Swimmer's Itch in Michigan lakes

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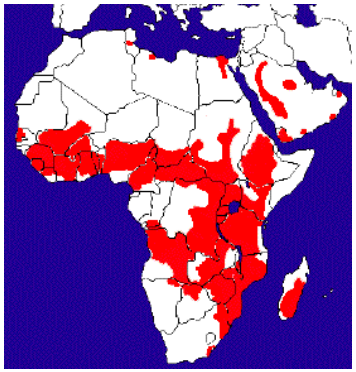
OAKLAND UNIVERSITY
Biological Sciences

Schistosomiasis:

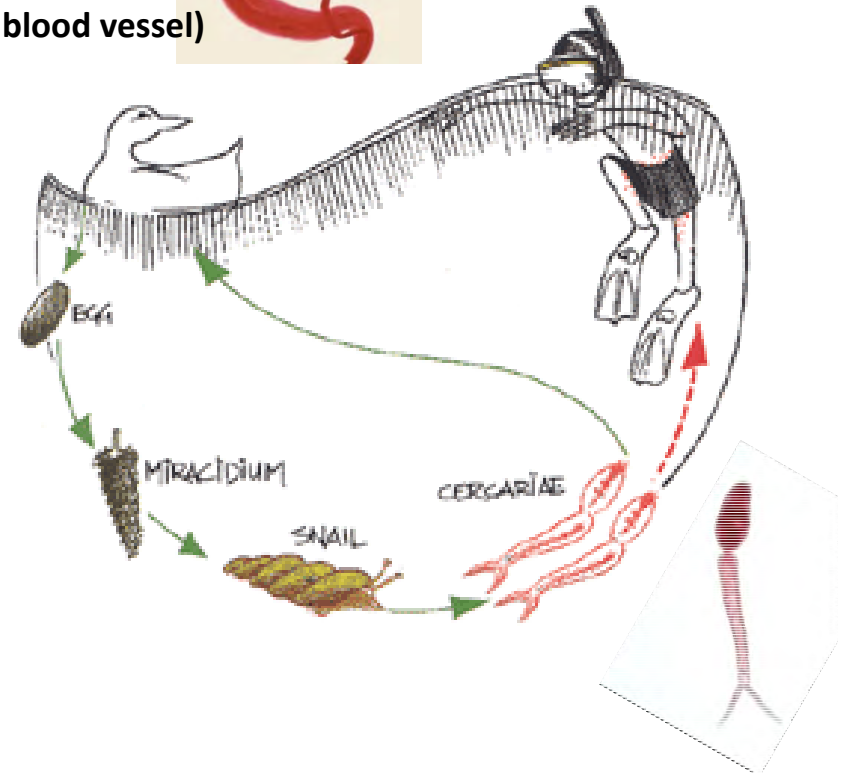


- 2-host life cycle (SNAILS)
- Exposure in water
- **Human schistosomes** (3 spp)
  - 2nd most important tropical disease worldwide
  - 200-300 million people infected/yr; 800,000 deaths

Adult worms (in blood vessel)

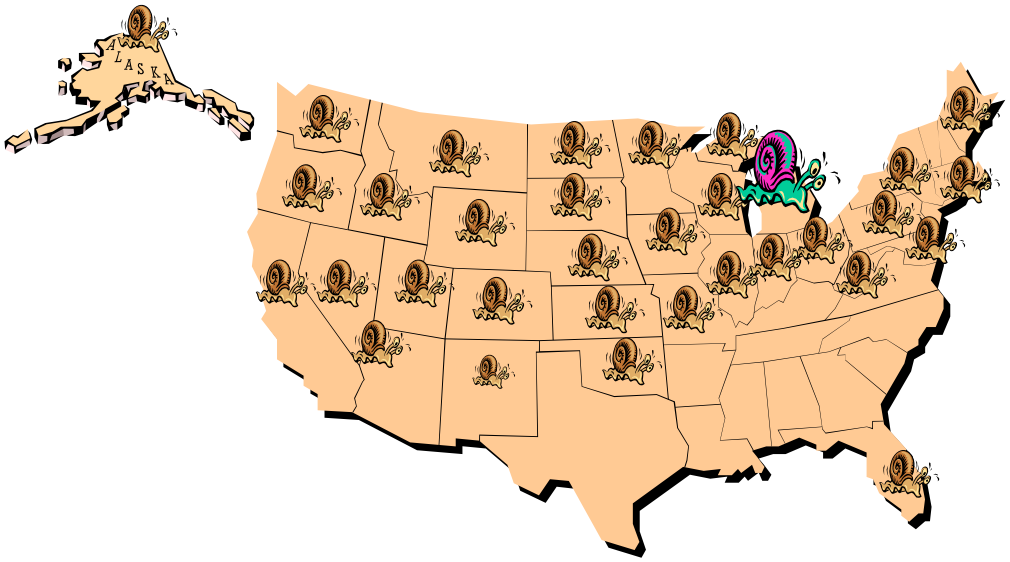
- **Avian schistosomes** (12-15 spp)
  - Trying to infect birds
  - Itchy bumps 1-2 days post-exposure
  - Gradually fade over ~1 week

Trichobilharzia cercaria penetrating skin



Michigan: home of swimmer's itch!

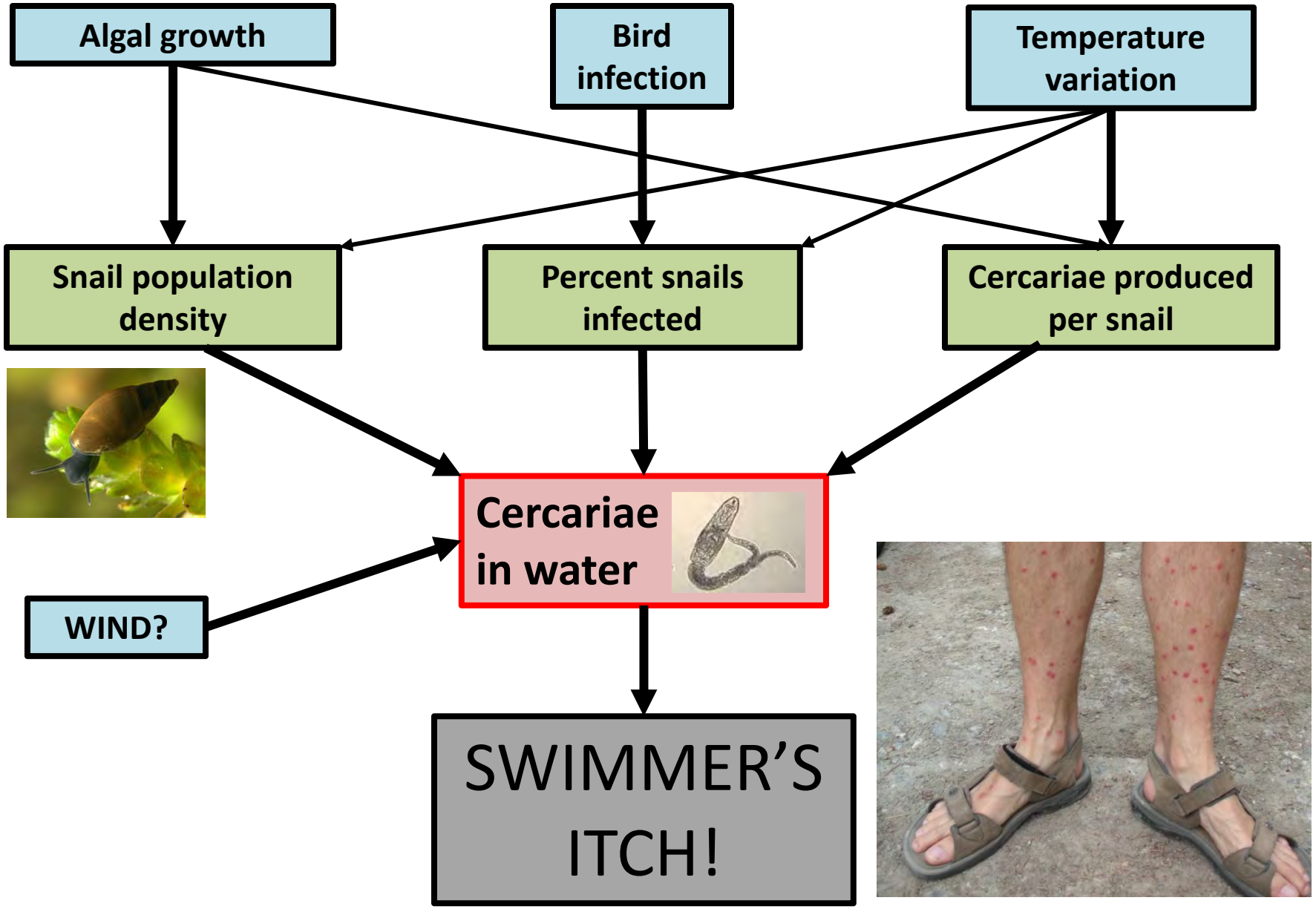
- *Trichobilharzia* spp.
- First described by Cort in Douglas Lake (1928)



