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$$\frac{\partial}{\partial t}(\nabla^2\phi)=\frac{\partial\psi}{\partial z}\frac{\partial}{\partial x}(\nabla^2\psi)-\frac{\partial\psi}{\partial x}\frac{\partial}{\partial z}(\nabla^2\psi)+\nu\nabla^2(\nabla^2\psi)+g\alpha\frac{dT}{dx}$$

Eastern Forest Environmental Threat Assessment Center

Forest Service U S Department of Agriculture

NCEAS Project 12378
Applying population ecology to strategies for eradicating invasive forest insects

Berec, Ludek	Institute of Entomology
Blackwood, Julie	University of Michigan
Epanchin-Niell, Rebecca	Resrources for the Future
Haight, Robert	USDA Forest Service
Hastings, Alan	Univ. of California, Davis
Herms, Dan	Ohio State University
Kean, John	AgResearch
Lee, Danny	US Forest Service
Liebhold, Andrew	US Forest Service
McCullough, Deborah	Michigan State University
Suckling, Max	New Zealand Int. Plant and Food Res.
Tobin, Patrick	US Forest Service
Yamanaka, Takehiko	Japanese Inst. Agricl. Environ. Sci.

Bioeconomics of Detection / Eradication

Becky Epanchin-Niell,
Resources for the Future

RESOURCES FOR THE FUTURE

Natural Resource Economics: Optimizing effort & funds

- **Detection (trapping)**

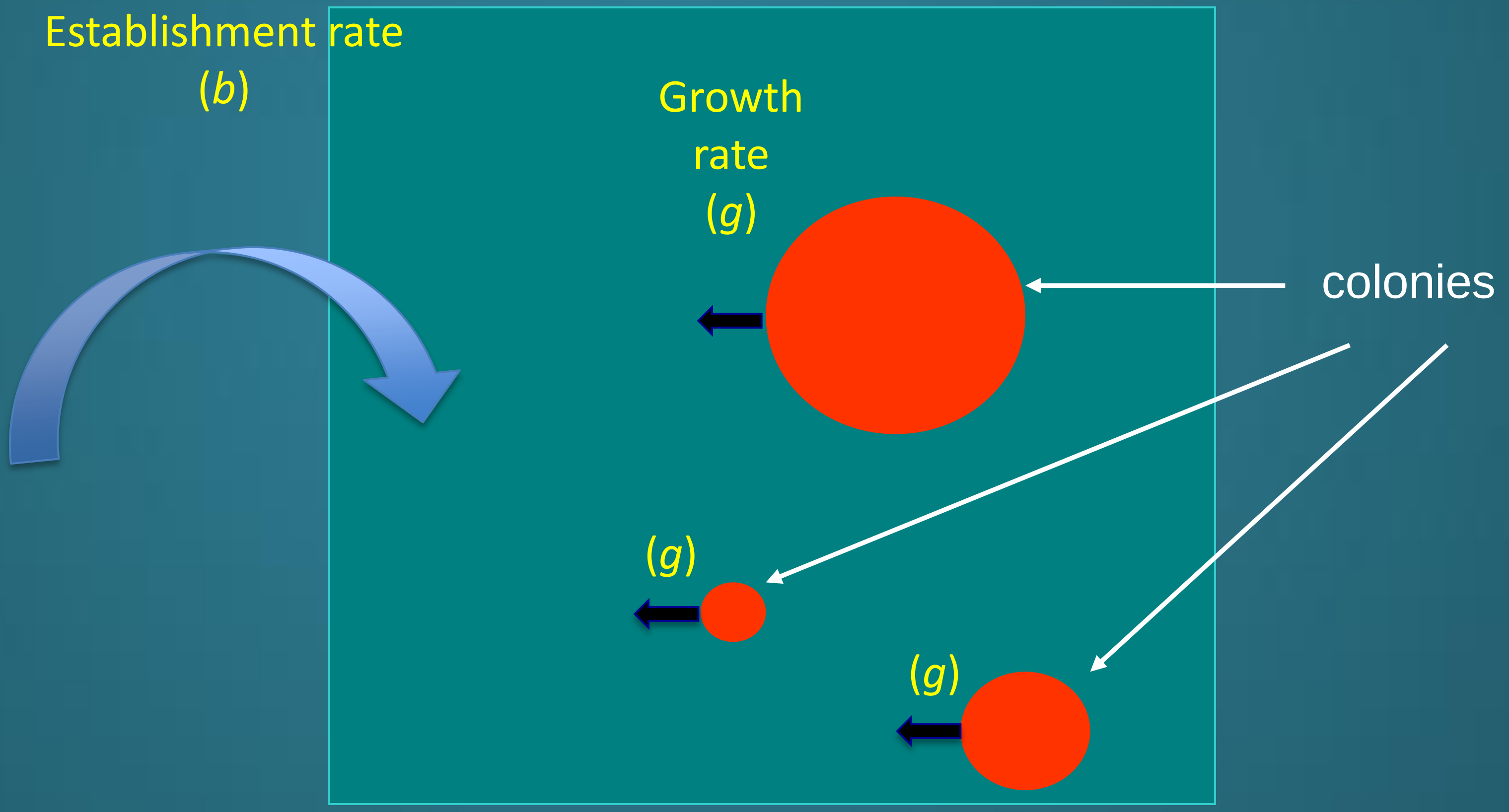
  <u>Goal</u>: to find newly founded populations

