Life by the drop:
the environmental DNA revolution in invasive species management

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Where is this talk going?

1. Overview of the problem we are facing in regards to invasive species, especially in the Northeast

2. What is environmental DNA and how does it ‘work’?

3. Applications of eDNA: aquatic invasive species + insect pests

4. When should you adopt an eDNA survey

Welcome to the Hotspot

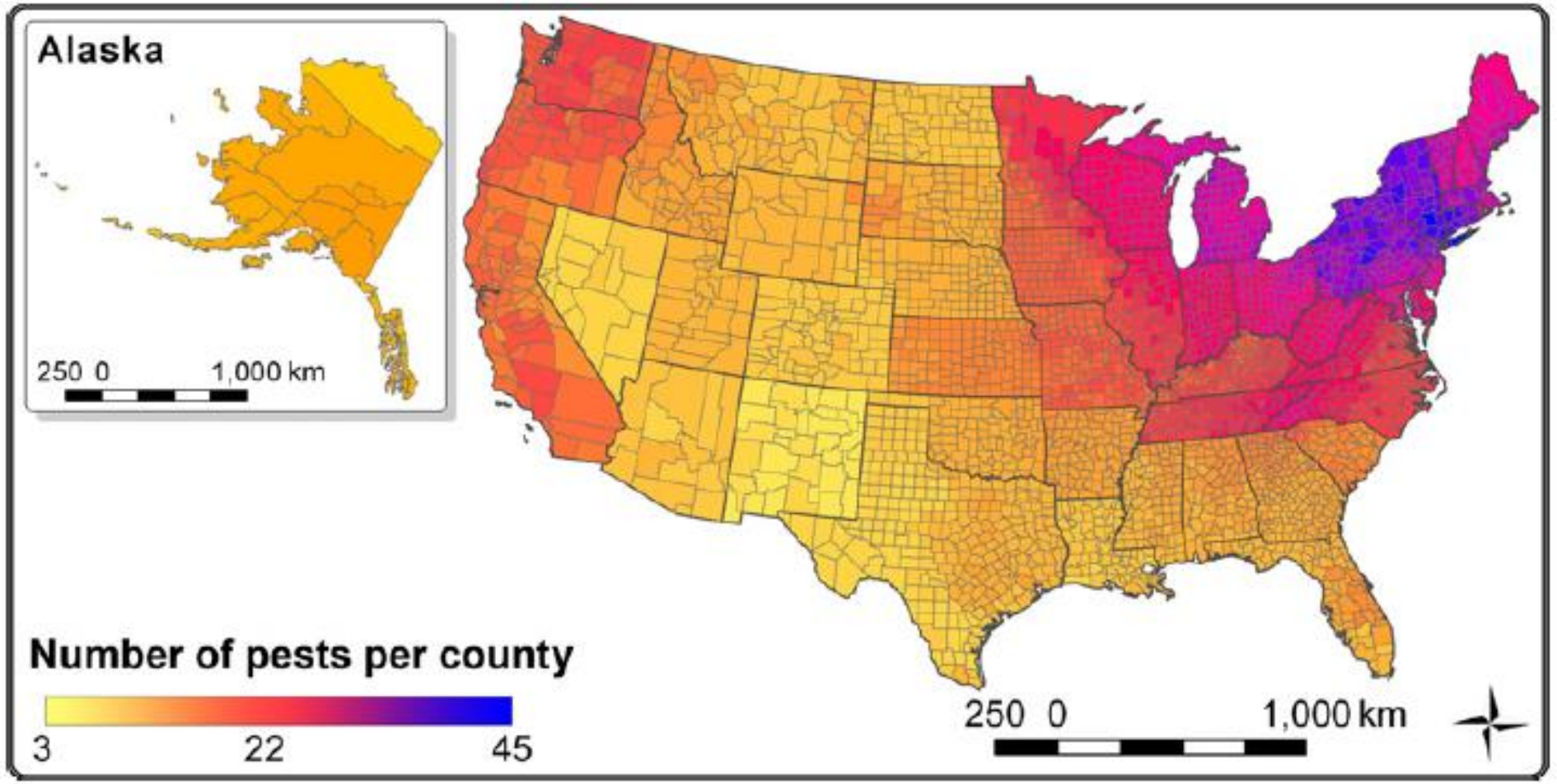
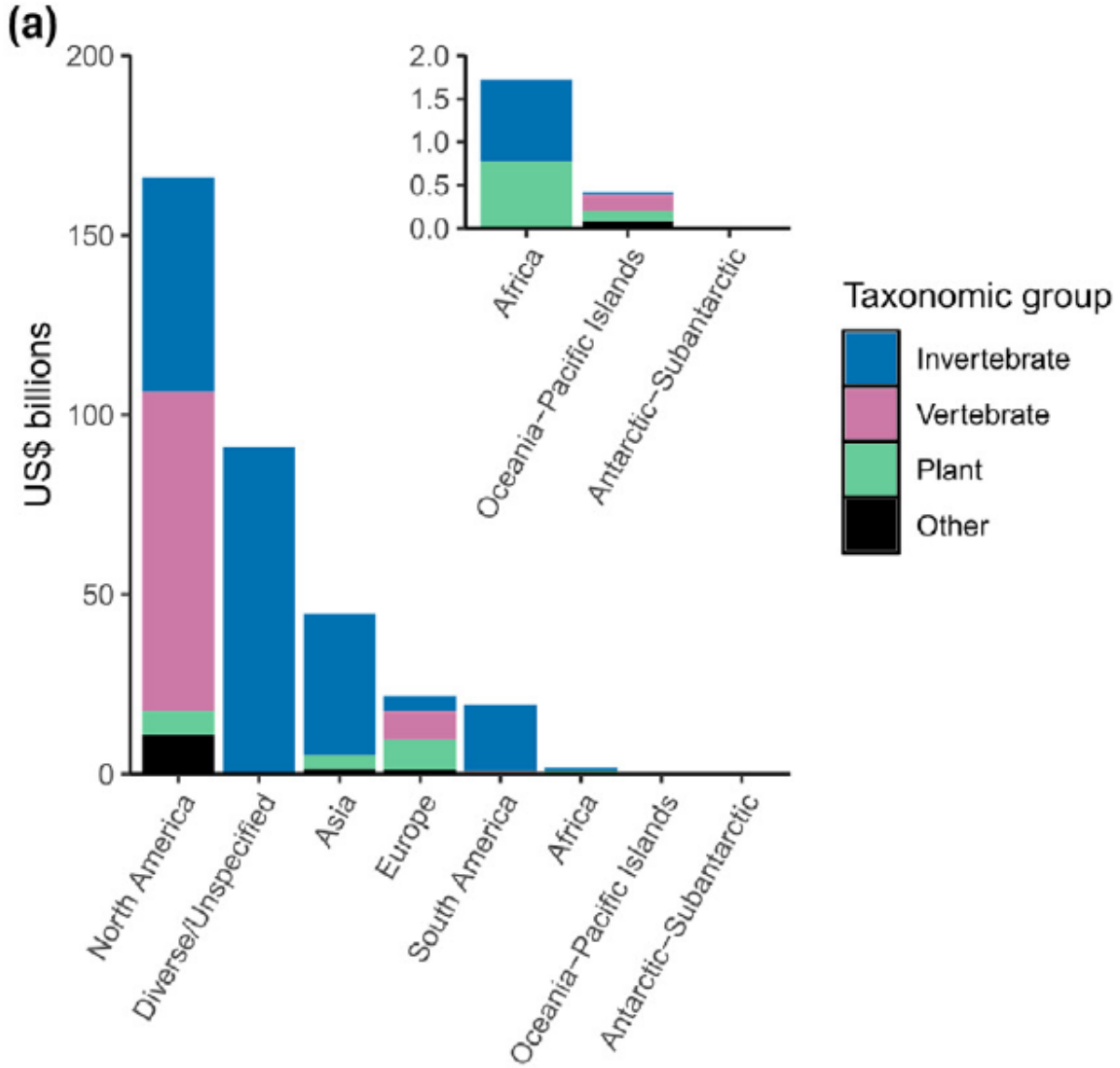
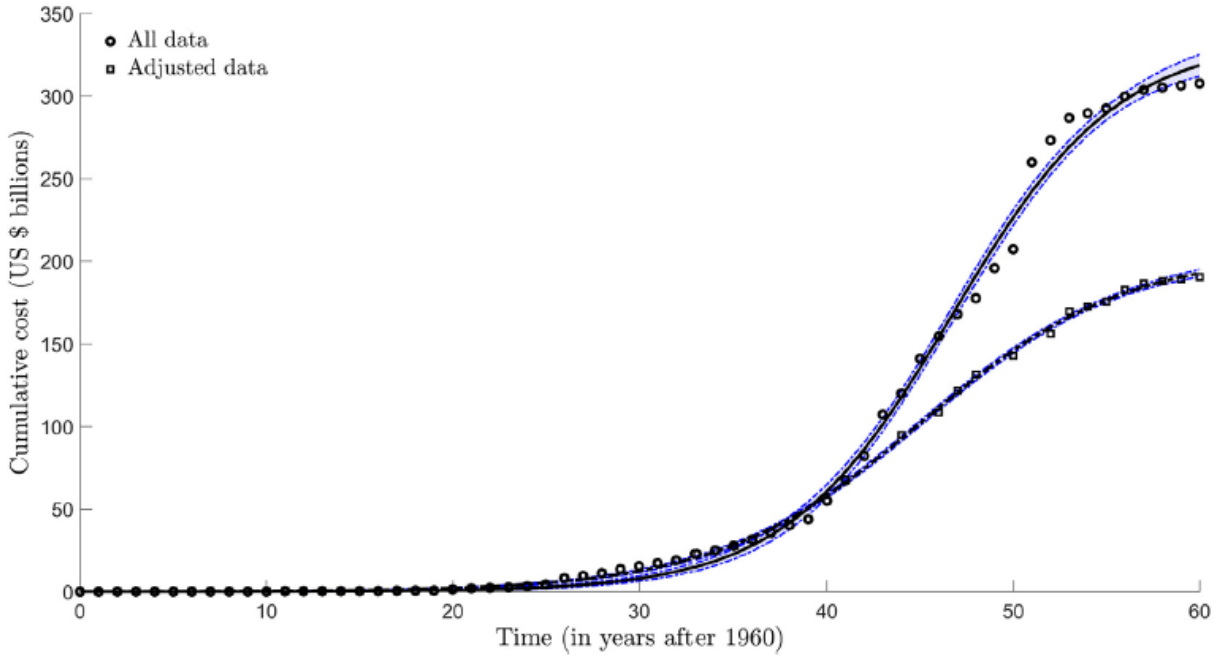


