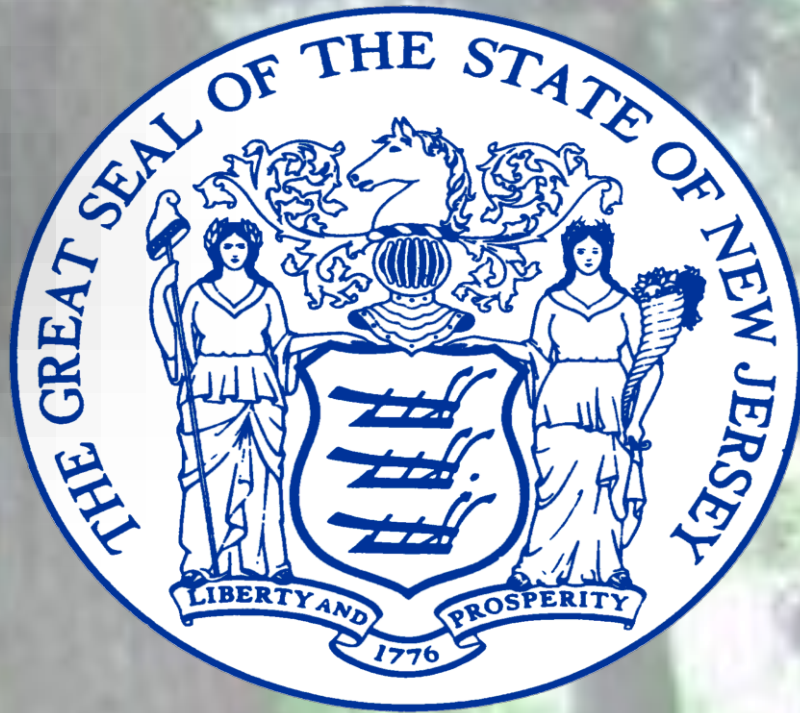# Headwaters Index of Biotic Integrity Monitoring Program

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Introduction

The Bureau of Freshwater and Biological Monitoring (BFBM) initiated the northern Fish Index of Biotic Integrity (Fish IBI) program in 2000 to supplement its Ambient Macroinvertebrate Network (AMNET) as an additional tool to assess the biological condition of New Jersey's wadeable rivers and streams. The United States Environmental Protection Agency advises that states use at least two biological indicators to assess aquatic life use because it provides a more comprehensive assessment of a stream's biota (ITFM 1995; Barbour et al. 1999).The northern Fish IBI was developed to assess water quality conditions in wadeable high gradient streams greater than 4 mi^2 in drainage area in northern New Jersey. However, the northern Fish IBI metrics were not applicable to small headwater streams due to low fish species richness (Figure 1) in headwater streams; thus there was no adequate assessment tool for vertebrates in wadeable streams with drainage areas smaller than 4 mi^2. The Headwaters Index of Biotic Integrity Monitoring program was developed to fill this monitoring gap.

Figure 1. Fish species richness against log of drainage area(mi^2) from NJDEP Fish Index of Biotic Integrity and headwaters monitoring.

Tributary to Mill Brook, a quintessential headwater stream in Montague Township, Sussex County.

What is a headwater stream?

