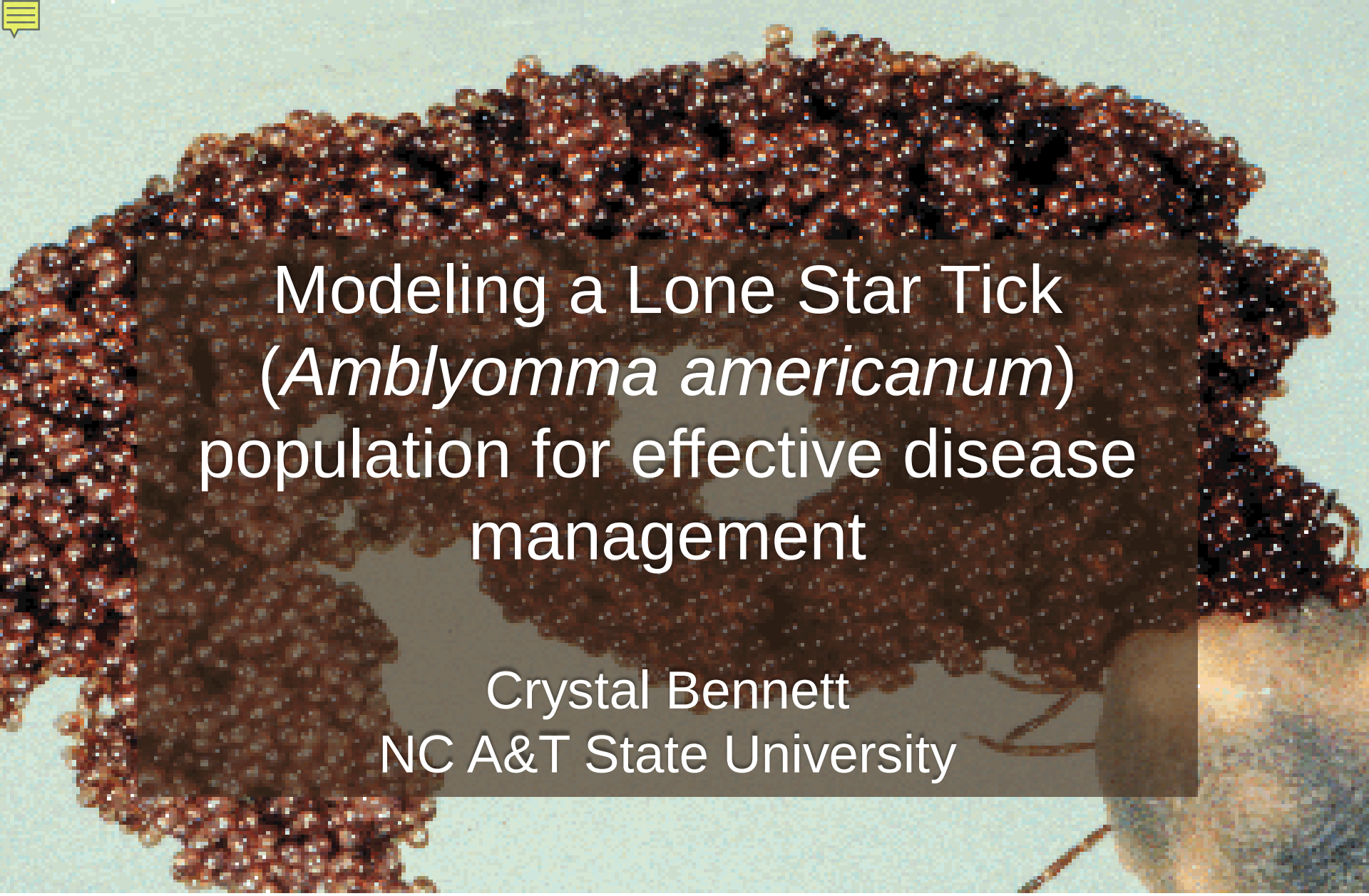

Modeling a Lone Star Tick (*Amblyomma americanum*) population for effective disease management

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NC A&T State University

http://www.ag.auburn.edu/aaes/communications/highlights/fall00/images/tickone.gif

