Optimizing Delimitation Trapping Surveys for Insect Pests

Hui Fang[1], Godshen R. Pallipparambil[1], Nicholas C. Manoukis[2] & Barney P. Caton[3]

1. Center for Integrated Pest Management, North Carolina State University, Raleigh, NC, USA
2. Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, Agricultural Research Service, Hilo, HI
3. Center for Plant Health Science and Technology, Plant Protection and Quarantine, Raleigh, NC

Background

- After detection of a new adventive pest in the US, a delimiting survey is done to determine the boundary of the population (IPPC, 2018).
- For many insects, delimitation surveying involves trapping.
- This has been done for several decades, but little is known about how best to design survey plans.
- In PPQ's New Pest Response Guidelines plans, a 5-mile-by-5-mile grid has often been the default design, regardless of biology.
- However, in these plans, dispersal potential of the insect and trap attractiveness don't seem to be considered, which are key factors.

Objectives

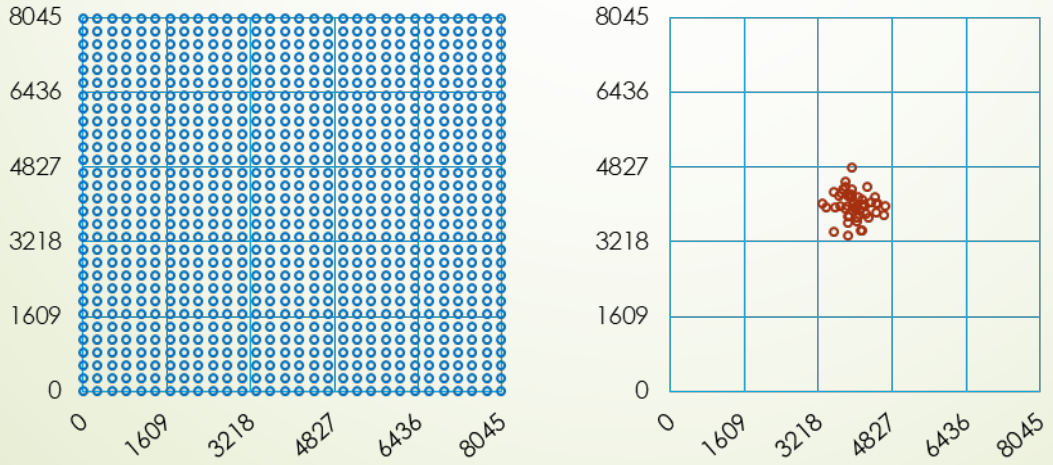
1. Evaluate delimitation survey performance across critical factors
   - Grid size by dispersal ability (*D*)
   - Trap density by trap attractiveness (λ)
   - Grid shape (square, circle)
2. Create guidelines for developing more optimal delimiting survey designs

Methods 1 – Critical factors

- Pest dispersal ability
  - Diffusion coefficient, *D*, in m^2/day [5 – 50,000]
- Grid size
  - Side length of square / diameter of a circle [1 - 12 miles]
- Grid shape
  - Square is typical (not efficient) [also circle, transects]
- Trap effectiveness
  - λ; $p_{(capture)}$ as a function of distance [0.03 – 0.15]
- Trap density
  - Number per square mile [9 - 121 traps/mi^2]

Methods 2 – Simulation model

- TrapGrid (Manoukis, N.C., Hall, B. Geib, S.M., 2014)
  - Landscape-level, spatially explicit model
  - Insect movement by diffusion
  - $p_{(\text{population escape})}$ at survey length, d
  - $p_{(\text{capture})} = 1 - p_{(\text{escape})}$



Methods 3 – Scenario analyses

1. Grid size by *D*

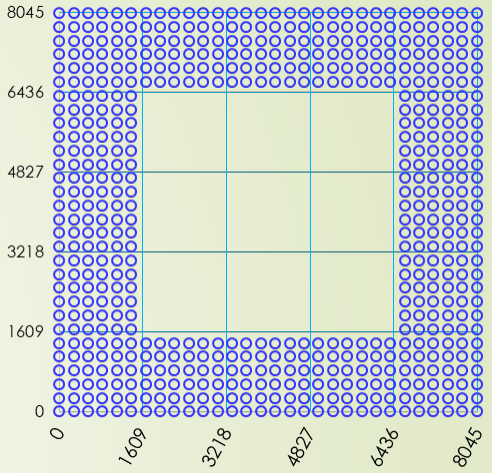
   Find grid size for each *D* at which $p_{(capture)} = 0$, using perimeter grid (+ small λ)

