

**A Multi-disciplinary Approach to  
Modeling the Impacts of Land Use  
Change on Vernal Pool-breeding  
Amphibians**

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**&**

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# Problem Addressed

- Land use affects vernal pool-breeding amphibians
  - Maine's new vernal pool legislation
- Interdisciplinary issue
  - Human drivers
  - Wildlife responses
- Spatial issue
  - GIS
  - Remote sensing

# Outline

1. Motivation
2. Previous work
3. Data/Study Area
4. Economic model
5. Landscape permeability model
6. Summary/Conclusions
7. Future work

# Motivation

- Land use – wildlife interactions
- Spatially explicit economic models of land conversion
- Spatially explicit landscape ecology models of permeability
- Maine's vernal pool legislation

# Previous Research

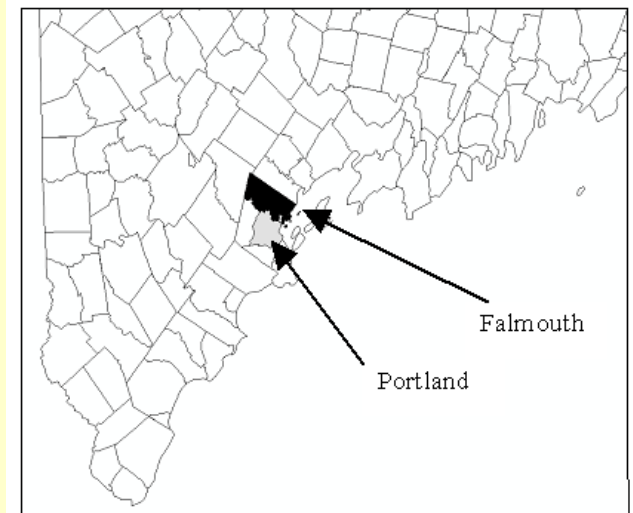
- Economics of land conversion
  - Bockstael 1996
  - Kline and Alig 1999
  - Irwin and Geoghegan 2001
  - Bell and Irwin 2002
  - Hite et al. 2003
  - Carrion-Flores and Irwin 2004
  - Newburn and Berck 2006
- Landscape permeability
  - Dunning et al. 1992
  - Schippers et al. 1996
  - Semlitsch 2000
  - Ray et al. 2002
  - Singleton et al. 2002, 2004
  - Joly et al. 2003
  - Hope et al. 2006

# Previous Research (cont.)

- Vernal pool research
  - Calhoun et al. 2003, 2005
  - Regosin et al. 2003
  - Homan et al. 2004
  - Rothermel 2004
  - Baldwin 2005; Baldwin et al. 2006
  - Bauer et al. 2005
  - Patrick et al. 2006

# Data/Study Area

- One town (Falmouth, ME)
- GIS layers:
  - 1995 parcels (n=4,089)
  - 2005 parcels (n=4,964)
  - Building footprints
  - Zoning
  - Public facilities
  - Natural resources
  - Vernal pools
- Tax Assessors' Database
- Land Cover
  - 1993 – Maine Gap Analysis (30m)
  - 2004 – Maine Land Cover Data (5m)



