

A photograph of a stream flowing over mossy rocks in a forest. The water is clear and fast-moving, creating white rapids. The rocks are large and covered in green moss. The background is a dense forest with various trees and plants, including some palm-like plants in the foreground.

# Title Benthic Macroinvertebrates as Indicators of Stream Quality in Hawaii

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# Overview

- ❖ What are Benthic Macroinvertebrates
- ❖ What are Invertebrate Metrics
- ❖ Types of Metrics
- ❖ Why use Invertebrate Metrics
- ❖ Review of Current Project



# Benthic Macroinvertebrates

Stream animals without backbones that are larger than ½ millimeter

## Arthropoda

### Malacostraca

(crayfish, pill bugs, shrimp, and relatives)



### Insecta



## Annelida

(segmented worms)

### Hirudinea

(leeches)



### Oligochaeta

(aquatic earthworms)



## Platyhelminthes

Turbellaria



## Mollusca

### Gastropoda



### Bivalvia



# Invertebrate Groups

## ❖ Taxonomic Groups:

- Phylum, Class, Order, Family, Genus, or Species

## ❖ Trophic Groups (Functional Groups):

- Predators, Grazers, or Scrapers

## ❖ Status of Origin Groups:

- Native or Non-Native





## What is an Invertebrate Metric?

- ❖ Metric: a measure of the structure, function, or other characteristic of the biological community that changes in some predictable way with changes in human influence
- ❖ Core Metrics: those metrics that are best at differentiating among sites according to levels of environmental impairment
- ❖ Index: an integrated group of core metrics (IBI)



## Types of Metrics

- ❖ Richness: the number of distinct groups (presence/absence)
- ❖ Abundance/Density: the number of individuals collected in a sample *of known area or volume*
- ❖ Relative Abundance/Density: the percent represented by the abundance of a group out of total abundance of organisms
- ❖ Tolerance/Intolerance: measures of relative sensitivity to stressors. Based on REGIONAL values

# Advantages of Using Benthic Macroinvertebrates

- ❖ **Good indicators of localized conditions**
  - **Limited migration patterns**
  - **Sessile**
  - **Suited for assessing site-specific impacts**
- ❖ **Sensitive life stages respond quickly to stress**
  - **Overall community will respond more slowly**
- ❖ **Relatively easy to sample and identify to family**
- ❖ **Assemblages constitute a broad range of trophic levels and tolerances**
- ❖ **Field tested and reliable; incorporated into the bioassessments of many States and Regions.**

## Commonly Used Metrics

*Ratio of ~~Ephemeroptera~~:~~Plecoptera~~:Trichoptera*

Good biotic conditions would be reflected in communities with an even distribution among all groups.

*Percent Chironomidae*

Percentage of Chironomidae will increase with a decrease in water quality.



# Review of Current Project

## ❖ **USGS NAWQA Program on Oahu**

- 1999-2001: Sampled 12 sites on 9 streams
- Land Use
- Habitat Characteristics
- Contaminants in Bed Sediment and Fish Tissue
- Invertebrate samples
  - ✓ 14 Quantitative (Abundances)
  - ✓ 14 Qualitative (Presence/Absence)

## ❖ **Additional Sampling on Oahu**

- 2002: Sampled 5 sites on 5 streams

## ❖ **Additional Sampling on Kauai**

- 2003: Sampled 9 sites on 7 streams

# Quantitative Targeted Invertebrate Sampling: Slack Sampler



- 425-micron mesh net
- Standardized method
- Riffle habitats
- 5 samples composited
- Known area (density)
  - Abundance
  - Relative Abundance
  - Richness  
(presence/absence)

# Qualitative Multihabitat Invertebrate Sampling: D-Frame Net - NAWQA









- **210-micron mesh net**  
(revised to 500-micron)
- **Standardized methods**
  - **Consistent effort**
- **Sampled all available habitats**
- **Richness Only**  
(presence/absence)