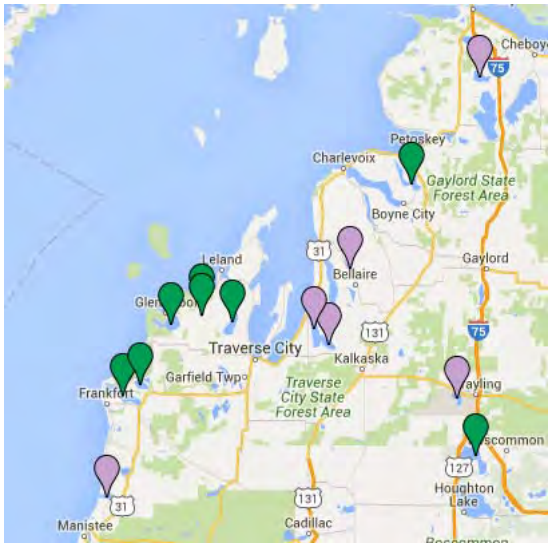
Lymnaea catascopium*
(= Stagnicola emarginata)

Physa integra

What determines swimmer's itch exposure?



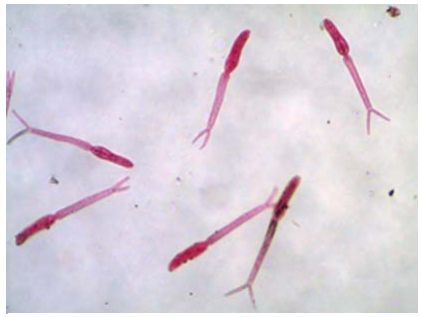
2016 Summer Research Aims:

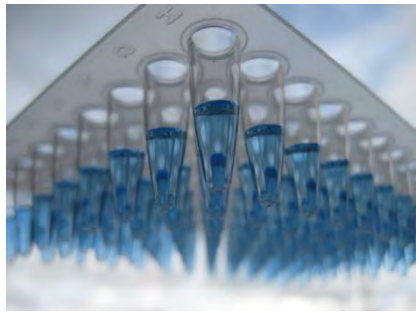


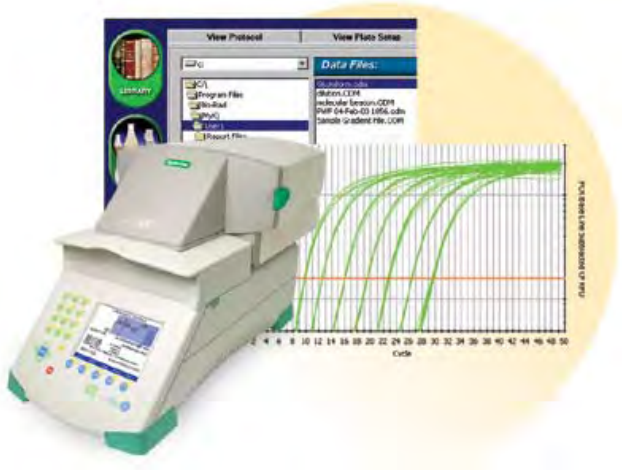
1. <u>Spatial Survey:</u> Sampled 14 sites on 8 lakes to test predictors of schistosome abundance. What factors make some lakes higher-risk?

2. <u>Temporal surveys</u>: What factors influence <u>daily</u> variation in cercaria abundance at individual sites?

Sampling for avian schistosome cercariae:







Quantitative/Real-time PCR

1. Spatial survey (2015):

Maddie Messner:

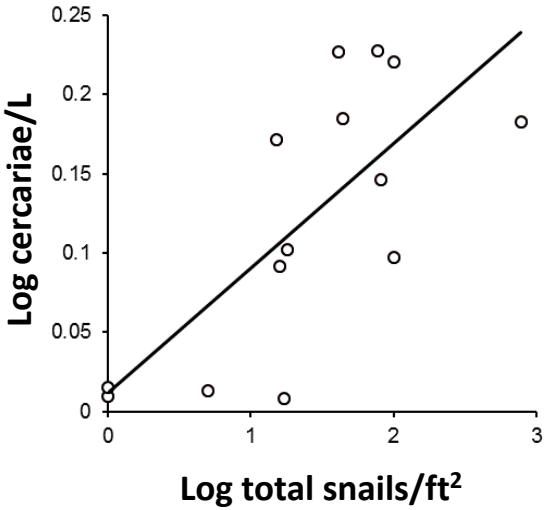
- Organized survey & provided training
- Surveyed snail populations
- Measured environmental variables
- Adapted qPCR assay for field sampling
- Processed cercaria DNA & water chemistry

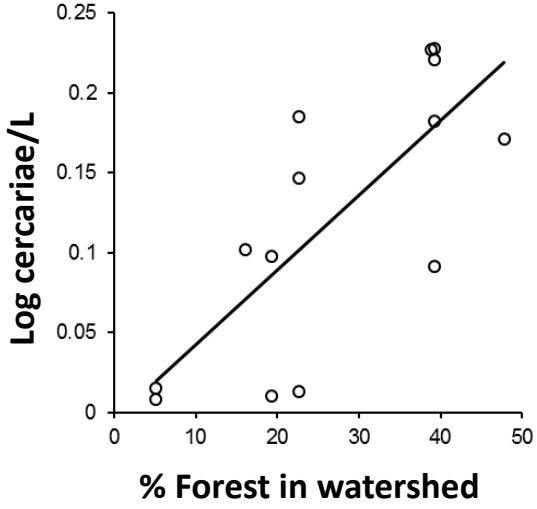
Lake Association assistance:

- Volunteers collected daily filter samples for 2-4 weeks during July/August
- Financial support to analyze cercaria DNA and water chemistry samples
- Helped select sampling sites

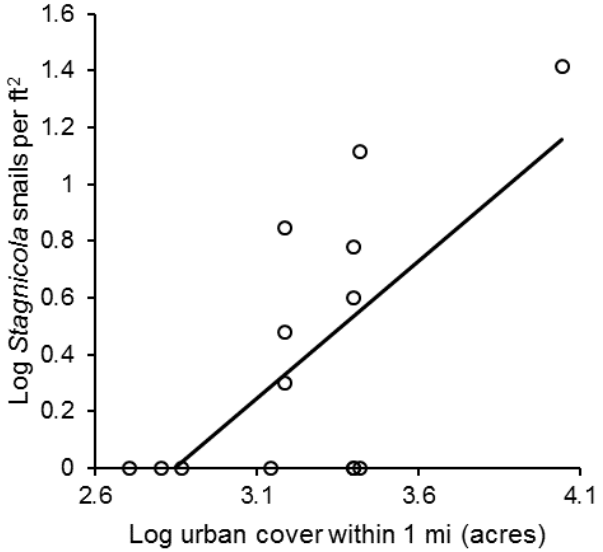
Preliminary Results – best predictors from 2015 (14 sites):