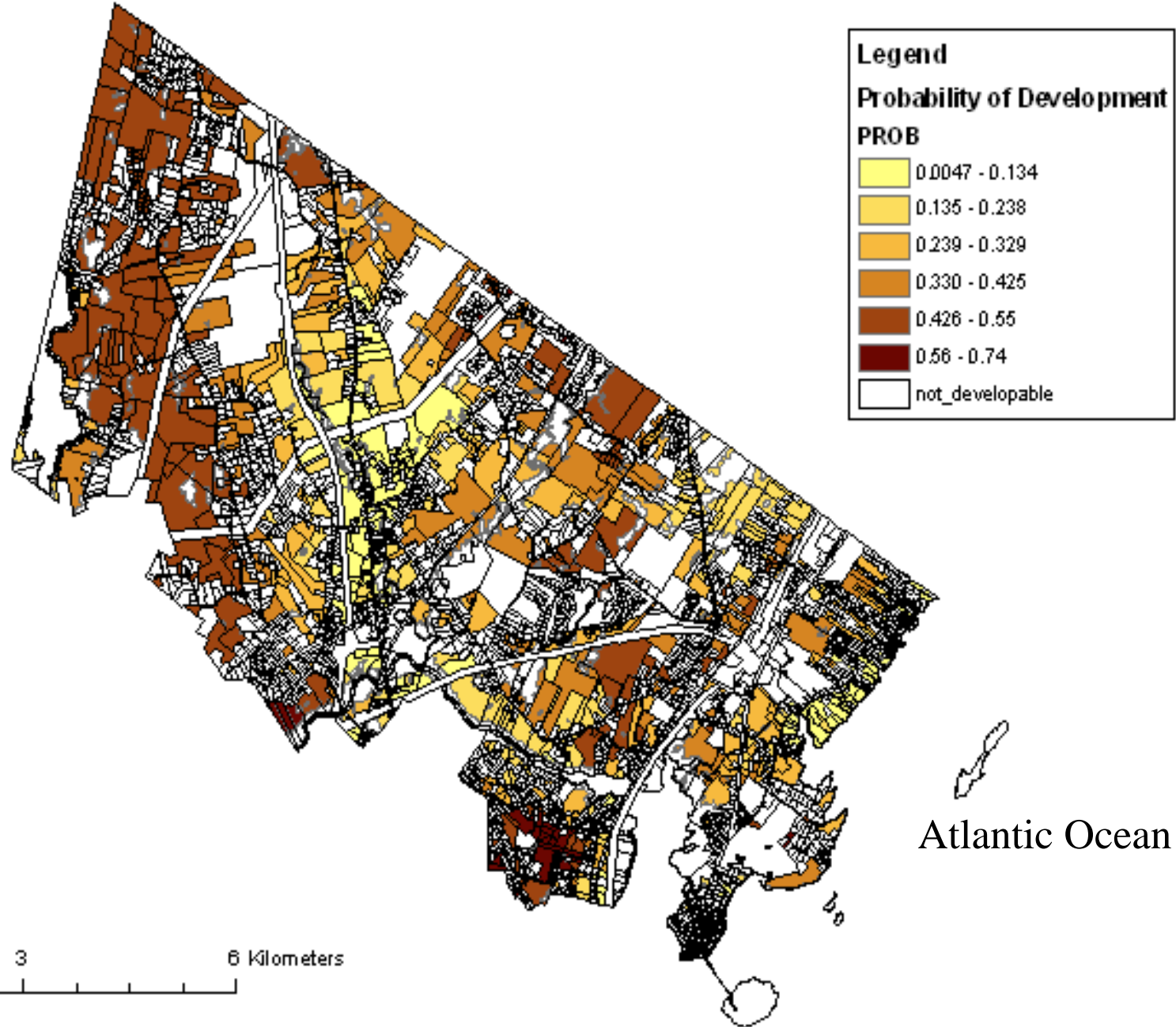
# Economic Model

- Assume return maximization (static)
- Net returns are a function of parcel attributes:
  - Proximity to (dis)amenities (e.g. coast, I-95...)
  - Costs of development (steep, hydric soils, ...)
  - Neighboring land use (ag, forest, developed, ...)
  - Local regulations (zoning, minimum lot size, ...)
- Binary logit model of conversion to residential use
- Predict future probabilities of conversion

# Results of Economic Model

VARIABLE	COEFFICIENT	STD. ERROR	P-VALUE	MARGINAL EFFECTS
INTERCEPT	-0.607	2.587	0.815	-0.124
SEWER1500	0.991	0.190	0.000	0.208
MINLOTSIZE	1.74E-05	4.01E-06	0.000	0.000
AG500	0.022	0.005	0.000	0.005
DEV100	-0.014	0.006	0.021	-0.003
DEV1_500	0.028	0.011	0.009	0.006
LOGDPORT	-1.51	0.302	0.000	-0.309
LOGDMJRD	0.429	0.084	0.000	0.088
LOGDCOAS	0.528	0.089	0.000	0.108
LOGDVMU	0.589	0.116	0.000	0.120
N = 1,435				
Log Likelihood = -775.28				
Restricted log likelihood = -912.47				
AIC = 1.094				