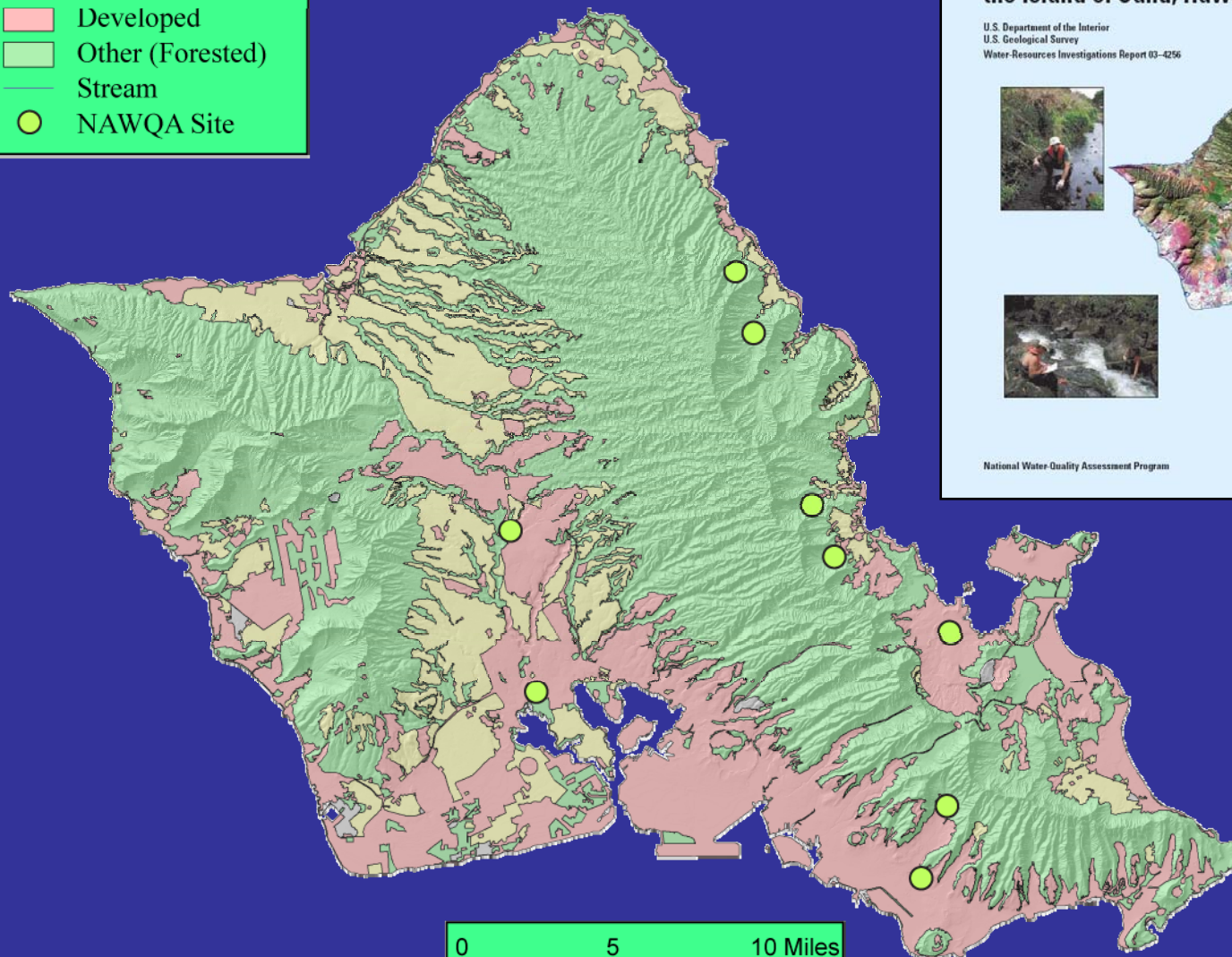


## EXPLANATION

### Land Use

-  Agriculture
-  Barren
-  Developed
-  Other (Forested)
-  Stream
-  NAWQA Site

# Oahu NAWQA Sampling Sites



## Associations Among Land Use, Habitat Characteristics, and Invertebrate Community Structure in Nine Streams on the Island of Oahu, Hawaii, 1999–2001

U.S. Department of the Interior  
U.S. Geological Survey  
Water-Resources Investigations Report 03–4256










