Modeling Integrated Pest Management strategies for common carp in lake-marsh systems

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Common Carp

- Introduced in the US in 1870s
- Invasive since early 1900s
- USA and worldwide

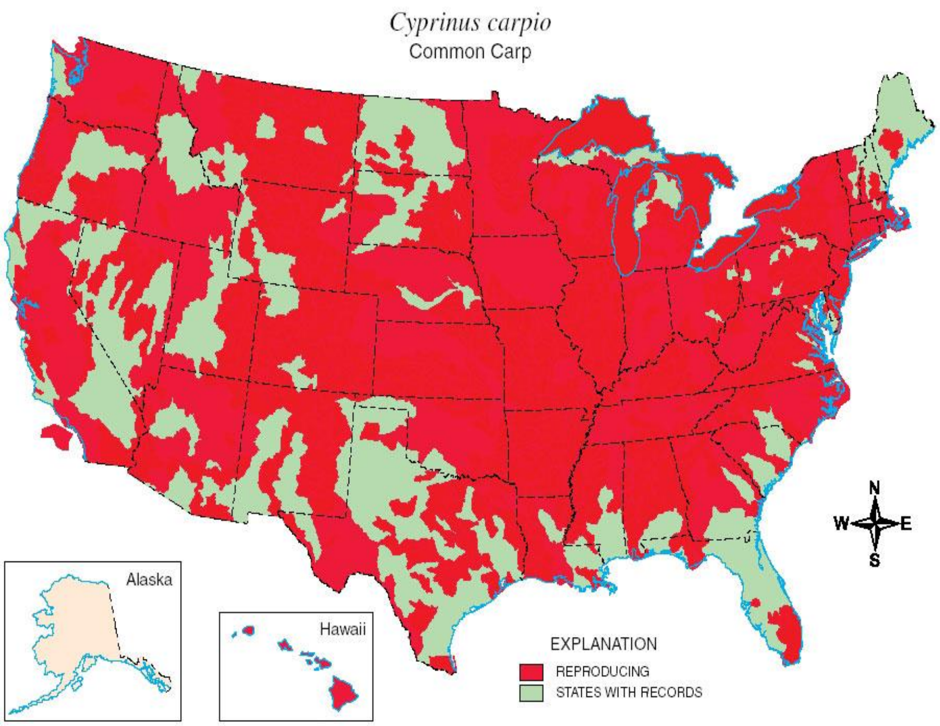


Plate 5. Distribution of Common Carp in the United States. See Methods for details regarding data used to create maps, definition of "reproducing" and shading of HUCs and states.

http://fl.biology.usgs.gov/Carp_ID/html/cyprinus_carpio.html

Common Carp

- Environmental engineers
- Highly fecund
- Mobile
- Physiologically resilient

http://www.arkive.org/common-carp/cyprinus-carpio/video-ca08.html

http://www.kcfisheries.com.au/index.php?view=detail&id=4&option=com_joomgallery&Itemid=59

Current control strategies effective primarily in systems that can be drained or poisoned and isolated

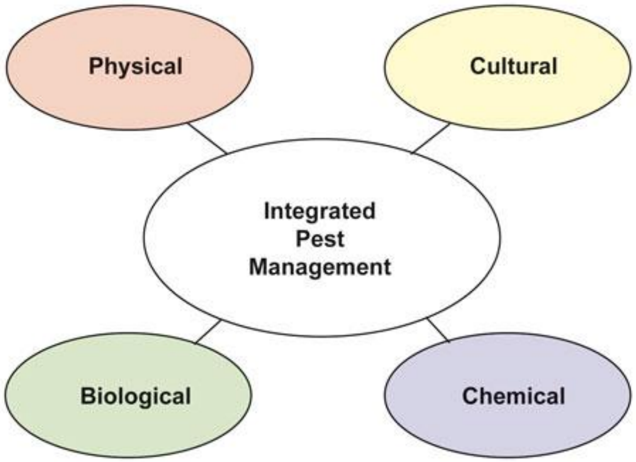
Poison with rotenone

Water-level management

Barriers

Integrated Pest Management for more complex and more open systems

- Use multiple control measures to reduce the impact of a nuisance species to a tolerable level of damage in an efficient, sustainable, and cost-effective way
- It uses current, comprehensive information on the life cycle of the pest and its interaction with the environment