# Predicted Probability of Future Development



0 1.5 3 6 Kilometers

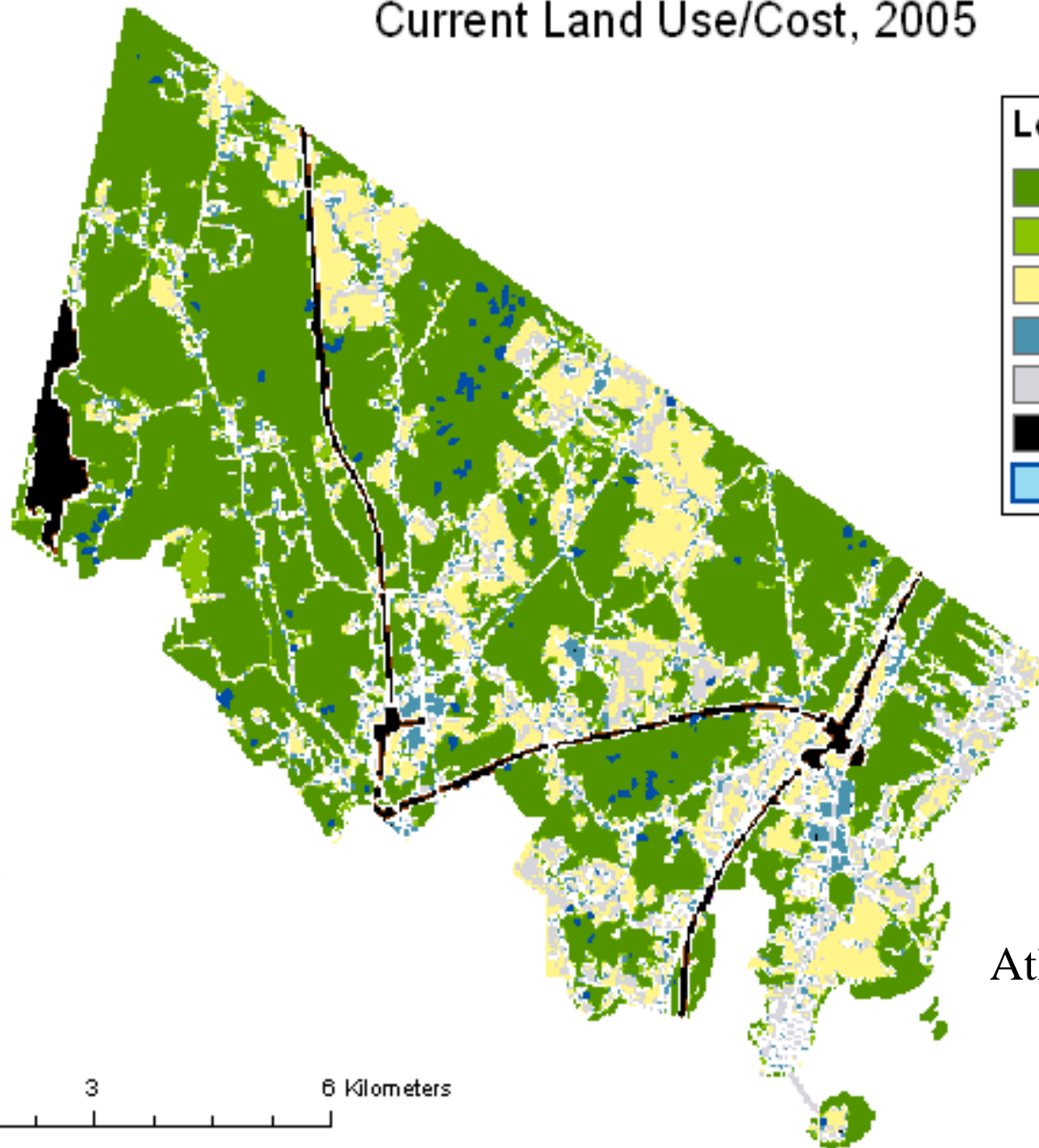
# Landscape Permeability Model

- Raster land cover image (MELCD 2004)
- Assign “cost” value to each cover/habitat type (cost of traveling across cell)
- Maximum dispersal distance of focal species (wood frog, *Rana sylvatica*)
- GIS “Cost Distance” function