Headwater streams originate in upland areas of a watershed and flow downstream joining larger streams to create a river network. These small unique habitats comprise greater than 70% of the total stream miles in the United States (Lowe and Liken 2005). In New Jersey, headwater streams account for approximately 80% of the total stream miles in the northern part of the state; of which 38% of the total stream miles in northern New Jersey are protected by antidegradation designations (Outstanding National Resource Waters or Category One waters) by the NJDEP Surface Water Quality Standards.
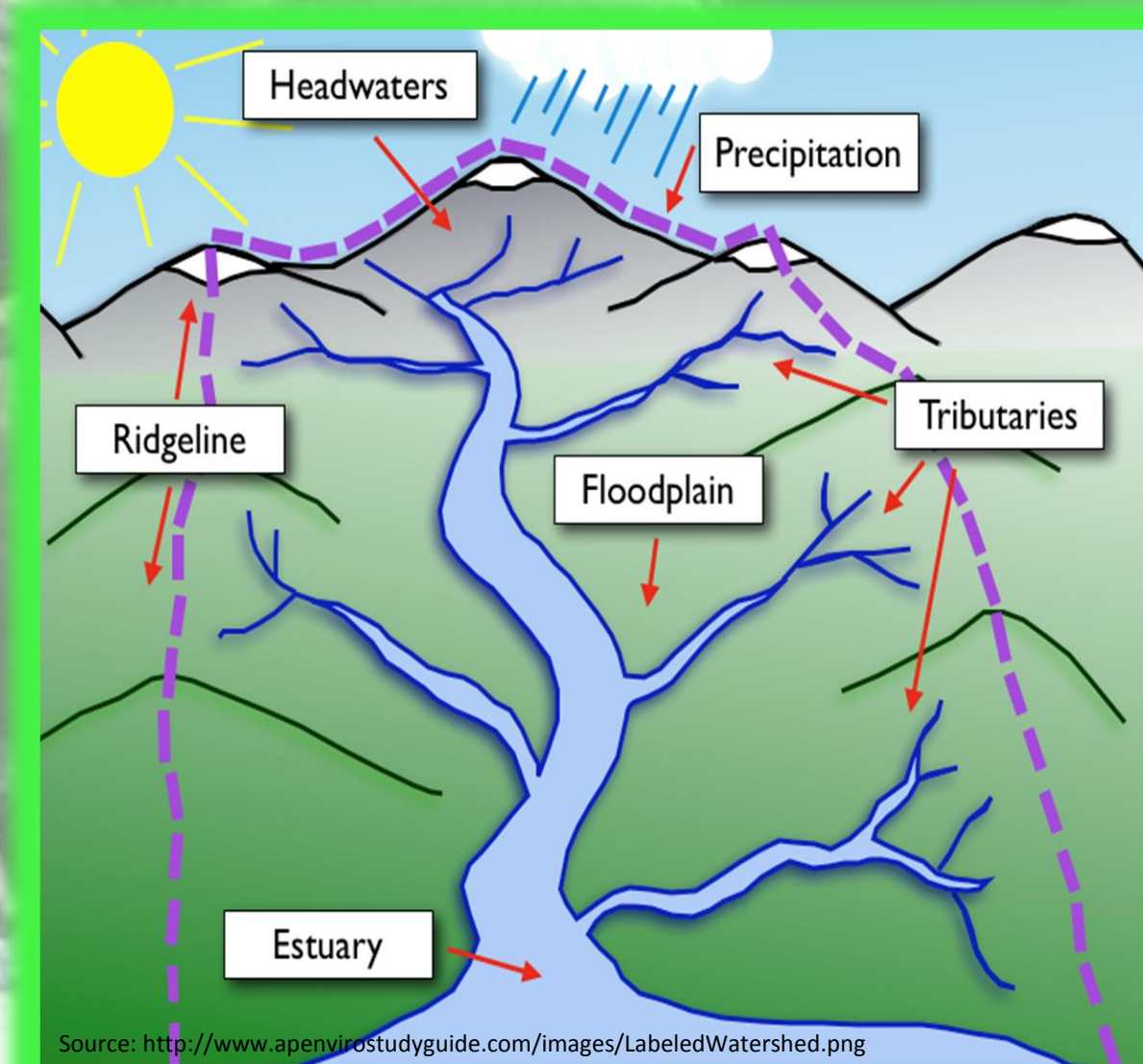
Figure 2. Schematic diagram of a watershed illustrating location of headwater streams on the landscape.

Why monitor headwater streams?