- **Snails + %Forest → More cercariae in water**

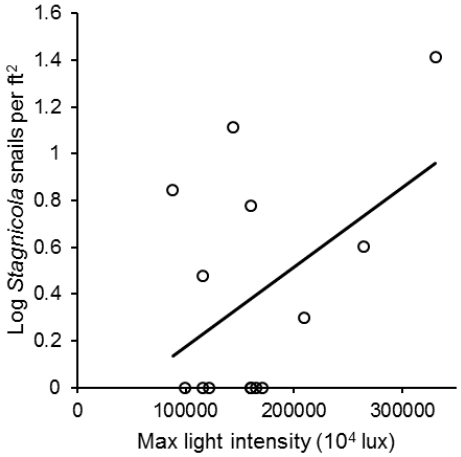


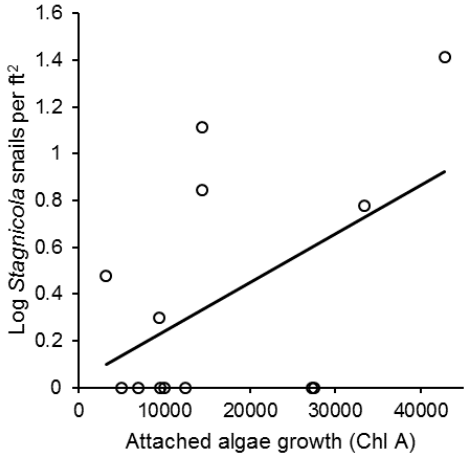


- **More urbanization** (within 1 mi of lake) → **More *Stagnicola* snails**



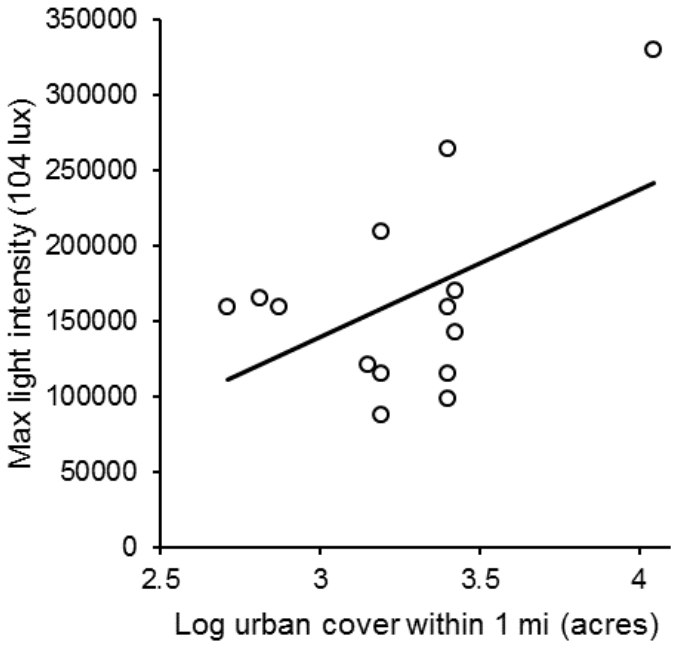
Other correlates: Light intensity & attached algae growth…



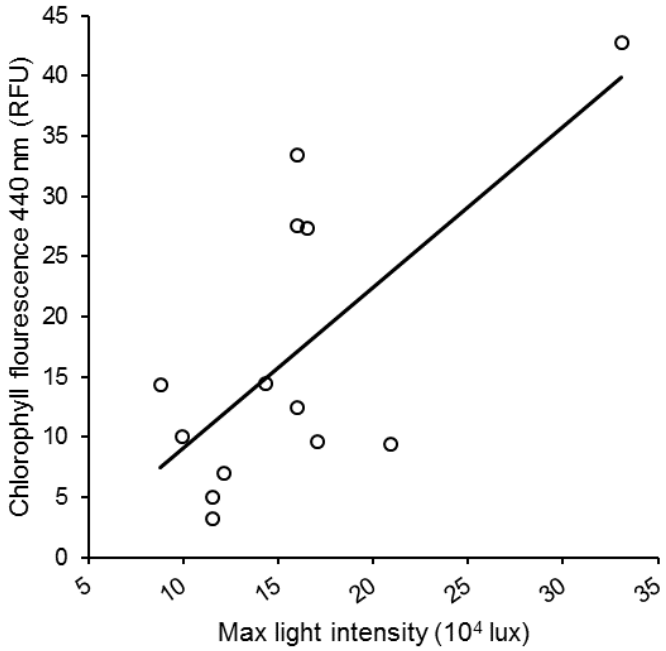


Preliminary Results – best predictors from 2015 (14 sites):

- **More urbanization** (within 1 mi of lake) **→ More light penetration (<u>water clarity</u>)**



- **More light penetration (<u>water clarity</u>) → More attached algae (periphyton growth)**



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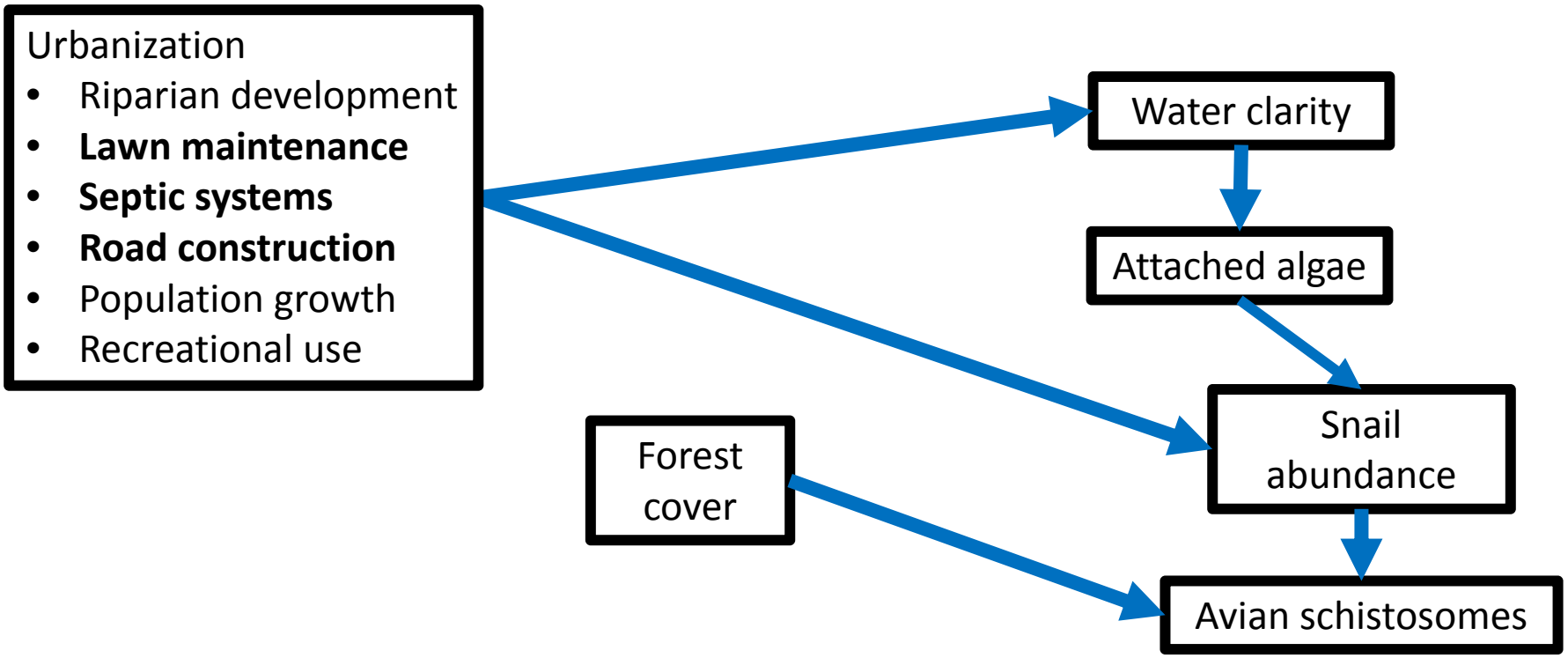
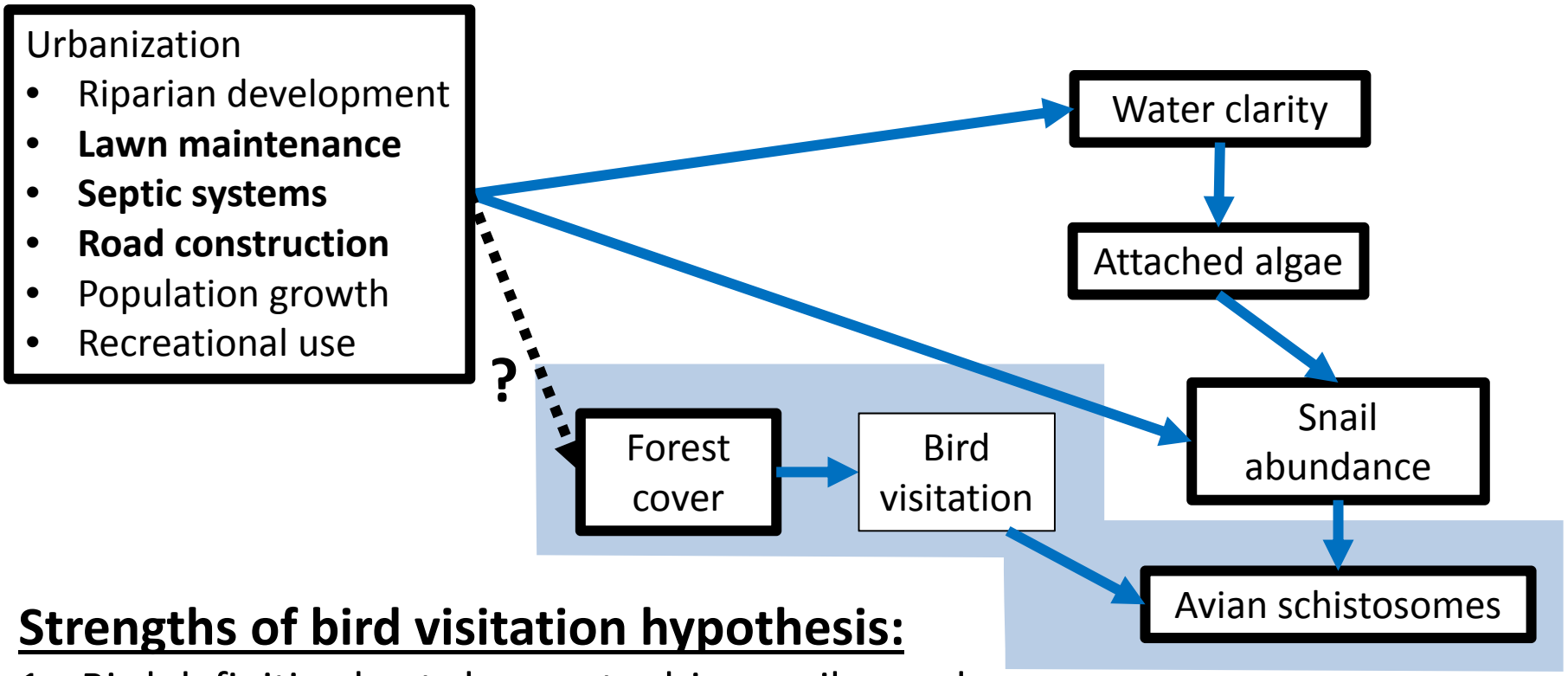