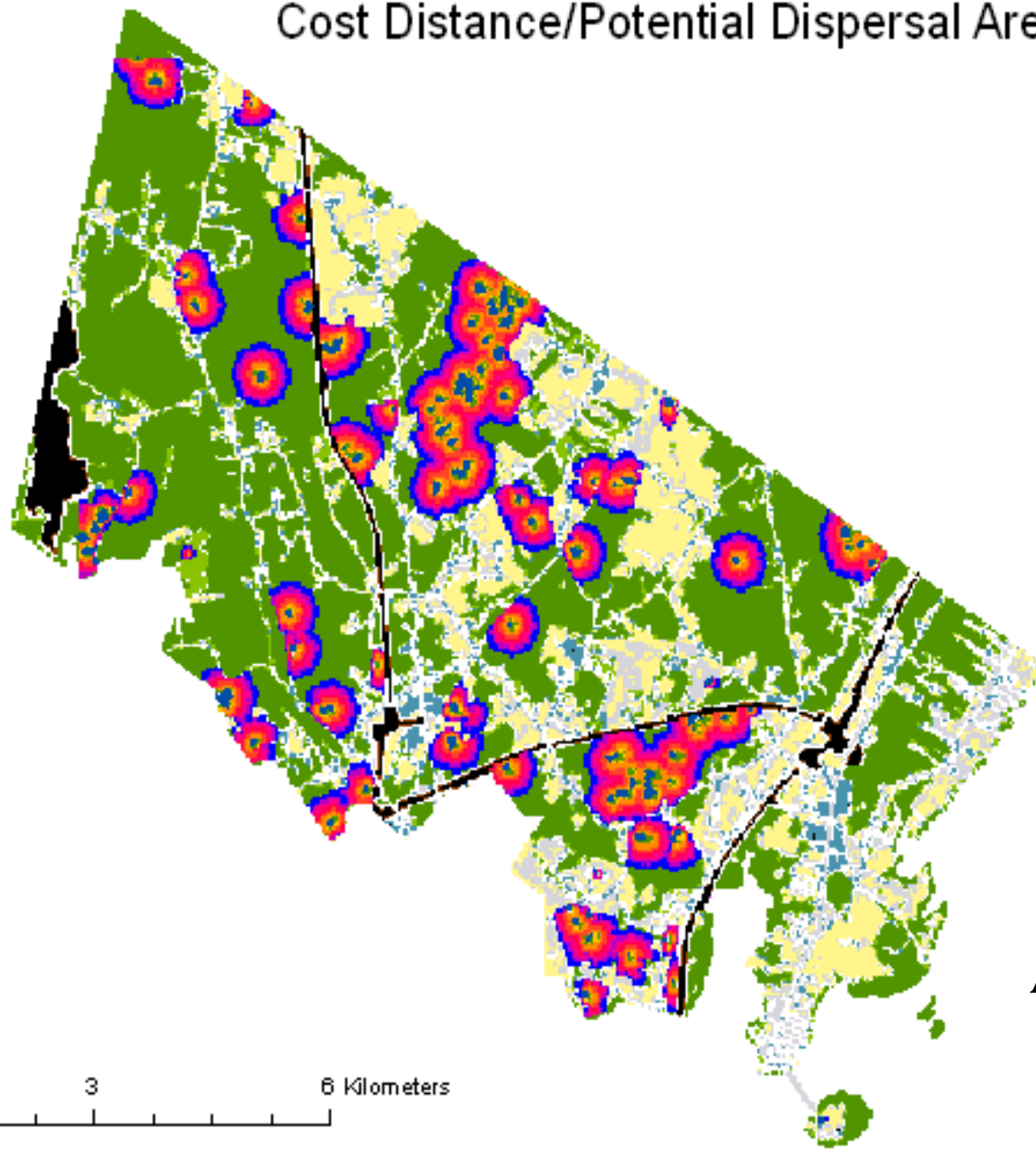
Photo credit: [http://www.nae.usace.army.mil/recreati/uvd/UVD\\_amphibians/uvdwoodfrog.html](http://www.nae.usace.army.mil/recreati/uvd/UVD_amphibians/uvdwoodfrog.html)