National Water-Quality Assessment Program

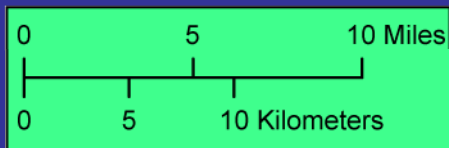
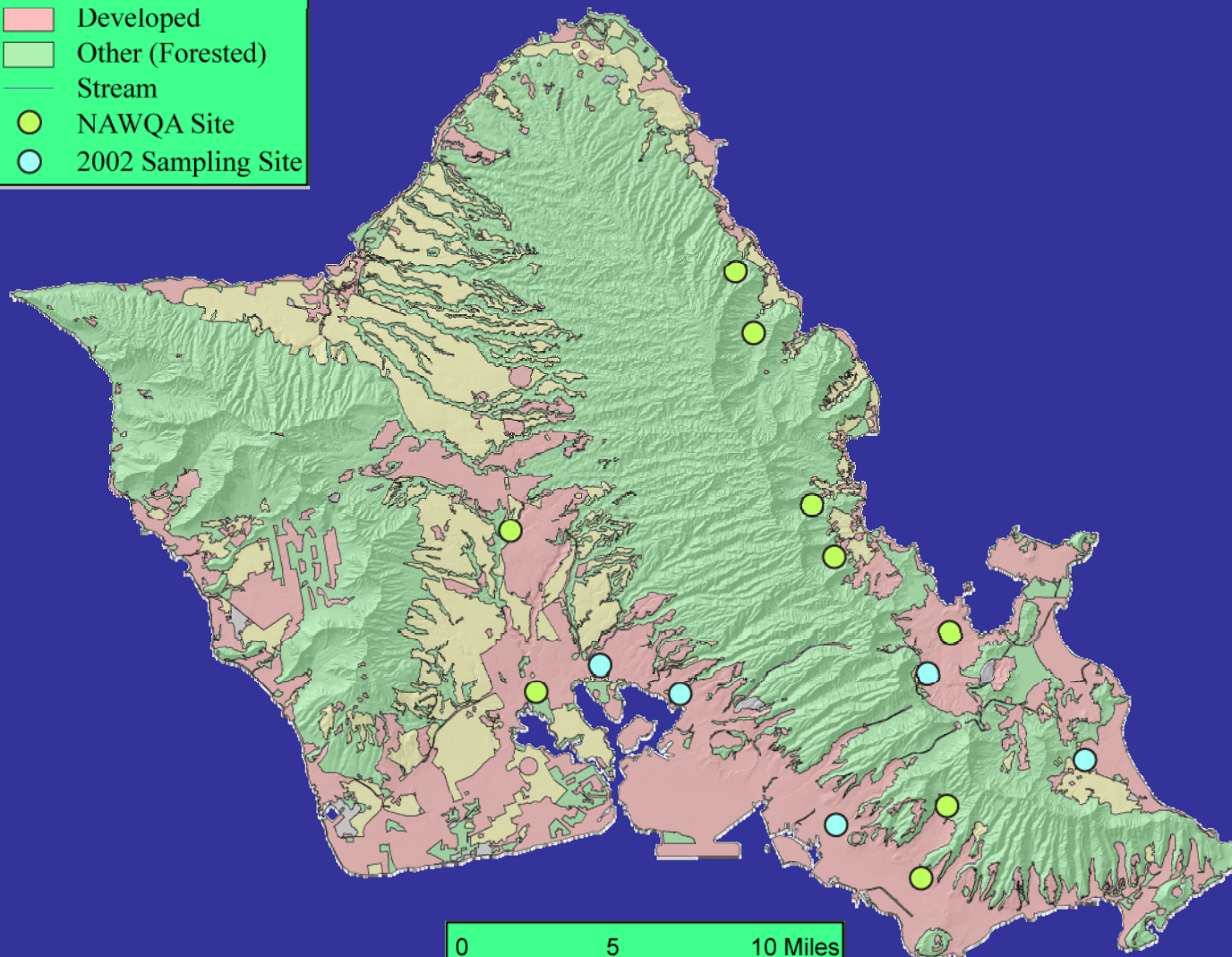


## EXPLANATION

### Land Use

-  Agriculture
-  Barren
-  Developed
-  Other (Forested)
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-  NAWQA Site
-  2002 Sampling Site