- **Ok, but what mechanisms could cause these effects?**

H1: Forest increases bird visitation → snail infection



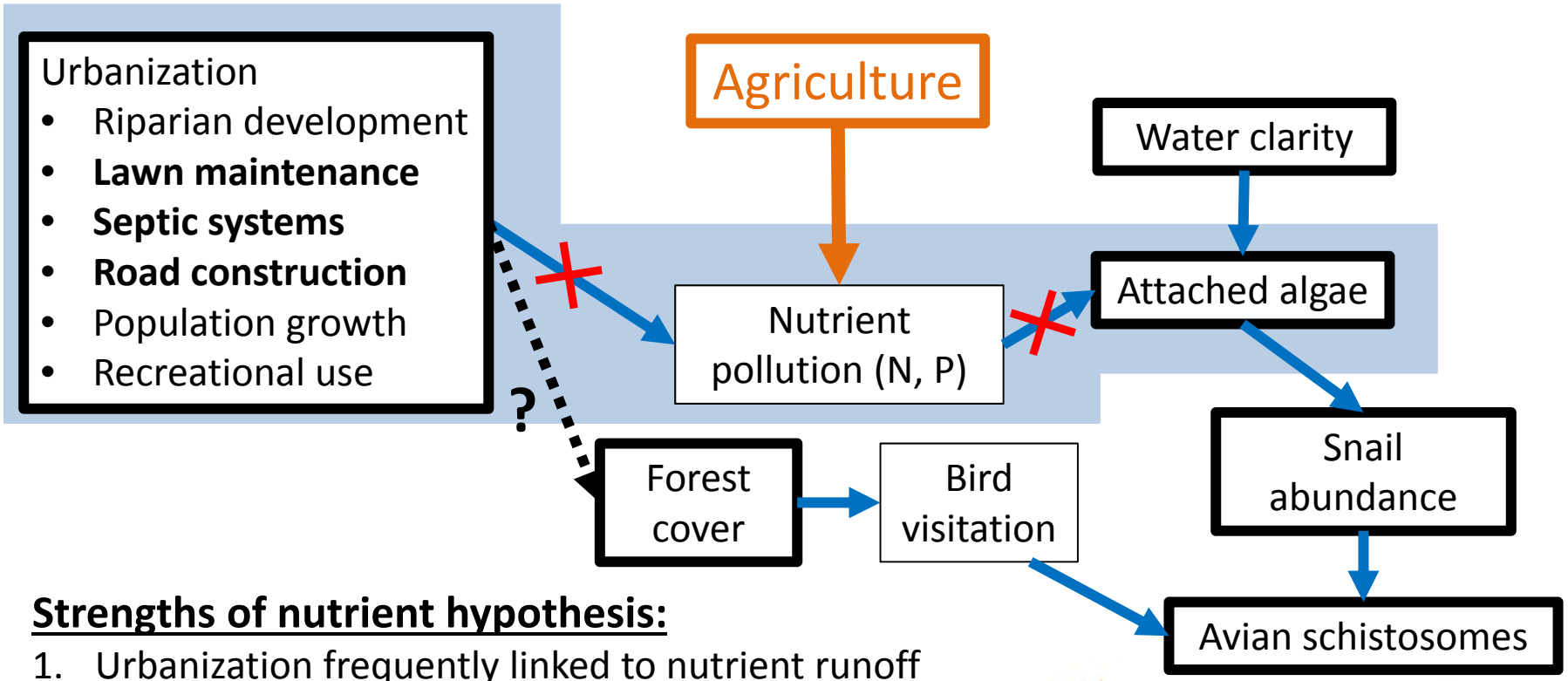
Strengths of bird visitation hypothesis:

1. Bird definitive hosts known to drive snail prevalence
2. Forest cover linked to bird visitation & trematode parasites in prior studies

Weaknesses:

1. Poor-quality bird data from 2015…

H2: Urbanization → Nutrient runoff → Eutrophication

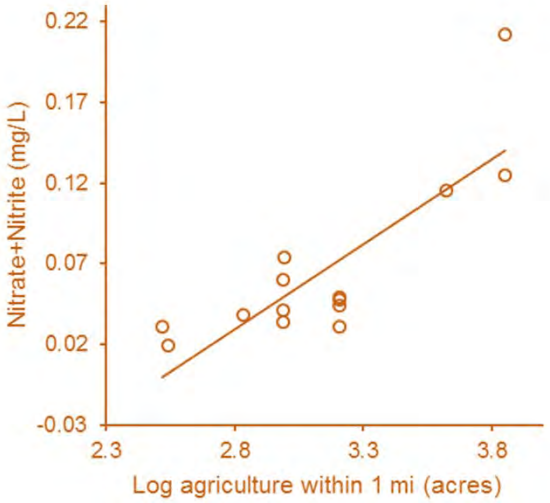


Strengths of nutrient hypothesis:

1. Urbanization frequently linked to nutrient runoff
2. Nutrient runoff frequently linked to algal blooms when nutrients are limiting

