# Modeling the Dispersal of Adult Stoneflies

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Philadelphia's waterways are highly urbanized

Presently, freshwater EPT macroinvertebrate indicators (Mayflies, Caddisflies and Stoneflies) are largely absent

Restoration projects by PWD aim to restore quality, habitat, etc. of streams

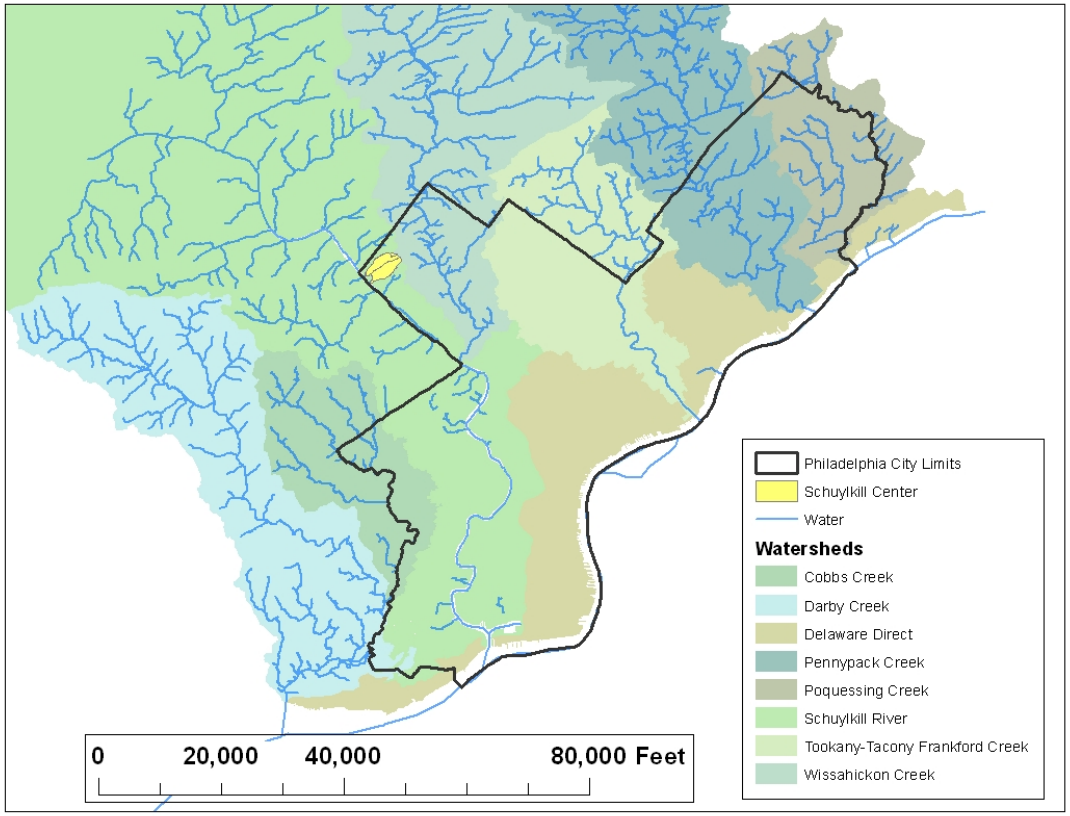
The presence or absence of pollution sensitive insects can be used to measure restoration success

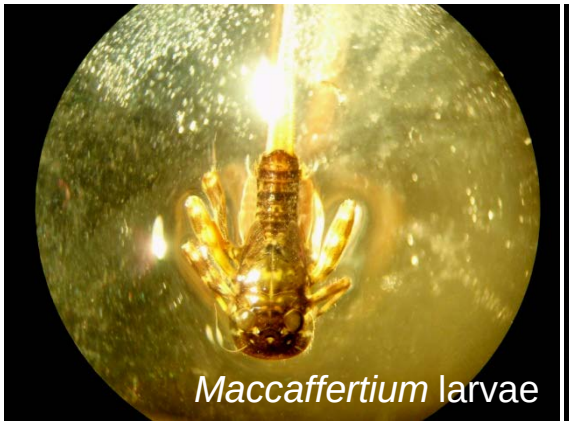
The Philadelphia stream network is greatly reduced, generally lacking headwater streams

The degree of habitat segmentation may prevent recolonization through passive downstream drift of aquatic larvae

Recolonization may depend on overland flight of adult macroinvertebrates

Can these freshwater indicator species be expected to recolonize Philadelphia?