## Additional Oahu Sampling Sites





## Kauai Sampling Sites

### EXPLANATION


#### Land Use


 Agriculture

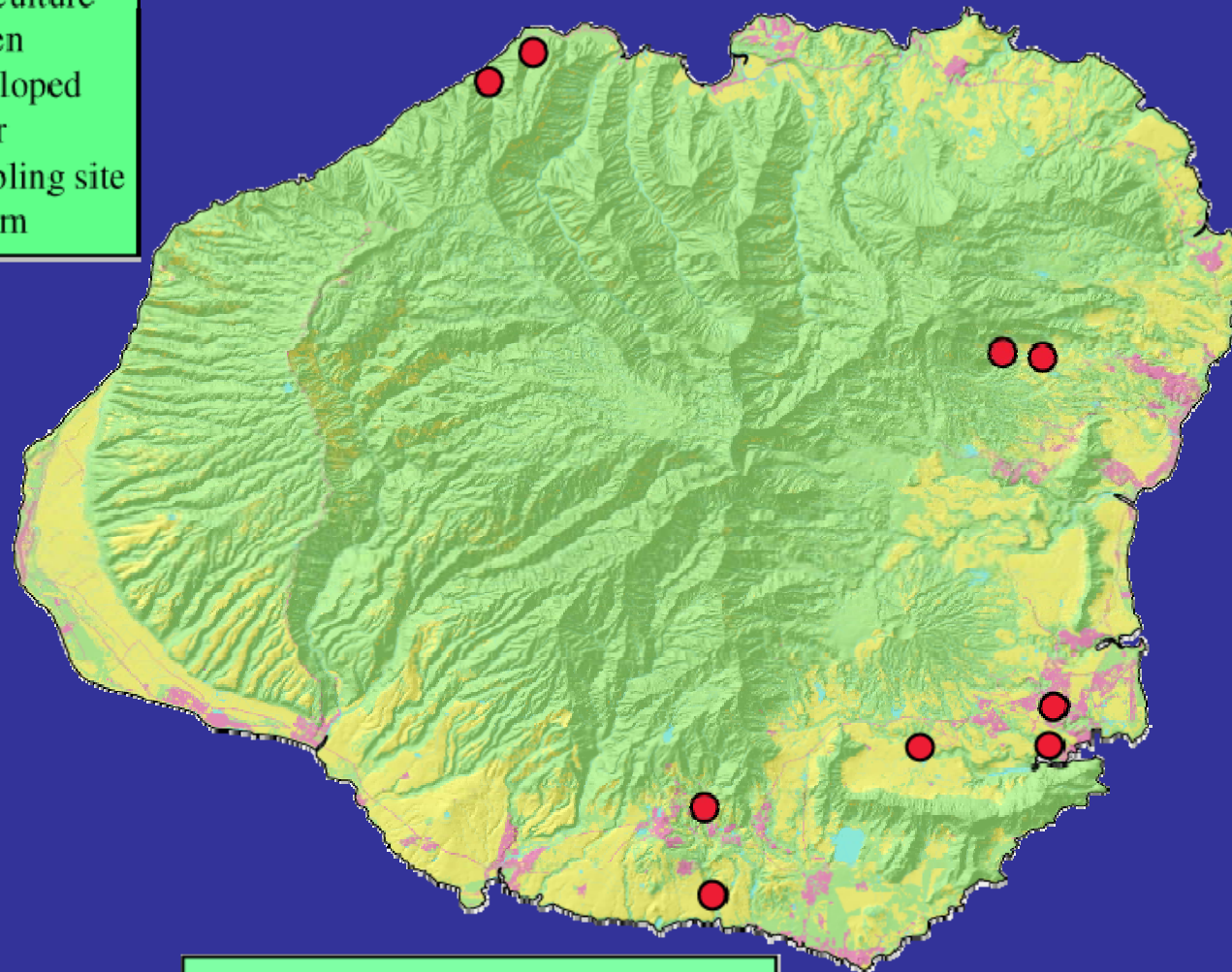
 Barren

 Developed

 Other

 Sampling site

 Stream



0 2.5 5 10 Miles



# Site Classification

- ❖ Land-use

- Klasner & Mikami, 2002

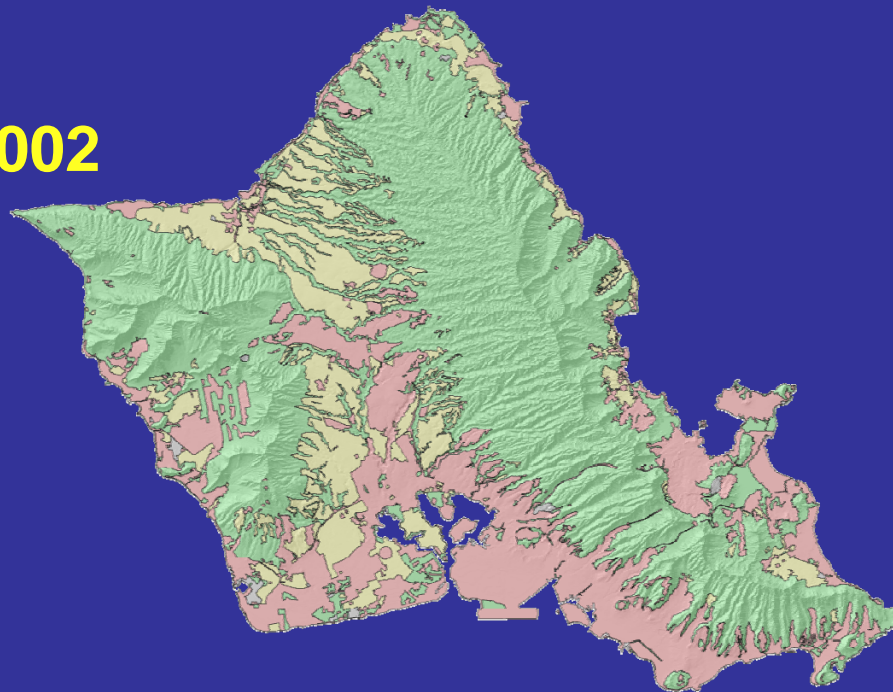
- ❖ Contaminants

- Bed Sediment
  - Fish Tissue

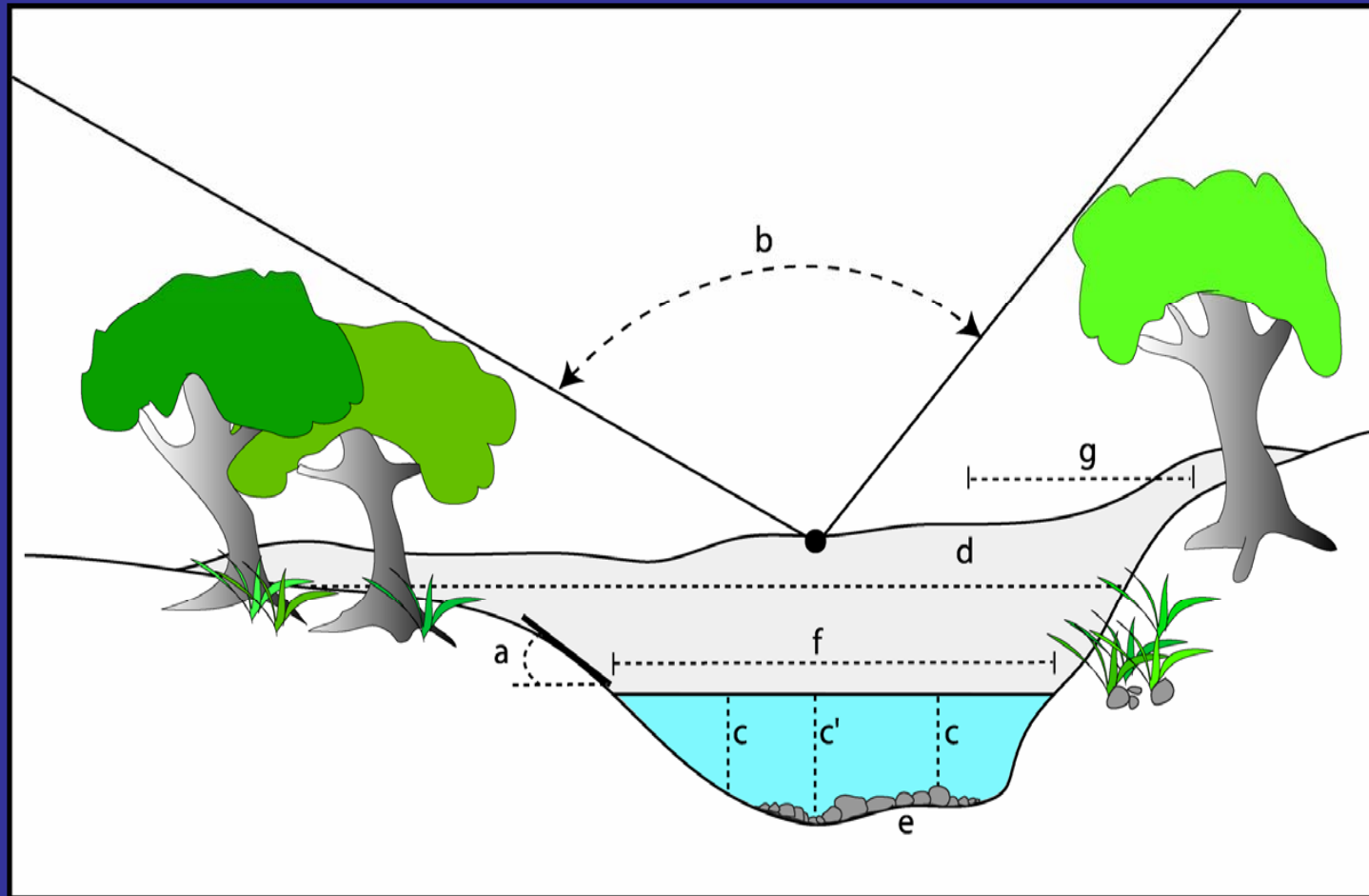
- ❖ Habitat Data

- Principal Components Analysis

- ❖ Expert experience/Local knowledge



# Habitat Characteristics



**Watershed - Reach - Transect - Point**

# Developing Metrics

1. Use a subset of sites to calibrate the metrics
2. Classify and rank the sites
  - Landuse, Contaminants, and Habitat Characteristics
3. Examine relationship between each metric and the site ranks
  - ~140 Mainland U.S. metrics
4. Remove metrics that are not applicable in Hawaii
5. Remove metrics that do not differentiate among sites