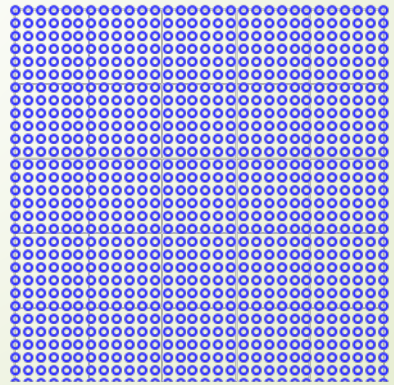
2. Trap density by λ

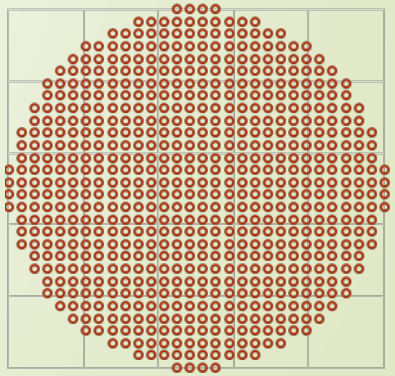
   For each λ, find density which gives $p_{(capture)} > 0.50$

3. Grid shape

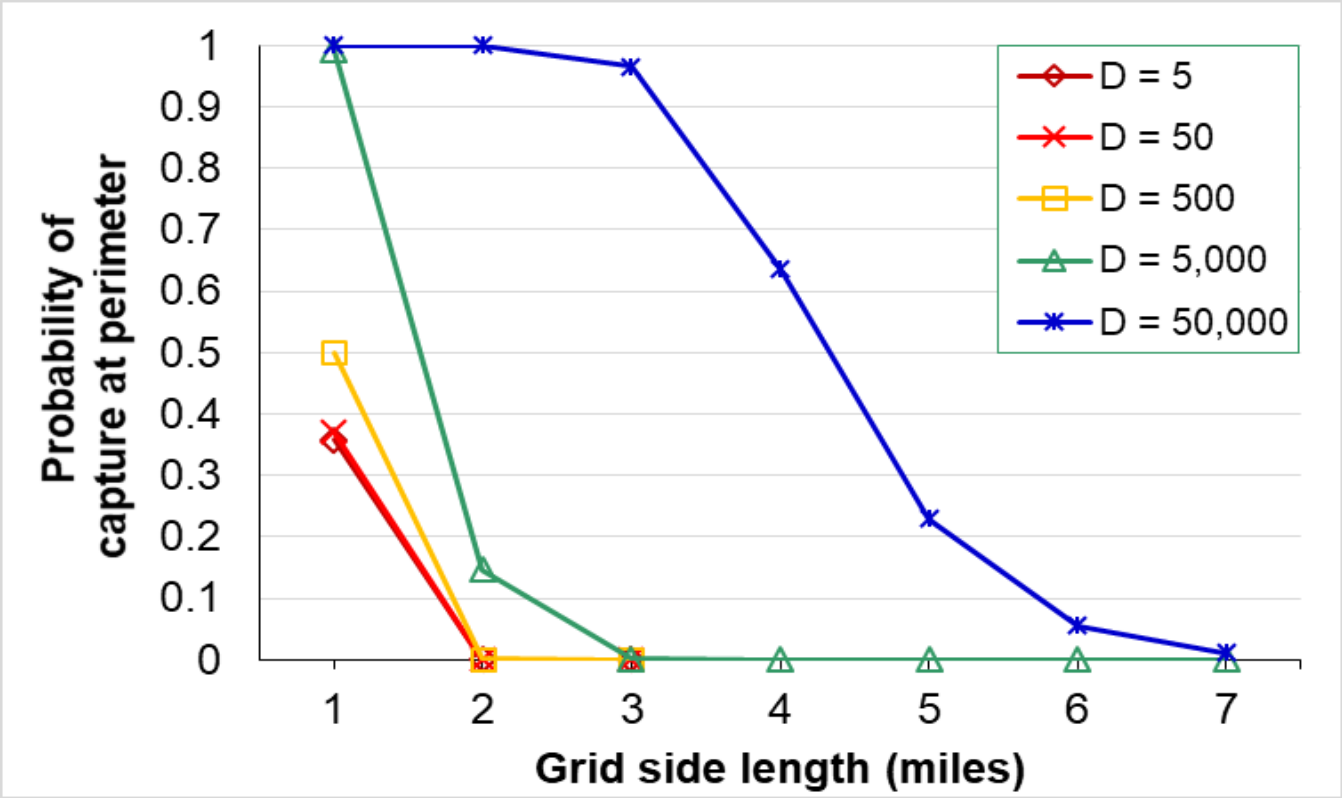
   Compare square to circle







Results 1 – Grid size by *D*



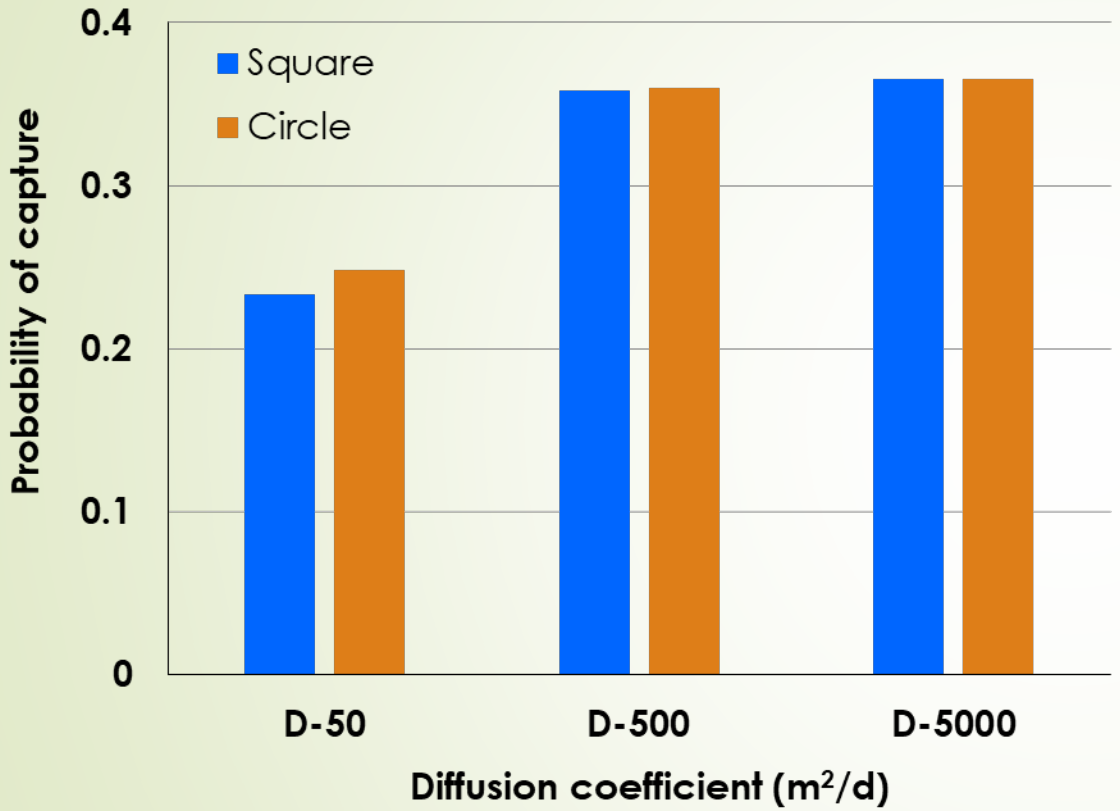
- Grids larger than 3-by-3 only seem necessary for *D* > 5,000 (= Medfly *D*)
- Default trapping grids (5-by-5 and 9-by-9) currently used may often be very oversized

Results 2 – Trap density and attractiveness

Trap density	Trap attractiveness (λ)					
	0.03	0.05	0.075	0.10	0.125	0.15
9	**0.697**	0.346	0.171	0.100	0.065	0.046
16	0.890	**0.539**	0.289	0.174	0.115	0.082
25	0.973	0.713	0.422	0.265	0.179	0.128
36	0.996	0.844	**0.556**	0.365	0.252	0.182
49	1.000	0.923	0.671	0.462	0.327	0.240
64	1.000	0.967	0.771	**0.559**	0.407	0.303
81	1.000	0.988	0.848	0.648	0.485	0.368