Figure 1 Numbers of damaging invasive forest pests per county.

Aquatic invasive species are an expensive and growing issue where impacts are ecological, economic, and health related

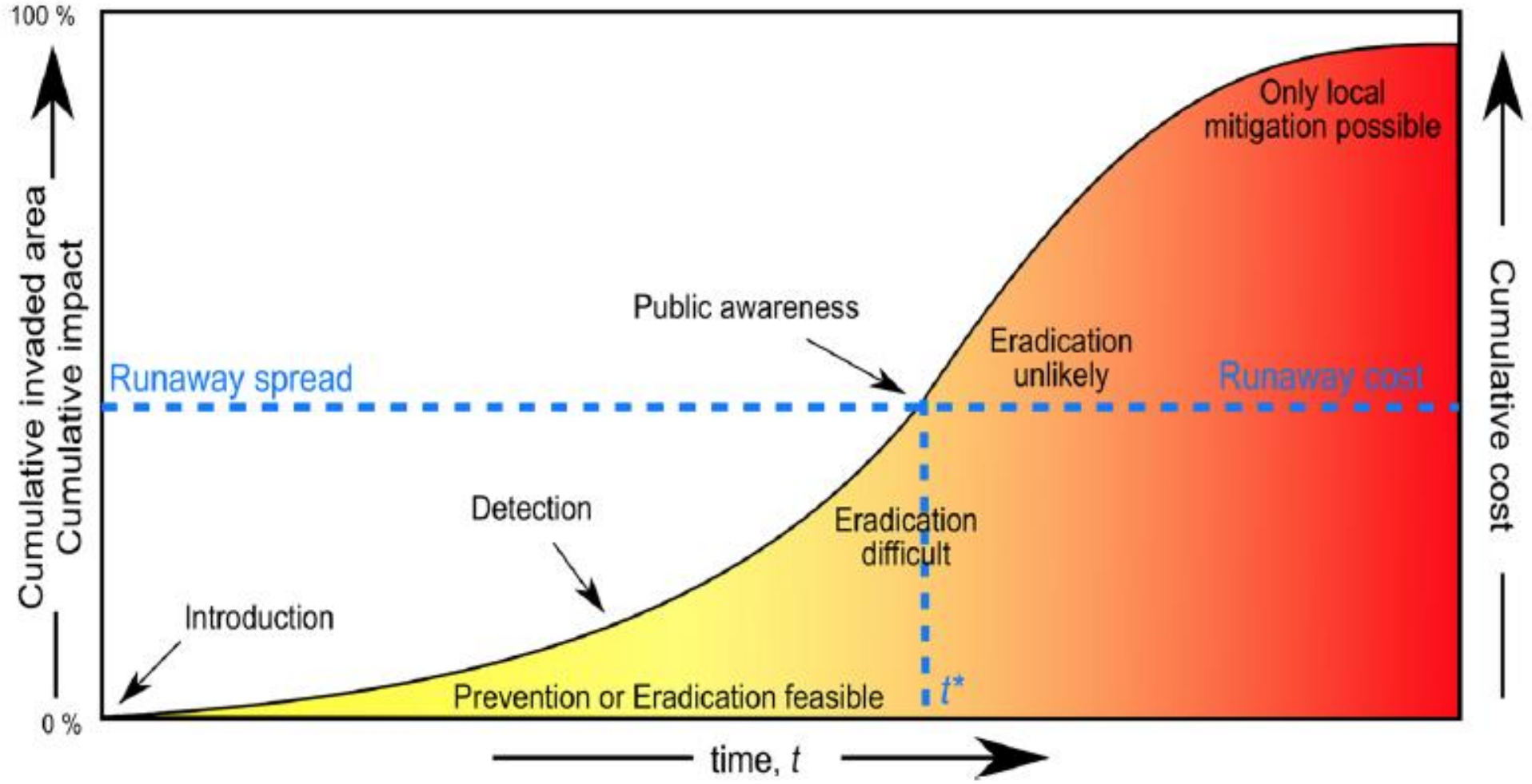


Cuthbert et al. 2021 Sci. Total Env.



The Cost of Inaction

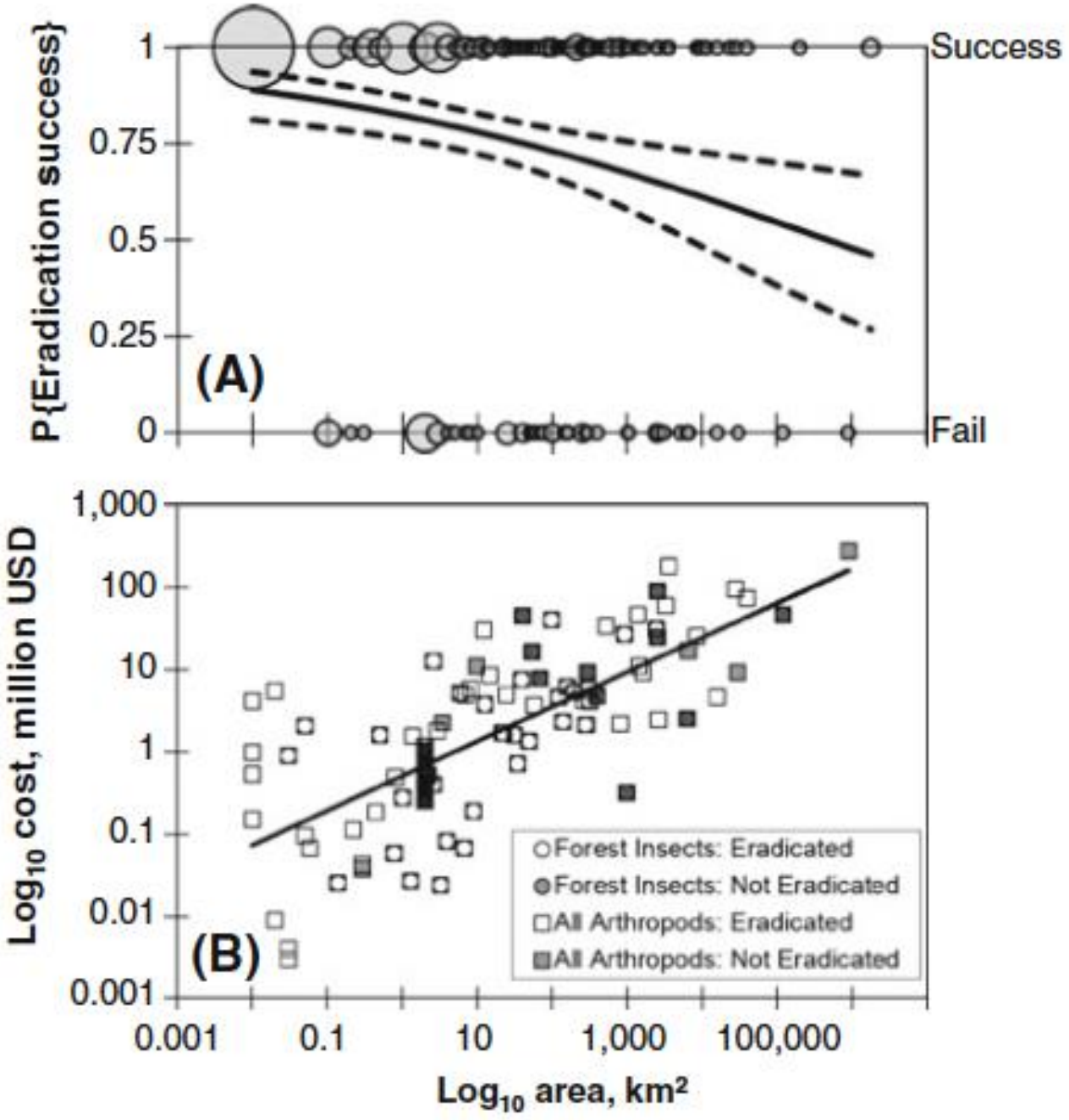
There is a point in the ‘invasion curve’ where spread of the non-native population and the costs for controlling that population hit ‘runaway’ status