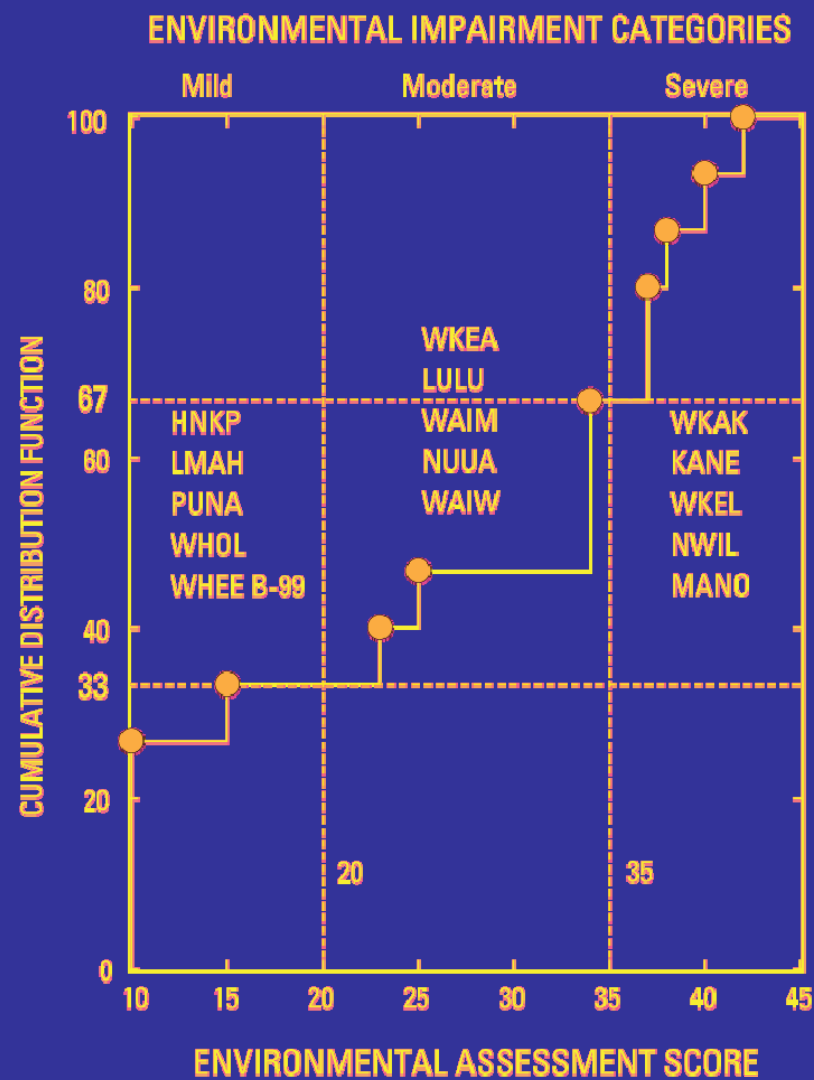


# Index Development

- ❖ **Select Core metrics**
  - **Best at differentiating among ranked sites**
  - **Ecologically informative**
- ❖ **Score each metric according to cut-off criteria using Cumulative Distribution Function**
- ❖ **Combine Core metrics to build an Index**
- ❖ **Test 'Hawaii Specific' Index with non-calibration sites**



# Results: Site Ranks



## Results: List of Metrics

Candidate metrics	Core metrics	Final P-HBIBI
<b>Invertebrate abundance</b>	<b>X</b>	<b>X</b>
Insect abundance	X	
Trichopteran abundance		
<b>Alien mollusc abundance</b>	<b>X</b>	<b>X</b>
Dominant taxa abundance		
<b>Amphipod abundance</b>	<b>X</b>	<b>X</b>
Chironomidae abundance		
Trichopteran-dipteran ratio		
Percentage of trichoptera	X	
Percentage of chironomidae		
<b>Percentage of insecta</b>	<b>X</b>	<b>X</b>
Percentage of oligochaeta	X	
Percentage of alien mollusca	X	
Percentage of amphipoda		
<b>Number of taxa</b>	<b>X</b>	<b>X</b>
<b>Native mountain shrimp P/A</b>	<b>X</b>	<b>X</b>
<b>Crayfish P/A</b>	<b>X</b>	<b>X</b>
Alien prawn richness	X	
Modified family biotic index		
Margelef's diversity		

# Preliminary Metrics Conditional Scores



**Metric**

**Condition**

**Score**

**Al Abundance**

$\leq 200$

$\leq 700$

$\leq 3,000$

$> 3,000$



**Alien Mollusc Abundance**  
**Sum of Metric Scores**  
**Impairment Category**

$\leq 14$

$> 90$   
Mild

1

3

5

**Amphipod Abundance**

$\leq 22$

$\leq 35$   
Moderate

1

3

5

$> 22$

$> 35$   
Severe



**Acta**

$\leq 75\%$

$\leq 90\%$

$> 90\%$

5

3

1

**r of Taxa**

$\geq 30$

(ess)

