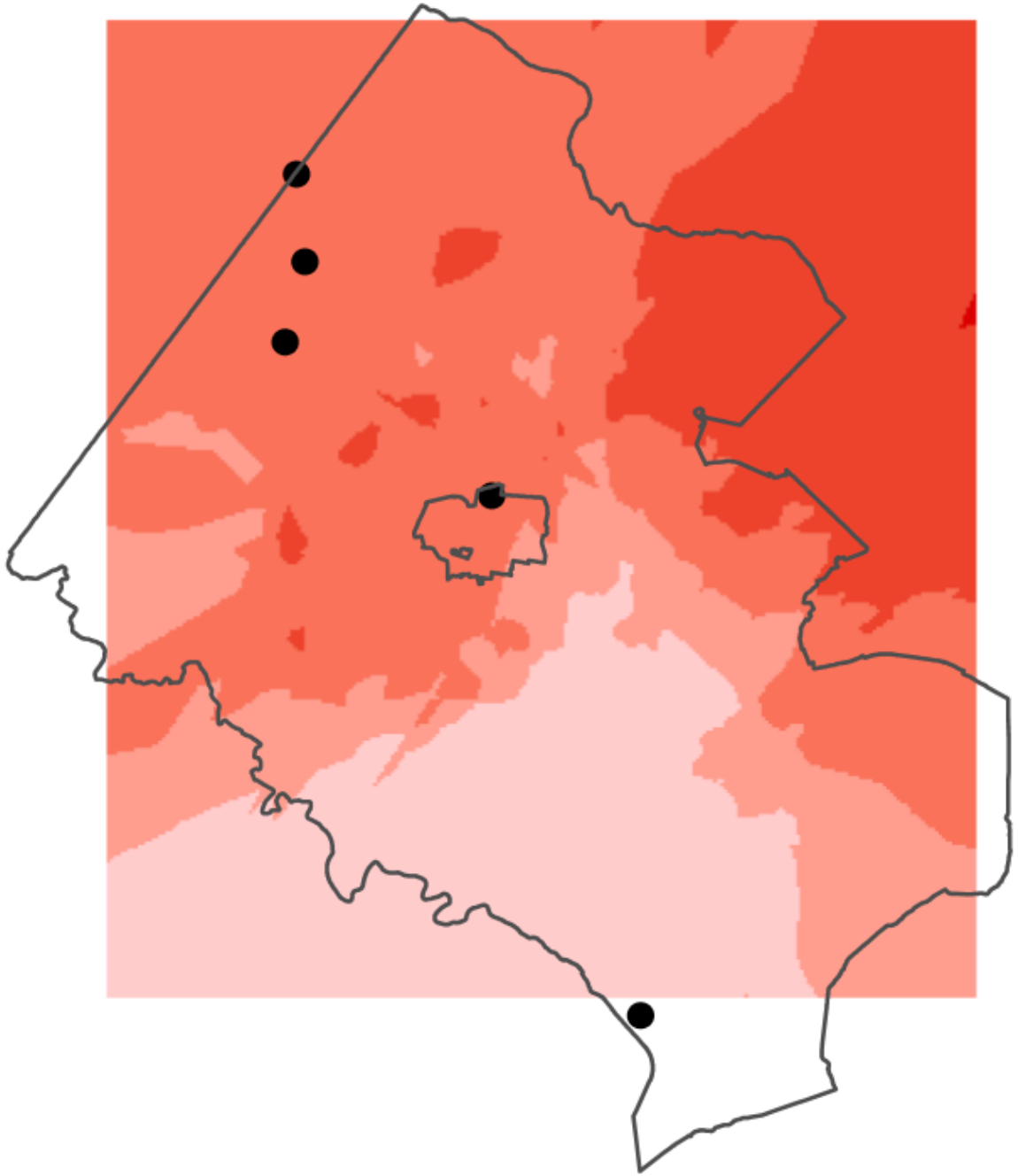
2017 *Culex* Abundance and WNV Cases



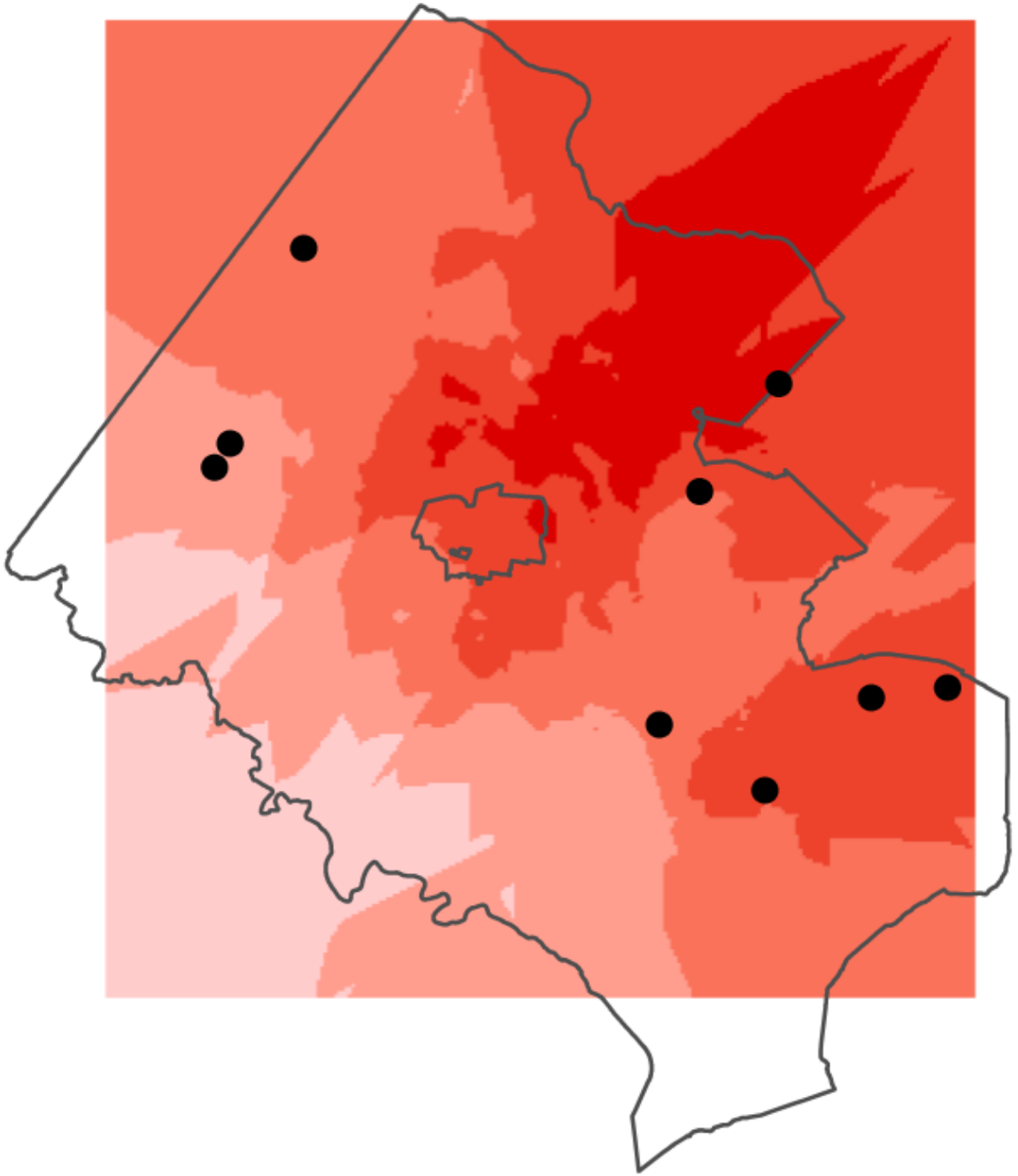
2018 *Culex* Abundance and WNV Cases



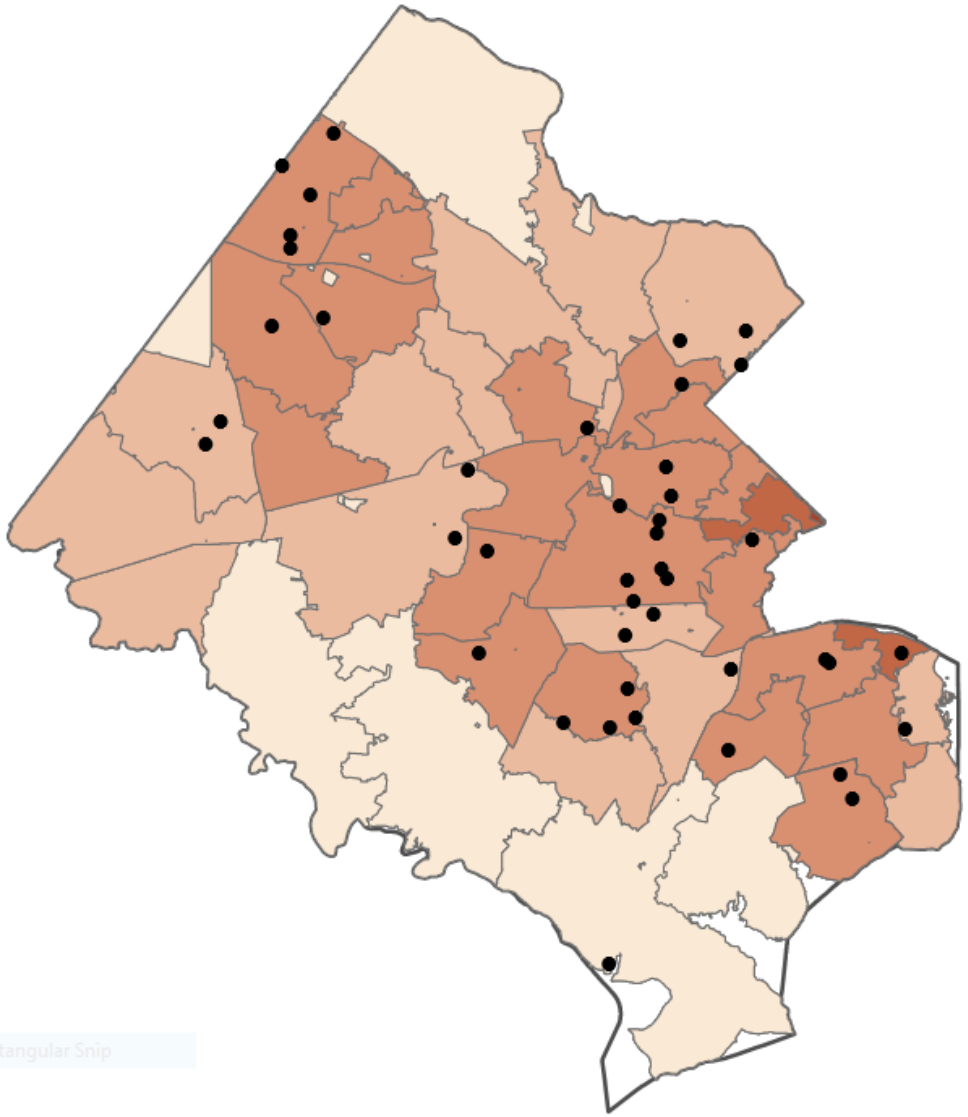