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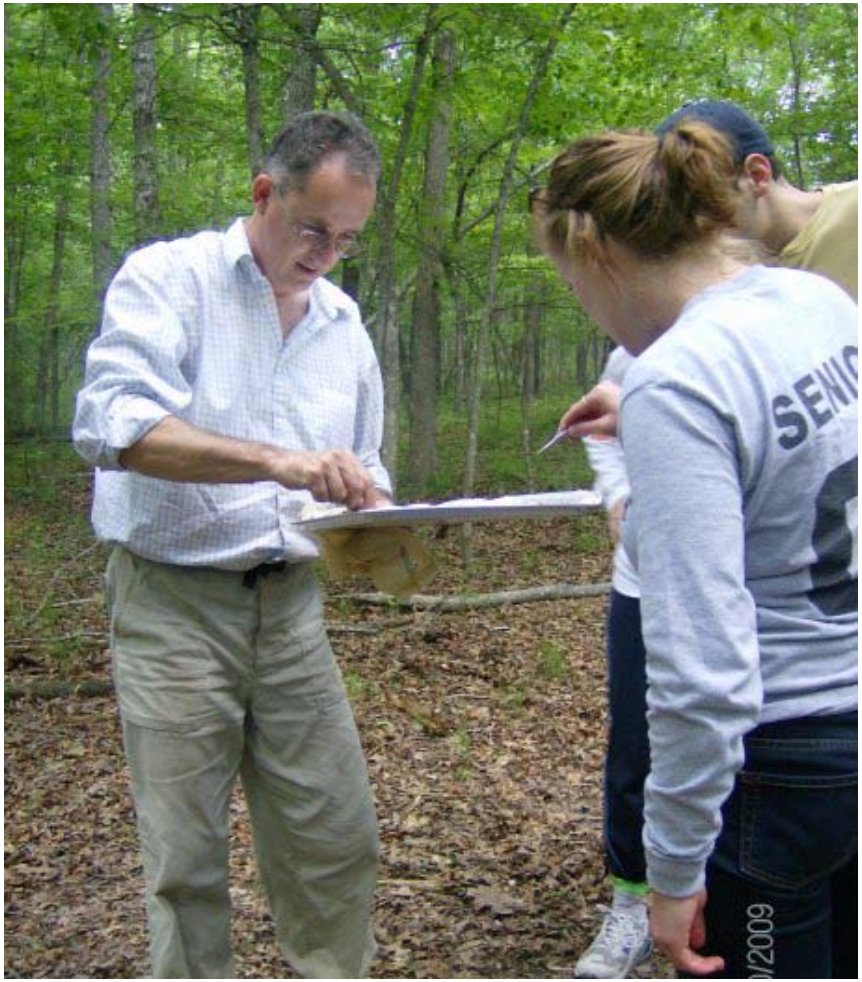
Mentors: Graham Hickling, PhD, Suzanne Lenhart, PhD,

Outline

- Goals
- Background
- Methods
- Model
- Conclusion



What's the Problem?

- Lone Star Ticks are the most common tick species in TN
- Aggressive – actively seek out & bite hosts
- All life stages can transmit diseases to humans

http://farm1.static.flickr.com/78/197572898_ddccb25d15.jpg?v=0

Goals

- To model the lifecycle of the Lone Star Tick within the Fairfield Glade (FFG) retirement community
- To determine a cost-effective layout of 4-poster feeders to reduce disease caused by Lone Star Ticks

