# Economic Modeling for Aquatic Invasive Weed Management in the California Bay-Delta

by

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2016 Bay-Delta Science Conference

November 16, 2016

Stockton, CA

# Economics of invasive aquatic weeds.

- The presence of aquatic weeds causes a variety of damages to different agencies operating on the Delta.
  - Marinas can lose business when slips become weed choked or access to dry docks are blocked.
  - Mosquito and vector control districts may need to increase surveillance and testing of mosquitos for West Nile Virus in surface aquatic weed patches.

# Economics of invasive aquatic weeds.

**Cost of Invasvie Weed Control - California Bay Delta**

| | 2013 | 2014 | 2015 |
|---|---|---|---|
| Public Agencies | | | |
| Port of Stockton | 50,602 | $305,827 | $168,000 |
| Bureau of Reclamation | 343,085 | $832,803 | $921,000 |
| Weed Control District - San Joaquin County | 222,506 | $72,849 | $36,940 |
| Weed Control District - Contra Costa | 74,169 | $0 | $0 |
| Marinas | 169,202 | $576,206 | $792,887 |
| Total | $859,564 | $1,787,685 | $1,918,827 |

# Economics of invasive aquatic weeds.

- To prevent these damages different agencies control both submerged and surface weeds.

- Bioeconomic model is being developed to estimate the costs of invasive weed management for different management alternatives.

# Economics of invasive aquatic weeds.

- The economic objective is to minimize the costs over time t of management m by each agency j and each site k, and the cost of damages d for each agency and site.

$$\min \sum_t C_t = \sum_j \sum_k \sum_m C_{jkmt} + \sum_j \sum_k \sum_d C_{jkdt}$$

- For j = 1,….J; k=1,...K; m=1,...M; d=1,...D and t=1,...T.

# Economics of invasive aquatic weeds.

- The cost of weeds depend on
  - the level of infestation at each site j, $I_{jt}$, and
  - the quantity of inputs used, q, and cost of the inputs, w, used to manage weeds for a given infestation level.

$$C_{jkmt} = \Lambda_{jkmt}\left(\bar{w}_{jkm}, \bar{q}_{jkm}; I_{jt}\right)$$

  - the value of damages for a given infestation level.

$$C_{jkdt} = \Lambda_{jkdt}\left(\bar{w}_{jkd}, \bar{q}_{jkd}; I_{jt}\right)$$

# Demonstration of economic model

- For demonstration purposes we assume that there are two sites of interest.

- At each site j the level of infestation $I_{jt}$ in time t depends on
  - spread within the site based on the previous time period level of infestation
  - inflows from other regions
  - outflows to other regions

# Demonstration of economic model using a 2 site model.

- Site 1 is upstream from site 2 and has only outflows (for example this could be a nursery site). Assumed that 1.5% of existing level of weeds in site 1 flows out of the site.

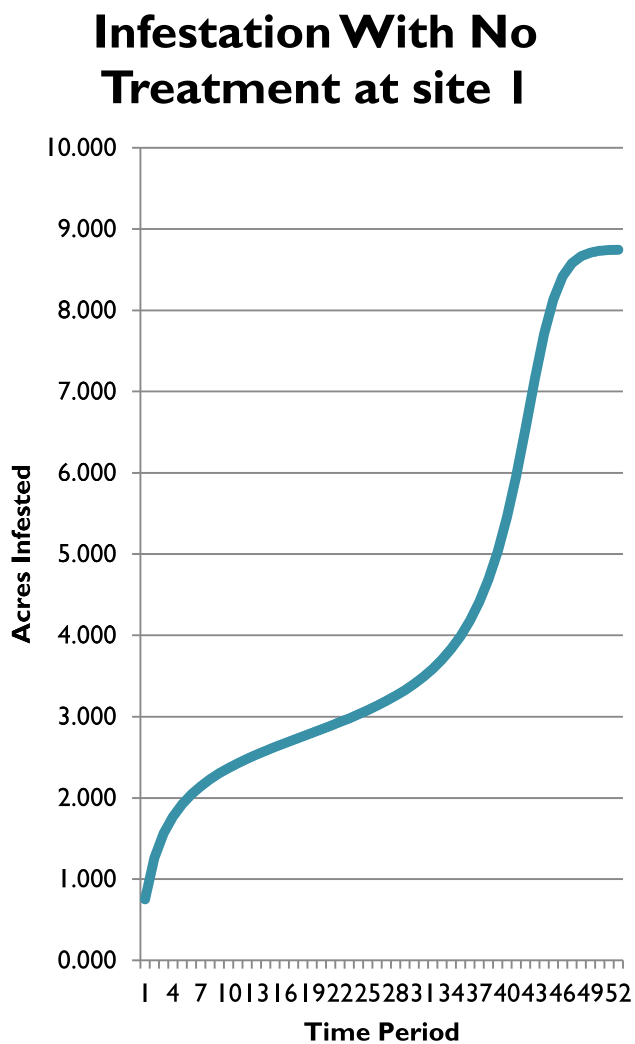
- Site 2 is downstream from site 1 and has only inflows (for example this could be a slough where extra mosquito monitoring is needed). One percent of the outflows from site 1 flow into site 2.