# Primary Research Goals

1) Measure rates of overland dispersal through trapping adult EPT at Schuylkill Center for Environmental Education

2) Develop and calibrate a predictive model for adult EPT dispersal

3) Estimate probability of EPT recolonization to guide post restoration monitoring programs

**Schuylkill Center for Environmental Education**

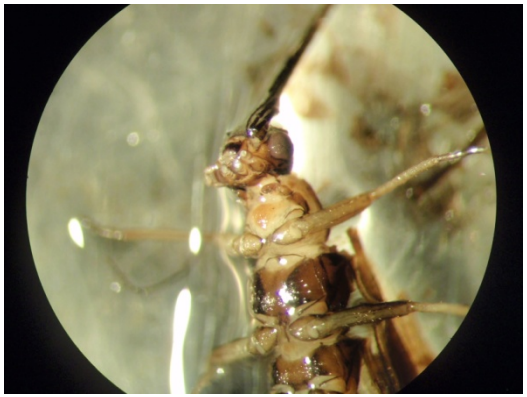
- 6 sticky traps (2 ft by 2 ft) installed laterally from Meig's Run to trap flying EPT adults

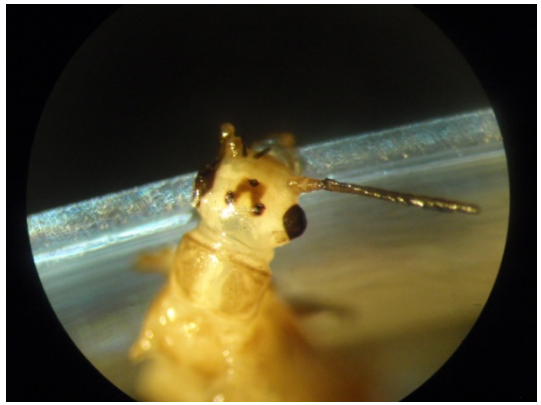
- Specimens collected every two weeks for a period of 10 months

- 712 EPT specimens collected; 13 taxa

**Caddisflies**

*Diplectrona modesta*
*Dolophilodes distincta*
*Neophylax mitchelli*
*Rhyacophila invaria*



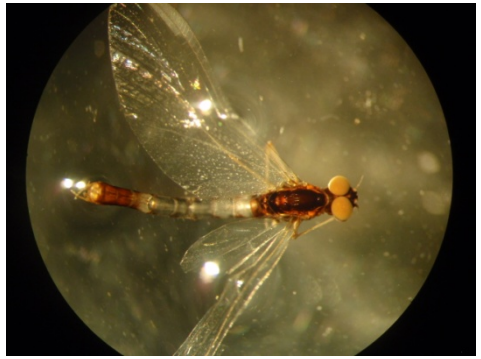


**Stoneflies**

*Allocapnia recta*
*Amphinemura nigritta*
*Isoperla holochlora*
*Leuctra ferruginea*
*Leuctra variabilis*
*Prostioa similis*

**Mayflies**

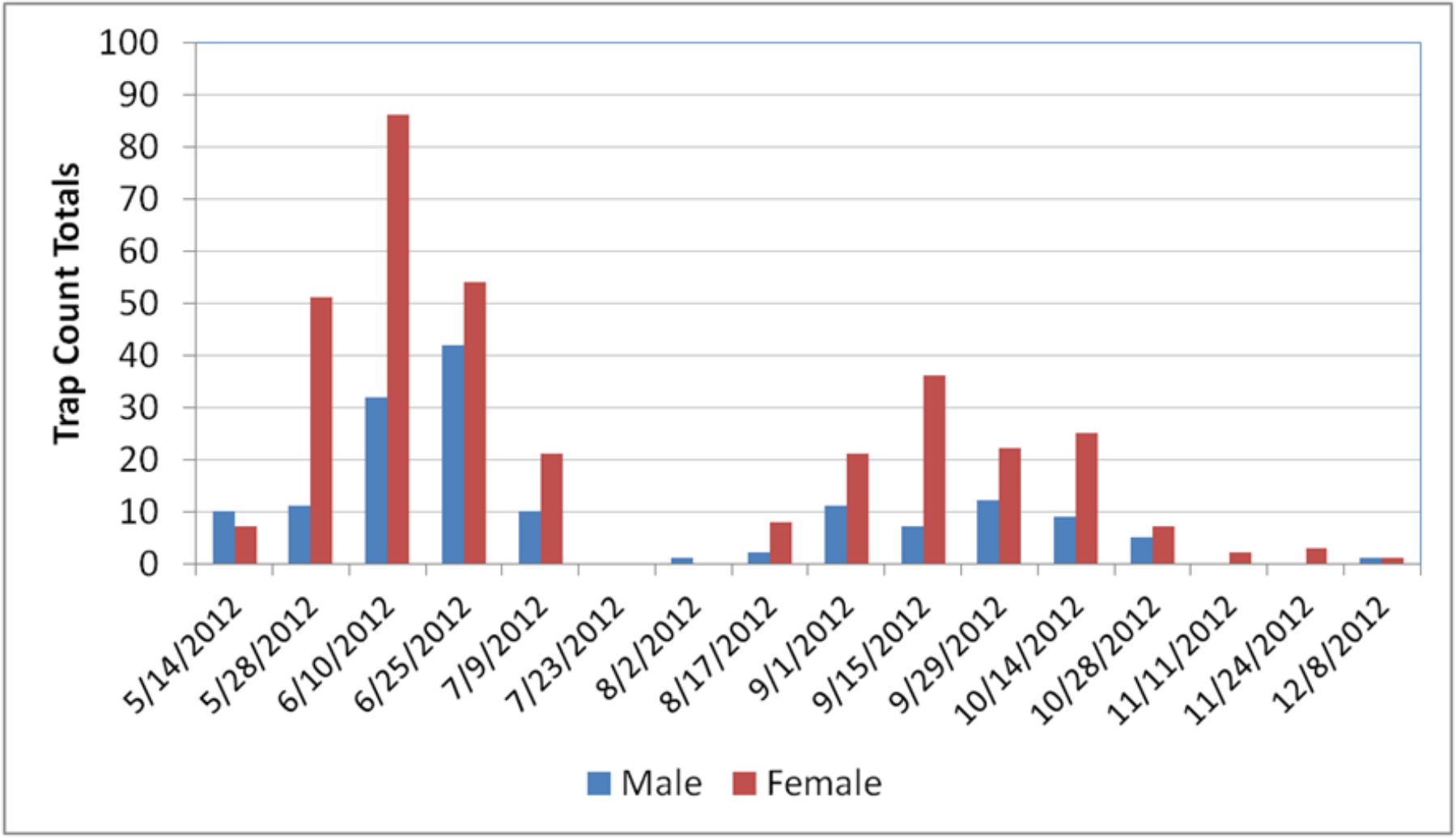
*Maccafertium puticum*
*Paraleptophlebia debilis*
*Paraleptophlebia guttata*