# Current Land Use/Cost, 2005




Atlantic Ocean


# Cost Distance/Potential Dispersal Area





**Legend**


 Vernal Pools


**cos\_dis\_curr**  
**COST DISTANCE**


 0 - 184


 185 - 351

 352 - 511

 512 - 669

 670 - 827

 828 - 984

 985 - 1,141



0 1.5 3 6 Kilometers

Atlantic Ocean

# Two Future Scenarios

(3 in paper)

## 1. Baseline Scenario

- Current zoning, 250 foot vernal pool buffer

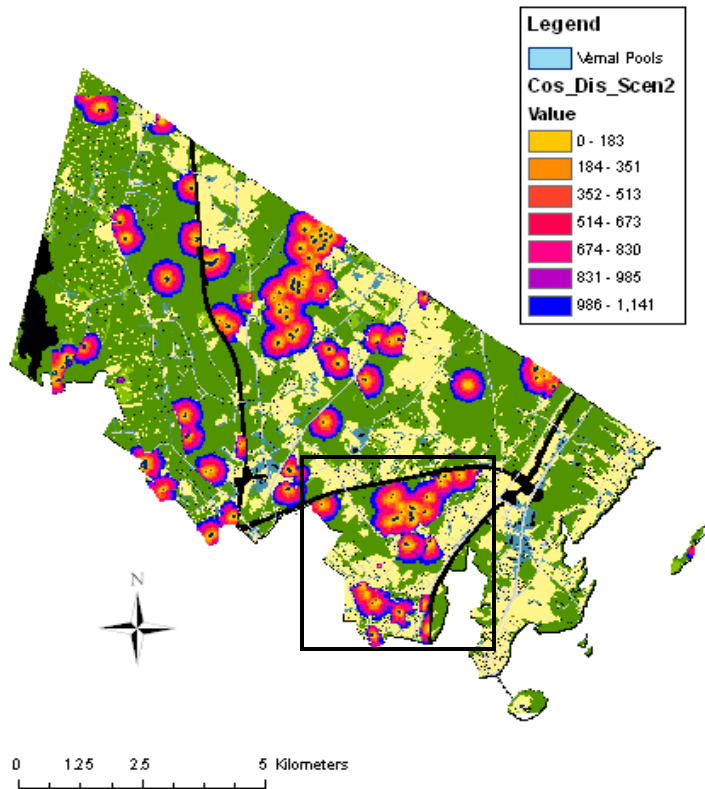
## 2. Conservation Scenario

- Current zoning, Best Development Practices (Calhoun, et al. 2005) around vernal pools
  - 250 foot buffer, <25% disturbance within 750 ft.