$\geq 21$

$< 21$



**Native Mountain Shrimp**  
(*Atyoida bisulcata*)

Absent

Present

**Crayfish**

(*Procambarus clarkii*)

Absent

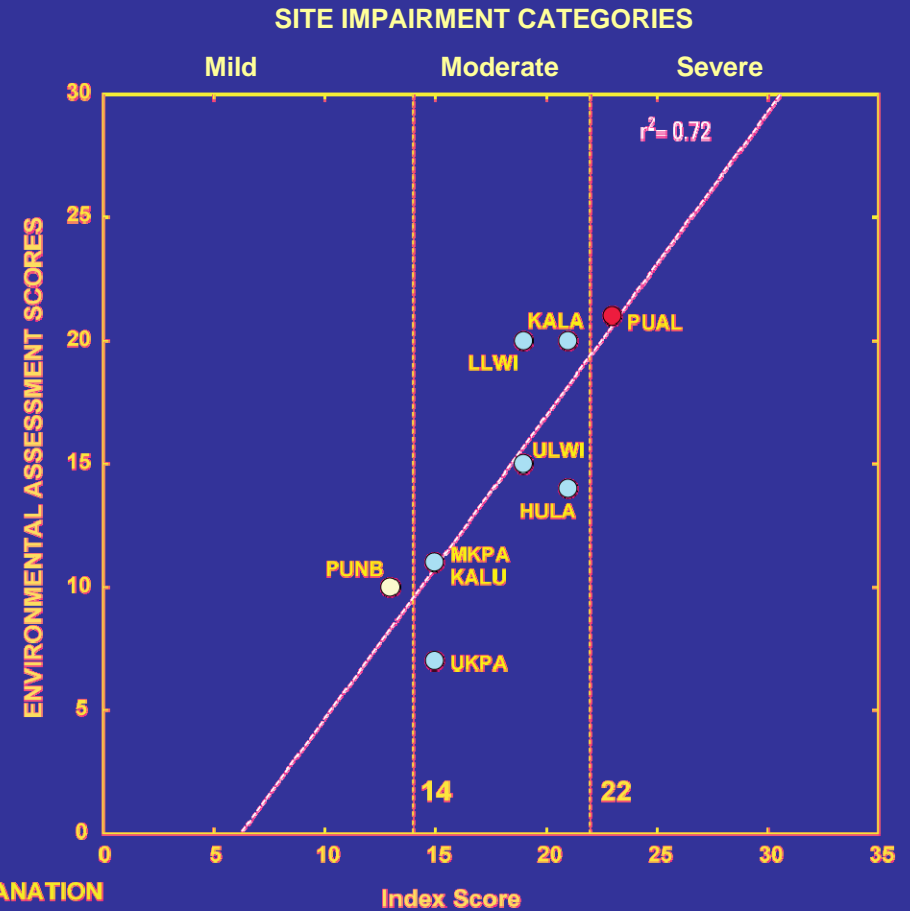
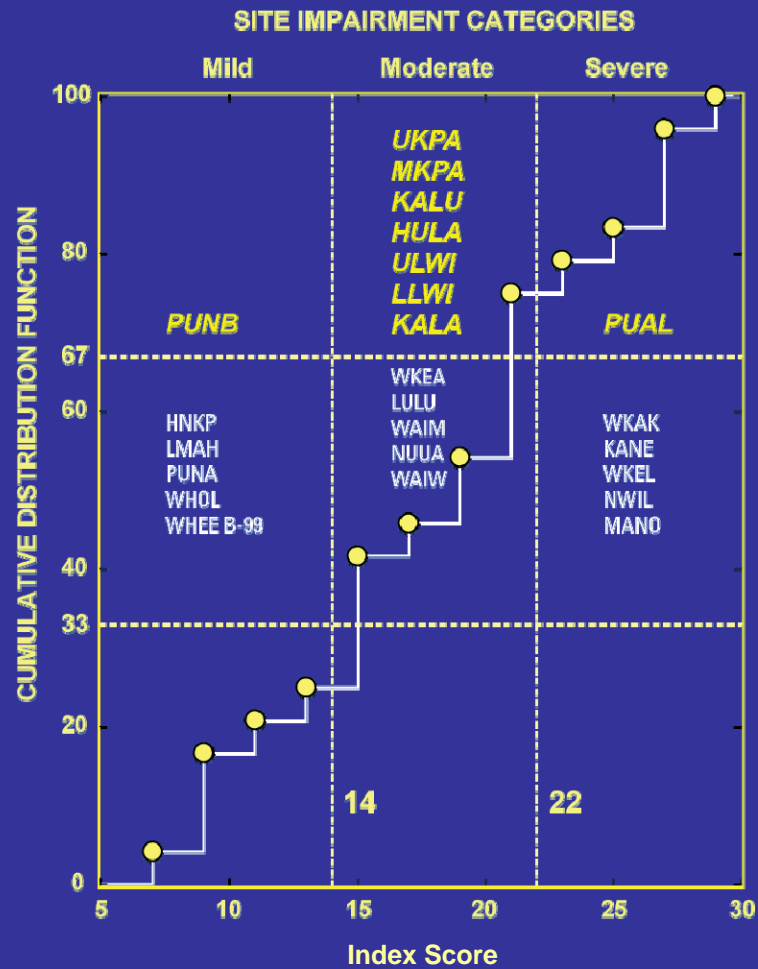
Present