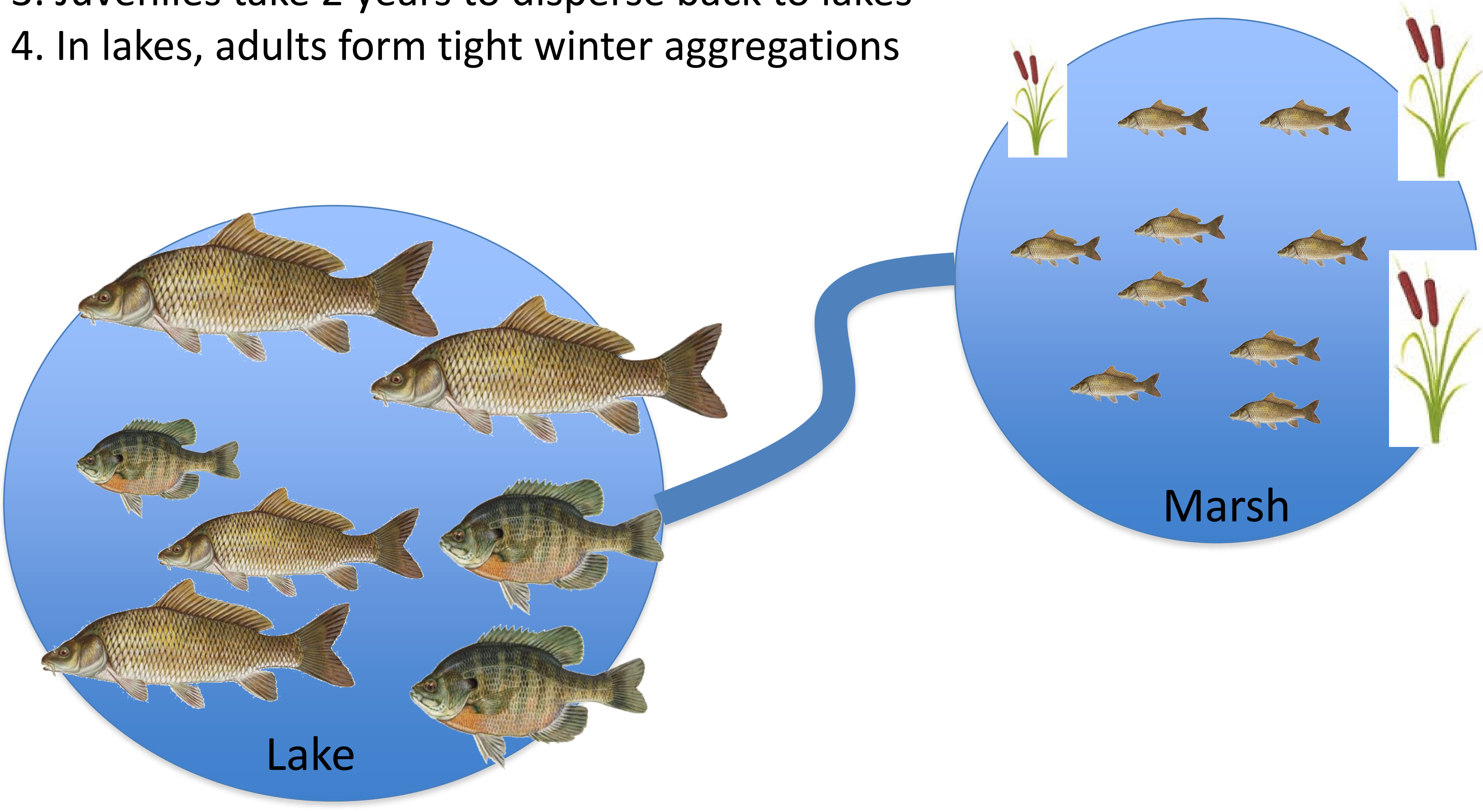


www.amalpest.com.au

escrop.com

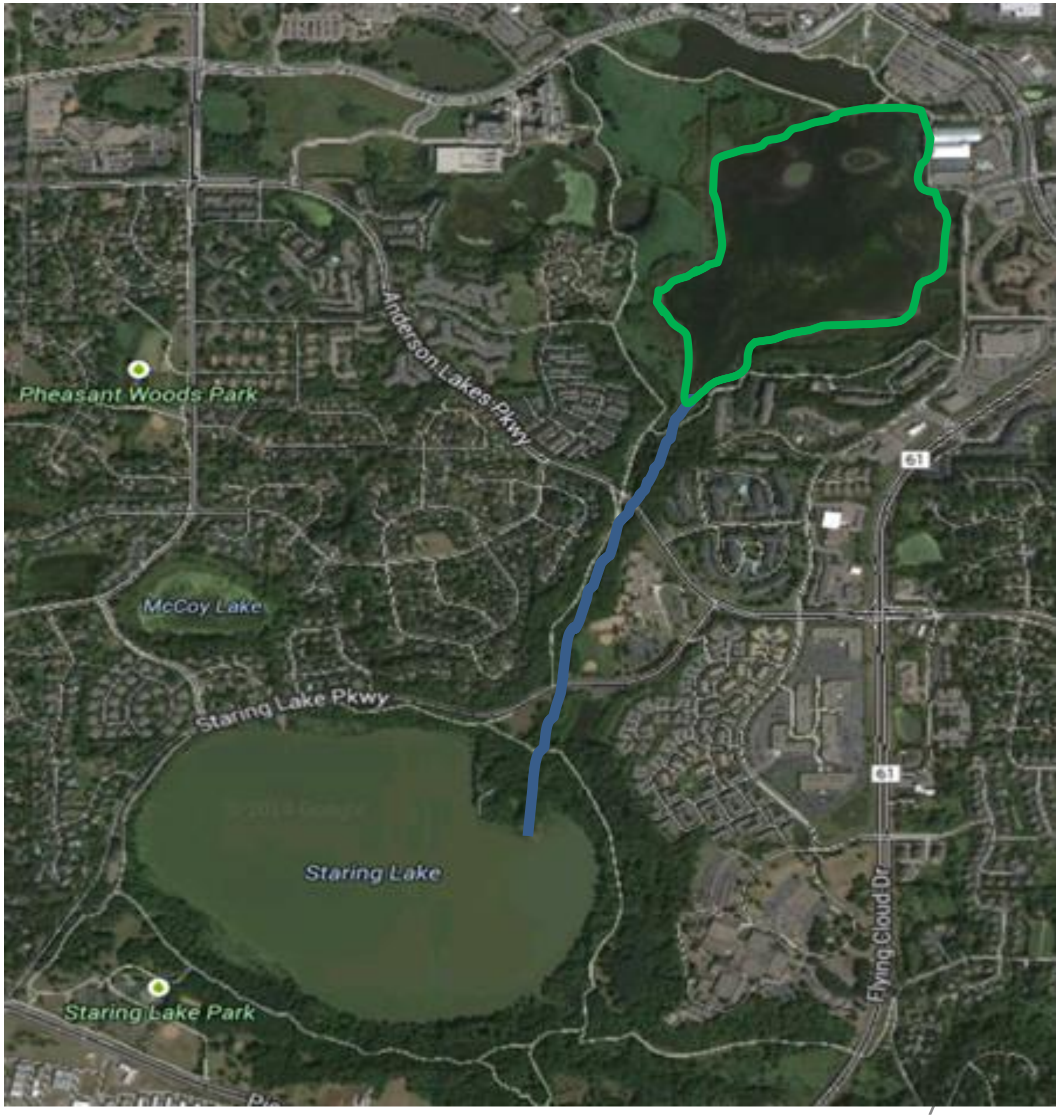
Weaknesses in Common carp life cycle

1. Larvae and eggs unable to survive in lakes dominated by bluegills
2. Adults need to migrate to winterkill-prone marshes to escape predators
3. Juveniles take 2 years to disperse back to lakes
4. In lakes, adults form tight winter aggregations