2017 Vector Index and WNV Cases



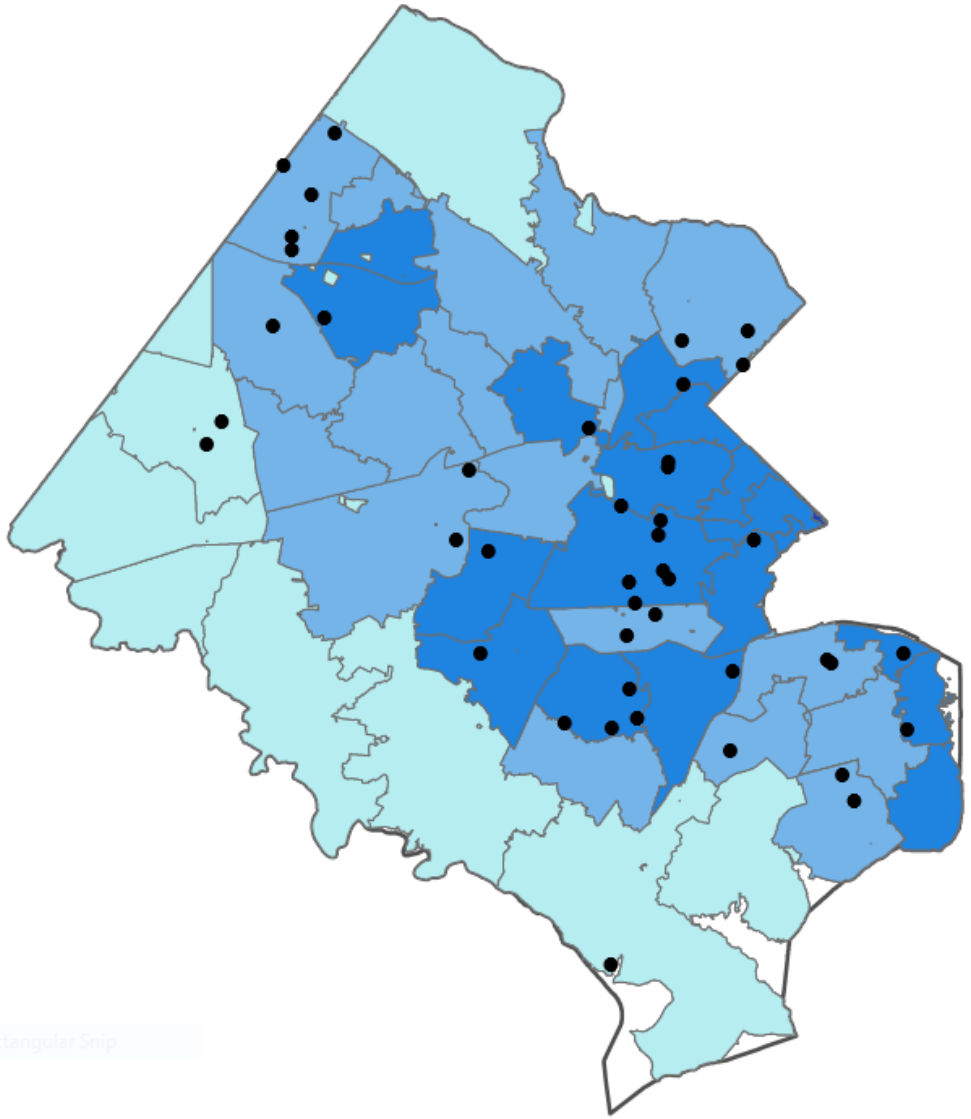
2018 Vector Index and WNV Cases



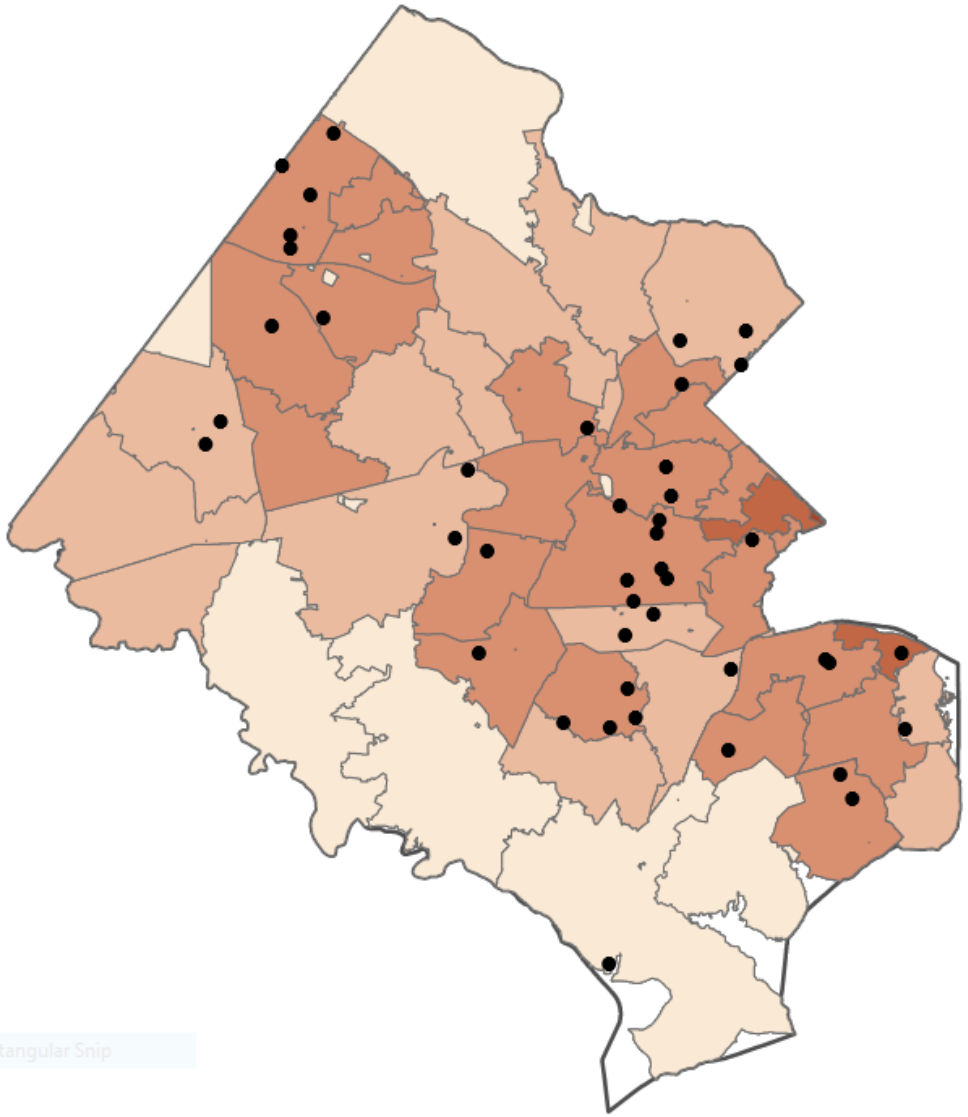
WNV Cases 2006-2018 & Population Density