http://www.sciencedaily.com/releases/2009/03/090328152625.htm

Background

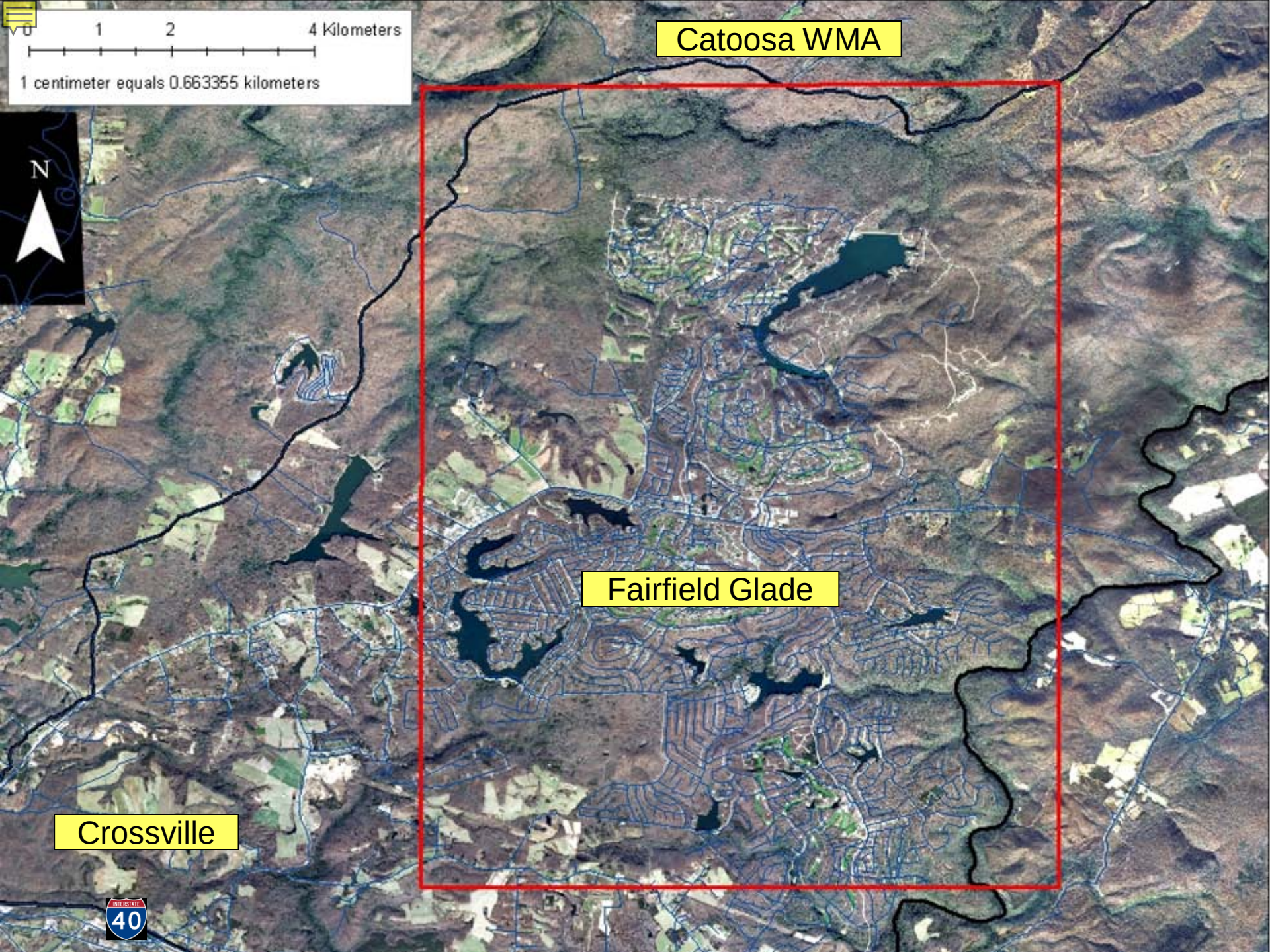
- Lone Star Ticks vector disease
- 10 pathogens isolated, *Ehrlichia chaffeensis* is the most important
- White-Tailed Deer are the ticks' natural host
- Egg →Larva → Nymph → Adult →Egg
- 3 blood meals during life cycle, usually on deer
- Spend 95% of time off host