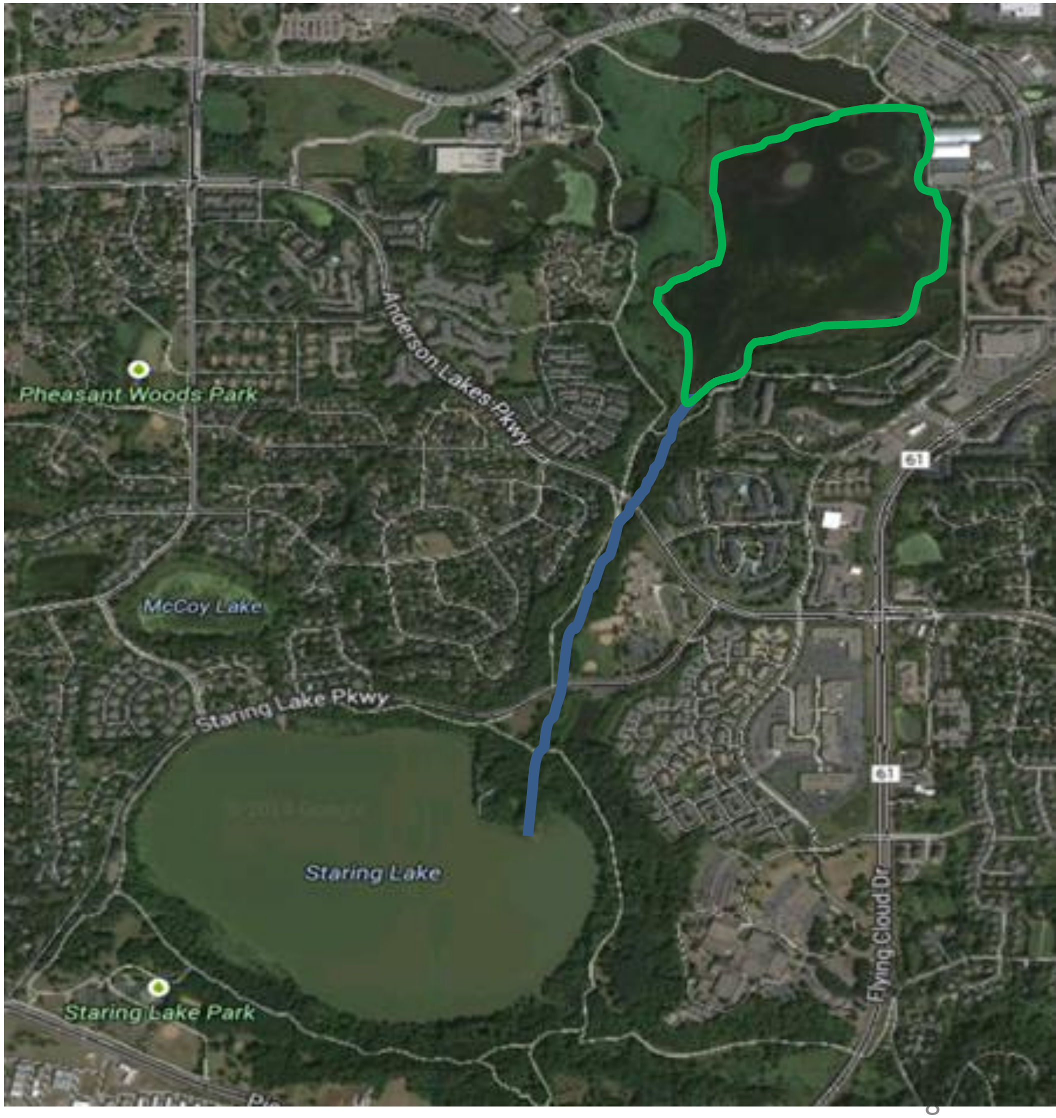
Objective: Develop an IPM for a model system by exploiting these weaknesses

- Eden Prairie, MN
- Lake
  - 65ha
  - Max depth 16ft
- Wetland
  - Winterkills every year
  - 60ha
  - Max depth 3ft
- Closed system