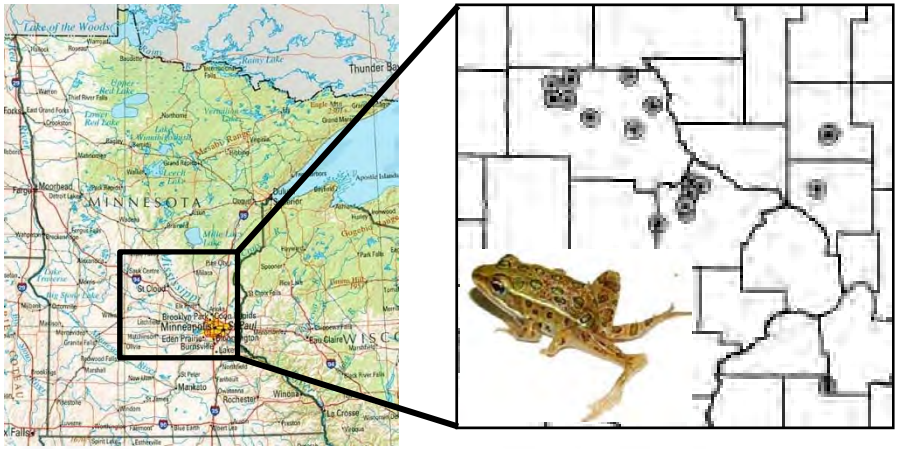
Weaknesses:

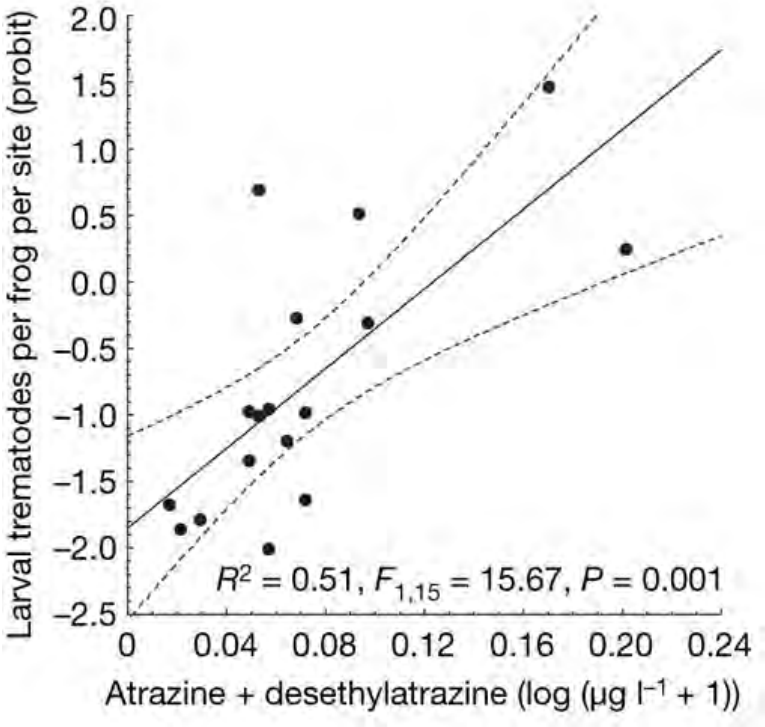
1. N & P poor predictors of attached algae, snails, & avian schistosomes in 2015
2. **N correlated with agriculture not urbanization in 2015 survey**



Herbicides & trematodes:

(2008 Study with Jason Rohr Univ. S Florida)



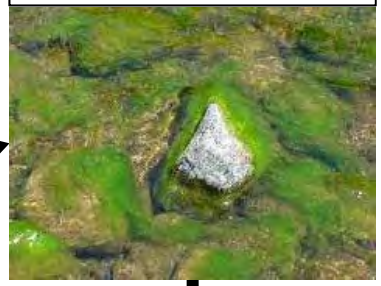


Cattle tank experiment:

Herbicide

Water Clarity

Attached algae

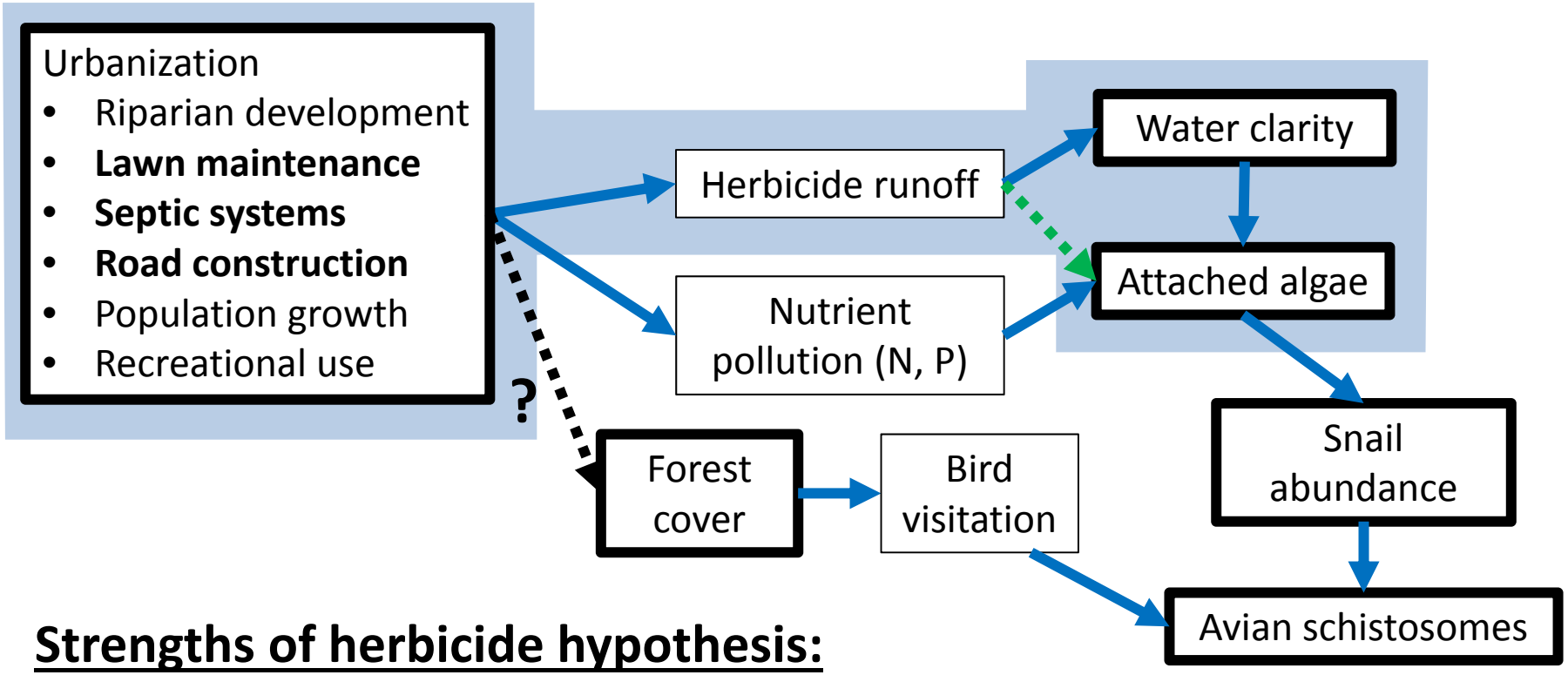


Fertilizer

Snails

Cercariae

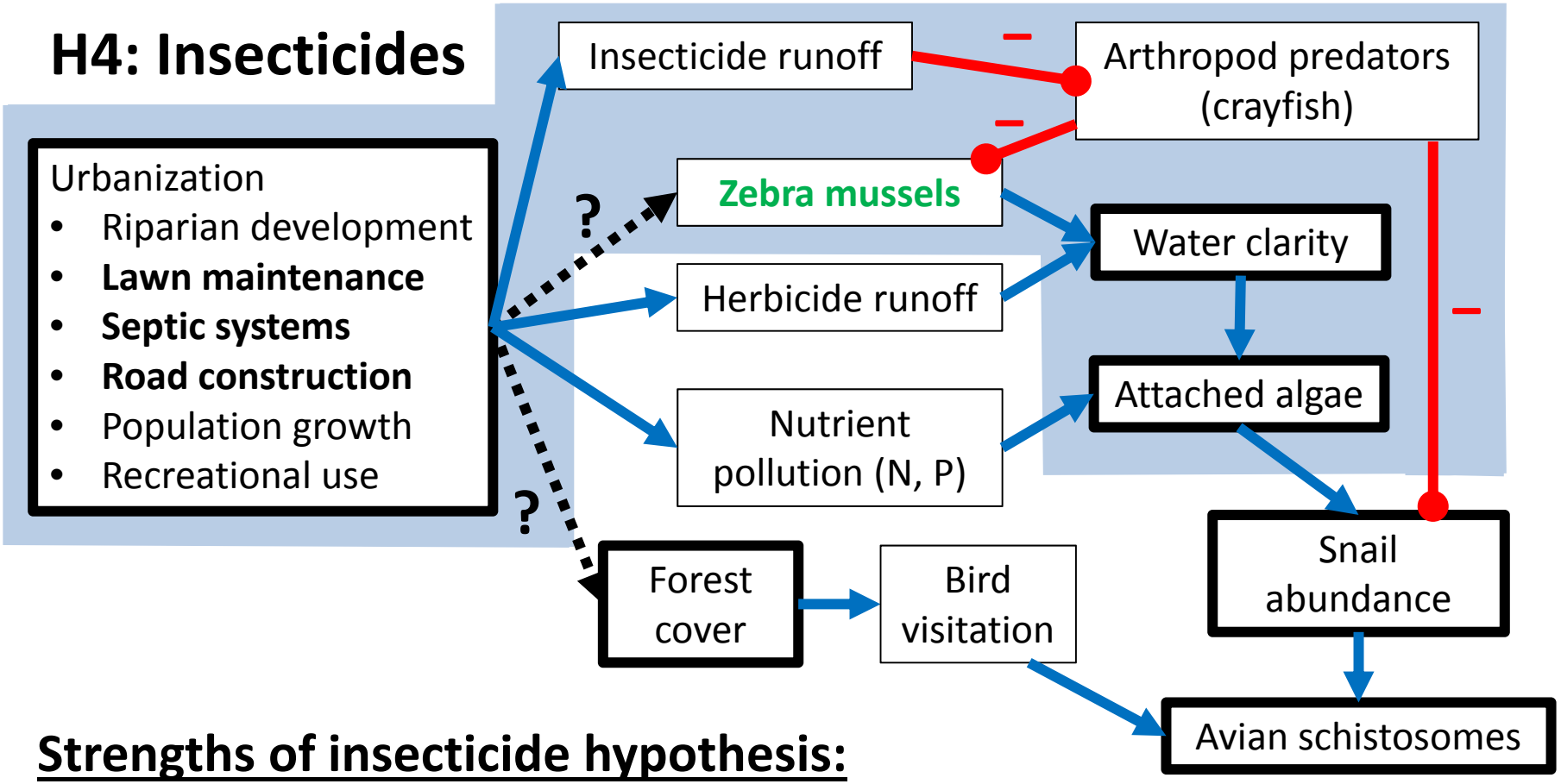
H3: Urbanization → Herbicide runoff → Water clarity



Strengths of herbicide hypothesis:

1. Herbicides increase water clarity & light penetration, leading to more growth of attached algae and more snails
2. Urbanization associated with different herbicides from agriculture (e.g., 2,4-D)
3. **Herbicides can drive changes in attached-algae communities reported by many lake associations (more diatoms = "golden algae")**

H4: Insecticides



Strengths of insecticide hypothesis:

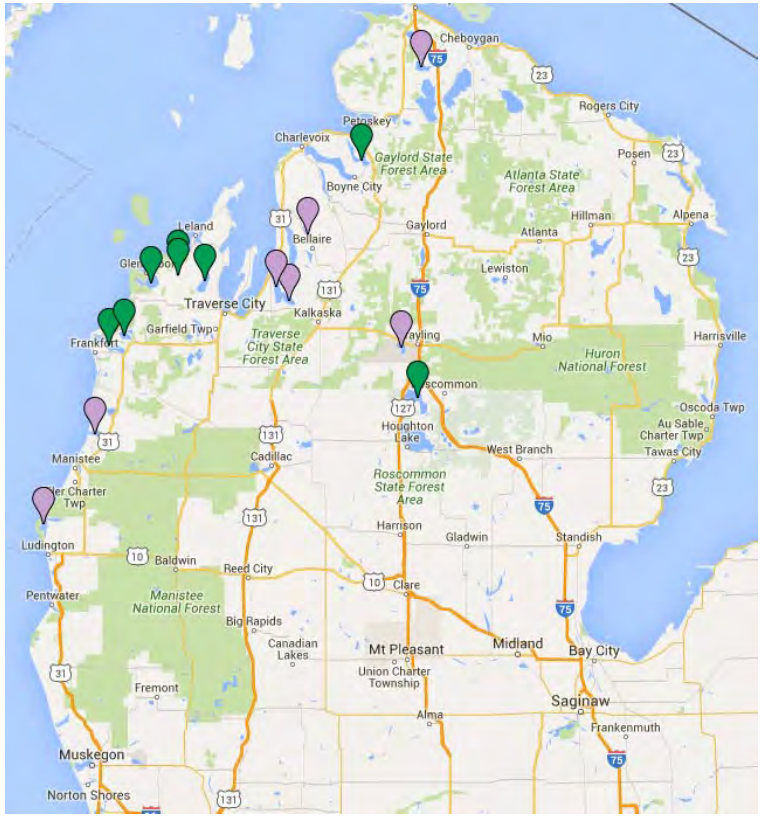
1. Large-scale experiments confirm that insecticides increase snail populations by killing their arthropod predators, including crayfish
2. **Crayfish are also important predators of zebra mussels, which have major effects on water clarity (and therefore attached algae)**

Spatial survey 2016 (15 lakes & 35 sites so far…)

What determines patterns of schistosome cercariae production across a broad landscape?

Potential predictors:

- lake size/depth/hydrology
- Land use & soil/rock types
- Climate (temp, precipitation, wind)
- Snail & invertebrate densities
- Pollutants (pesticides & nutrients)
- Algae/vegetation growth
- Bird visitation



Nutrients

Snail densities

Land Use

2016 survey parameters:

Continuous/Daily monitoring:

- Cercaria density - daily filtered-water samples (volunteers + qPCR)
- **Wind speed & direction (volunteers)**
- Water temperature & light penetration (HOBO loggers)

Weekly surveys:

- Snail quadrat sampling & **collection** (identification, size distribution)
- **Turbidity***
- **Crayfish trapping**
- **Zooplankton sampling (density, composition)**
- **Bird camera traps***

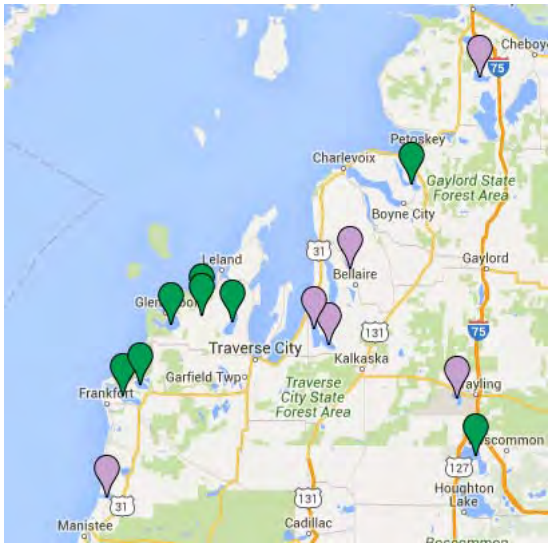
Site-level measurements:

- Attached algae (periphyton) growth & **composition***
- **Zebra mussel sampling (settling rate)**
- Water chemistry (nitrates+nitrites, organophosphate, ammonia)
- **Nutrient limitation (bioassay)***
- **Pesticides (atrazine + products; 2,4-D; organophosphates + carbamates)**
- **Sediment cores (Copper*, Phosphorus, Organic carbon)**
- Substrate & shoreline characteristics; fetch; **slope**

Lake-level characteristics:

- Land use in watershed & near shore
- Lake size & depth

2016 Summer Research Aims:



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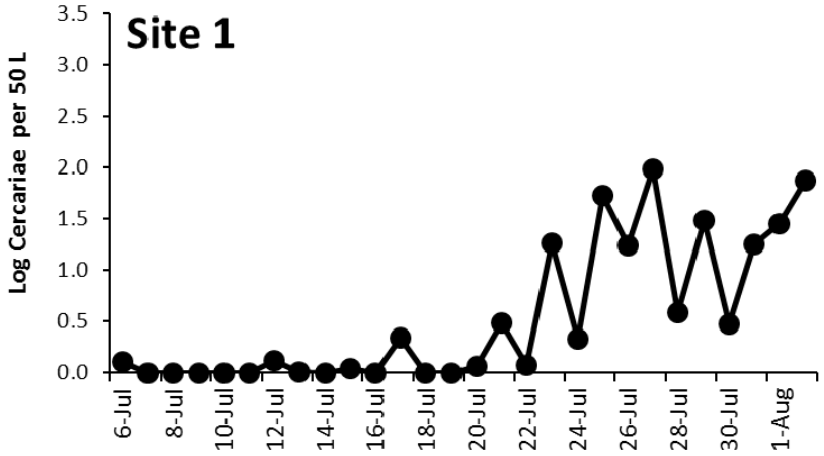
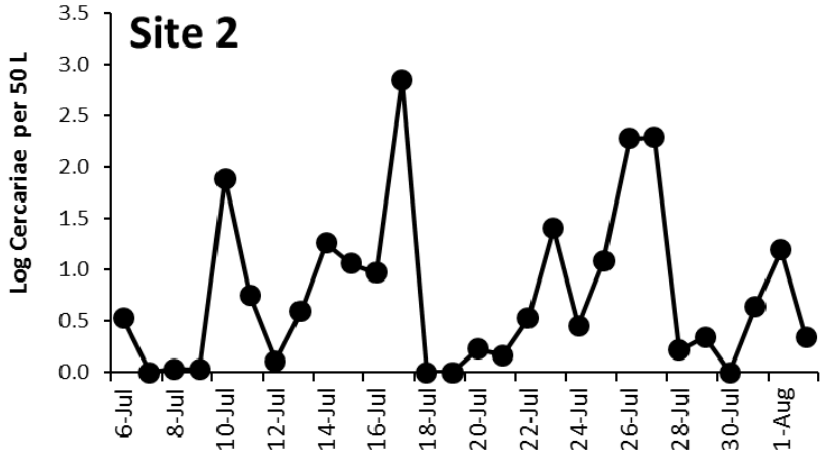
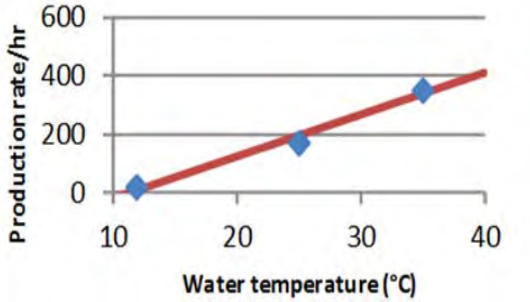


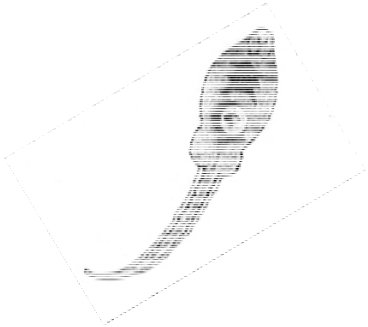


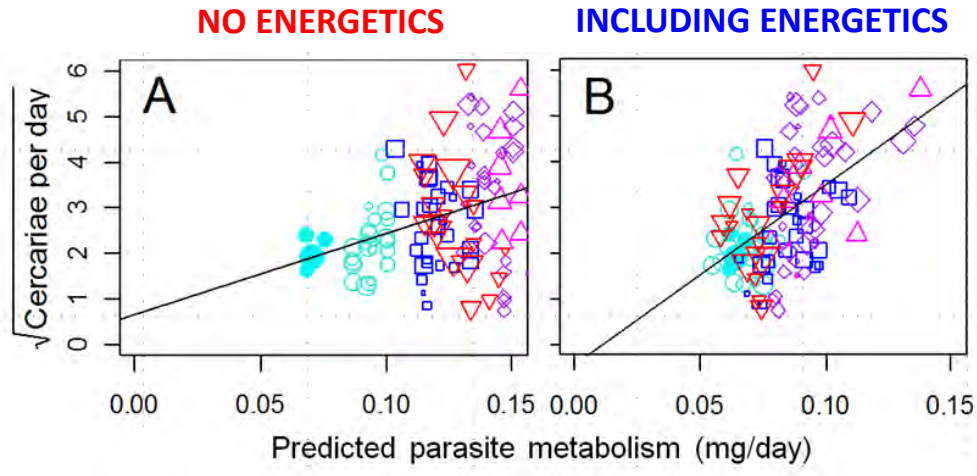
2. Daily variation (28 days sampling)

- Hypothesis– temperature-dependent cercaria production
  - Cercaria production rates change daily
  - Also depends on **<u>snail energetics</u>**
    - ➢ Temperature shifts change predictions…



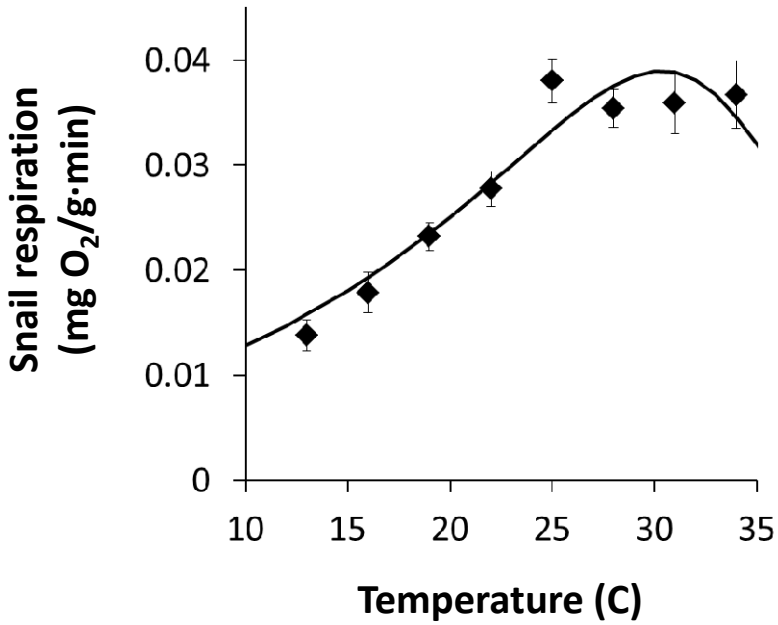
- <u>Predictive model (variable-temps):</u>
  - Based on **metabolic theory** & **dynamic energy budget** theory
  - Parameterized by measuring temperature-dependence of host <u>food assimilation</u> & <u>respiration</u>