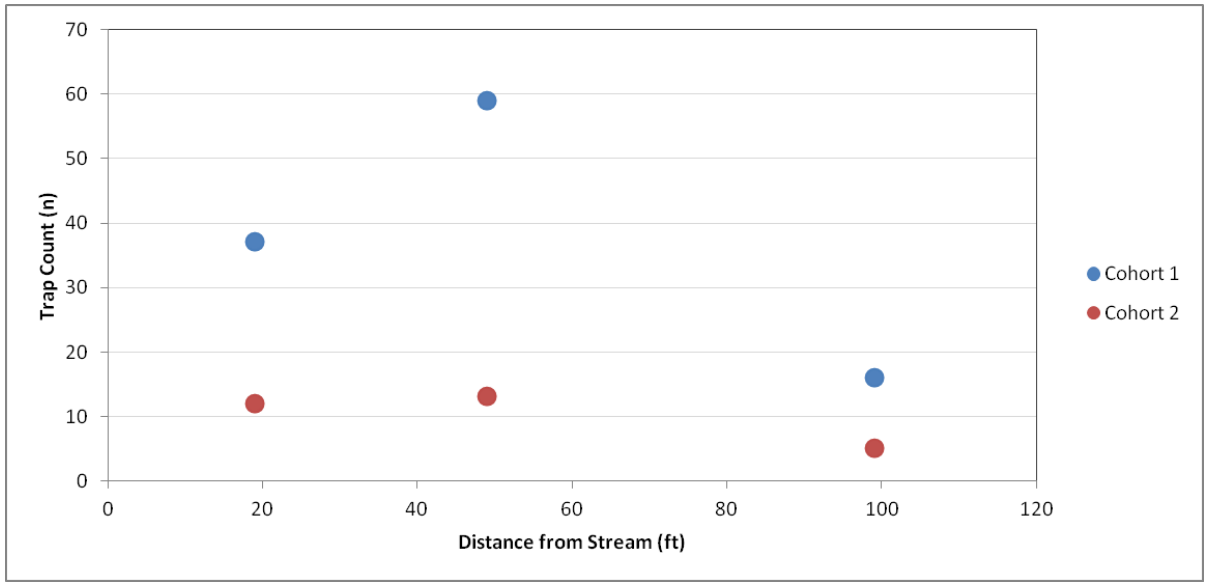
*Leuctra ferruginea*

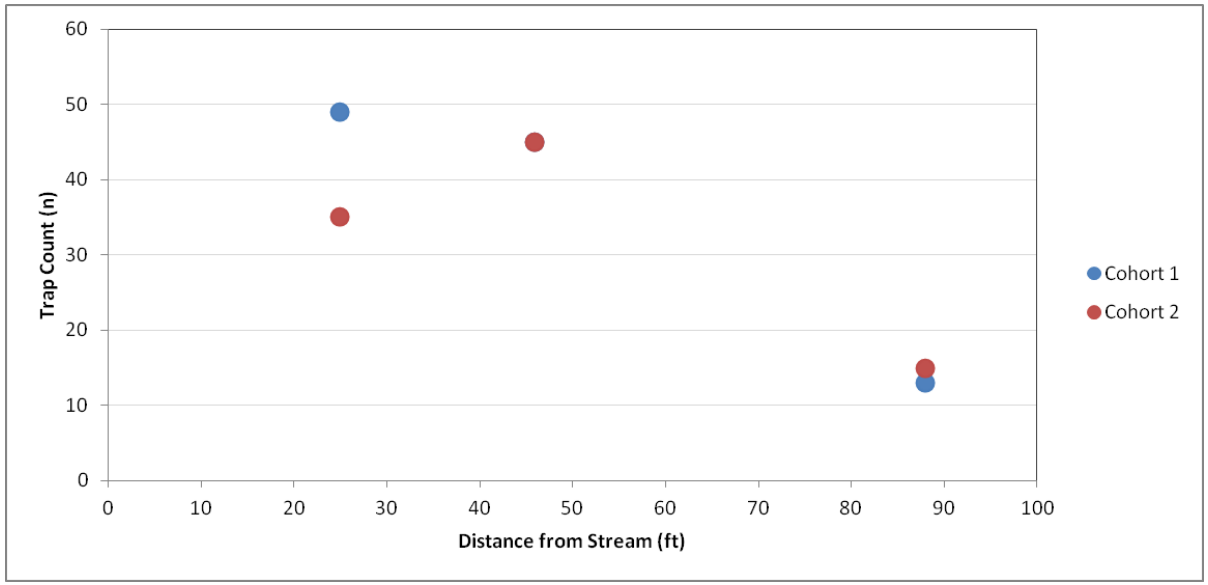
- Most abundant, 512 specimens collected
- Univoltine life cycle, two distinct cohorts
- Strong lateral dispersal observed
- Selected as study specimen to model adult dispersal

# Observed *L. Ferruginea* Emergence



# Regression Against Distance from Stream




-A trend of decreasing *L. ferruginea* density from stream is observed at each location

-Regression analysis does little to explain further dispersal distances

- Trap counts cannot be considered independently measured quantities

- More sophisticated analysis will improve dispersal and recolonization estimates

# Analysis of Field Obs; Review of Models

Models of Insect Flight in Existing Literature Reviewed