- **Eradication** (i.e., spraying)

  <u>Goal</u>: to force a population into extinction

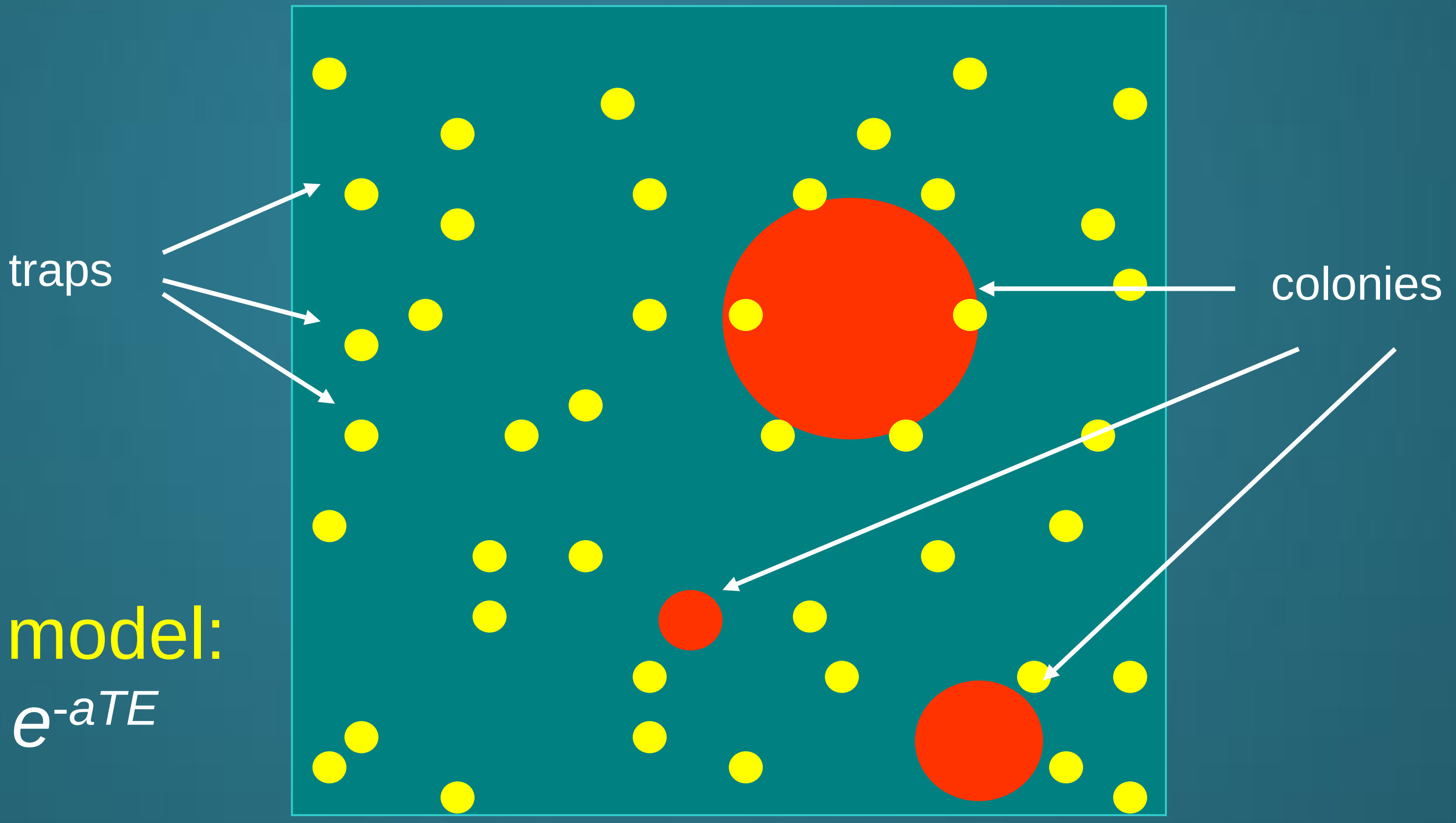
Invasion process:

- Colonies arrive and establish randomly
- Colony area grows



Probability of detecting a colony depends on:

- Size of colony - *a*
- Density of traps - *T*
- Trap sensitivity/effectiveness - *E*



Poisson model:

$$P = 1 - e^{-aTE}$$

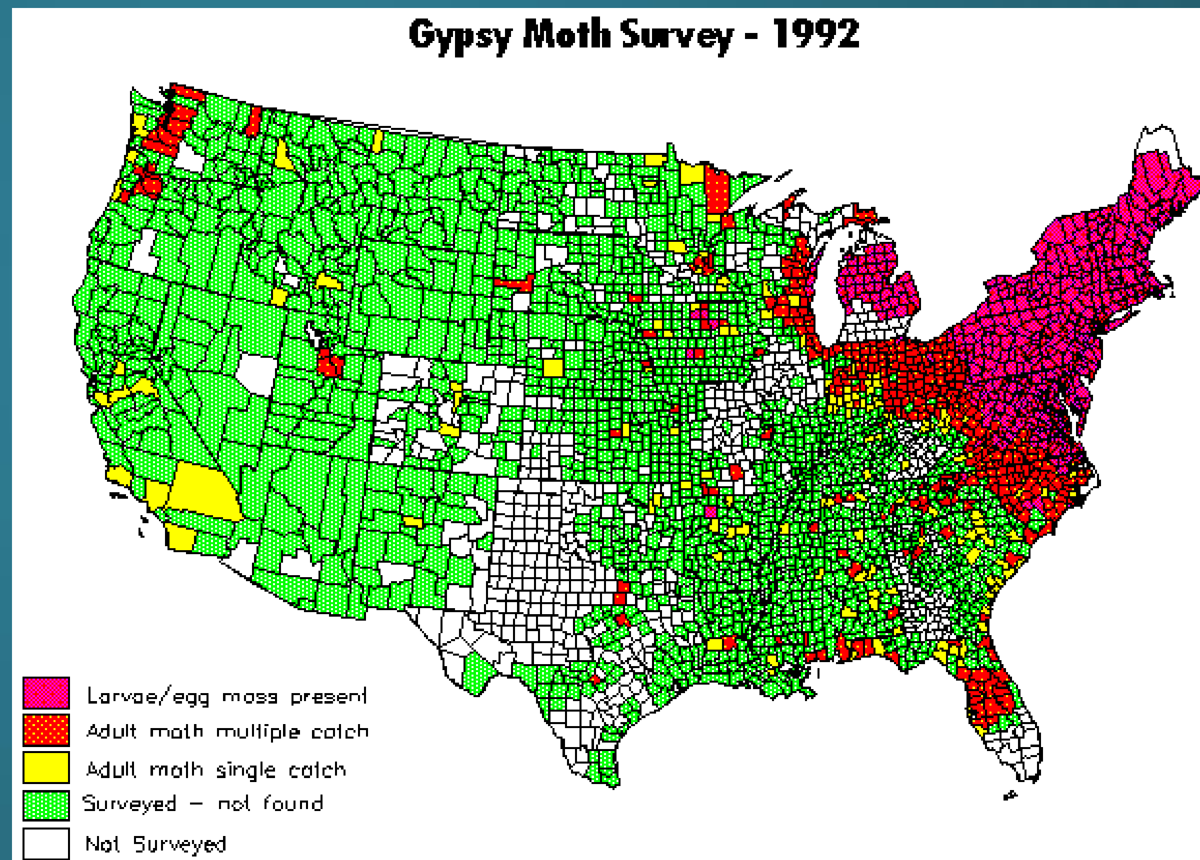
Bioeconomic model

- Probabilistic size (age) class model s∈(1,2,…S_{max})
  - Establishment rate
  - Detection effort
- Determine optimal equilibrium trap density

Choose *T* to minimize:

$$\underbrace{c_{trap}(T)}_{\text{Trapping costs}} + \underbrace{\sum_{s=1}^{S_{\max}} c_{erad}(s) * E(\text{detections}_s)}_{\text{Eradication costs}} + \underbrace{c_{big} E(S_{\max})}_{\text{Penalty costs}}$$