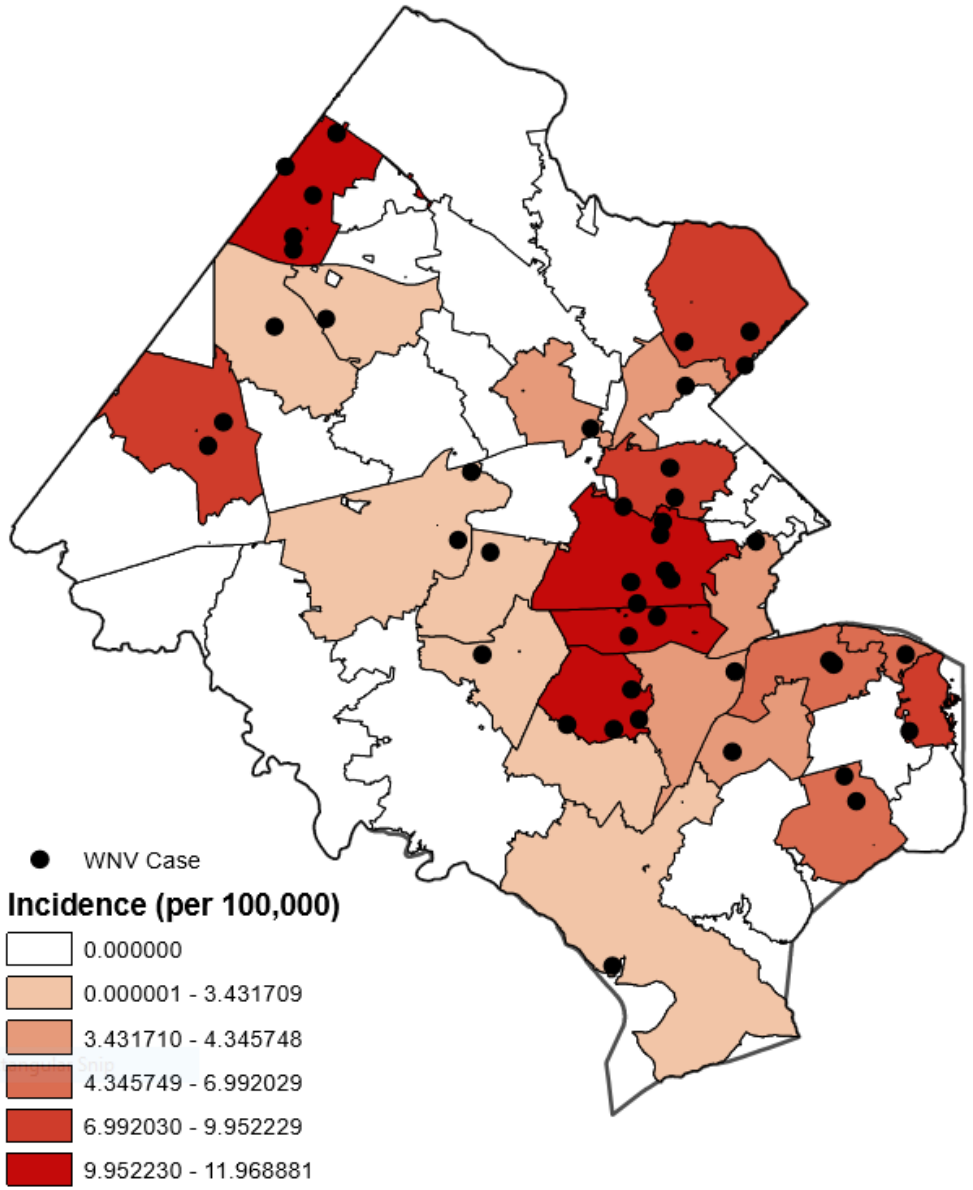
WNV Cases 2006-2018 & Population 65+

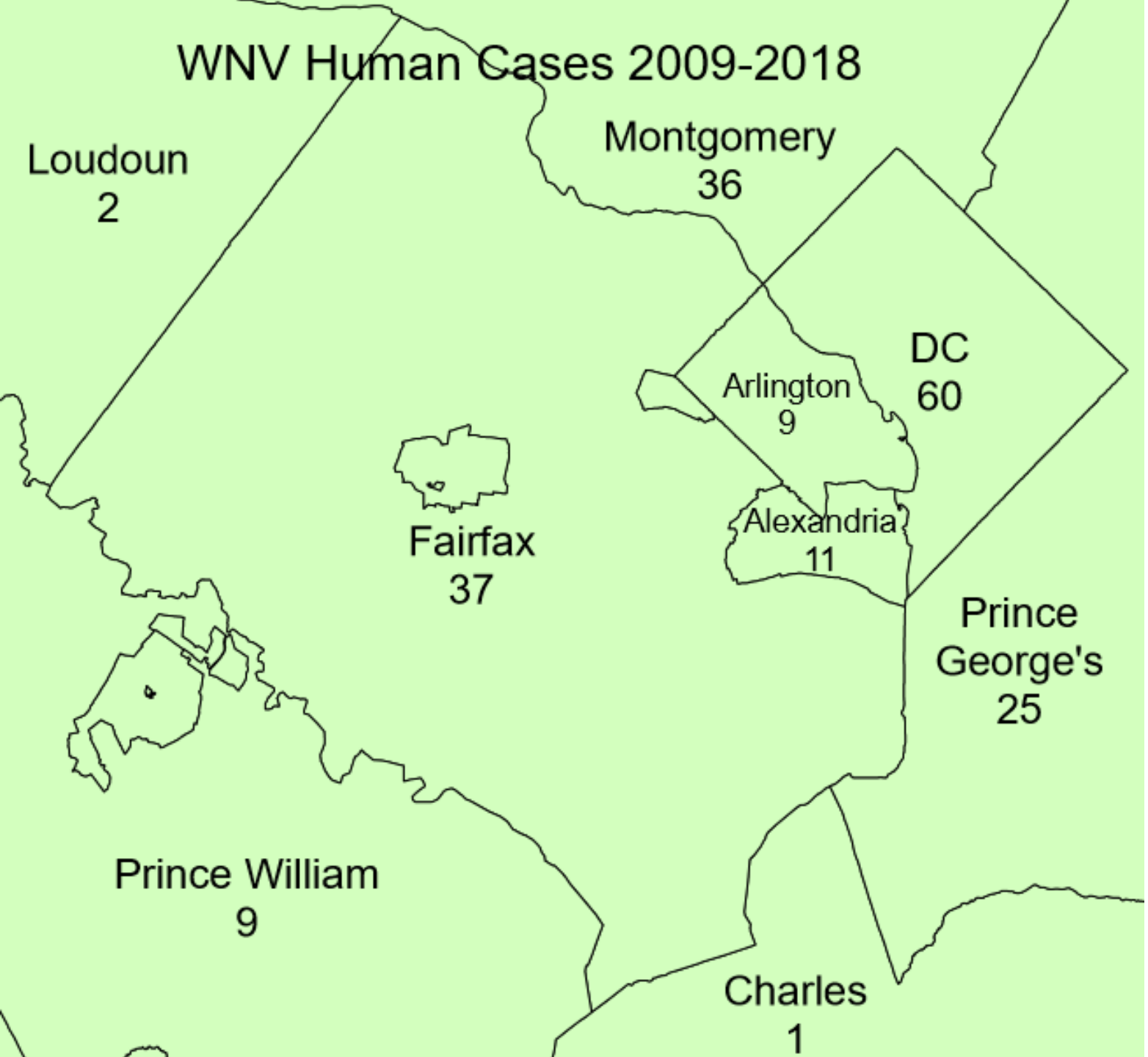