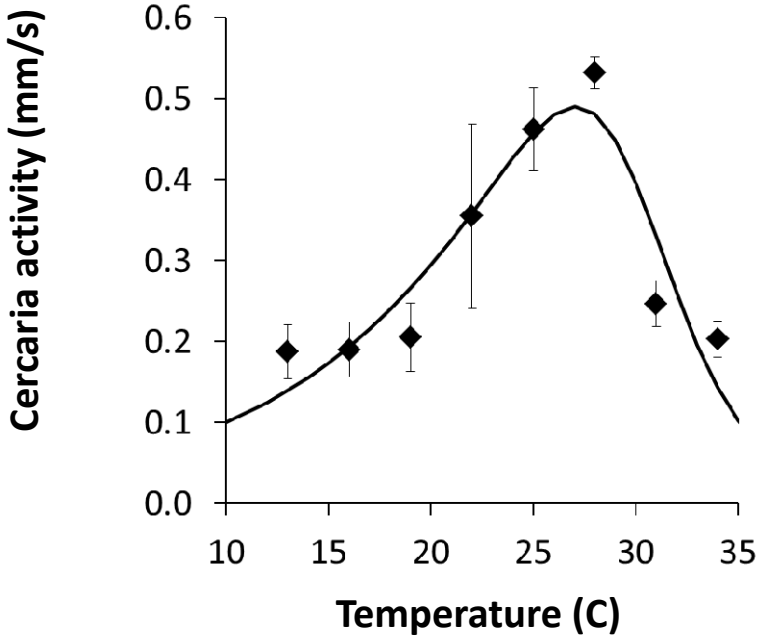


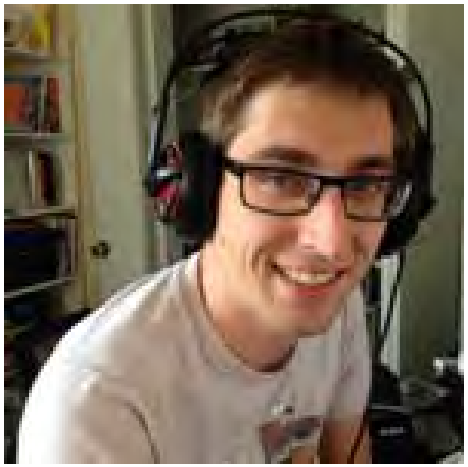


- **<u>Alternative predictors</u>**– wind speed/direction, snail densities

2. Modeling daily variation – lab experiments



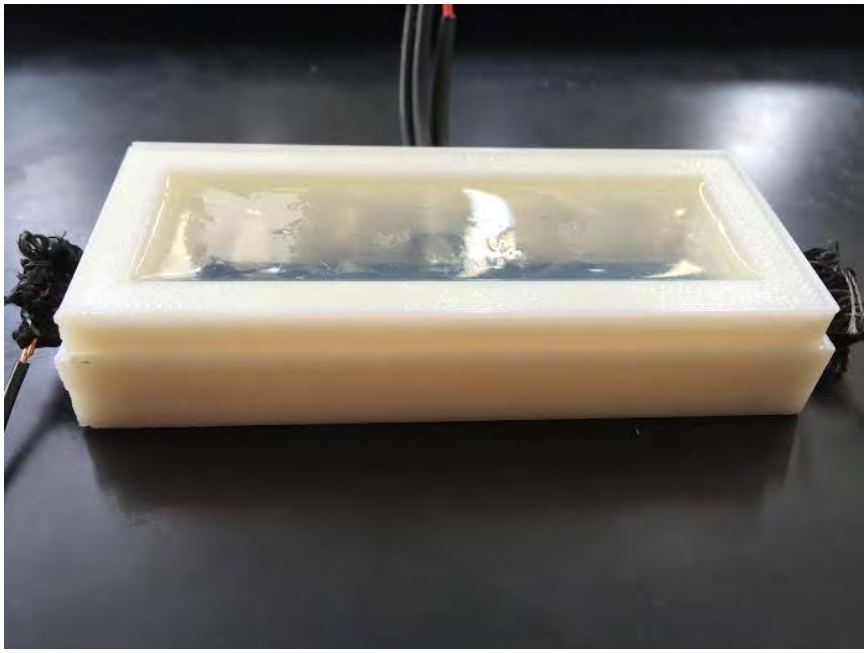


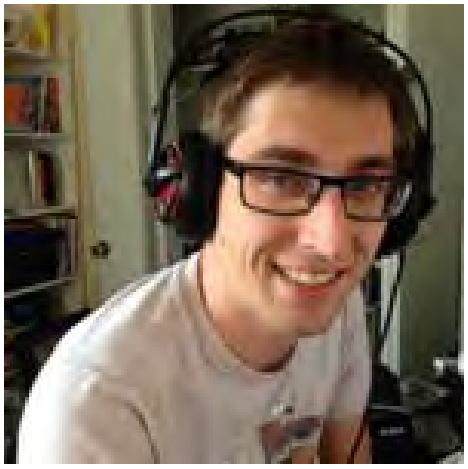


$$m_R\{T\} = R_{T0}\left(\frac{M_E}{M_{Emax}}\right) e^{\frac{E_a^R}{k}\cdot\left(\frac{1}{T}-\frac{1}{T_0}\right)}\left(1 + e^{\frac{E_d}{k}\left(\frac{1}{T_h^R}-\frac{1}{T}\right)}\right)^{-1}$$

$$m_P\{T\} = P_{T0}\left(\frac{M_E}{M_{Emax}}\right) e^{\frac{E_a^P}{k}\cdot\left(\frac{1}{T}-\frac{1}{T_0}\right)}\left(1 + e^{\frac{E_d}{k}\left(\frac{1}{T_h^P}-\frac{1}{T}\right)}\right)^{-1}$$

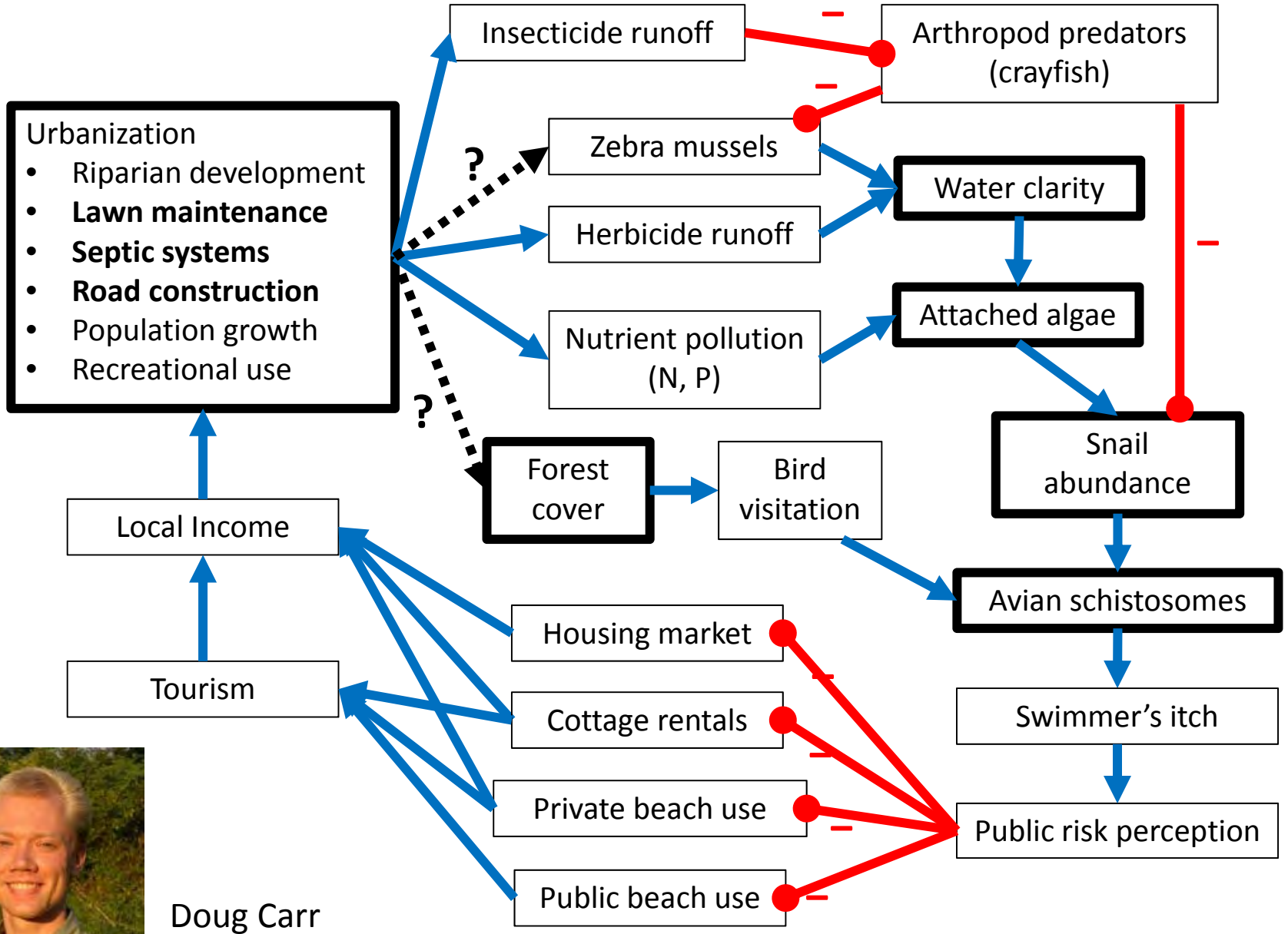
Side project: In vitro model to test skin cream effectiveness





Future direction: ECONOMIC IMPACT STUDY

Doug Carr
Oakland University



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