Ahmed et al. 2022 Biol. Invasions

One of the most pernicious problems when responding to invasive species is simply finding them, especially when they are at very low abundance

Survey false negative rate: when a survey tool fails to find evidence of the presence of a pest insect at a location when that pest is actually there = lost opportunity



Arthropod Eradication Attempts

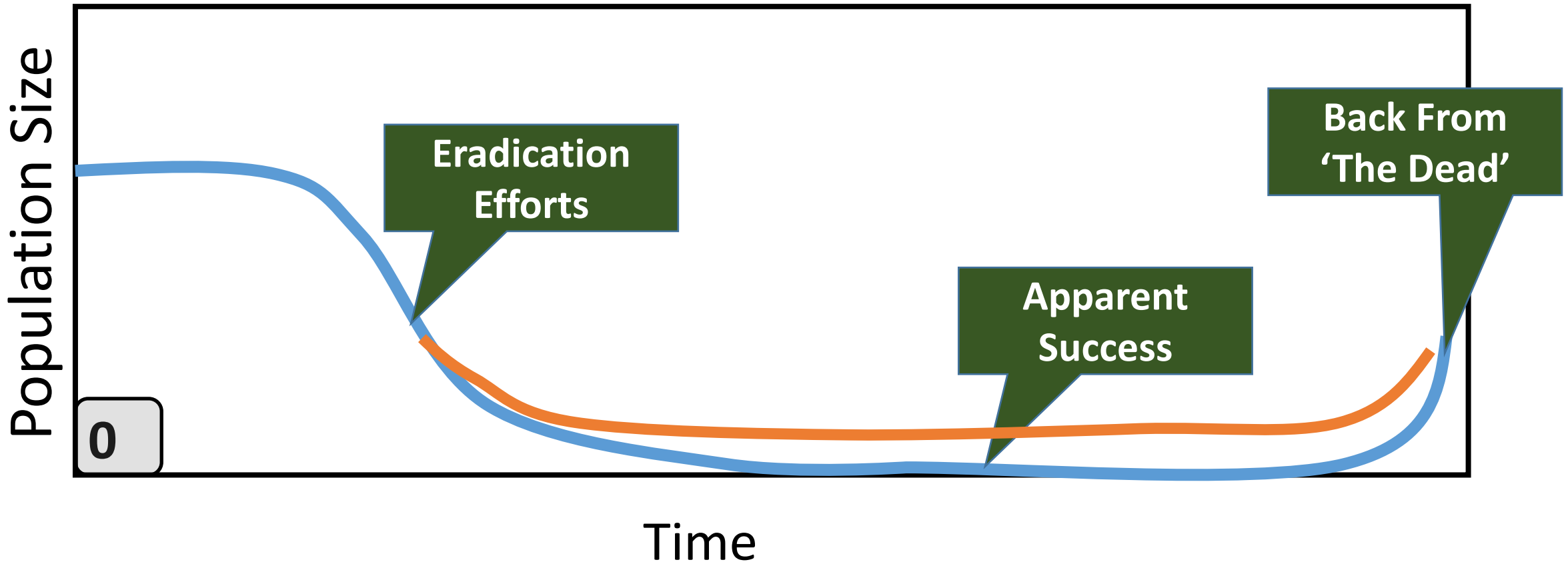
Success of Eradication and Stop-the-Spread Programs Depend Critically on the Ability to Detect the Presence of Target Species When They Are Rare

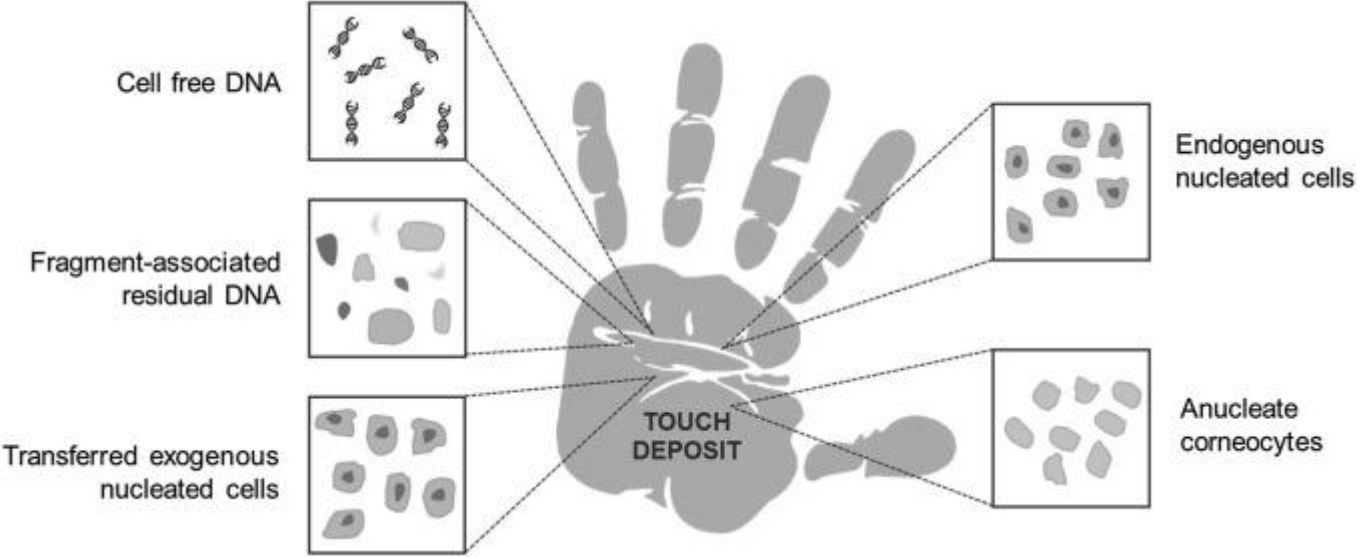
Tobin, P.C. et al. 2014 Biol. Invasions
Tobin, P.C. et al. 2013 Pop. Eco.
Pluess, T. et. Al. 2012 Biol. Invasions

Lazarus Effect

When is it safe to declare eradication success and ‘go home’?