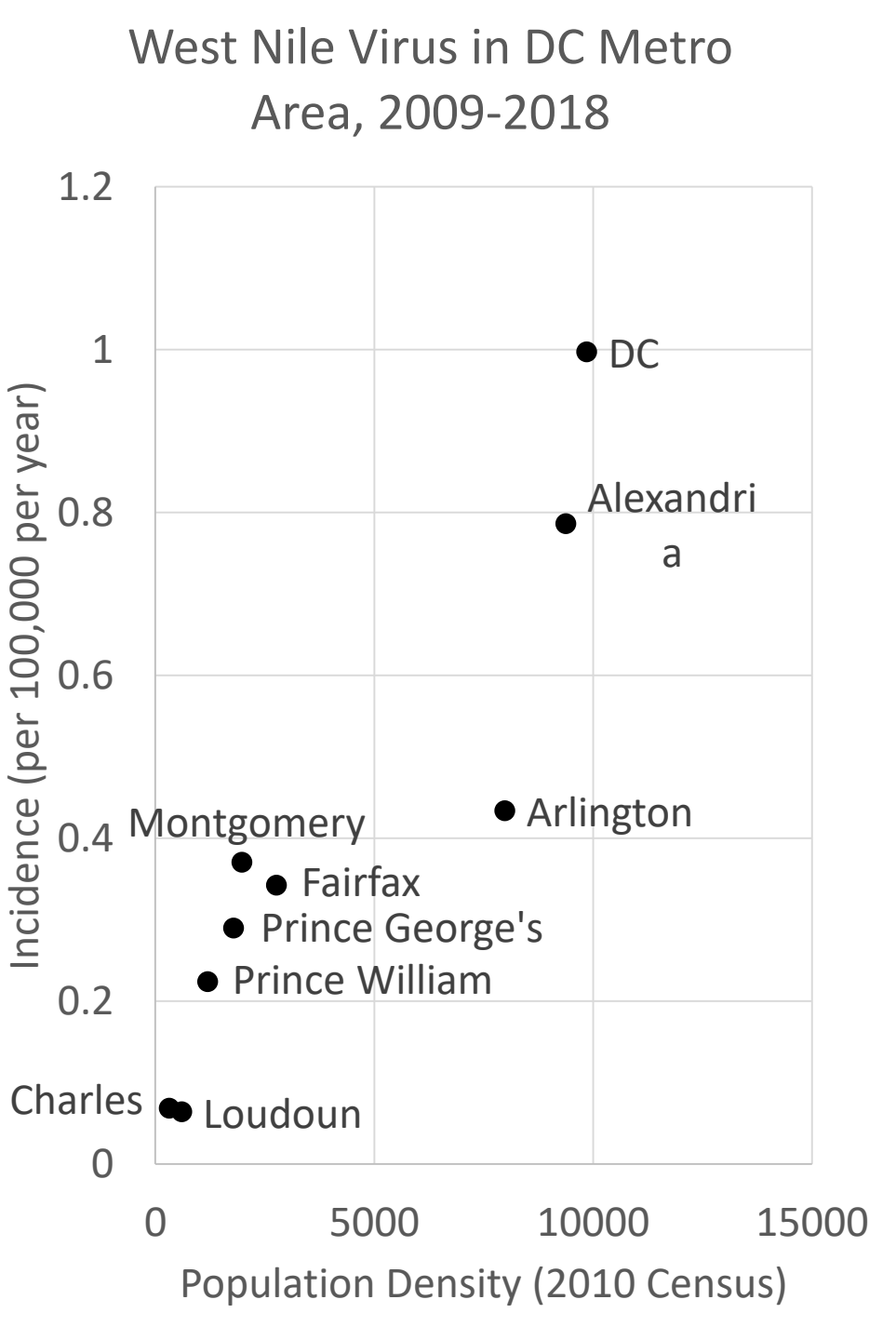
WNV Cases 2006-2018 & Population Density