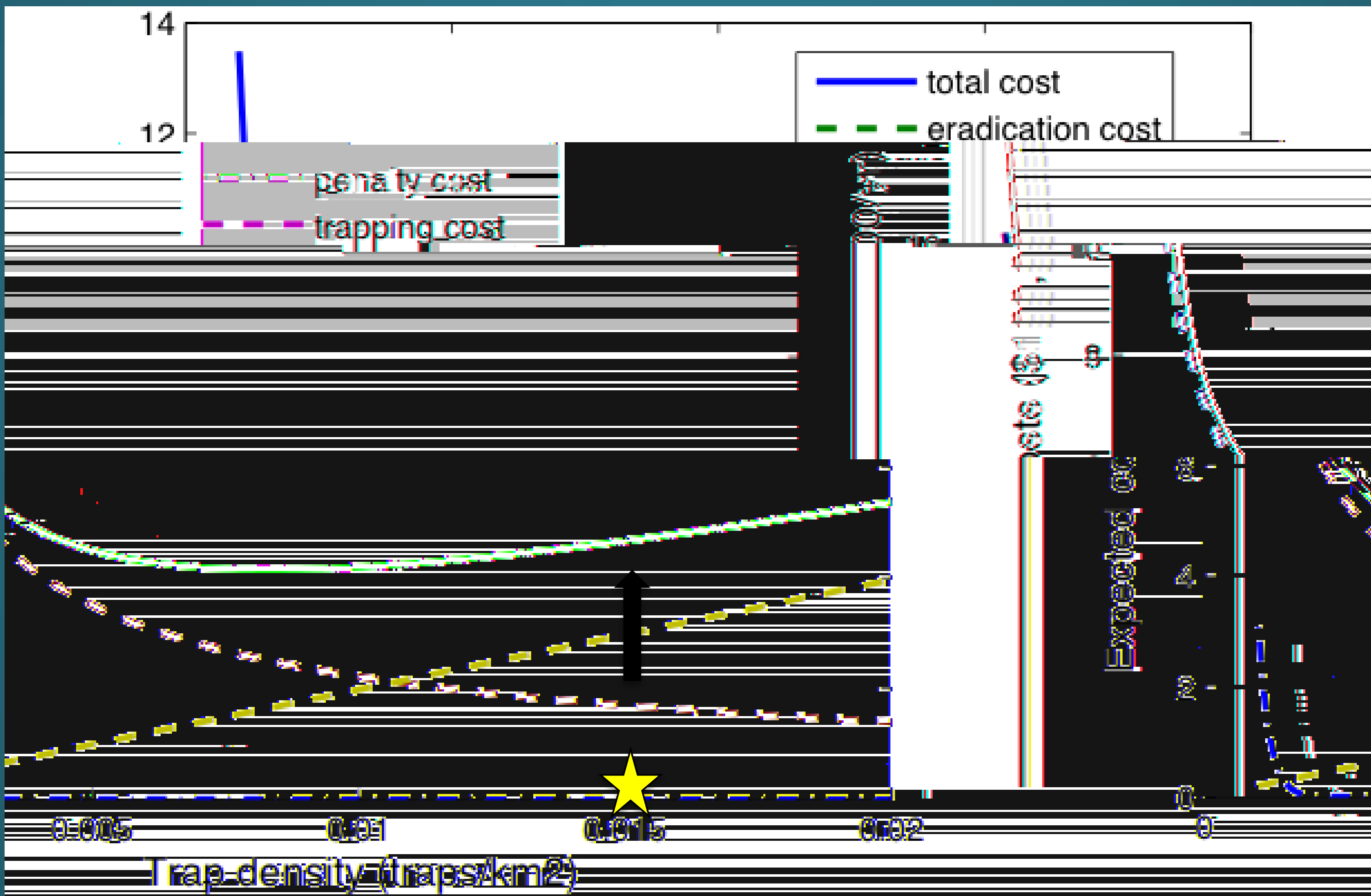
Case study: Gypsy moth (*Lymantria dispar)* eradication in California