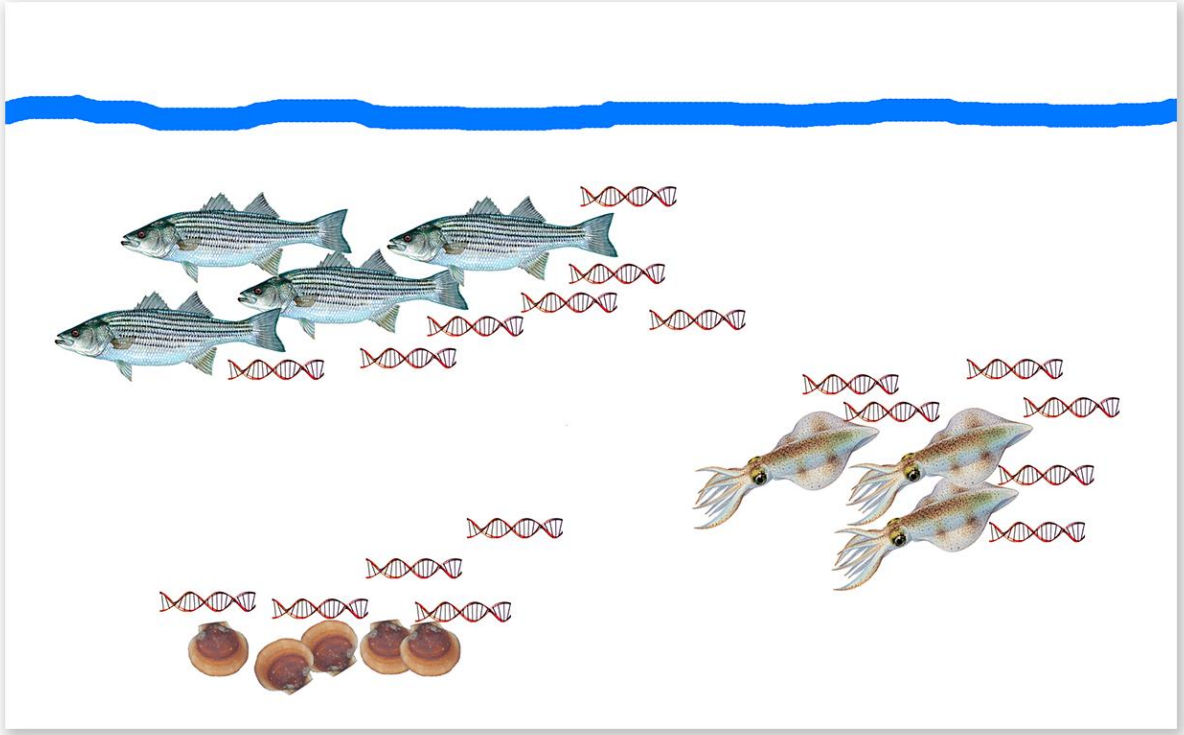
Detection at low abundance or in difficult to reach areas is critical to this decision



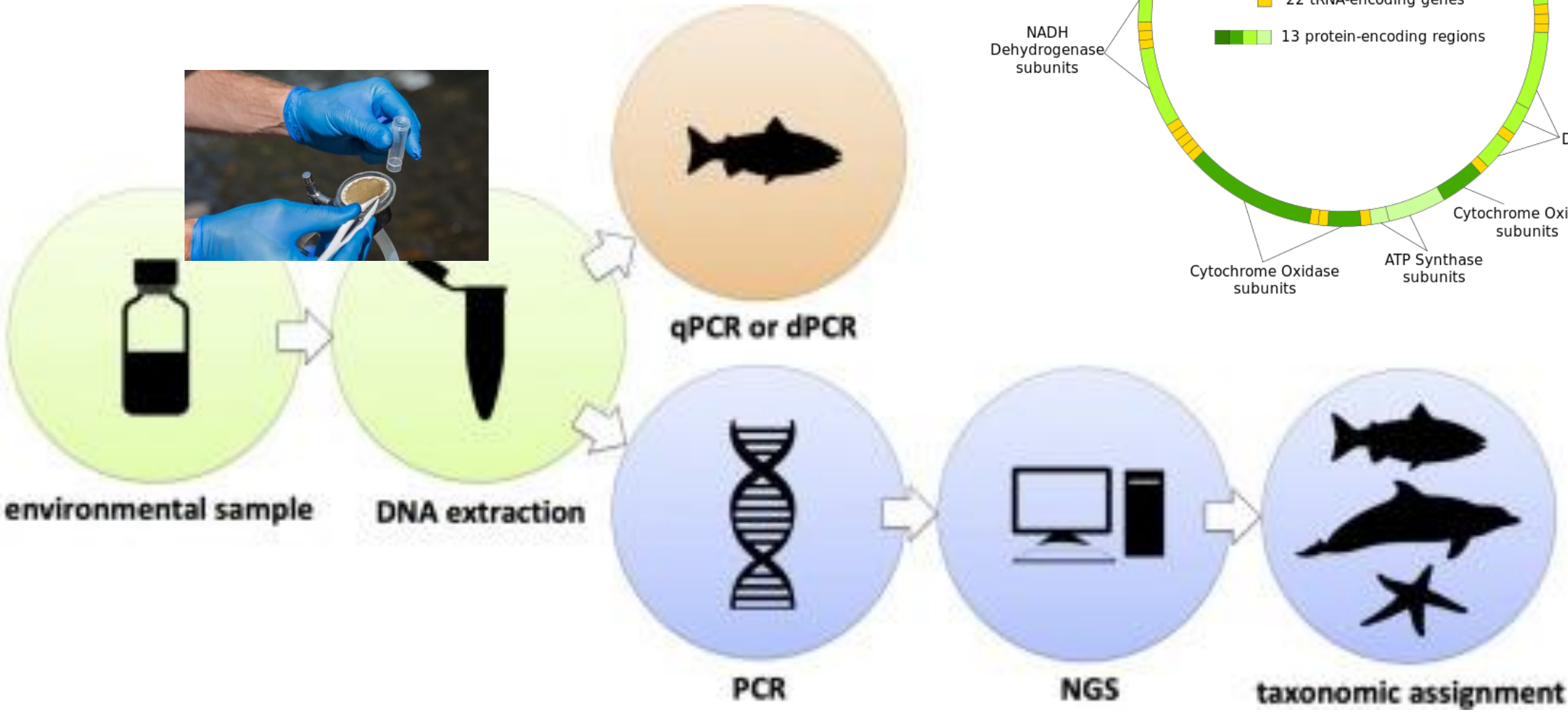


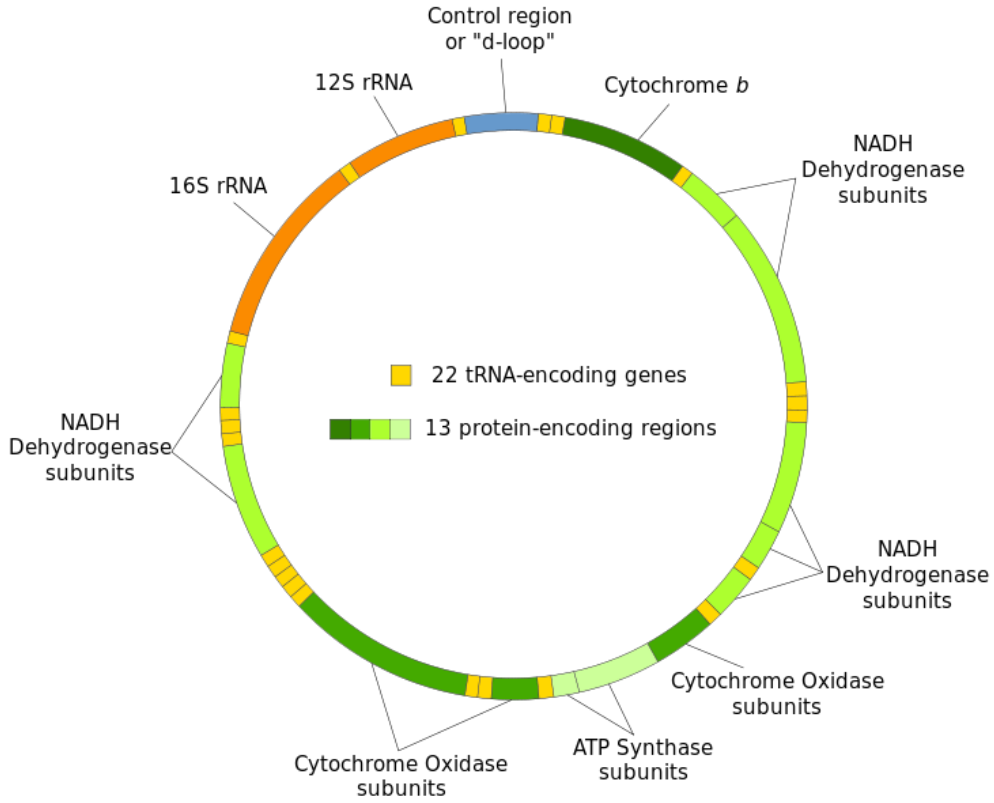
Environmental DNA is genetic material that is shed by living organisms into the environment and can be sampled through collection of bulk materials such as water and soil