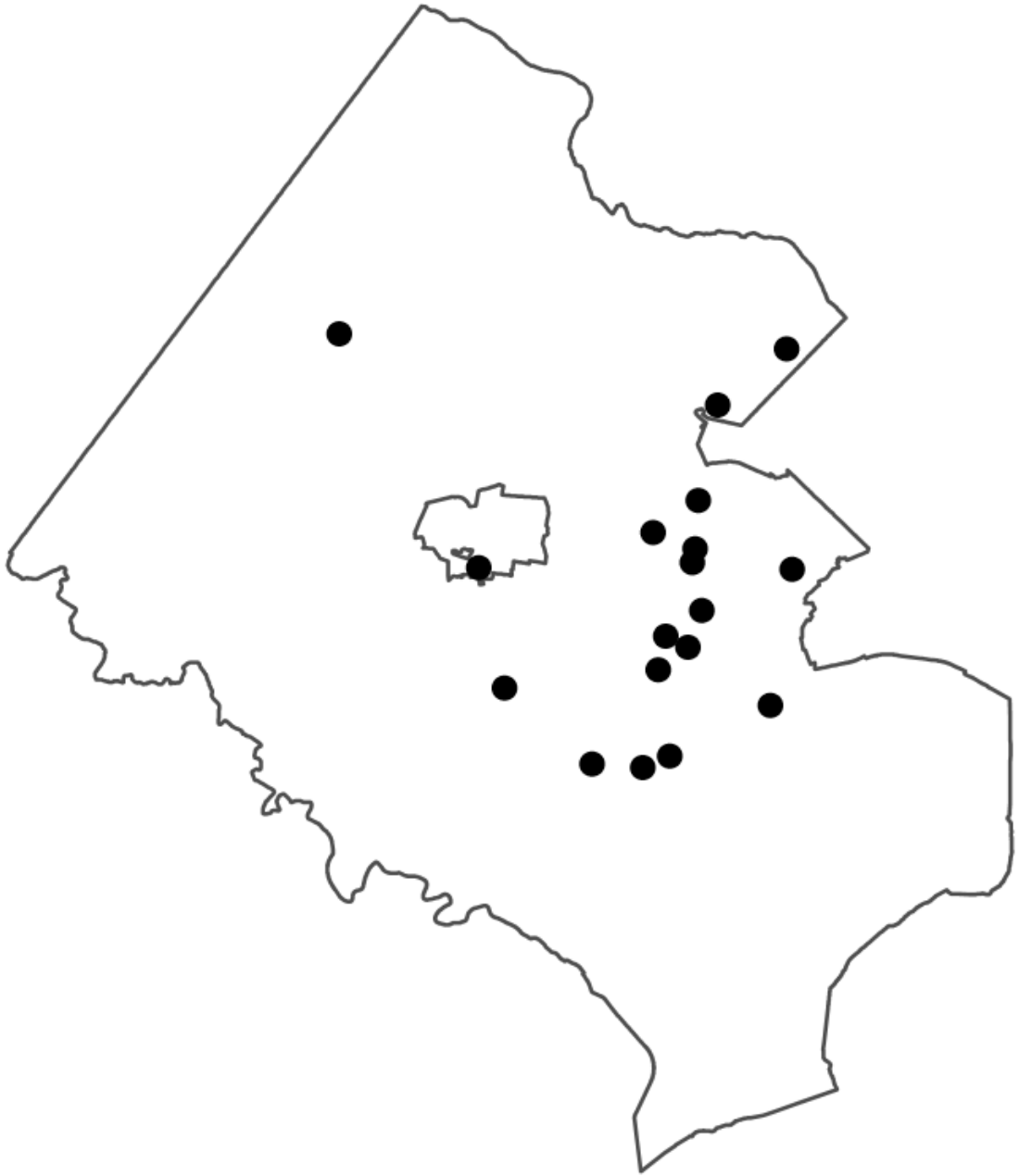
WNV Incidence 2006-2018



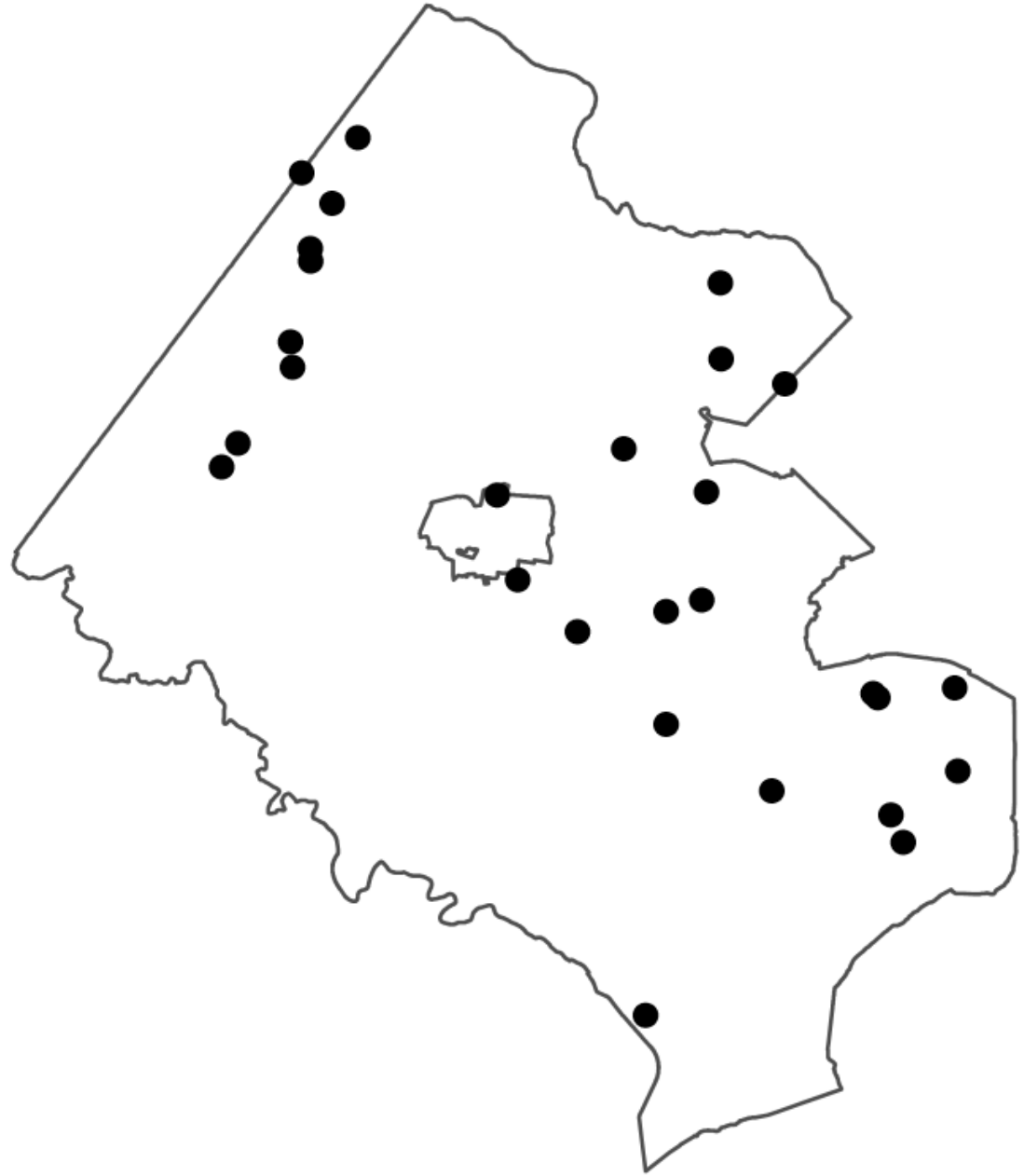

WNV Human Cases 2009-2018
Loudoun
2
Montgomery
36
DC
60
Arlington
9
Alexandria
11
Fairfax
37
Prince
George's
25
Prince William
9
Charles
1