http://www.umass.edu/umhome/images/upload/83388/tularemia_lone_star_tick-sm.jpg

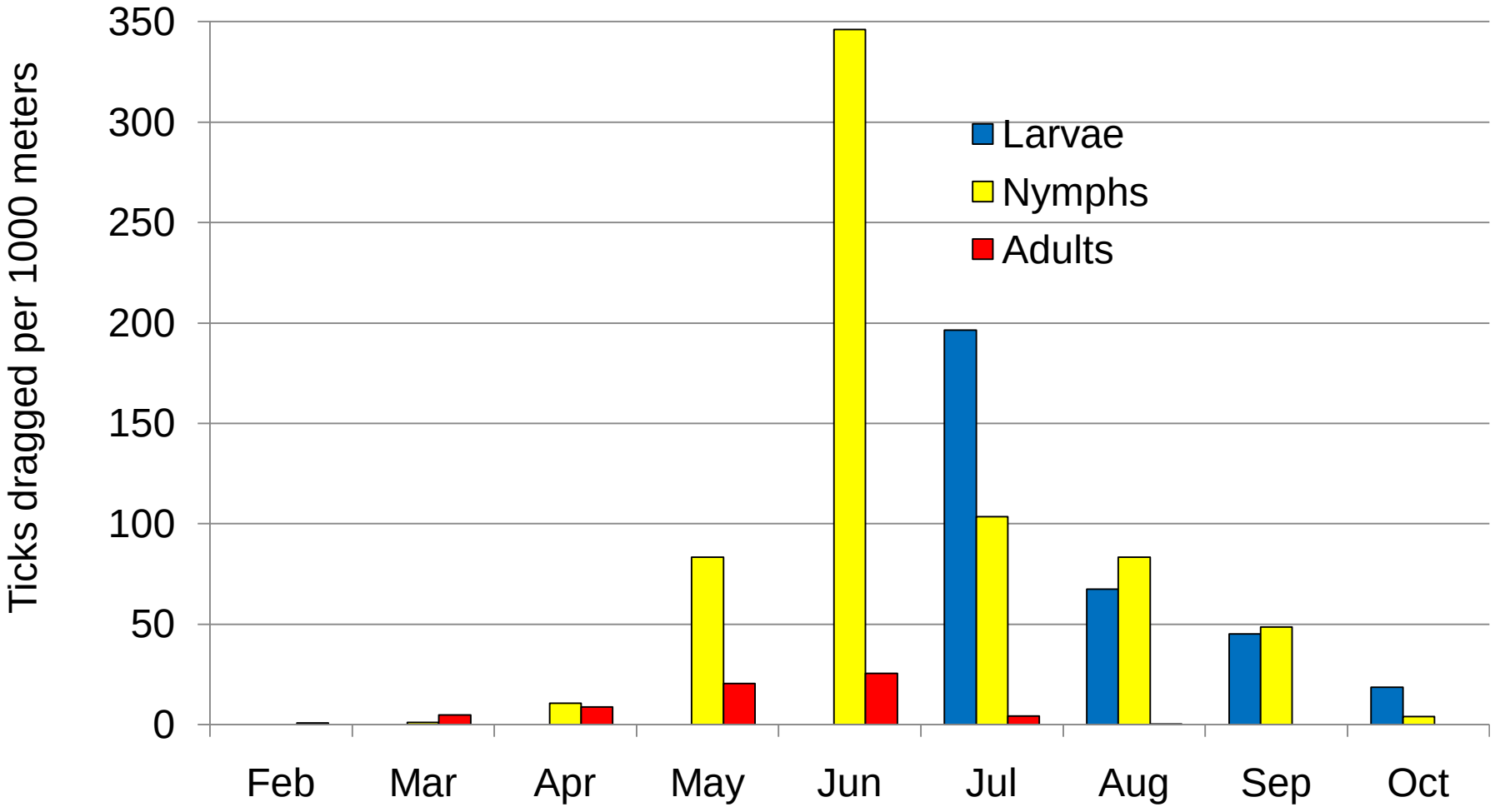
4-Poster System

- Management strategy targets ticks on deer
- Bait feeder plus acaricide
- Systemic vs. topical
- 7 - 9 feeders in use at FFG
- Cost is ~$16,000 annually
- Feeders have achieved close to 100% reduction in tick numbers at other locations
- Tick numbers remain high around FFG feeders

http://www.sciencedaily.com/releases/2009/03/090328152625.htm


0
1
2
4 Kilometers
1 centimeter equals 0.663355 kilometers
N
Catoosa WMA
Fairfield Glade
Crossville
INTERSTATE
40

Monthly Lone Star Tick Rates



Methods

- Discrete Time Model of *A. americanum* in FFG
- Based on 7 life stages
- Using MATLAB to run a simulation model for 4 years
- Monthly time step begins in April
- Overwintering of unfed nymphs & unfed adults
- Eggs laid by overwintering fed adult population
- Compare to field data collected at FFG

Model Coefficients and Rates

- Obtained from Haile and Mount (1987) "Computer Simulation of Population Dynamics of the Lone Star Tick, *Amblyomma americanum*" – some were adjusted to fit the Fairfield Glade data.
- Mortality and host-finding rates based on temperature and humidity
- Sex ratio of 1:1
- Females lay 5,000 eggs

Temporal Component of Model

Assumptions:

- Eggs, unfed adults, and unfed nymphs start each year
- 52% of laid eggs hatch in 2 months
- Disease risk is assumed to be correlated with tick numbers
- Constant deer population

Features:

- Host Finding and Mortality Rates
- Seven stages: eggs, unfed larvae, fed larvae, unfed nymphs, fed nymphs, unfed adults, fed adults

Initial Conditions:

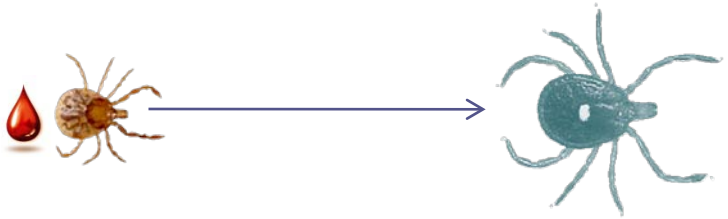
- 25,000 eggs, 150 unfed nymphs, 60 unfed adults
- Less if the area is residential