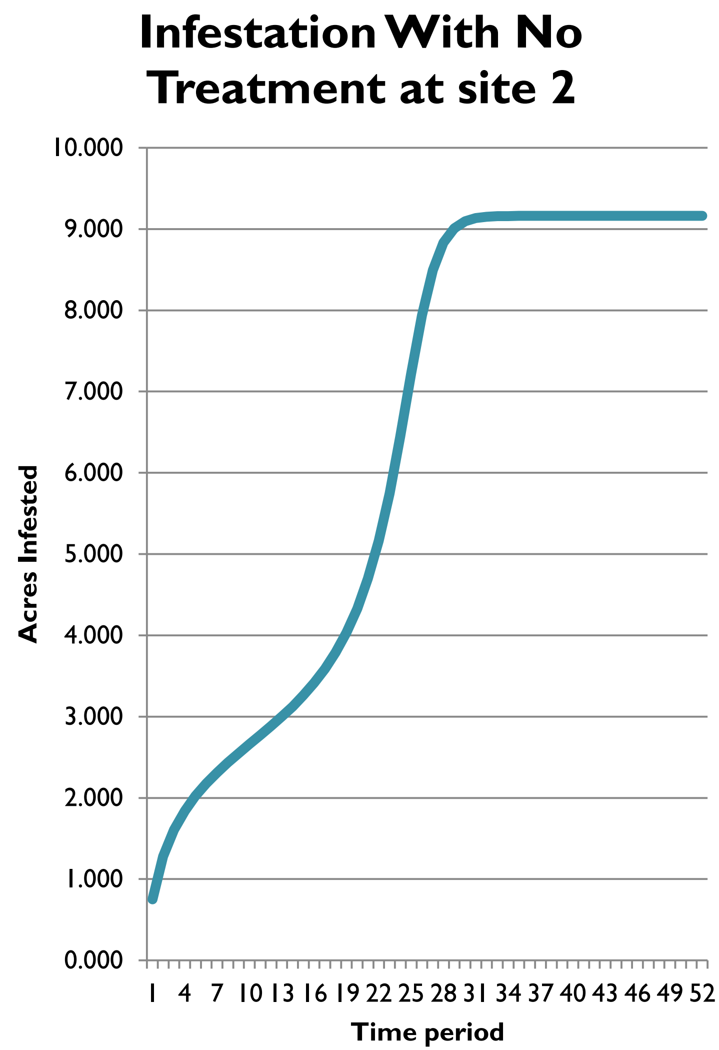
- Spread within a site follows a logistic model.

$$I_{jt} = \frac{\alpha_j}{1+\beta_j e^{-\mu_j I_{jt-1}}} = \frac{10}{1+10_j e^{-0.5 I_{jt-1}}}$$

- Note that for the demonstration each site is identical.

# Weeds infestations with no treatment



# Demonstration of economic model

- Simulation Objective: When should the infestation be managed so that total costs are minimized?

- Compare management and damage costs for infestations treated when they reach the following levels in each site:
  - 3 acres
  - 4 acres
  - 5 acres
  - 6 acres
  - 8 acres

# Results for minimum cost treatment simulation for each acreage assumption.

| | 3 acres | | 4 acres | | 5 acres | | 8 acres | |
|---|---|---|---|---|---|---|---|---|
| Weed Control Only | | | | | | | | |
| | Times Treated | Cost | Times Treated | Cost | Times Treated | Cost | Times Treated | Cost |
| Total | | 154 | | 104 | | 117 | | 97 |
| Site 1 | 2 | 65 | 1 | 35 | 1 | 37 | 1 | 44 |
| Site 2 | 3 | 89 | 2 | 68 | 2 | 80 | 1 | 53 |
| Weed Control Plus Downstream Damages | | | | | | | | |
| Total | | 2,601 | | 2,850 | | 2,959 | | 3,191 |
| Site 1 | 2 | 1,285 | 1 | 1,374 | 1 | 1,396 | 1 | 1,468 |
| Site 2 | 3 | 1,315 | 2 | 1,476 | 2 | 1,563 | 1 | 1,723 |

# Demonstration of economic model

- The cost minimizing management decision is 8 acres.
- At this level of control the cost to managing invasive aquatic weeds is $97.
- When both the management and damage costs are considered though the cost minimizing solution is 3 acres.
- At this level of control total costs are $2,601: however, management costs are at their highest at $154.

# Demonstration of economic model

- In reality management decisions are typically undertaken with budget constraints in mind.
- For example, if we assume that total management costs cannot exceed $120 a year, the budget-constrained cost minimization solution is to manage invasive weeds when infestations reach 4 acres.
- At this level management costs are $104 and total costs are $2,850.

# Conclusions

- Simplified model, but useful for showing how different economic and biological factors come into play when deciding the optimal management strategy.
- Model can be used both for determining the cost minimizing solution given existing technologies and for estimating the benefits of new technologies.
- Cost minimizing solution for one agency may not be the cost-minimizing solution for another or for society as a whole.

# Conclusions

- The optimal solution may not be a marginal change in management.
- The optimal solution may involve a shift to a choice when infestations are much smaller.
- Such a shift may require more resources to improve the timing of control.
- Solution becomes a social/political decision, in addition to a bioeconomic decision.