- Linear regressions (Petersen, 2009;
- Model relating number of insects to distance and time (Freeman 1977)
- ArcGIS based deterministic Cauchy diffusion model (Mayer, 1999)
- Individual Insect Based Random Walk Model (Petrovskii, 2011; Walters, 2006)

*Random Walk Model* chosen as starting point (Petrovskii et al, 2011)

- Stochastic approach to modeling stonefly behavior
- Easily simulates the trapping of insects, allows for validation with field data
- Relies on estimates of individual behavior rather than broad estimates about population behavior
- Allows greatest flexibility for testing of ecological hypothesis
- Originally designed to model aphids, a crawling terrestrial insect

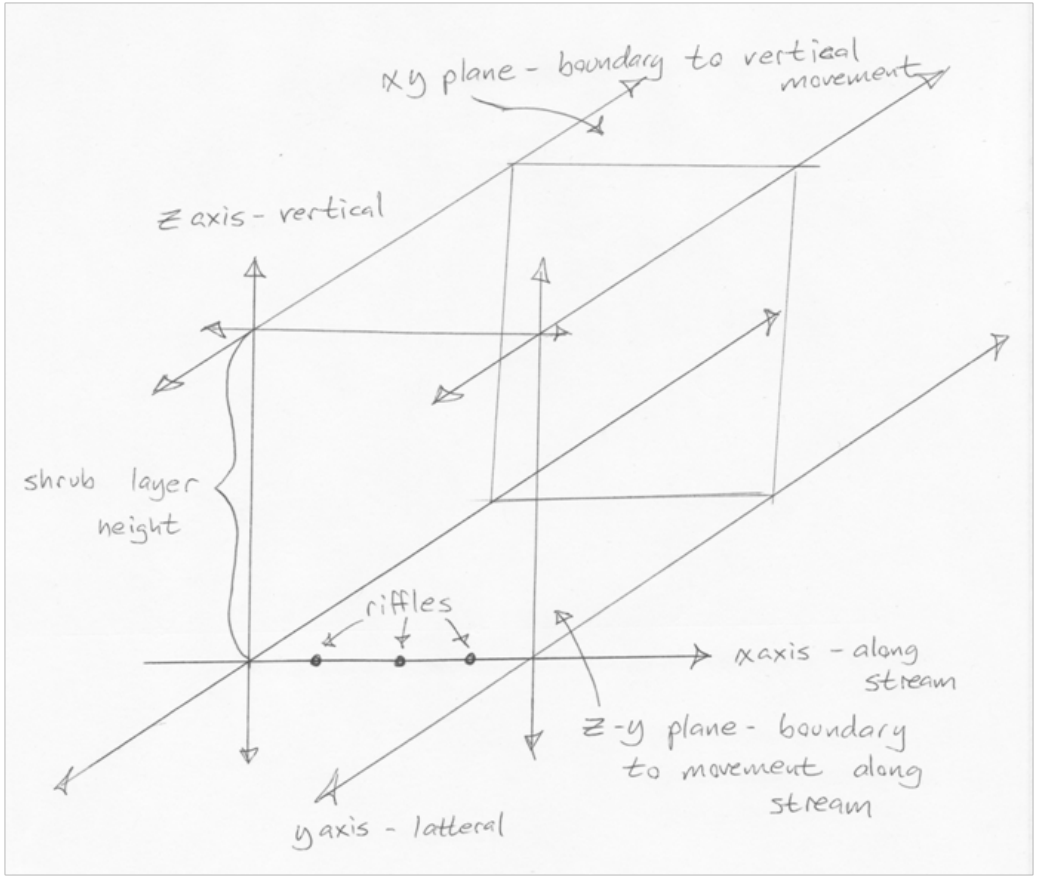
# Proposed Modifications for Stonefly Dispersal