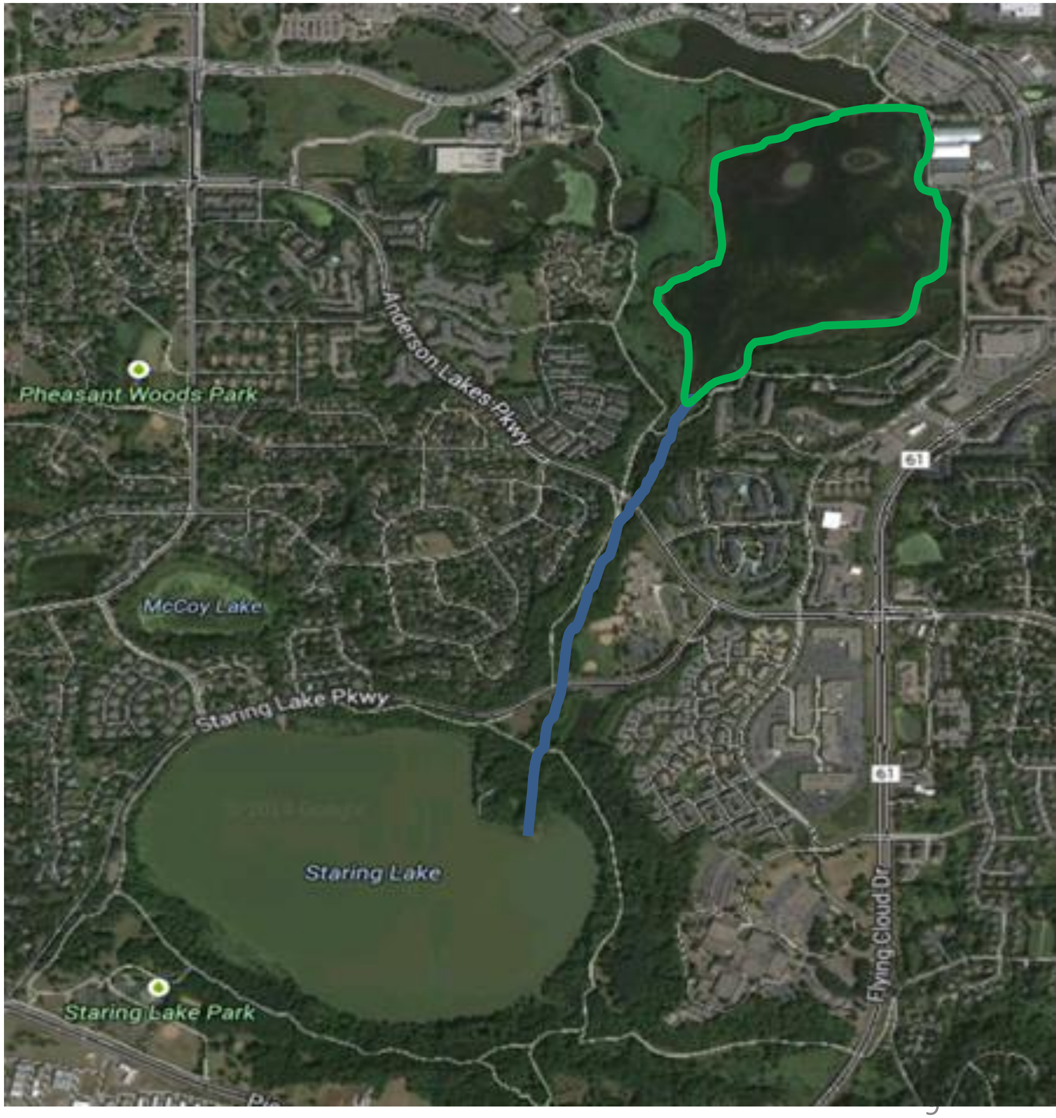
Specific management options:

- Prevent winterkills in the lake to maintain healthy bluegill population
- Reduce water level in the marsh to trap and freeze juveniles before they disperse back into the lake
- Conduct winter seining in the lake to remove adults



Realistic estimates for each option

- Biocontrol:
  - Up to 450 recruits per female in wetland (bluegills absent)
  - 0-3 recruits per female in lake (bluegills present)
- Juvenile winter mortality: 0.4, 0.6, 0.8
- Juvenile out-migration: 0.003
- Winter seining: 0-0.9