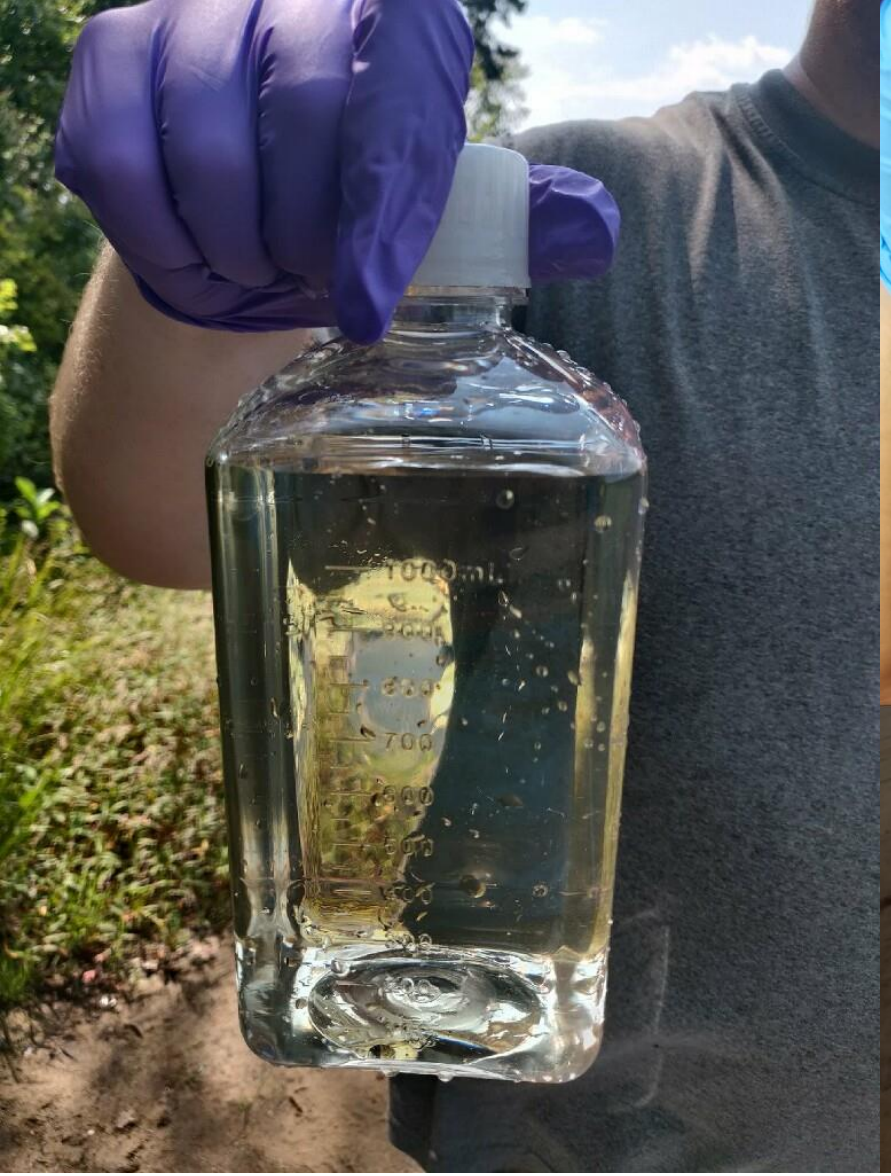
Sight Unseen Detection

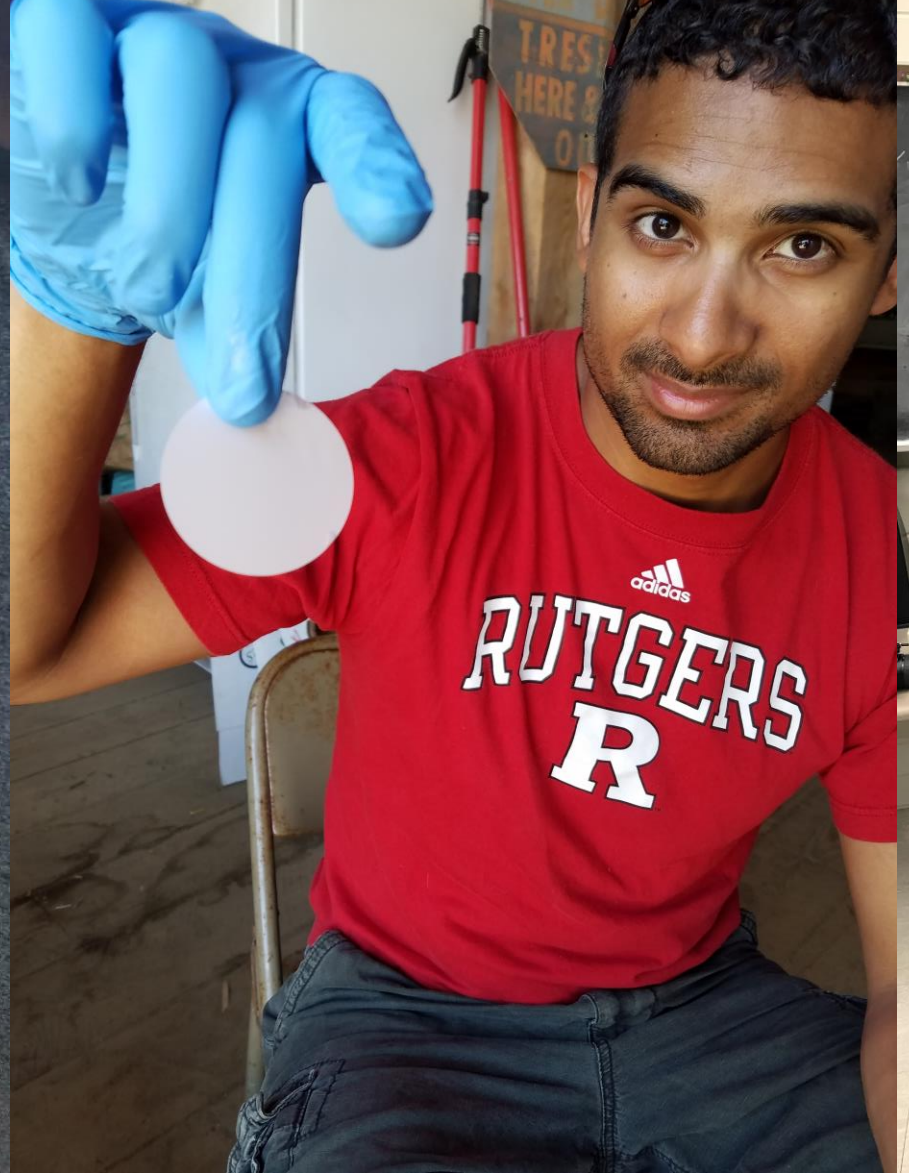


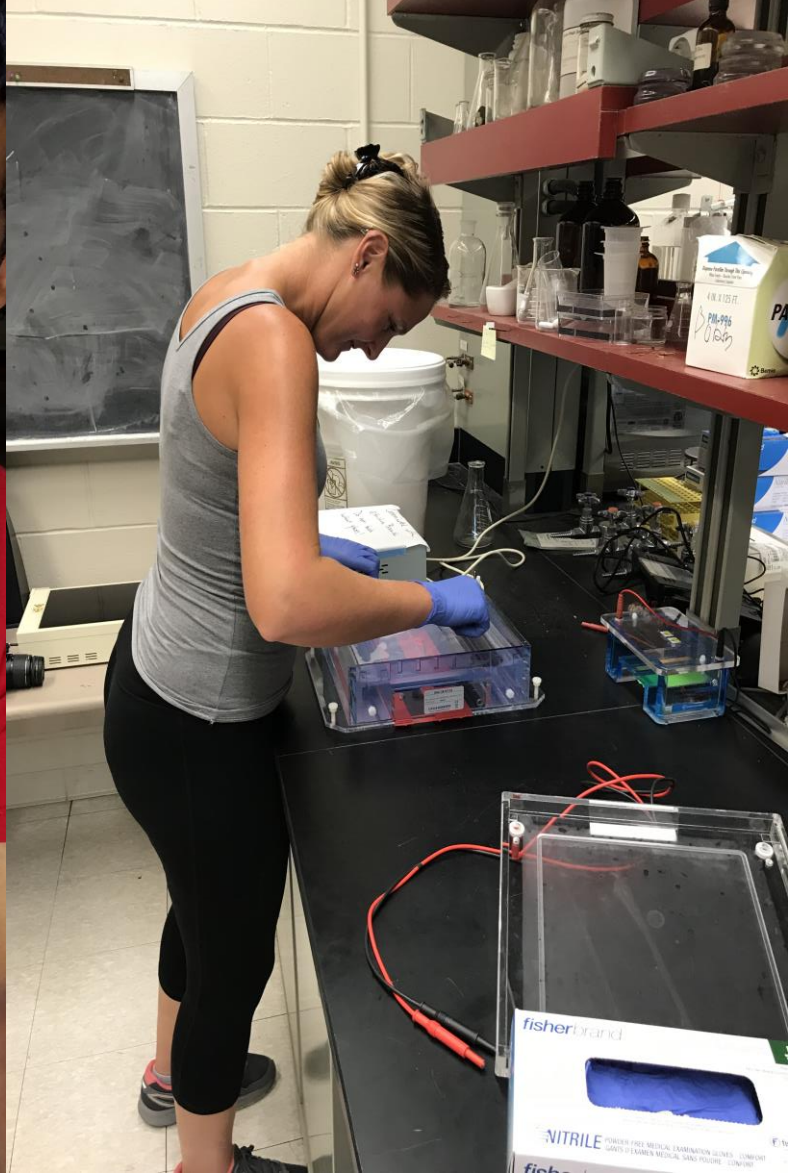
How do I know a species was present at a site based on the DNA collected from an environmental sample?