State and County Specific Parameterization

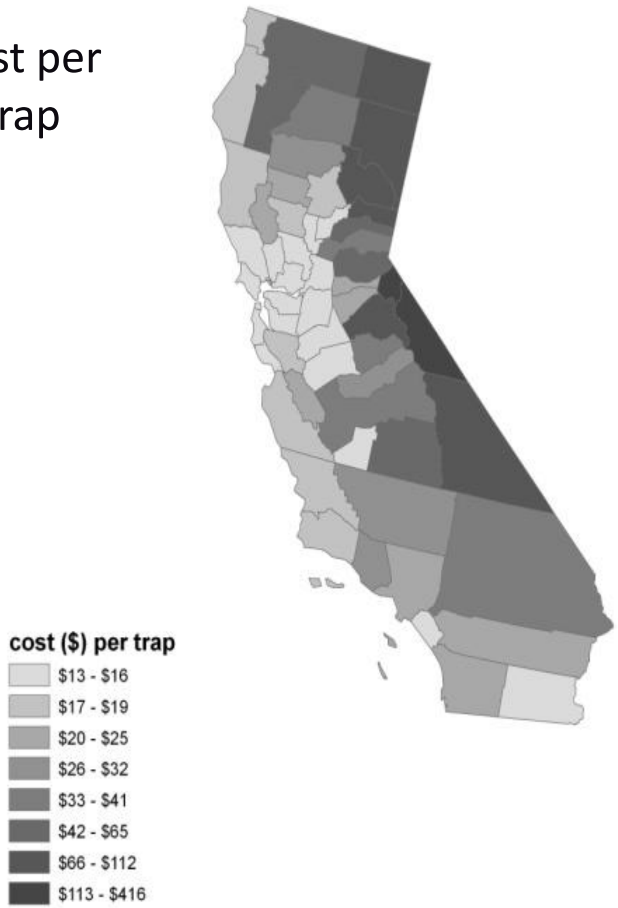
Parameter		California	Counties
same	Colony growth (km^2/ $year^2$), g		2
age	20	same	Maximum colony
	\$50,000,000	same	Penalty cost
effectiveness	1	same	Trap sensitivity/e
n (\$/km^2), c_e	5,000	same	Cost of eradicatio
), A	414,633	7,149 (s.d.=8,187)	Forest area (km^2)
(trap), c_s	47.78	43.15 (s.d=68.74)	Cost of search (\$/
shment rate (col/10,000km^2/yr), b	0.021	0.142 (s.d=0.657)	Colony establis