Headwaters streams provide important ecological services in providing stream flow, transport of organic matter, storage of nutrients, regulation of sediments, and providing vital habitat that supports biodiversity (Lowe and Liken, 2005; Alexander et al. 2007; Meyer et al. 2007; Wipfli et al. 2007). Headwaters are essential to watershed health because they dictate the downstream water quality; however, due to their small size they are highly vulnerable to anthropogenic disturbances and changes in climate (Lowe and Liken 2005, Brooks 2009). The quality of headwater streams typically deteriorate with increasing anthropogenic stress (land development, altered flow regime, pollution, ect.) and results in measured changes in a stream's biota.

Headwater stream monitoring

The health of these small streams is measured by the Headwaters Index of Biotic Integrity (HIBI), a multimetric index that assesses the overall condition of a headwater stream based on the biological assemblage present within and along the stream corridor. The HIBI uses four biological indicator groups (fish, crayfish, salamanders and frogs) to determine a stream's biological condition.
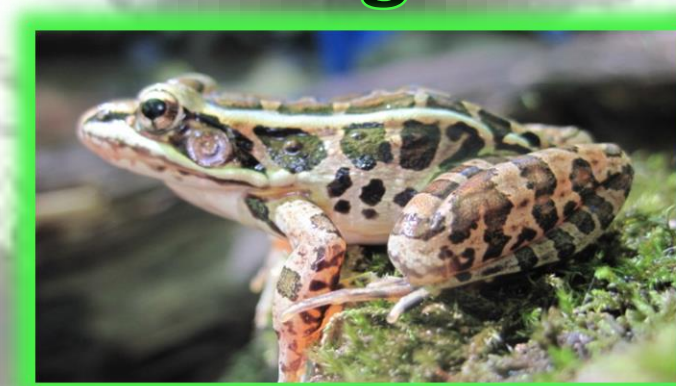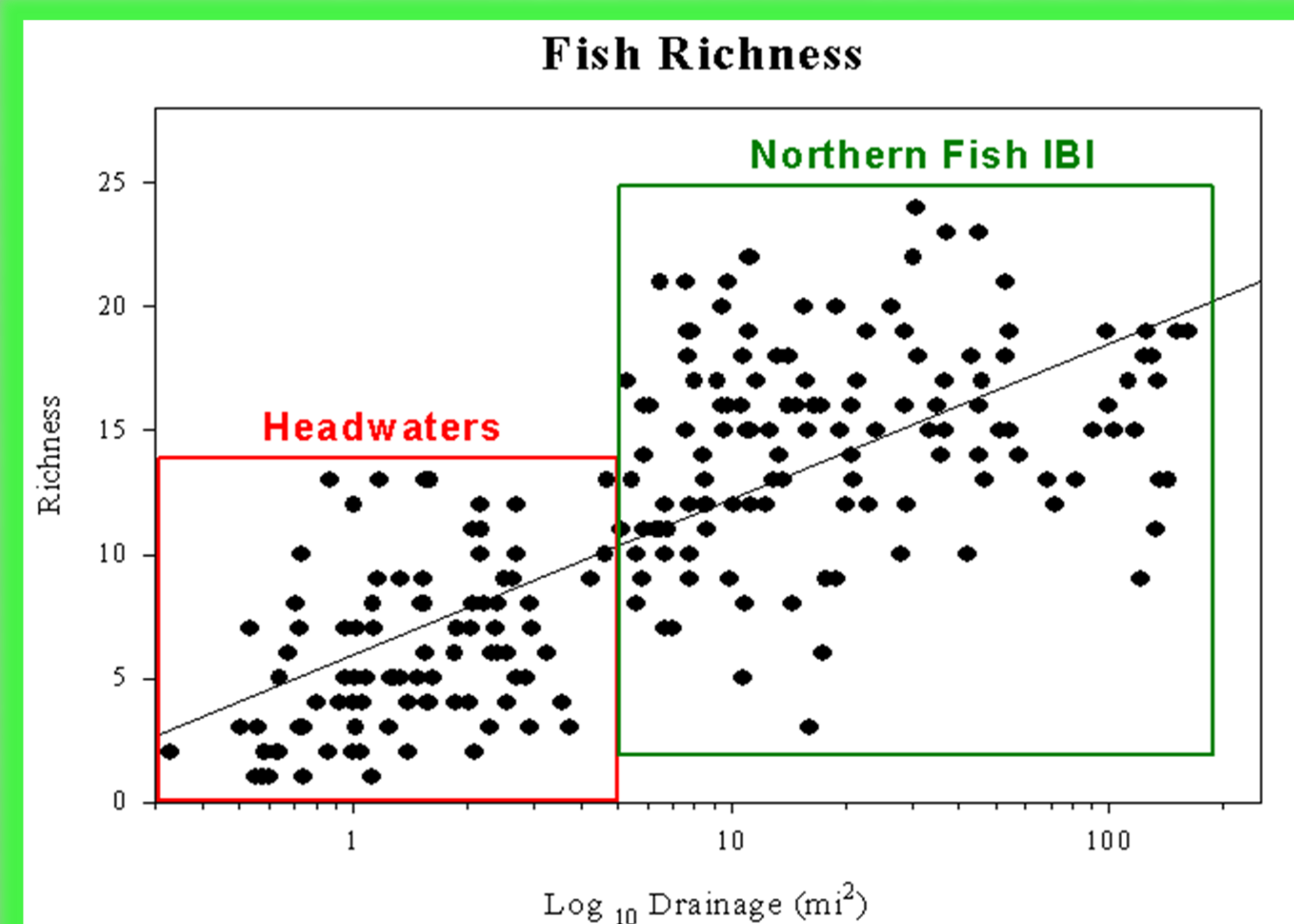
HIBI Biological Indicators