-Third dimension added to simulate flying insects

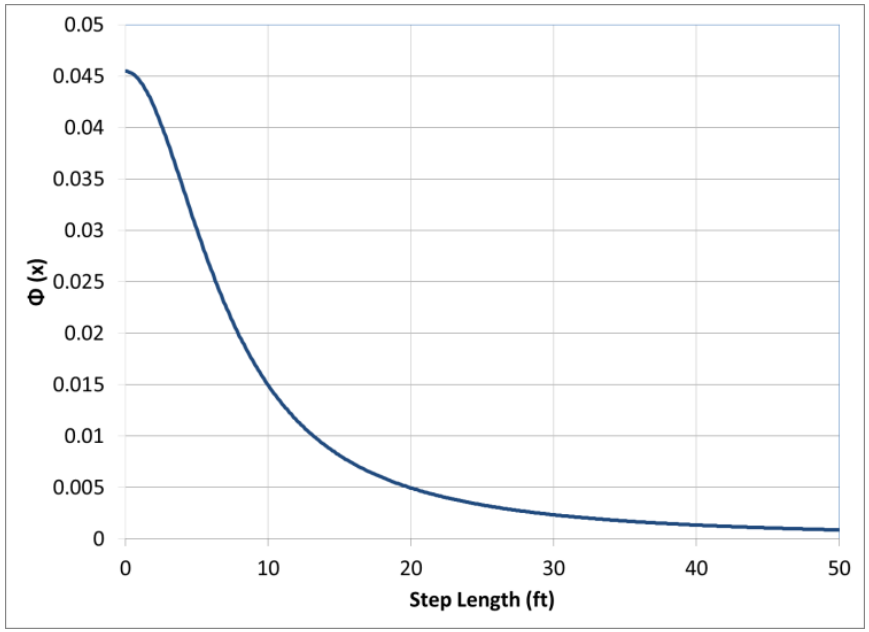
- Reflective boundaries added to reduce computational demand

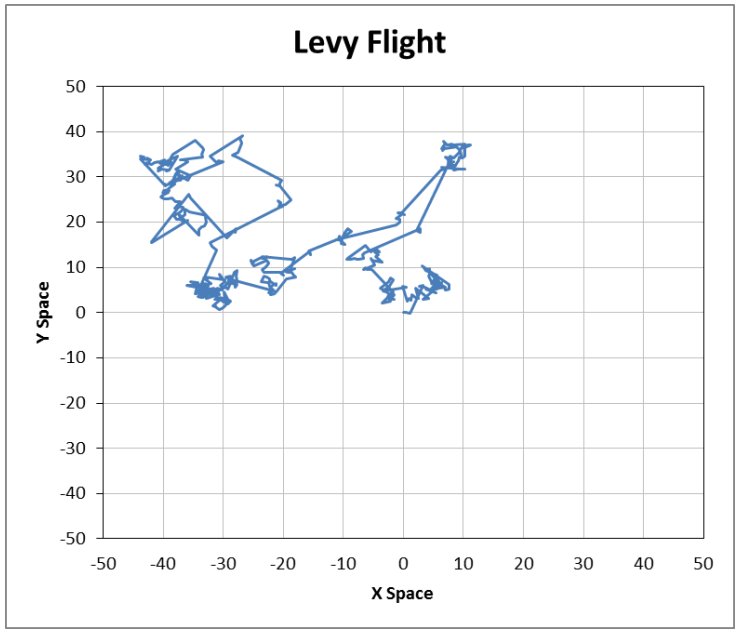
-Solution technique rewritten; numerically identical to solution proposed by Petrovskii etal (2011)