Sample Equations

- Fed Nymphs

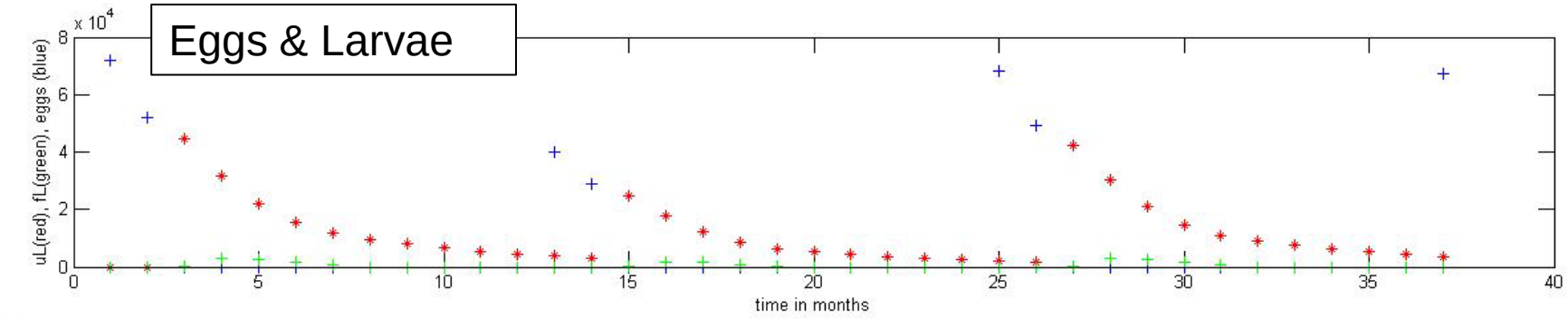
$fn(k+1) = ohsr_n * hfr_n(p) * un(k)$

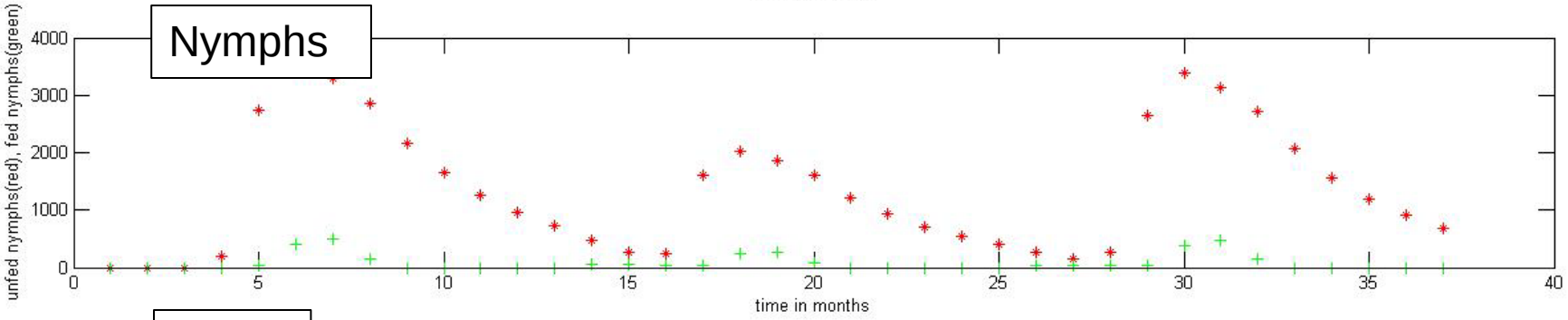
- Unfed Adults

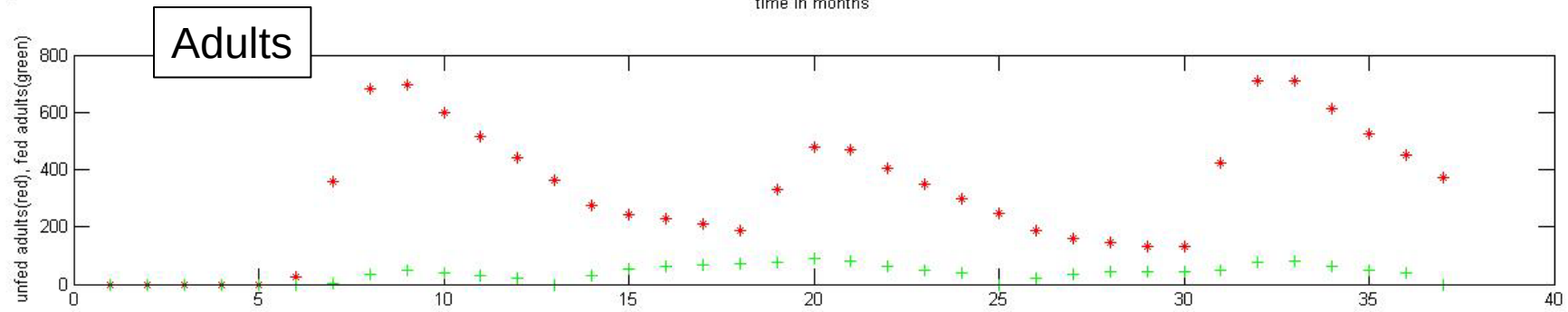


$ua(k+1) = ua(k) * (1-.14) - hfr_a(p) * ua(k) + .85 * fn(k)$

Sample Output







Time in months

Preliminary Spatial Model

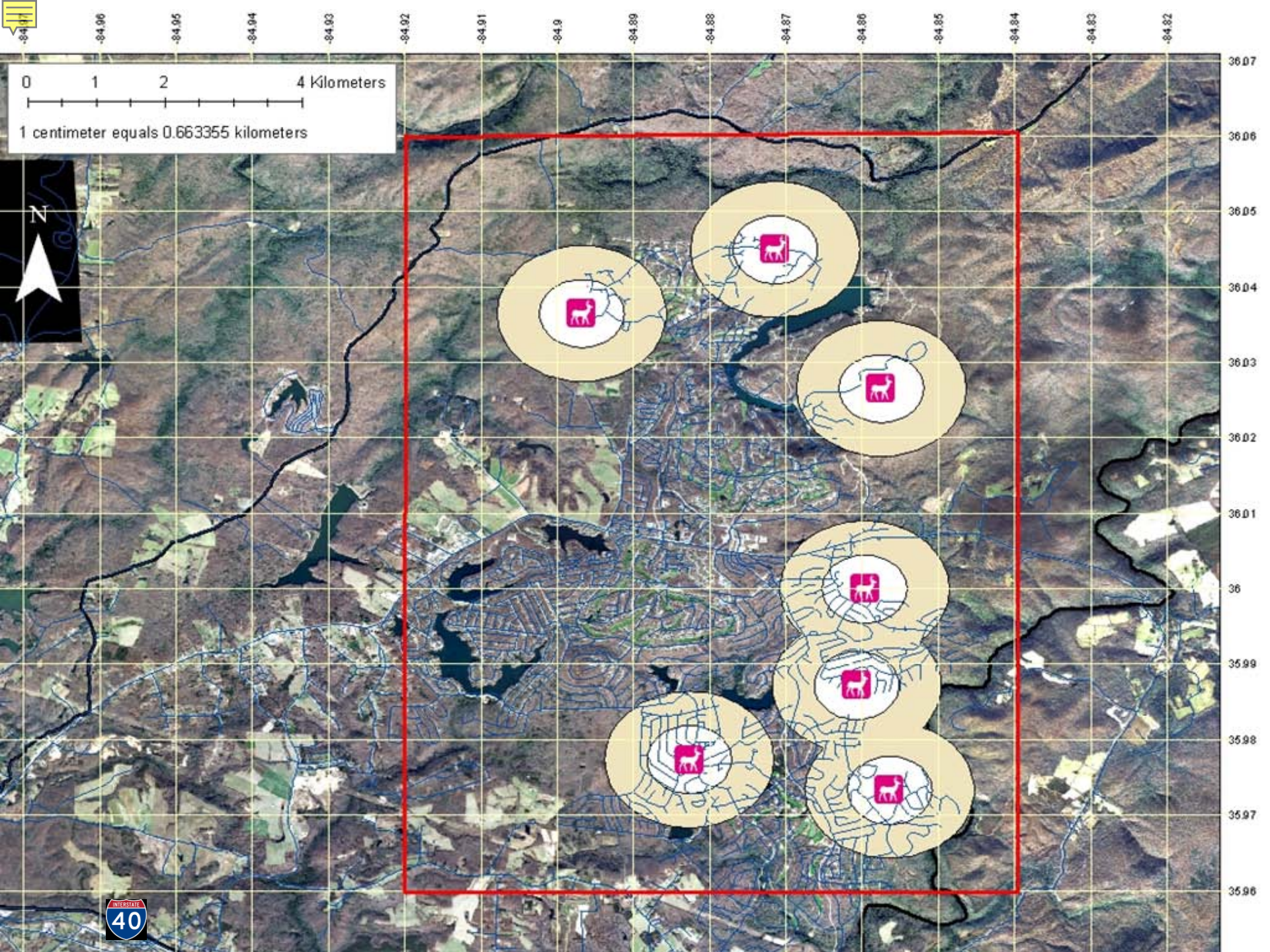
- Divide FFG into a 10 x 8 grid
- Categorize grid squares as ‘Developed’ or ‘Undeveloped’
- A tick model runs in each grid square
- A specified number of feeders, with a specified layout, are added to the grid

Feeder position affects on-host tick survival

- In each grid square position (i,j):
- Area Type affects initial conditions, Developed and Undeveloped.
- Feeder proximity affects on-host survival rate (nearby, in square, or none).