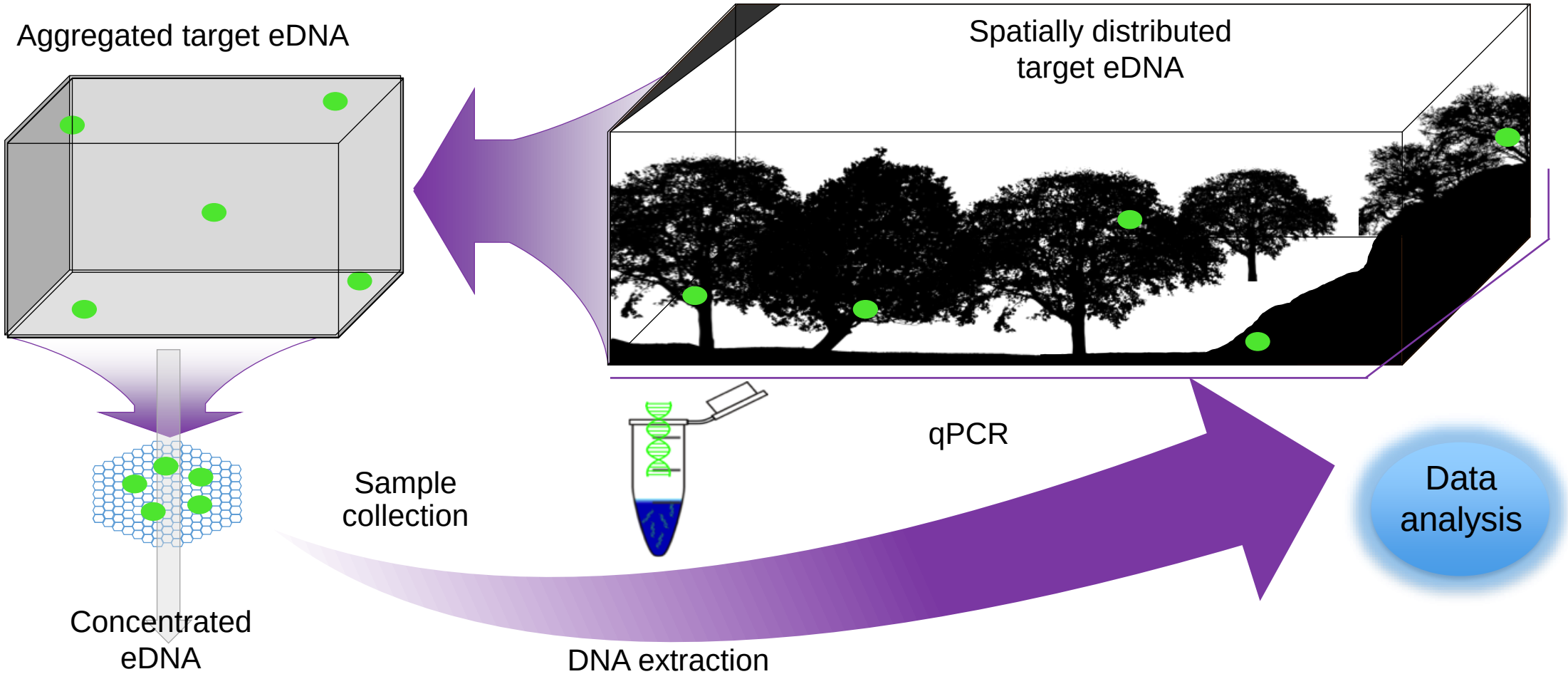




From Field to Lab

Spray Sampling

Roller Sampling



Valentin, R. et al. 2018 Frontiers in Ecol. And Env.

Chinese Pond Mussel

Impacts: (1) filter feeder that can alter availability of food in water body (2) generalist parasitic stage that competes for host fish with native mussels

We are developed an eDNA assay for the species. Used this assay to conduct eDNA surveys to confirm that eradication, and if not, as guide to next steps AND to survey broadly to ensure that it has not silently spread to other waterways