100	1.000	0.996	0.907	0.731	**0.566**	0.438
121	1.000	0.999	0.945	0.798	0.637	**0.504**

- Very good traps (e.g., pheromone-based) can use low densities
- Good traps often need densities greater than the typical default (25 no./mi^2)
- Poor traps—and there are **many** such—need densities that exceed most plans

Results 3 — Alternative shape

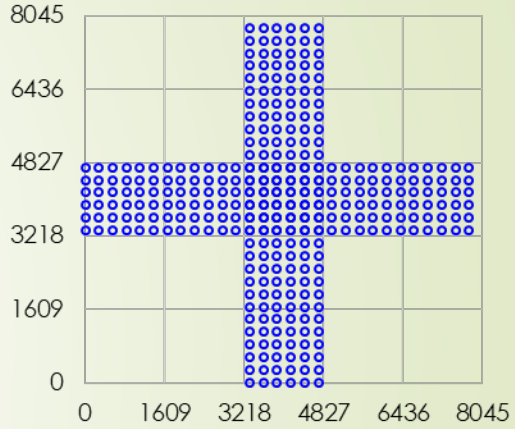


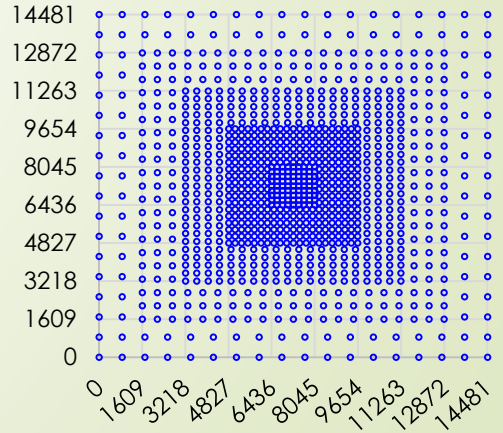
Shape	Area Covered (mi²)	Traps (no.)	Proportion
Square	25	900	—
Circle	19.7	664	0.74

- Circles are more trap efficient and provide similar p(capture)
- While plans **all** specify squares, circles are actually used in the field

Further work

- Model verification (CA quarantines)
- Create design guidelines ver. 1
- Identify modifications for resource-limitations
- Investigate other shapes (e.g., transect)
- Test efficiency of variable density designs






Thank you!