West Nile Virus in DC Metro Area, 2009-2018
Incidence (per 100,000 per year)
1.2
1
0.8
0.6
0.4
0.2
0
DC
Alexandria
Arlington
Montgomery
Fairfax
Prince George's
Prince William
Charles
Loudoun
0
5000
10000
15000
Population Density (2010 Census)

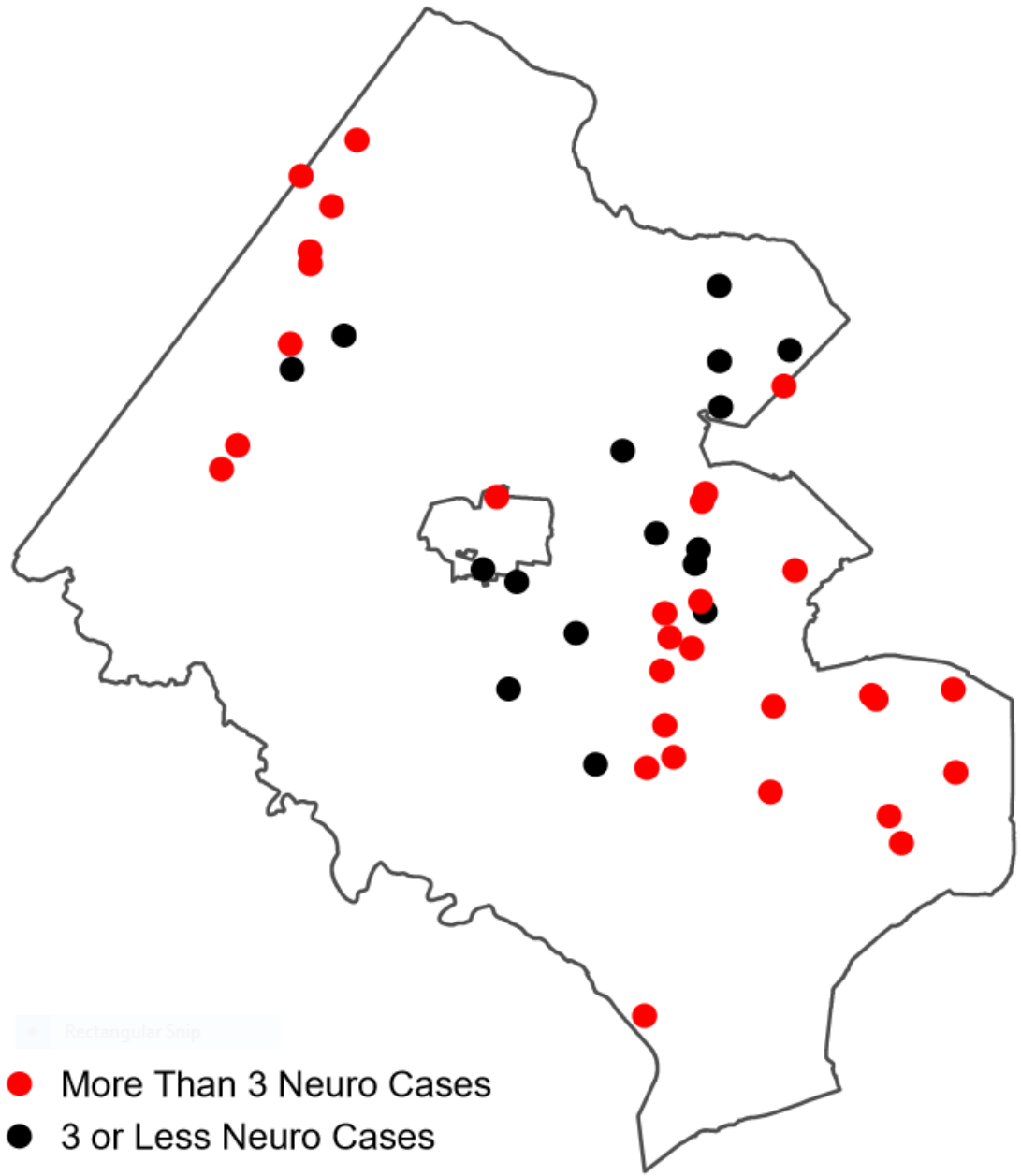
WNV Cases 2006-2012

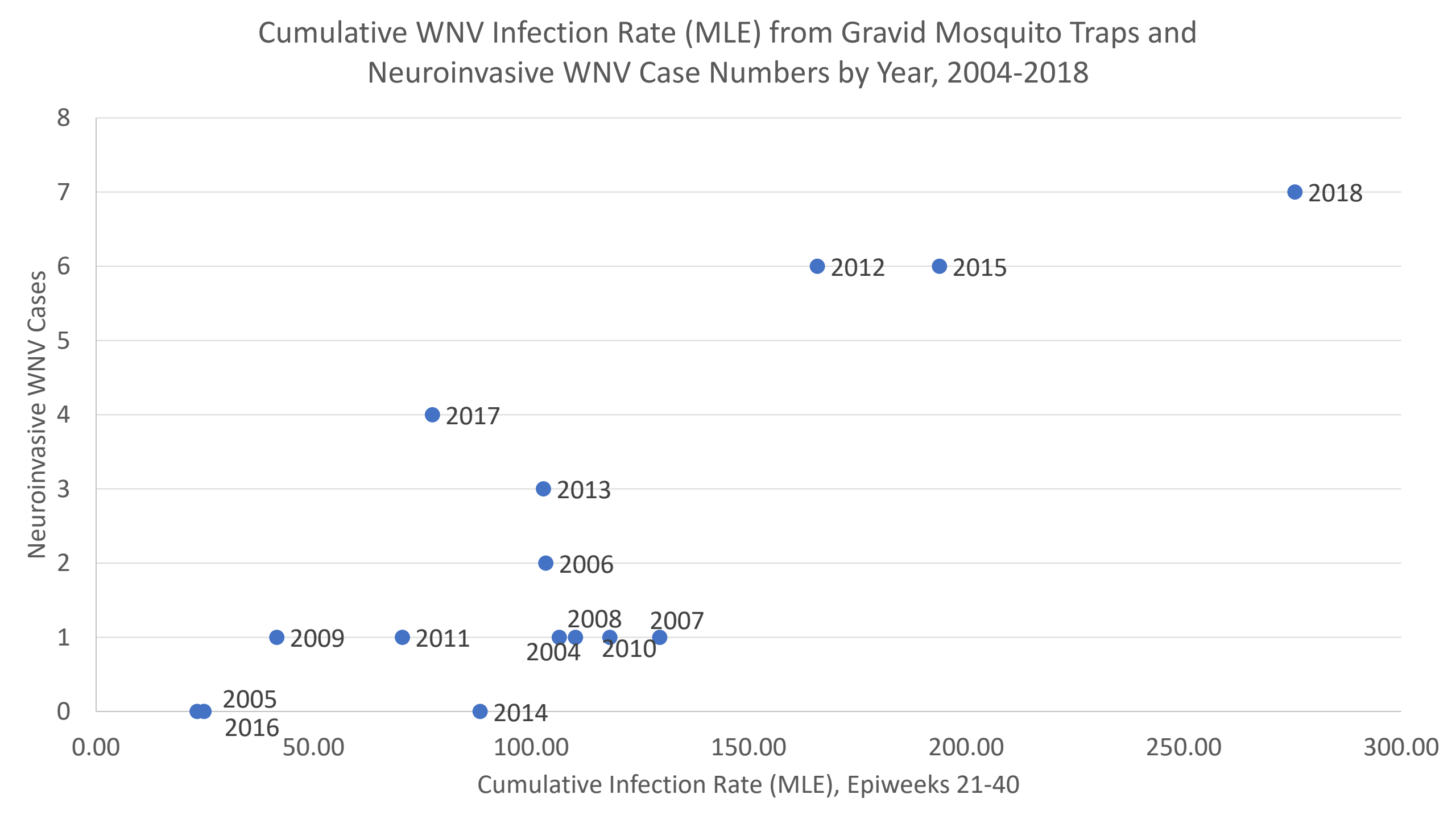


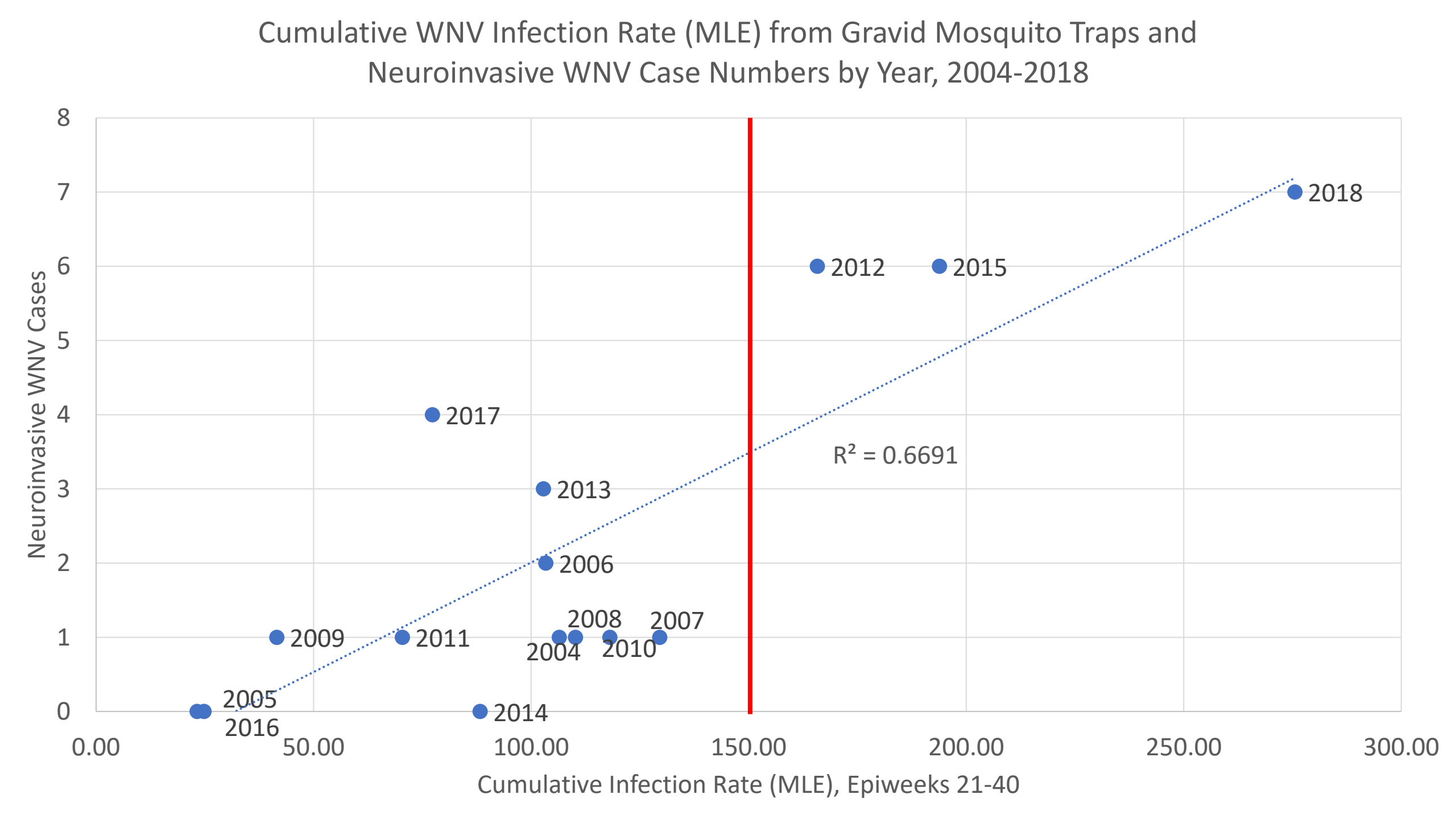
WNV Cases 2013-2019

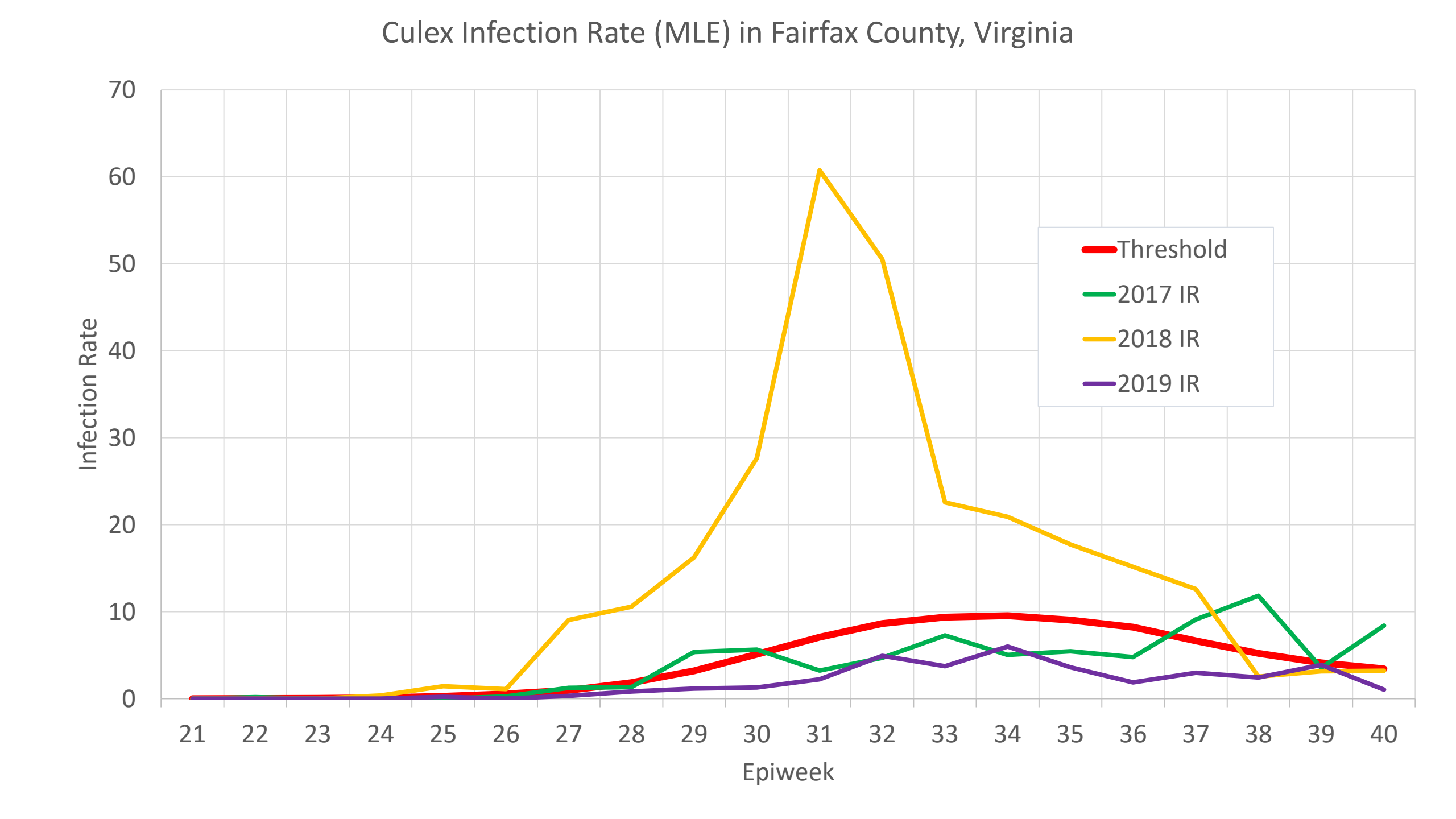


WNV Cases 2006-2019



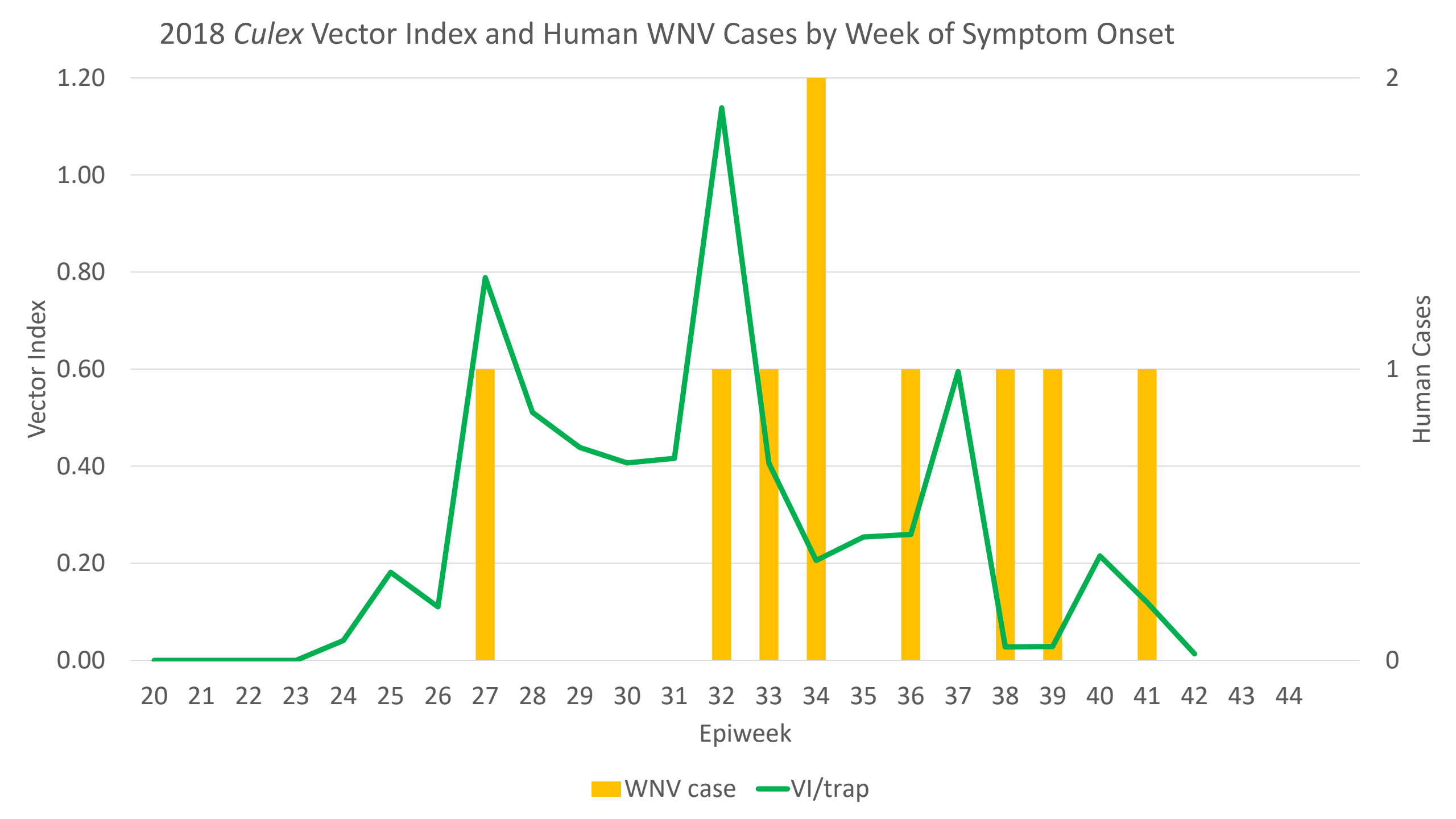

Cumulative WNV Infection Rate (MLE) from Gravid Mosquito Traps and Neuroinvasive WNV Case Numbers by Year, 2004-2018
Neuroinvasive WNV Cases
0
1
2
3
4
5
6
7
8
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Cumulative Infection Rate (MLE), Epiweeks 21-40
2018
2012
2015
2017
2013
2006
2008
2007
2009
2011
2004
2010
2005
2016
2014


Cumulative WNV Infection Rate (MLE) from Gravid Mosquito Traps and Neuroinvasive WNV Case Numbers by Year, 2004-2018