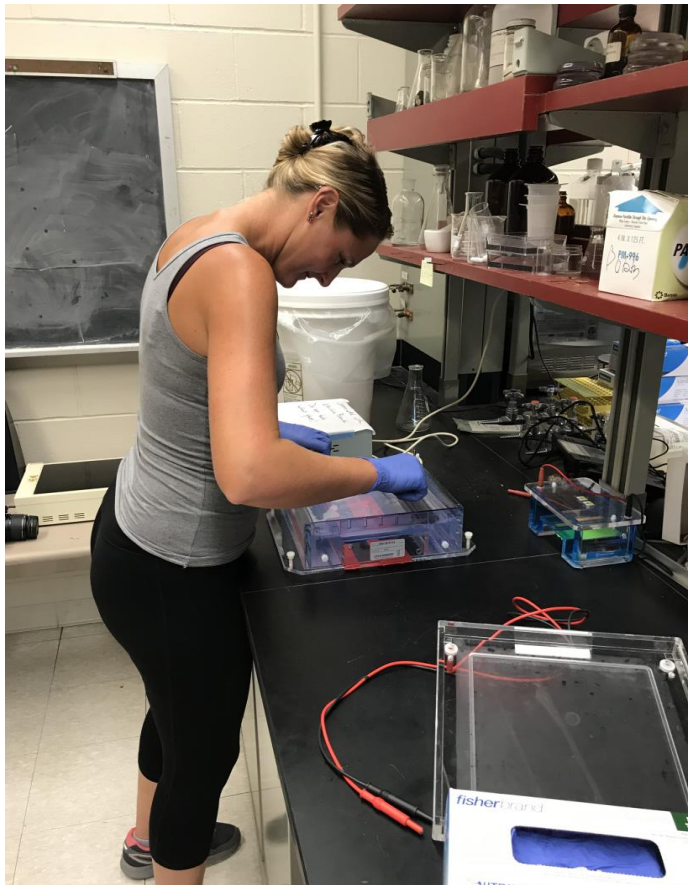
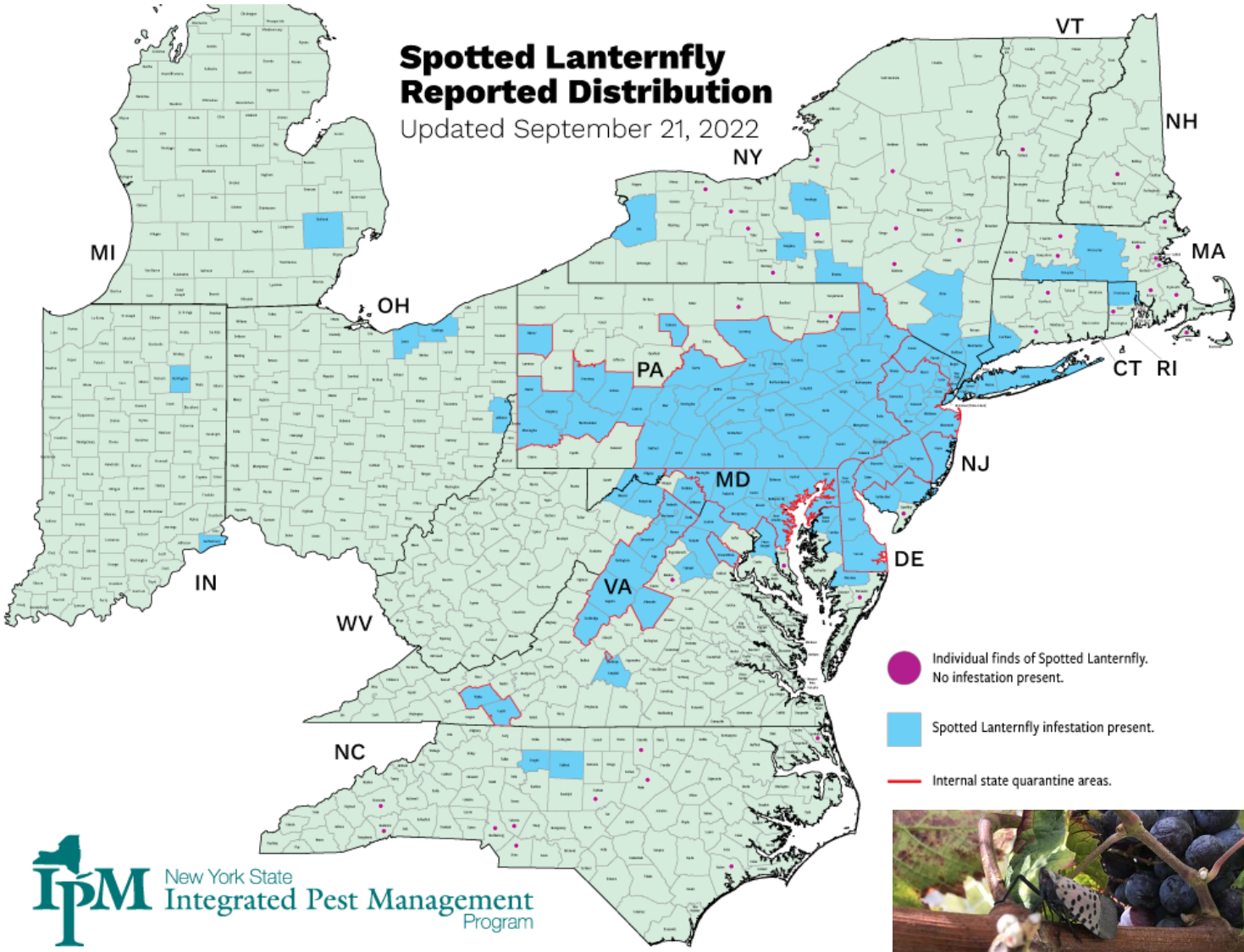
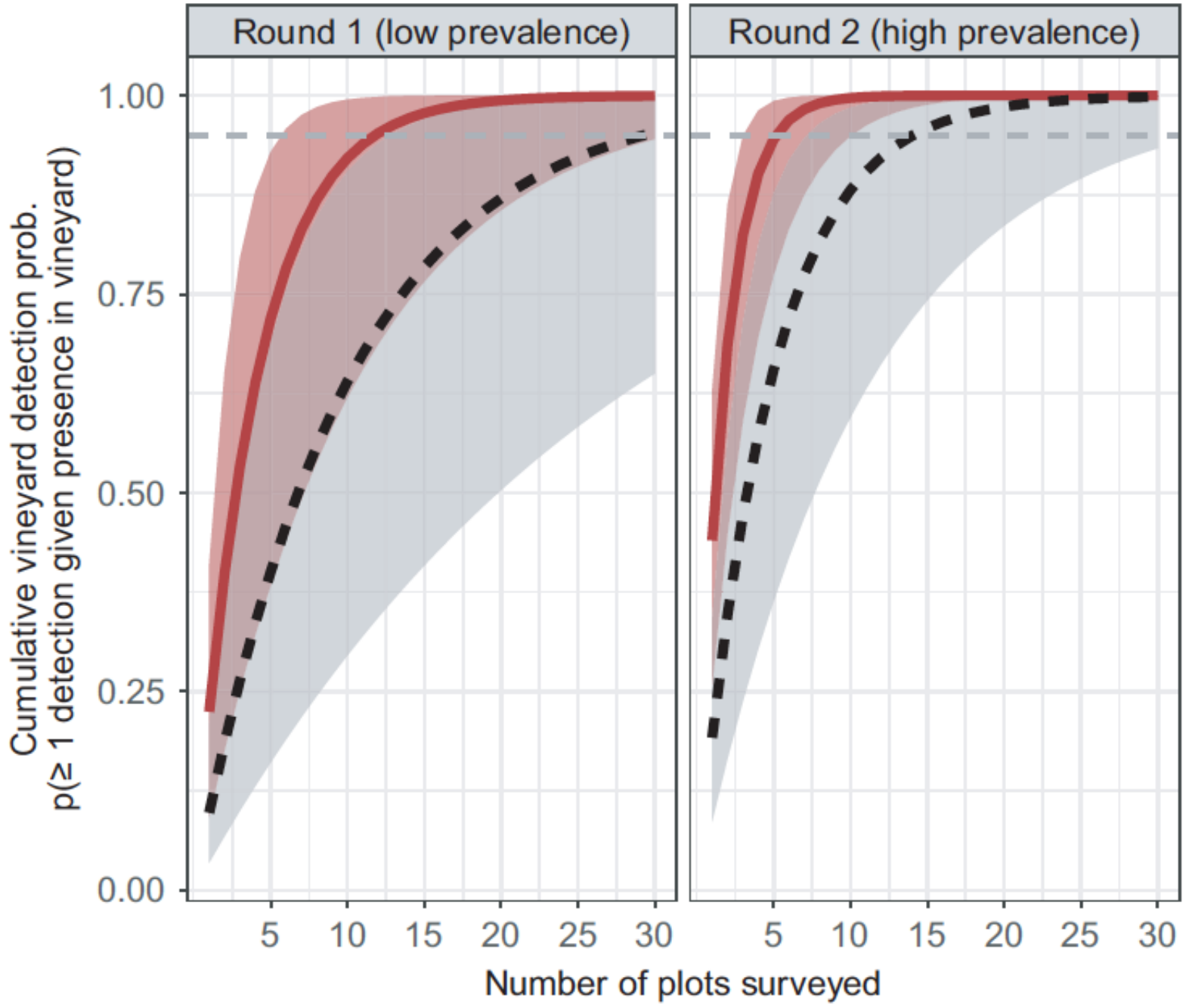
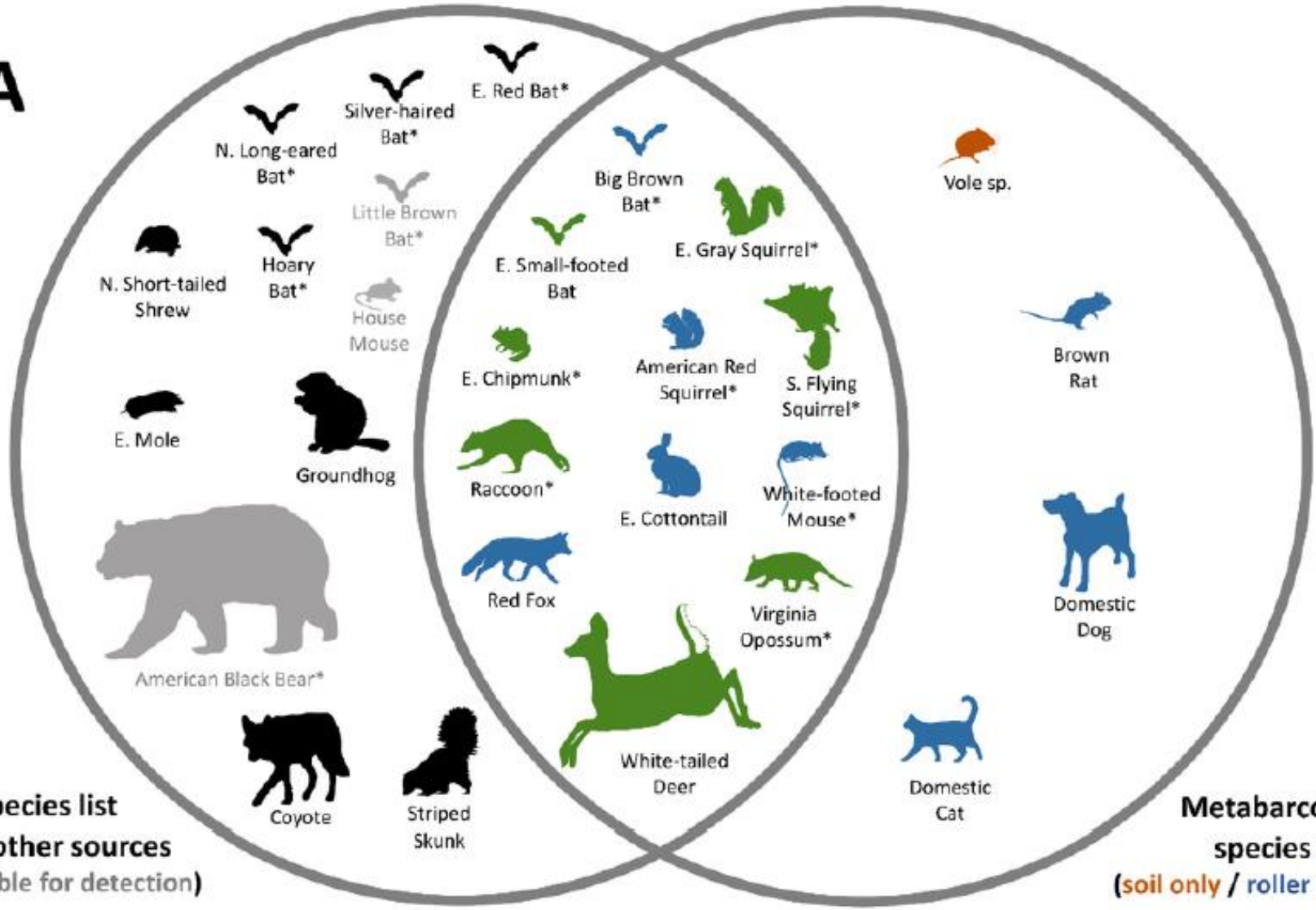