# Landscape Permeability

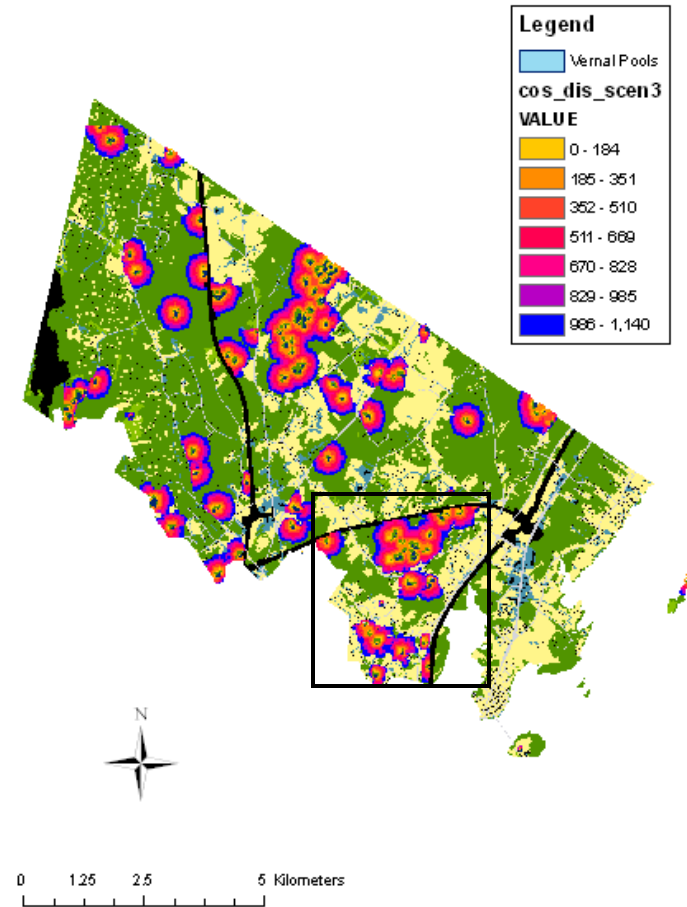
## Baseline Scenario

Cost distance to vernal pools, Scenario 2  
max. dispersal distance = 1141 ft. (340 m)



## Conservation Scenario

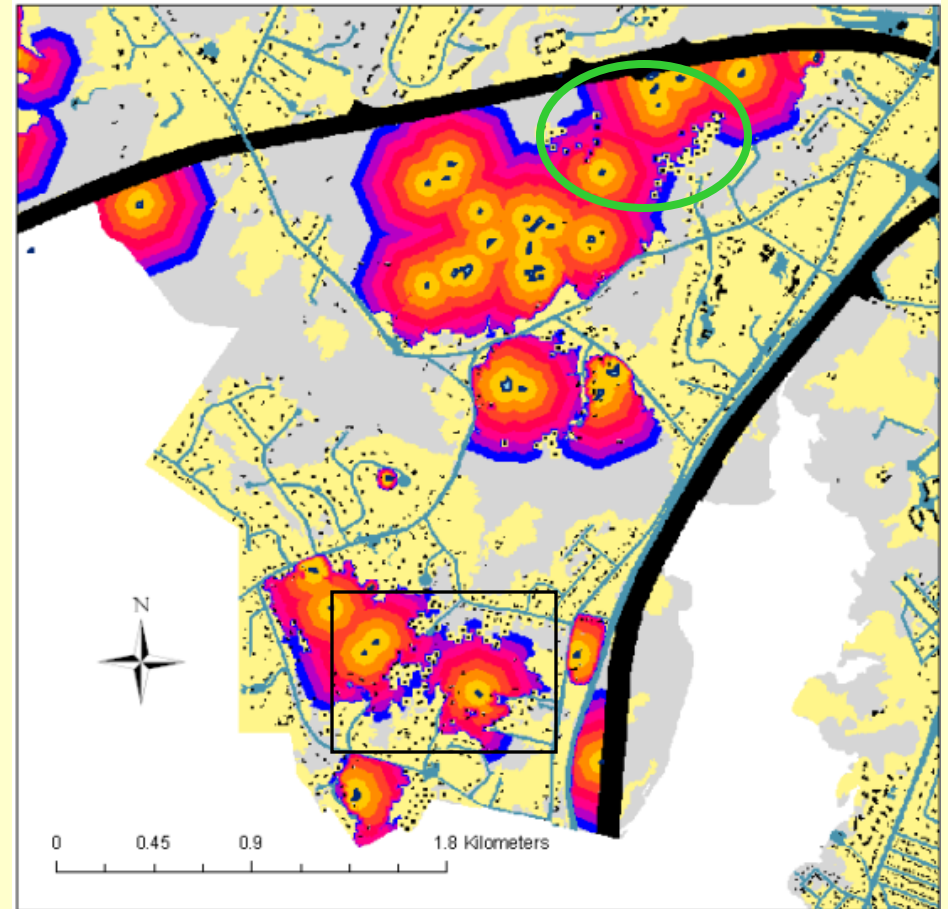
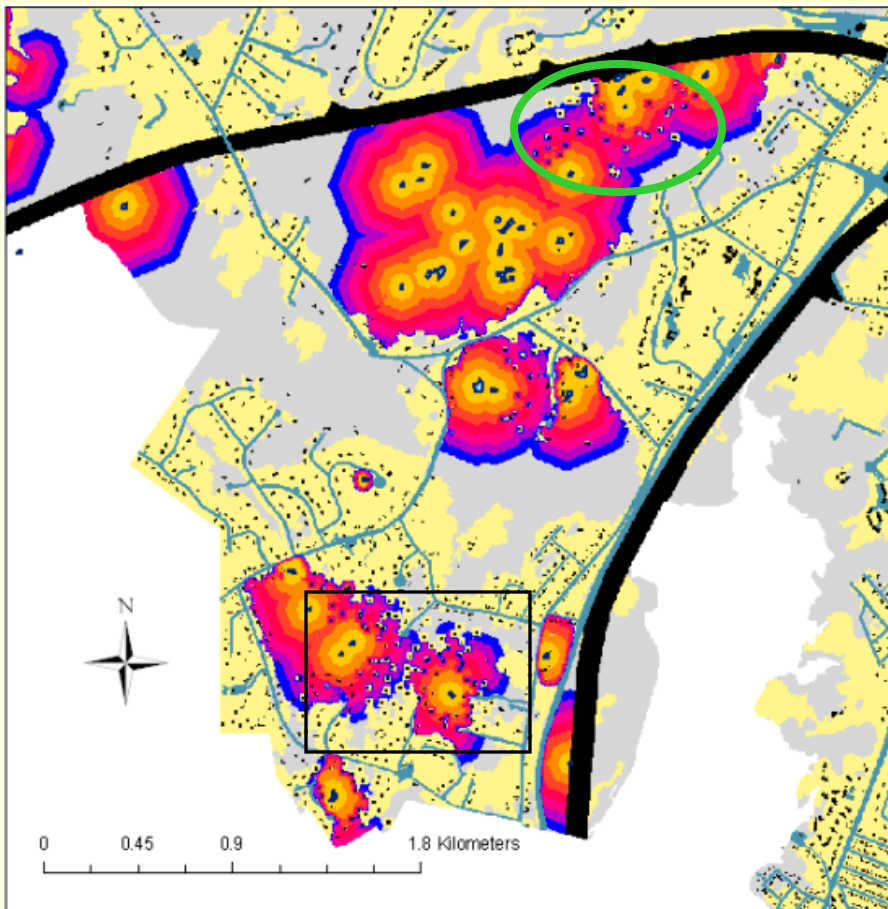
Cost distance to vernal pools, Scenario 3  
max. dispersal distance = 1141 ft. (340 m)