Crayfish

Fish

Frogs

Stream Salamanders

Why monitor stream salamanders?

Trophic guild
- Top vertebrate predator in fish-less streams

Life history
- Aquatic larval stages up to 4 years

Physiology
- Lungless, respire cutaneously through moist permeable skin

Abundance
- Stable populations, small home range

Ubiquity
- Found in almost all streams but highly perturbed

Sensitive to multiple stressors
- Contaminants, climate change, drought, flooding, acid mine drainage, logging, land development

HIBI Sampling Methods

Electrofishing
- A stream reach of 150 m is electrofished moving upstream sampling all available cover using one or two backpack electrofishing units to collected fish, crayfish, frogs, and salamander larvae

Area Constrained Survey
- An area of 90 m2 (2 transects measuring 15 x 1 m area in the water and a 15 x 2 m area along the shore) is sampled by area constrained survey (ACS) by a crew of two individuals flipping all available cover(rocks, logs, debris). All crayfish, salamanders and frogs are captured with the aid of dip nets

Habitat Survey
- Gradient, canopy cover, wetted width
- EPA's Rapid Habitat Assessment

Water Quality
- Ambient water quality parameters (dissolved oxygen (DO; mg/L), DO (% saturation), pH, temperature and conductivity)

HIBI crew electrofishing Dock Watch Hollow Brook in Warren Township, Somerset County.