- Various mechanisms for behavior tested against observed trap counts (brownian motion, levy flight, etc)



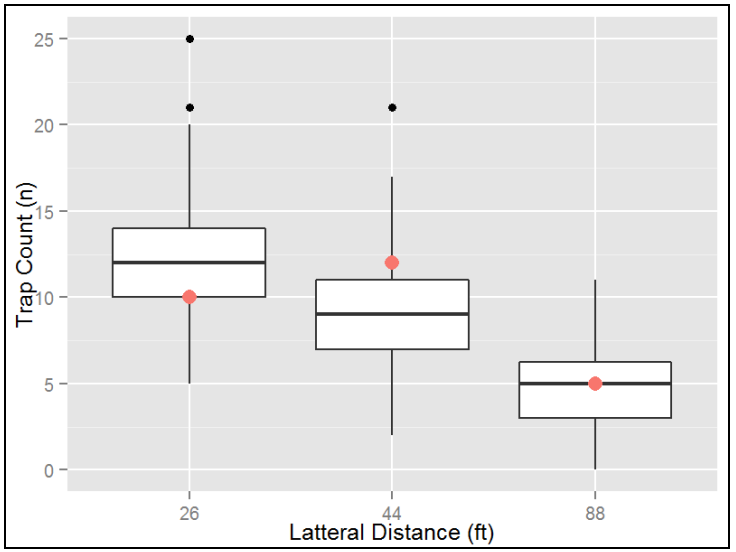
# Levy Flight Random Walk Model