# Permeability in Southeast Falmouth

Baseline  
Scenario

Conservation  
Scenario



# Comparison of Current Landscape, Two Future Scenarios

	Current Landscape	Baseline Scenario	Conservation Scenario
# cells in potential dispersal area	523,509	515,052	515,729
Potential dispersal area (total)	13,087,725m <sup>2</sup> ~3,234 ac.	12,876,300 m <sup>2</sup> ~3,182 ac.	12,893,225 m <sup>2</sup> ~3,186
Potential area lost to development	---	211,425 m <sup>2</sup> ~52 ac.	194,500 m <sup>2</sup> ~48 ac.

# Summary/Conclusions

1. Significant drivers of residential conversion identified
  - Local control over sewer, min. lot size
  - Incentives needed to encourage higher density?
2. Areas of highest development probability, vernal pool threat identified
3. 250' buffers alone unlikely to protect enough matrix habitat for VP-breeders
4. Best Development Practices more likely effective
5. Interdisciplinary approach important

# Future Work

- Expert consultation on permeability model
  - Dispersal distance
  - Adults vs. juveniles
  - Cost values
  - Multiple habitat requirements
- More realistic placement of houses, roads, open space
- Model municipal growth management policies
- More heterogeneity in economic model

A photograph of a forest stream. The water is calm and reflects the surrounding greenery. The banks are covered in lush green plants and trees. The scene is peaceful and natural.

Thanks.

Any questions?