HIBI crew conducting an area constrained survey at a tributary to Capoolong Creek in Franklin Township, Hunterdon County.
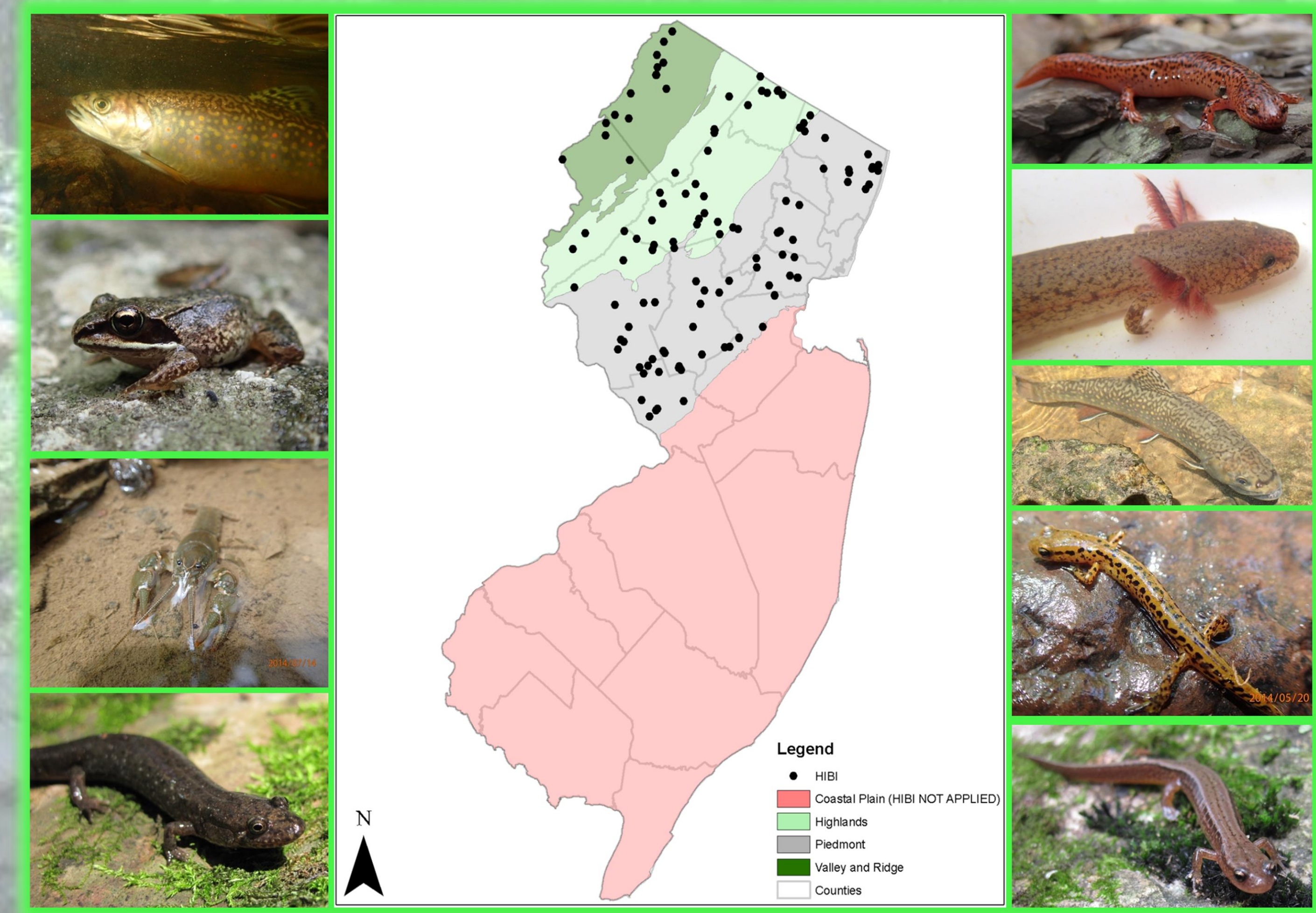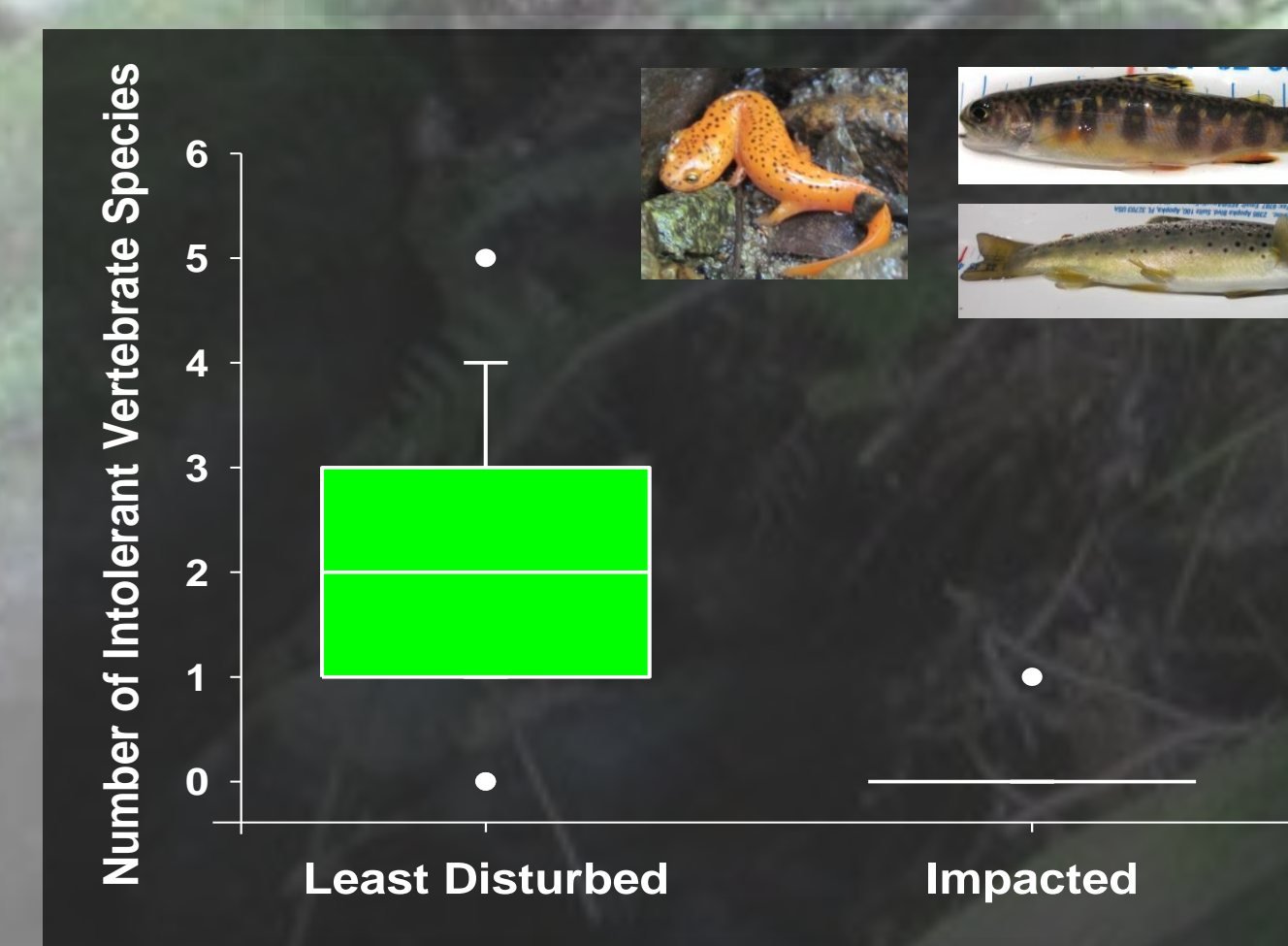