RESULT:

(i,j) **D**	D	**0%** U
D	U	50% U
U	U	95% U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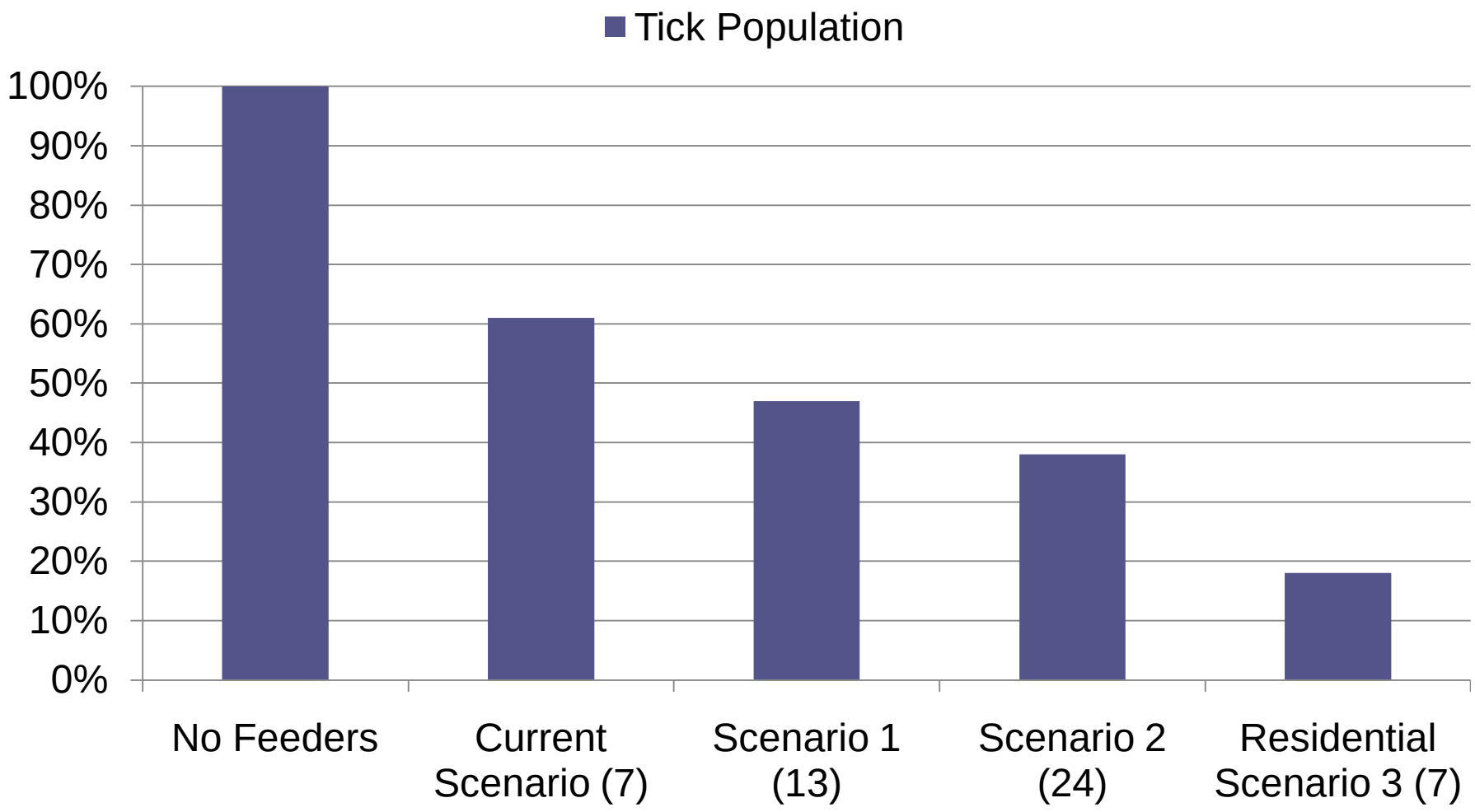
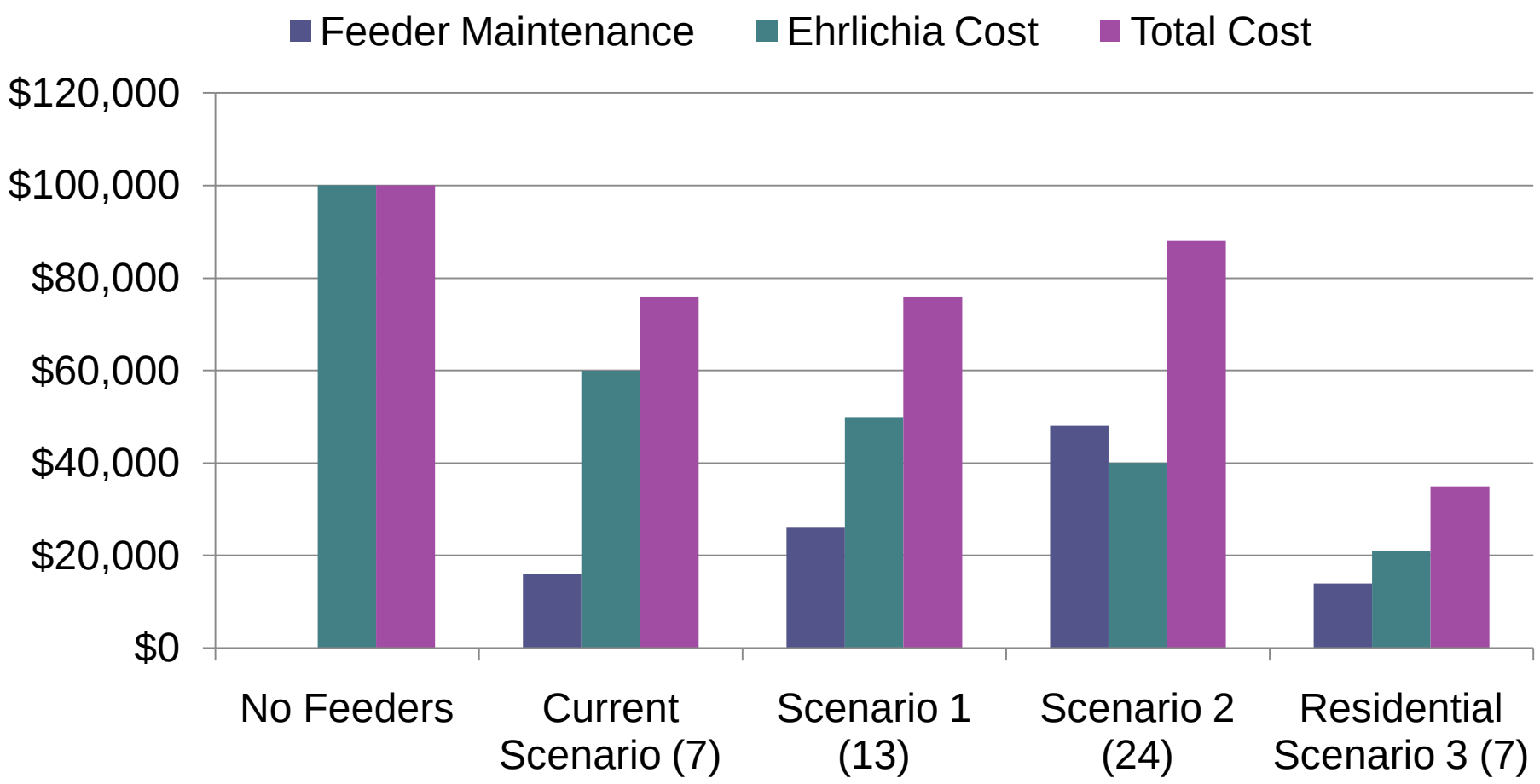
36.01
36
35.99
35.98
35.97
35.96
0 1 2 4 Kilometers
1 centimeter equals 0.663355 kilometers
N
INTERSTATE
40

Four Scenarios - Modeled Effect of Feeder Number on %Tick Population



Scenario Analysis



Conclusions

- Practical objective of making tick management suggestions to FFG
- First goal was to understand the biology to build a discrete time model
- Second goal was to construct a spatial & temporal model to assist with assessing cost-effective efficient layouts for the 4-posters
- Reducing tick numbers may help to prevent future Ehrlichiosis outbreaks
- Completed a small number of scenario analyses
- Aim to investigate the full optimization problem

Acknowledgements

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