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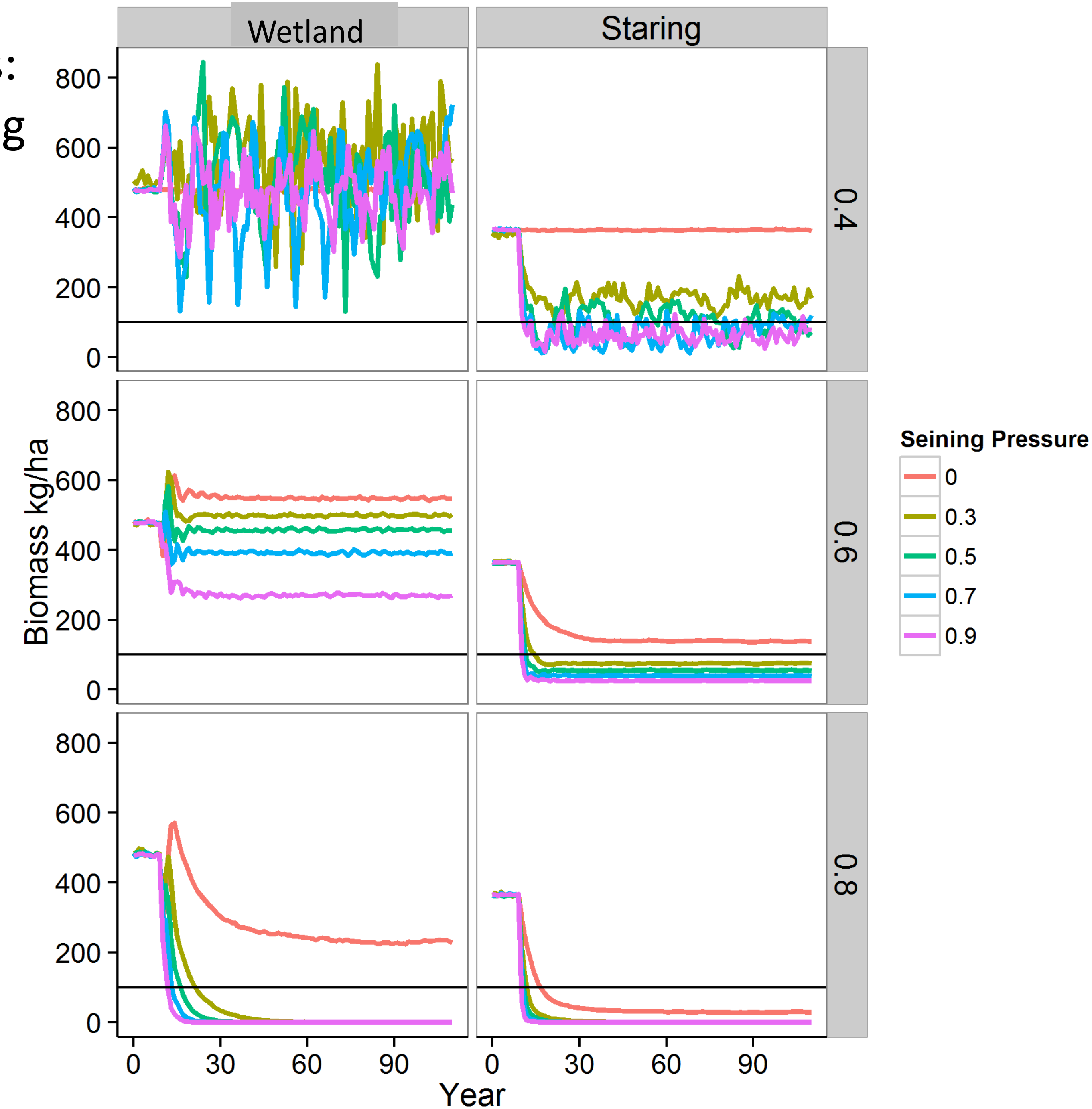
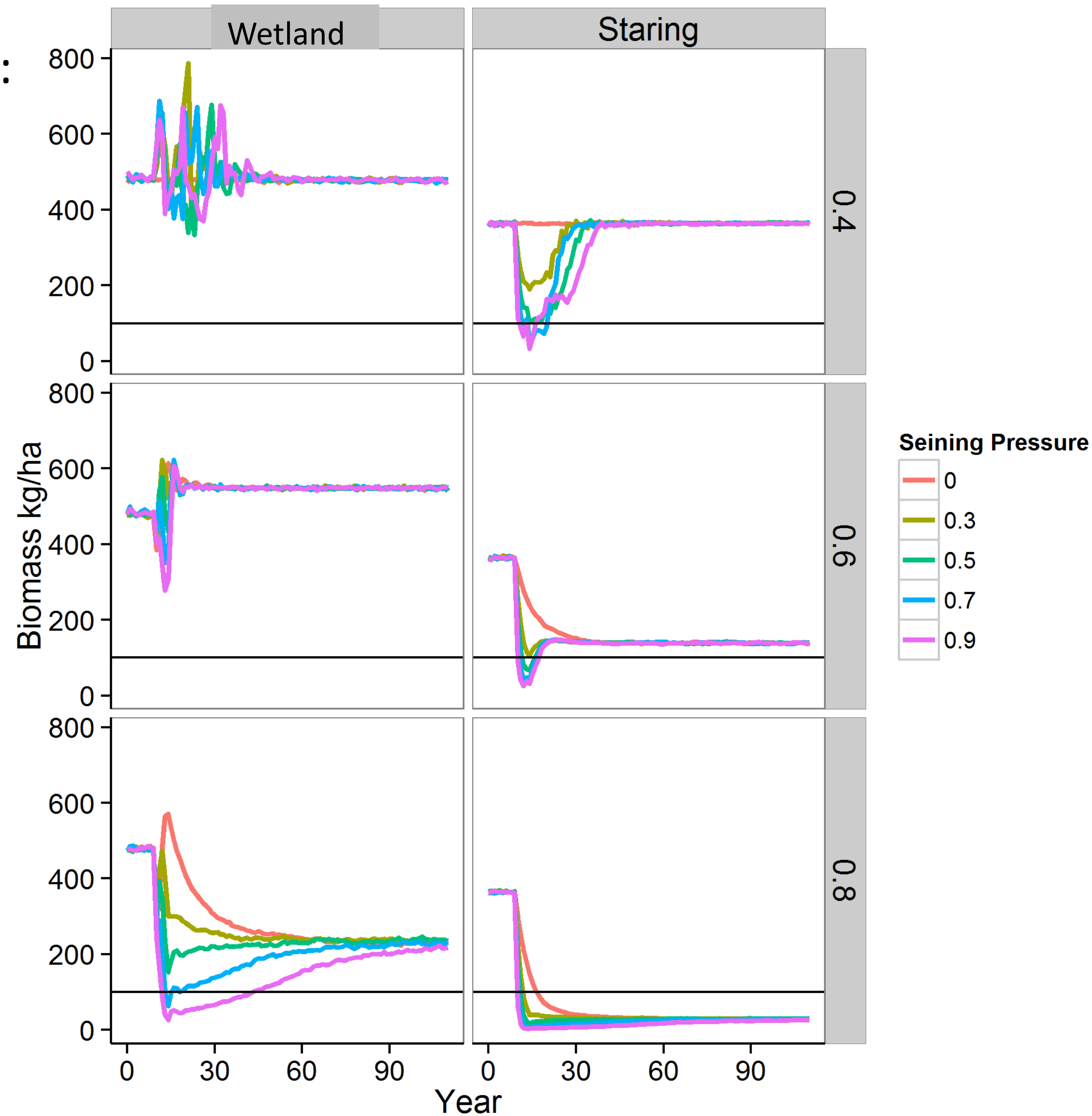
Parameter	Symbol	Estimate
Partial migration probability	α	0.9
Return probability	β	0.7
Winterkill probability	α	1.0
Mortality probability during a winterkill	ε	0.4, 0.6, 0.8
Recruitment in a lake or in a marsh during non-winterkill year	τ	$\tau = \frac{0.24}{k!} \cdot e^{-k} - 0.01 \cdot S$
Recruitment in a marsh during a winterkill year	τ	$\tau = 106.6 \cdot (3.92 \cdot e^{(-0.01 \cdot S)})$
Juvenile dispersal probability	κ	if age 0 or 1 $\kappa = 0.5$ if age ≥ 2
Annual natural mortality probability	ν	$\nu = 1 - e^{(0.06 - e^{(L/L_\infty)^{-1.5}})} + 1 \cdot 10^{-4} L$
Growth	L_t	$L_t = \begin{cases} L_{t-1} + I_t, & I_t \geq 0 \\ L_{t-1}, & I_t < 0 \end{cases},$