Figure 3. Map of headwater sites sampled by the Academy of Natural Sciences of Drexel University and NJDEP Bureau of Freshwater and Biological Monitoring, 2003-2014 (N= 135 samples).

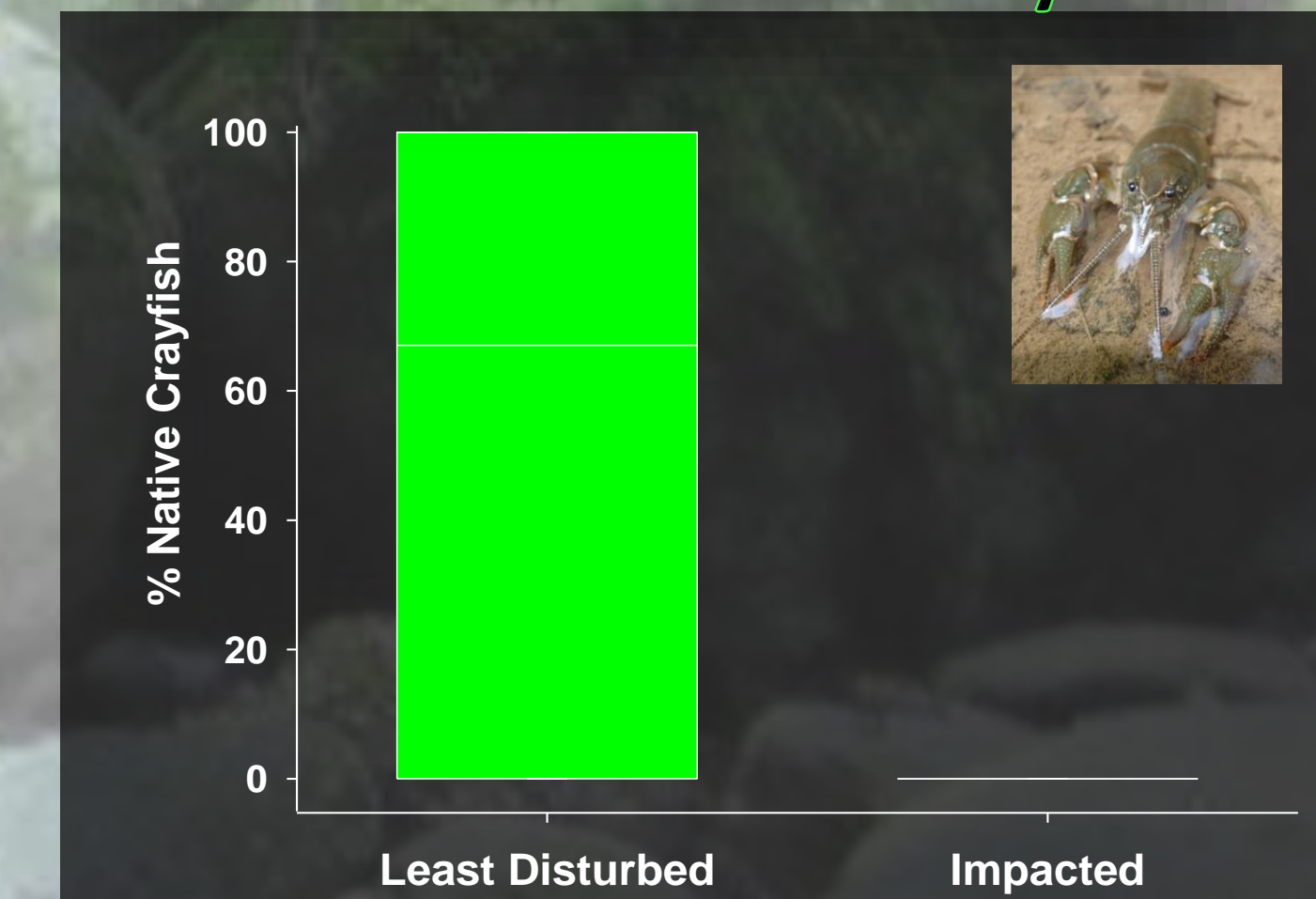## Candidate HIBI Metrics

Number of intolerant vertebrate species

Percent of tolerant fish individuals

Brook trout density

Percent of native crayfish