Figure 2: Map depicting eDNA sampling results. The sampling locations: five aquaculture ponds (W_4-W_8), upstream "beaver pond" (W_B), outflow drain (O), and nearby creek as it exits the property are labeled in white. Surface samples (S_1 and S_2) and grab bottle (B) sample locations are labeled to indicate the number of positive technical replicates in the sample with the most positive results (green: 0/3, yellow: 1/3, orange: 2/3, red: 3/3). Satellite imagery: Google Earth.


Spotted Lanternfly
Reported Distribution
Updated September 21, 2022
VT
NH
NY
MA
MI
OH
PA
CT
RI
NJ
MD
DE
VA
IN
WV
NC
Individual finds of Spotted Lanternfly.
No infestation present.
Spotted Lanternfly infestation present.
Internal state quarantine areas.
New York State
Integrated Pest Management
Program


Round 1 (low prevalence)
Round 2 (high prevalence)
Cumulative vineyard detection prob.
p(≥ 1 detection given presence in vineyard)
1.00
0.75
0.50
0.25
0.00
5
10
15
20
25
30
Number of plots surveyed

A



Species list from other sources (unavailable for detection)

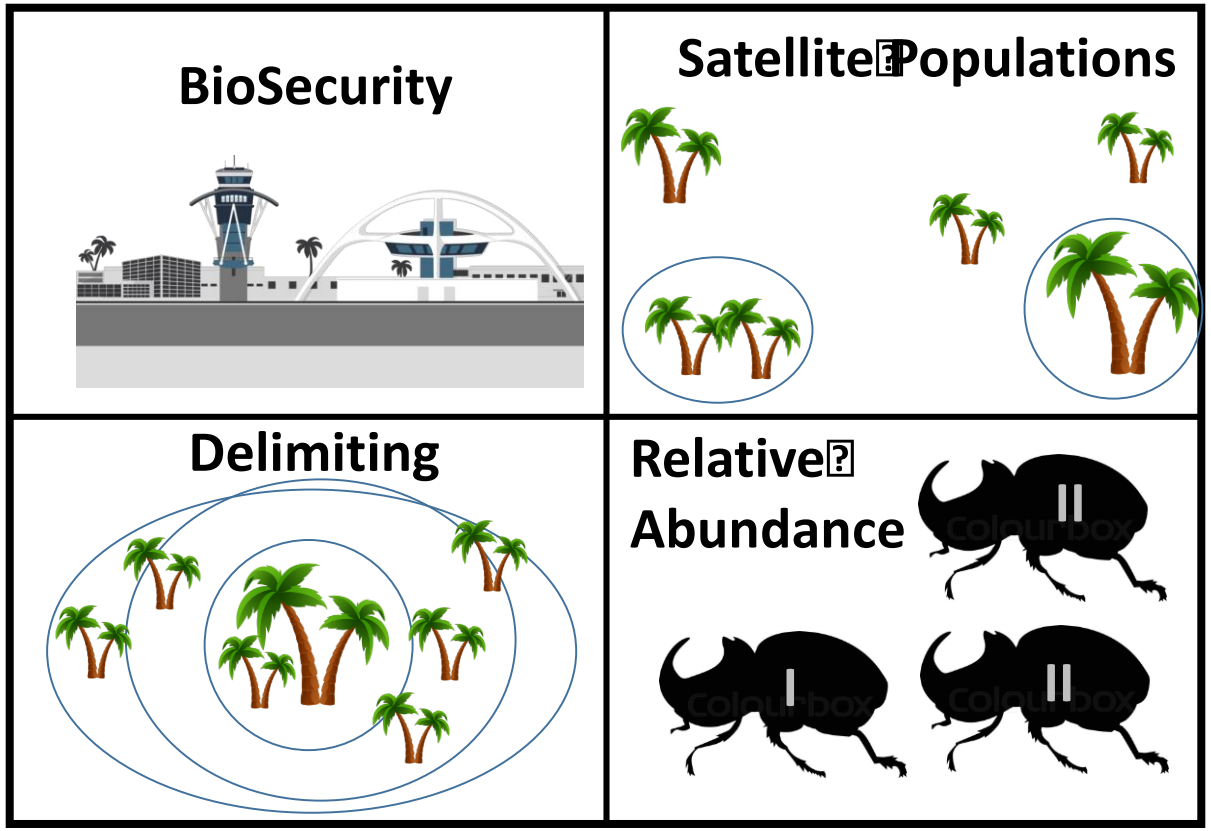
Metabarcoding species list (soil only / roller only / both)

b.

Applications of eDNA surveys in the context of invasive species

Start with asking when you would NOT use eDNA for invasive species surveys.
Answer: when density of the targeted invasive species is high enough that their presence is obvious

But you may want to use an eDNA survey in any of these situations, which are characterized by invasive species populations being in low densities, when they are cryptic and hard to find, or where accessing a location can be very expensive



Also may want to use eDNA…

Avoiding destructive techniques

Elusive species

Sampling is dangerous

Species ID is not obvious

Costs?

Field collection is low tech

PRECISION BIOMONITORING

It's in our DNA

Genome BritishColumbia

What about the lab part?

SMITH-ROOT, INC.

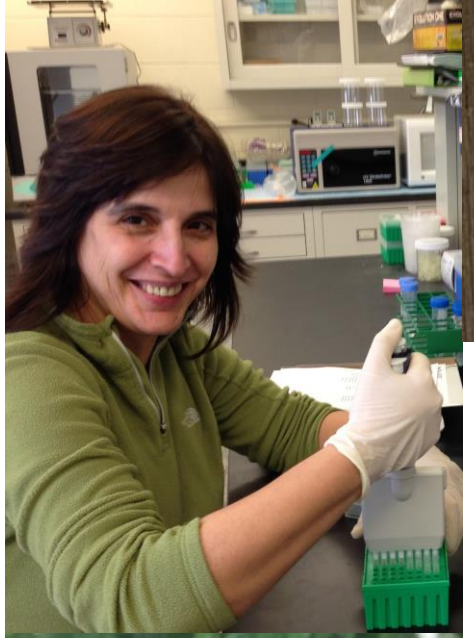
Technology For Fisheries Conservation

Natural Resource eDNA Lab

Environmental DNA (eDNA) allows for detailed and efficient surveys of species that are of conservation concern, are invasive, or are harvested. We maintain an active eDNA lab where we develop cutting-edge statistical and molecular survey tools for use in critical resource management decisions. Our projects span terrestrial and aquatic ecosystems. The Natural Resource eDNA lab can assist in developing species-specific or multi-species molecular assays, develop eDNA aggregation techniques suited for a variety of biological situations, and provide decision-support tools that incorporate eDNA survey results into project-specific resource management objectives.

New Jersey Conservation Foundation

McIntire-Stennis Cooperative Forestry Research Program 1962 • 2012 Fiftieth Anniversary



New Jersey Department of Agriculture

U.S. Fish & Wildlife Service — Department of the Interior

New Jersey Department of Environmental Protection

NIFA

NIFA Grants

SARE Sustainable Agriculture Research & Education