Modeling Results: Consistent Seining



Modeling Results: Seining First Five Years



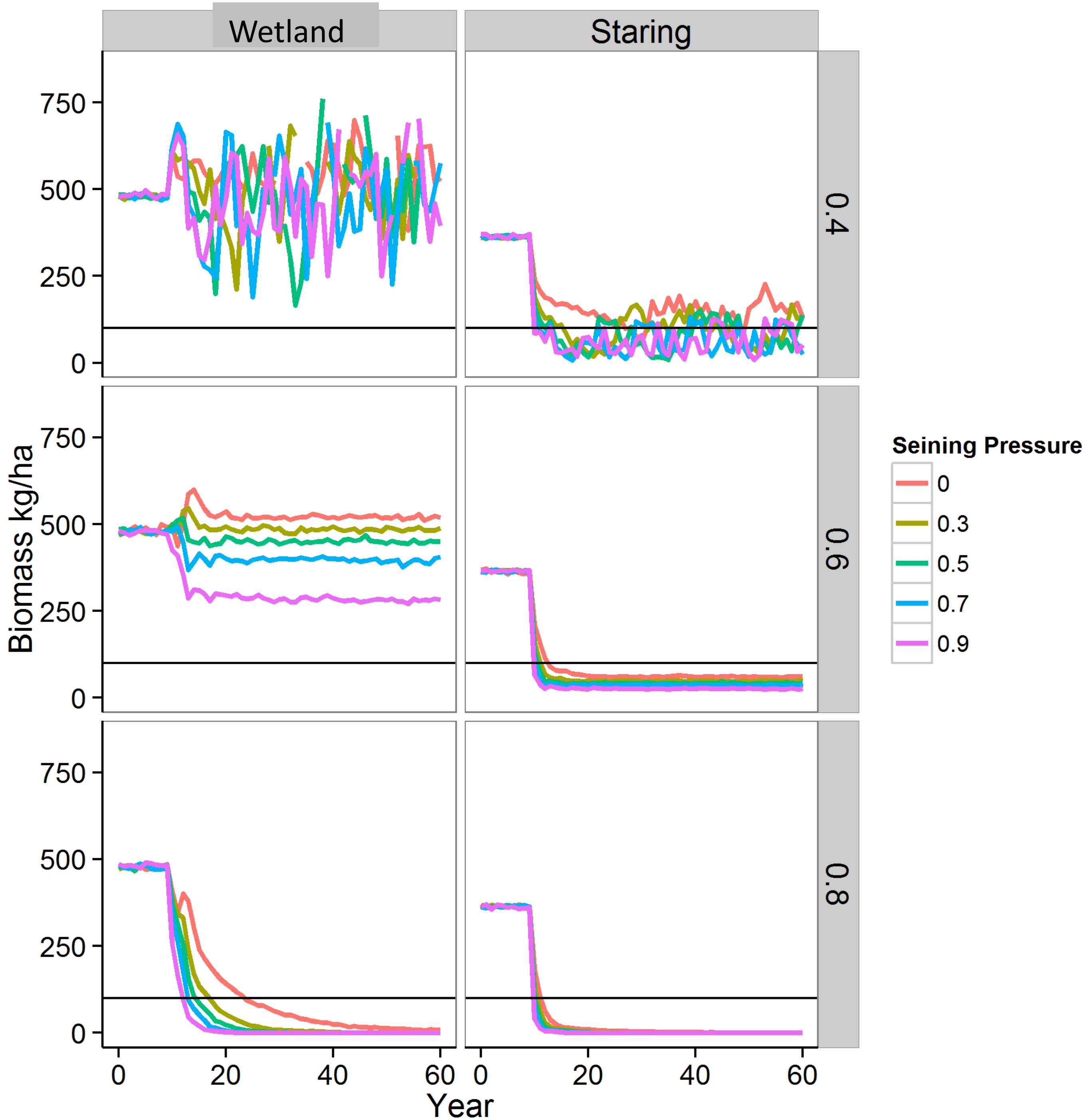
Conclusions

- Control of common carp populations is achievable with moderate seining effort but only if winterkill mortality rates of juveniles are 0.6 or higher
- Controlling the wetland (recruitment) is more important than removing the adults
- IPM is required
  - Even at high winterkill mortality rates (0.8); the wetland remained a source if seining is discontinued

Possible Improvements

- Prevent adults from returning to the lake after spawning using a barrier
- Remove adults as they leave or return to lake
- Reduce number of overwinter refuges in wetland

Modeling Results: Consistent Seining; 50% of Adult Return Movement Blocked via Barrier



Conclusions

- Every system/target species is different and may require different strategies
- More effective IPM still need to be developed
  - More research is required to develop additional tools

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Questions/Comments

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