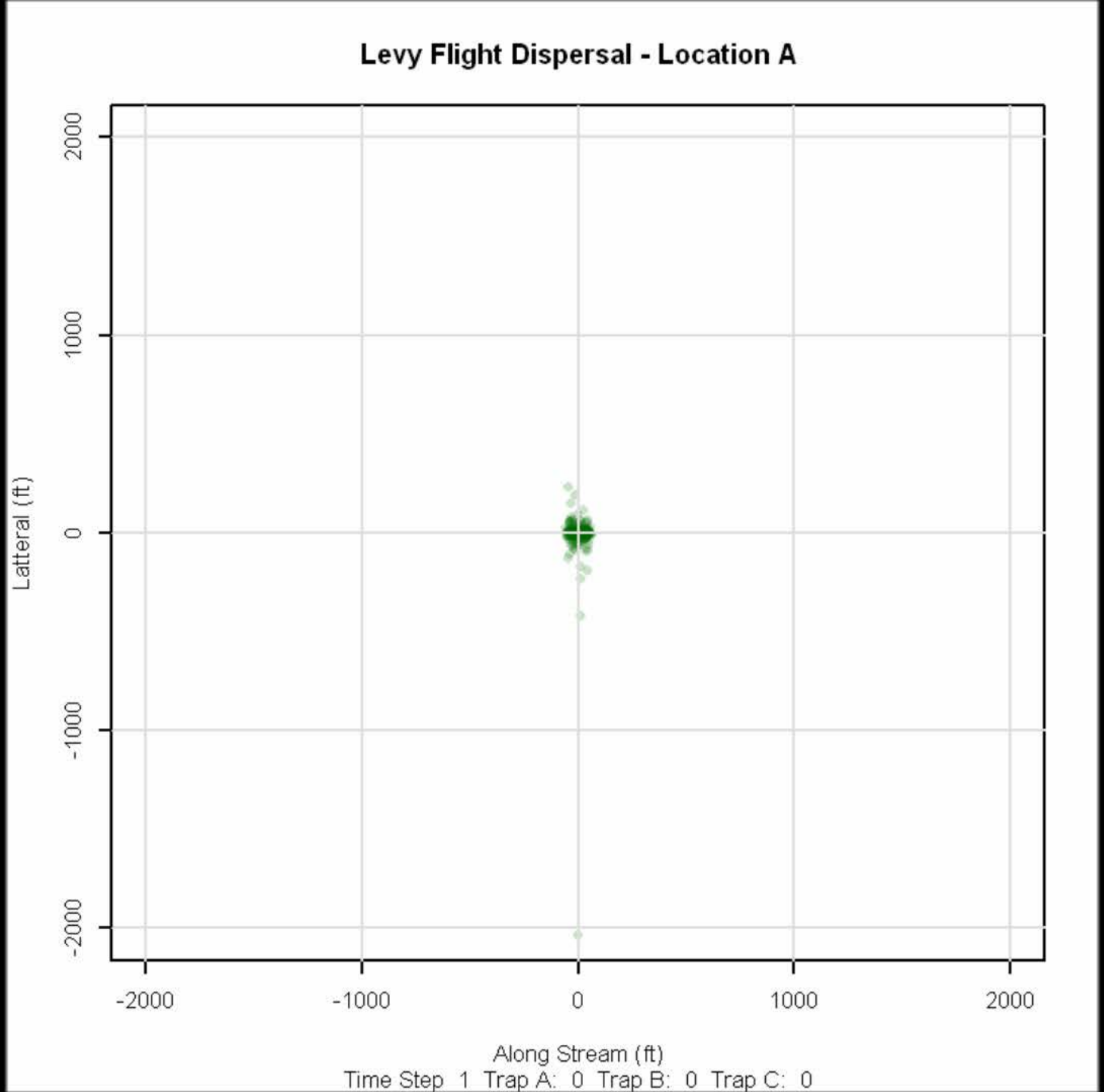


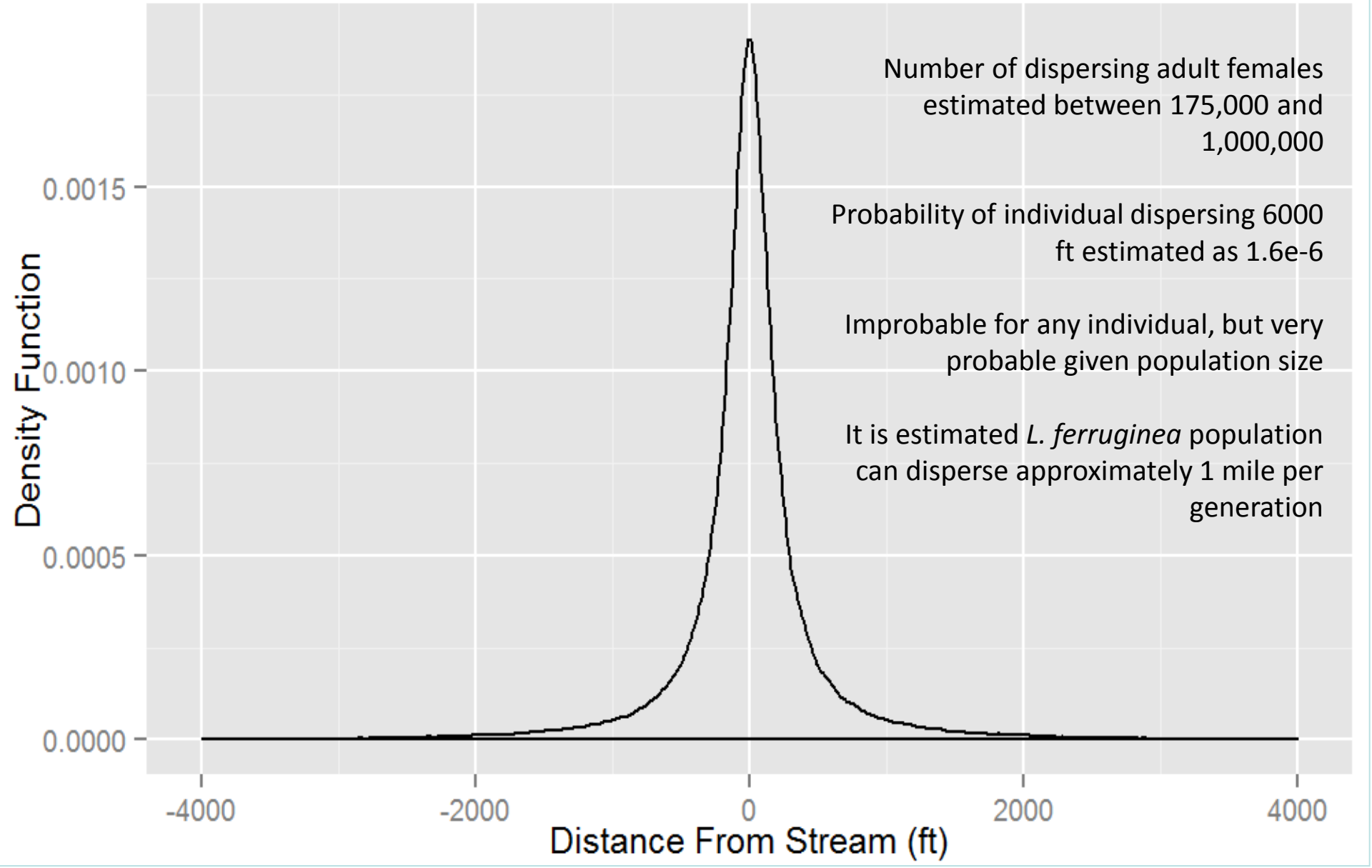




Levy Flight provides best match to field observations of all theoretical random walks evaluated