Expected Management Costs
- California -

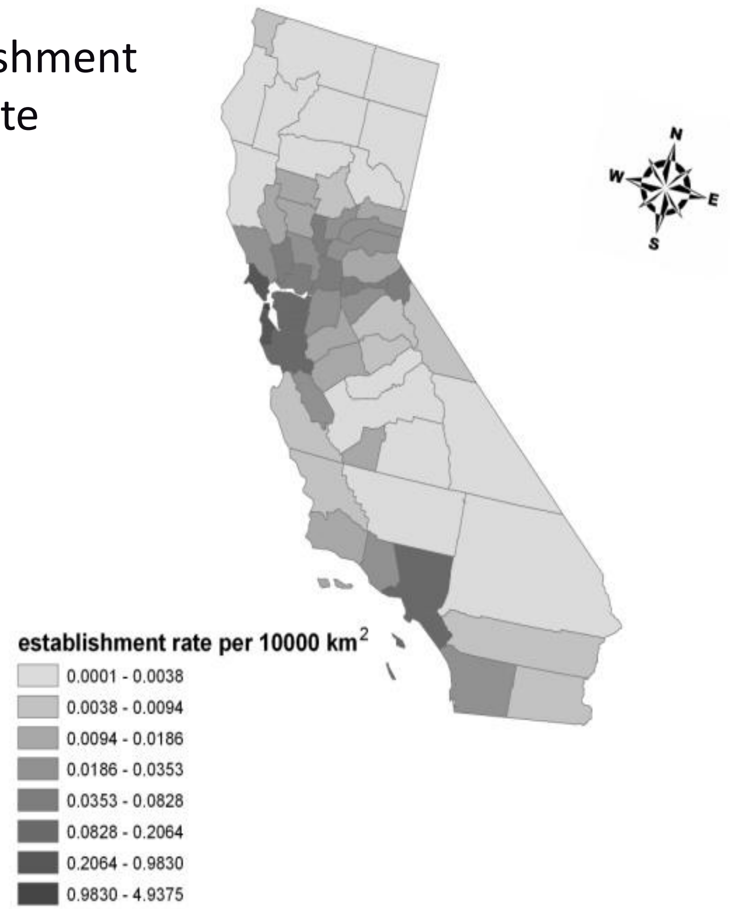


Variation in trapping cost and establishment rate among counties

Cost per trap

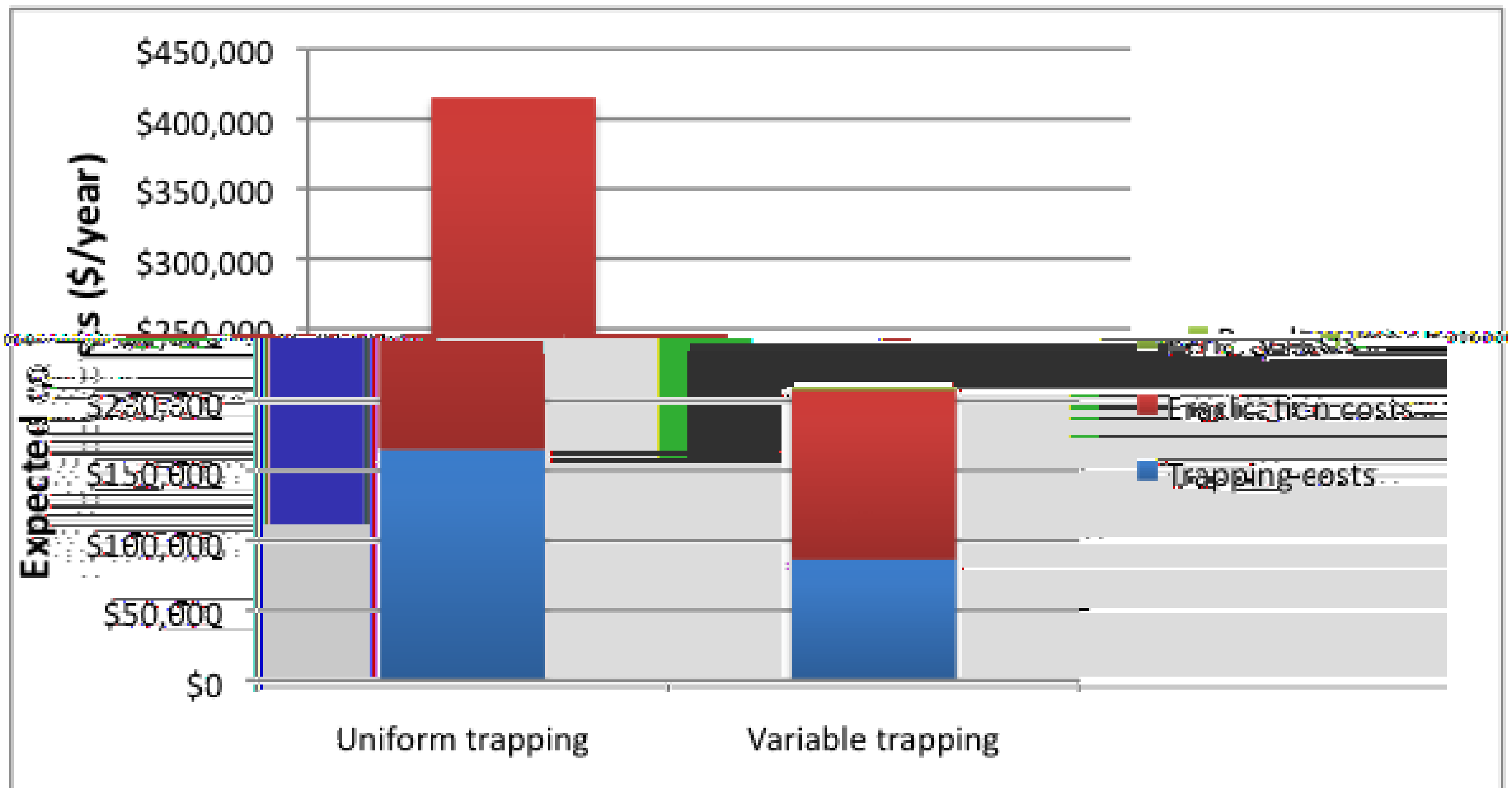


Establishment rate

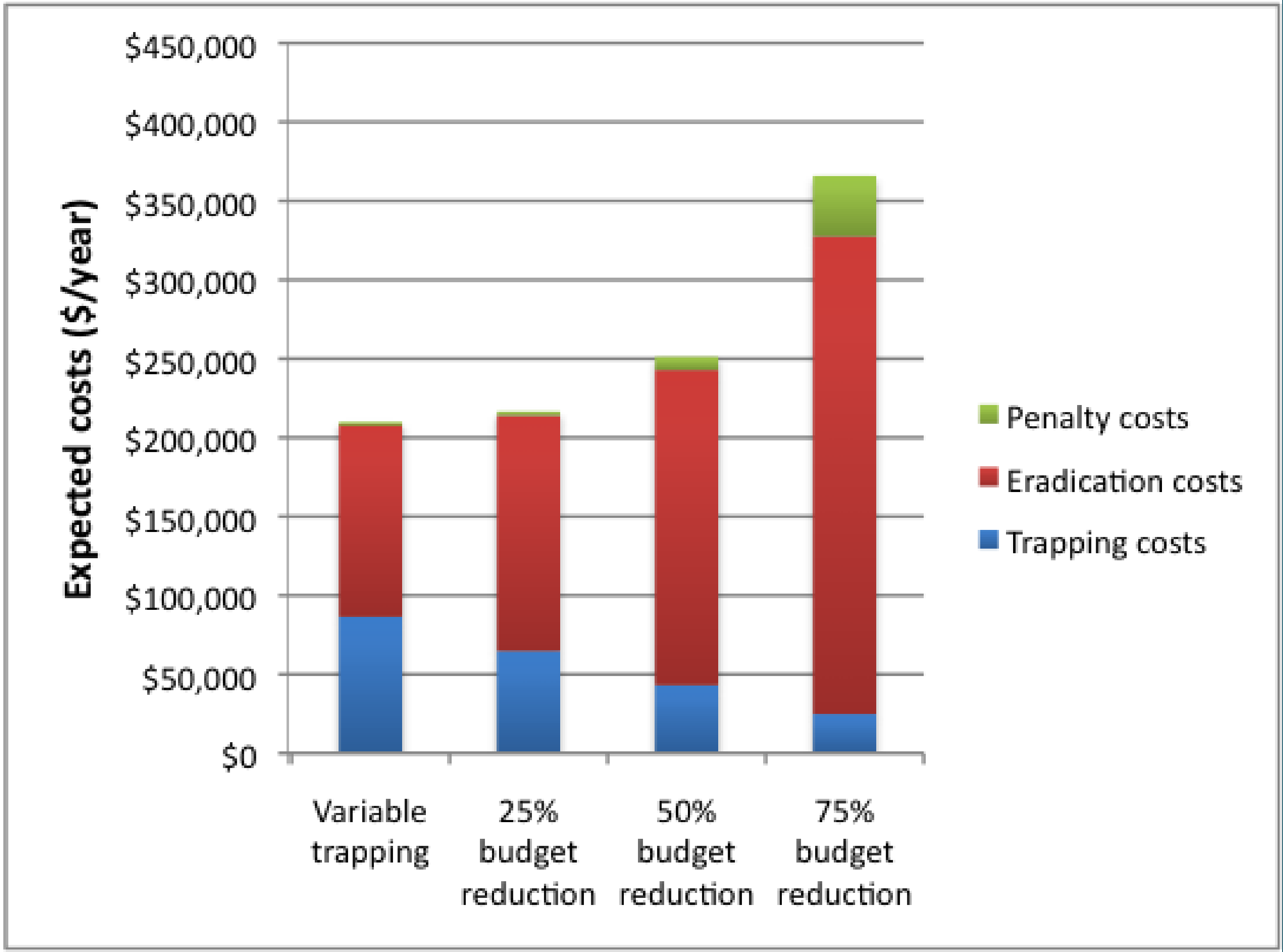


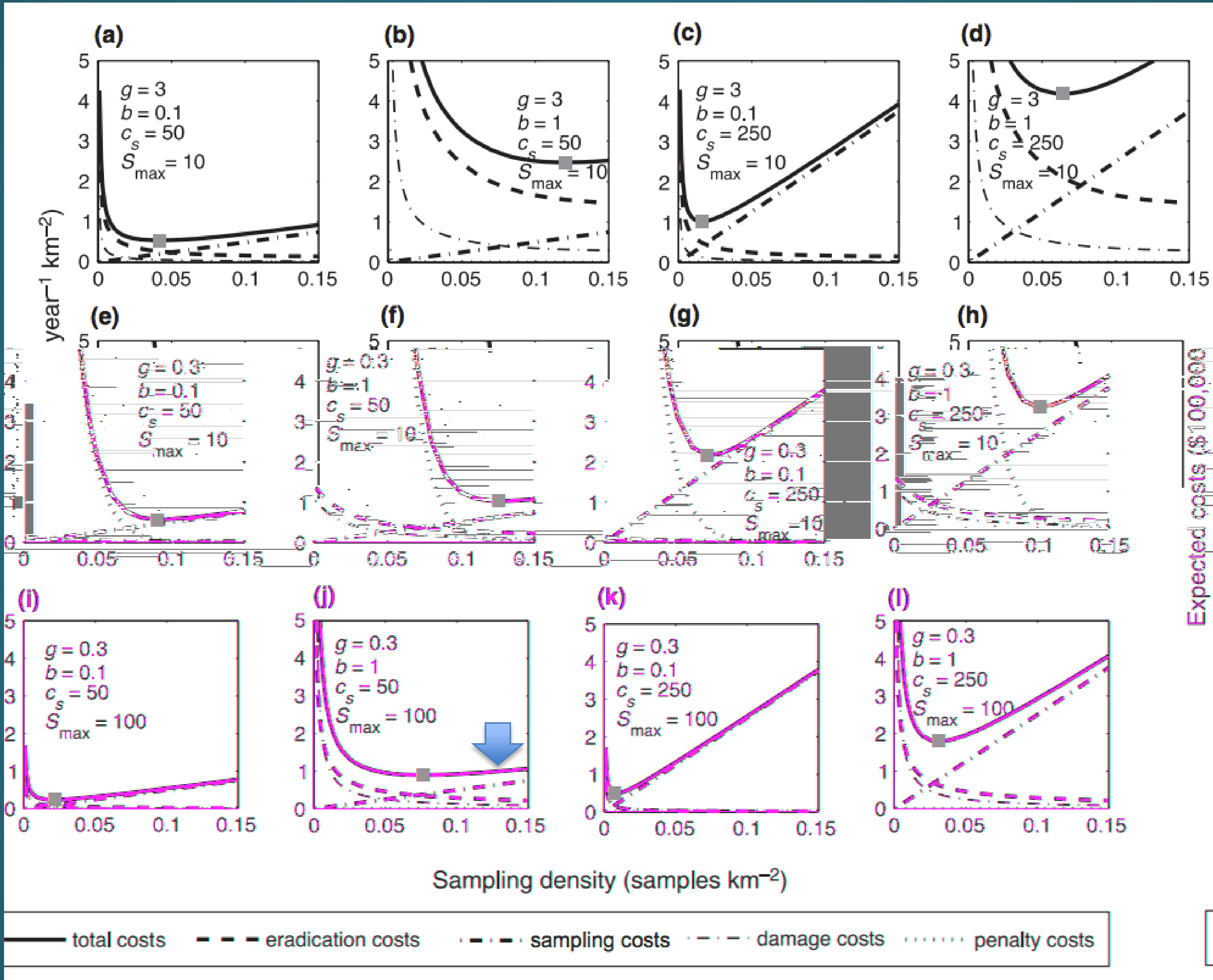
Optimize trap density across entire state

- Uniform trap density across state
- Allow varying trap densities by county



Budget constraints on trapping





(a)
g = 3
b = 0.1
c_s = 50
S_max = 10
(b)
g = 3
b = 1
c_s = 50
S_max = 10
(c)
g = 3
b = 0.1