Neuroinvasive WNV Cases
Cumulative Infection Rate (MLE), Epiweeks 21-40
0
1
2
3
4
5
6
7
8
0.00
50.00
100.00
150.00
200.00
250.00
300.00
2018
2012
2015
2017
2013
2006
2009
2011
2008
2007
2004
2010
2005
2016
2014
R² = 0.6691


Culex Infection Rate (MLE) in Fairfax County, Virginia
Infection Rate
70
60
50
40
30
20
10
0
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Epiweek
Threshold
2017 IR
2018 IR
2019 IR

How would we like to respond?

- Adulticiding—wide-scale, repeated applications
  - To reduce Infection Rate
  - To reduce Vector Index (by reducing abundance) until Infection Rate drops
- Larviciding
  - Inspecting and treating areas not previously inspected
  - Increasing frequency
- Outreach
  - Improved public notification


2018 *Culex* Vector Index and Human WNV Cases by Week of Symptom Onset
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Vector Index
2
1
0
Human Cases
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Epiweek
WNV case
VI/trap

What does WNV response success look like?

- Fairfax County makes up a smaller proportion of total VA cases

	Population (2010 Census)	Neuro WNV Cases (06-19)
Virginia	8,001,024	124
Fairfax County	1,081,726 (13.5%)	32 (25.8%)

- When compared to surrounding jurisdictions:
  - Lower infection rates in mosquitoes
  - Lower incidence

Key Points

- Mid-Atlantic region pattern
- WNV in mosquitoes precedes human cases
- Epiweek of 5th positive early season indicator
- Positives from host seeking traps/bridge vectors may be more common in “big years” but not geographically predictive of cases
- Incidence related to population density
- Cumulative infection rate (linked to case numbers) can set thresholds

Acknowledgments

- Fairfax County Health Department, Disease Carrying Insects Program
  - Joshua Smith
  - Andy Lima
  - Lauren Lochstampfor
  - Daniel Sherwood
- Virginia Mosquito Control Association

Thank you