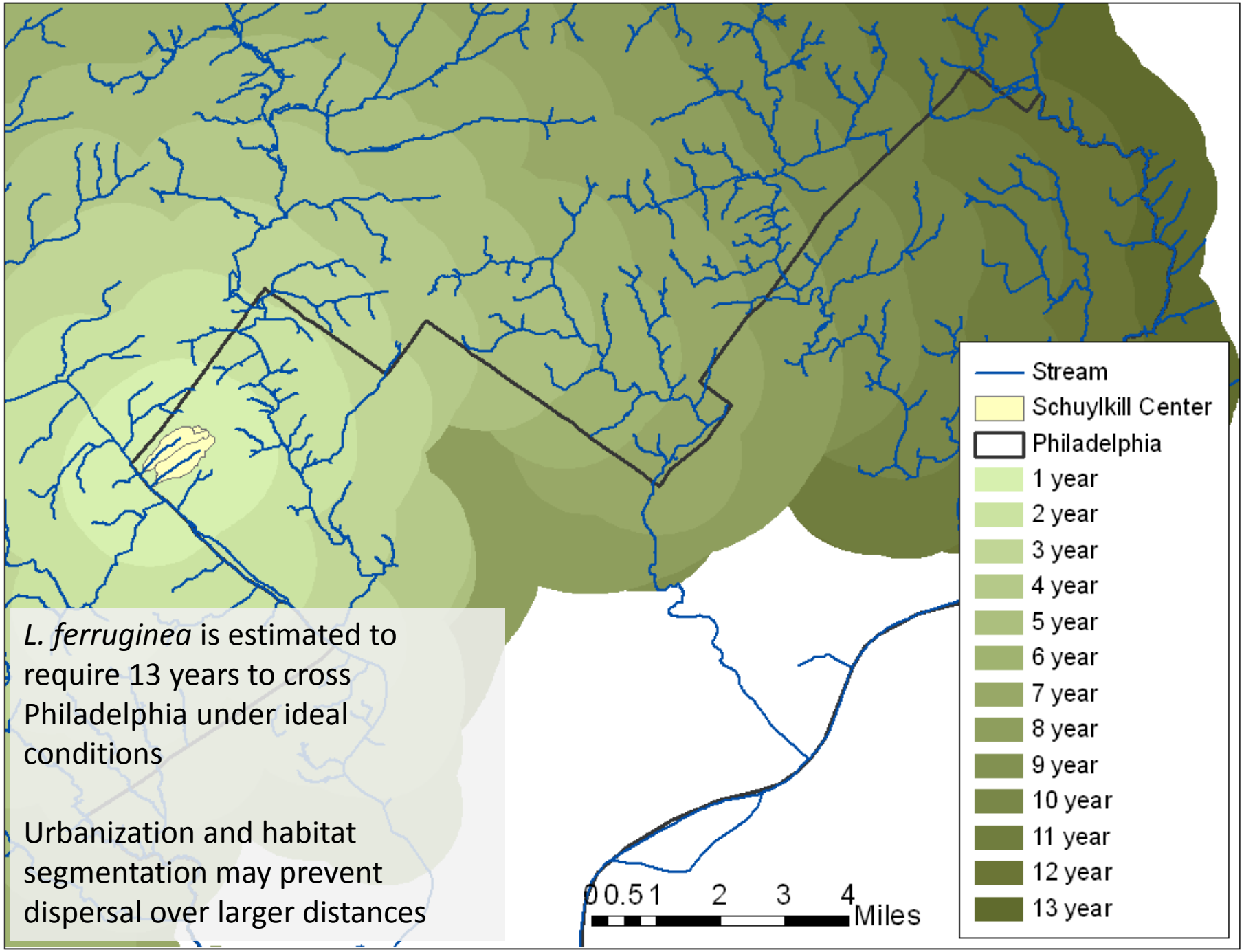
Levy Flight behavior suggests stonefly movement is a specialized trait to optimize search efficiency




Levy Flight Dispersal - Location A
2000
1000
0
-1000
-2000
Latteral (ft)
-2000
-1000
0
1000
2000
Along Stream (ft)
Time Step 1 Trap A: 0 Trap B: 0 Trap C: 0




Model derived estimate of lateral dispersal behavior of *L. ferruginea*




*L. ferruginea* is estimated to require 13 years to cross Philadelphia under ideal conditions

Urbanization and habitat segmentation may prevent dispersal over larger distances

# Conclusions

Individual insect based random walk simulations are useful in predicting the dispersal of adult EPT insects

Overland dispersal by adult *L. Ferruginea* may be a viable pathway for recolonization of restored waterways

“Field of dreams” hypothesis (Palmer et al, 1997) of stream restoration not always a safe assumption

EPA recommended 5 year post restoration monitoring program for wetlands may not be a valid restoration template within Philadelphia

Local conditions such as EPT population density and habitat segmentation must be considered when developing in stream biomonitoring programs

# Acknowledgements

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