c_s = 250
S_max = 10
(d)
g = 3
b = 1
c_s = 250
S_max = 10
(e)
g = 0.3
b = 0.1
c_s = 50
S_max = 10
(f)
g = 0.3
b = 1
c_s = 50
S_max = 10
(g)
g = 0.3
b = 0.1
c_s = 250
S_max = 10
(h)
g = 0.3
b = 1
c_s = 250
S_max = 10
(i)
g = 0.3
b = 0.1
c_s = 50
S_max = 100
(j)
g = 0.3
b = 1
c_s = 50
S_max = 100
(k)
g = 0.3
b = 0.1
c_s = 250
S_max = 100
(l)
g = 0.3
b = 1
c_s = 250
S_max = 100
Expected costs ($100,000 year⁻¹ km⁻²)
Sampling density (samples km⁻²)
total costs
eradication costs
sampling costs
damage costs
penalty costs

Summary

- Bioeconomic modeling can help inform improved surveillance and eradication
- Specific findings:
  – Allowing for variable trap densities that accommodate heterogeneity in trapping costs and establishment rates increases efficiency
  – Budget constraint on detection increases overall costs
  – Too few traps is worse than too many traps

READ ALL ABOUT IT:

Rebecca Epanchin-Neill, Robert Haight, Ludek Berec, John Kean, & Andrew Liebhold 2012.

Optimal surveillance and eradication of invasive species in heterogeneous landscapes

Ecology Letters 15: 803-812

More good stuff to come from Becky and Sandy!!!