1

3



# Results: Test Sites



## EXPLANATION

- Trend line
- Cut-off values

### Degree of Impairment

- Mild
- Moderate
- Severe

UKPA Abbreviation of sampling site name

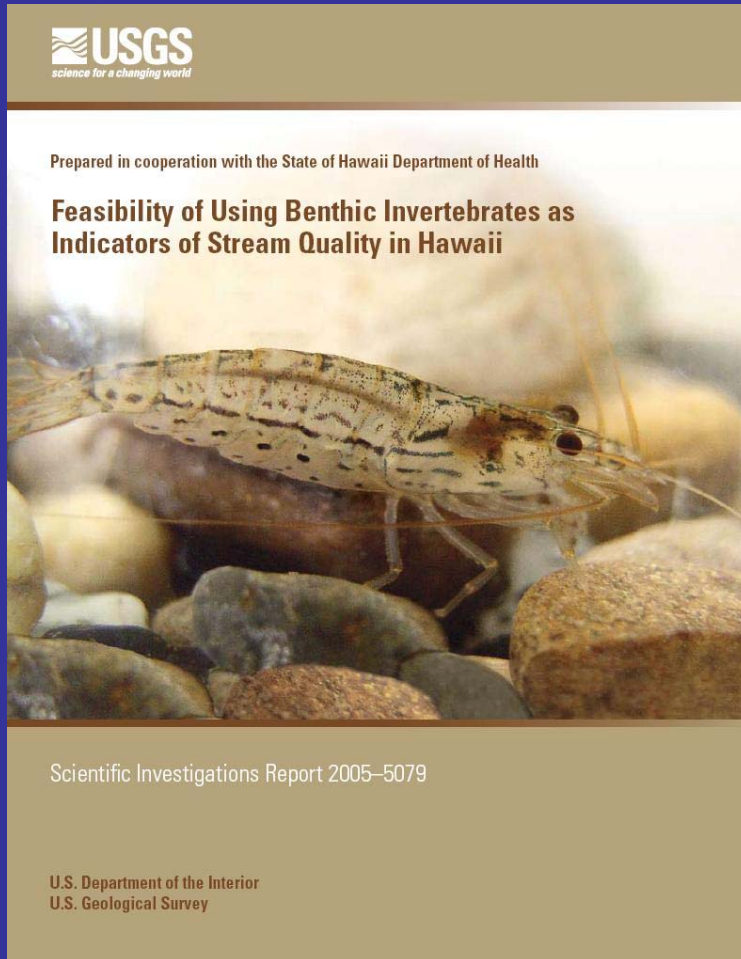
## 2005 - USGS Report:

### Feasibility of Using Benthic Invertebrates as Indicators of Stream Quality in Hawaii

#### Conclusions

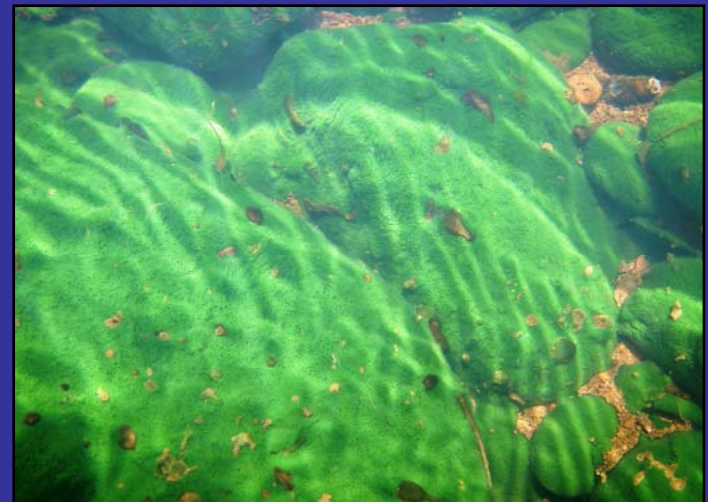
The development of a reliable Hawaiian benthic index of biotic integrity (HBIBI), based on macroinvertebrate assemblages, **is feasible.**

However, a larger sample size, including more samples from 'pristine' sites and from the other islands, would be required.

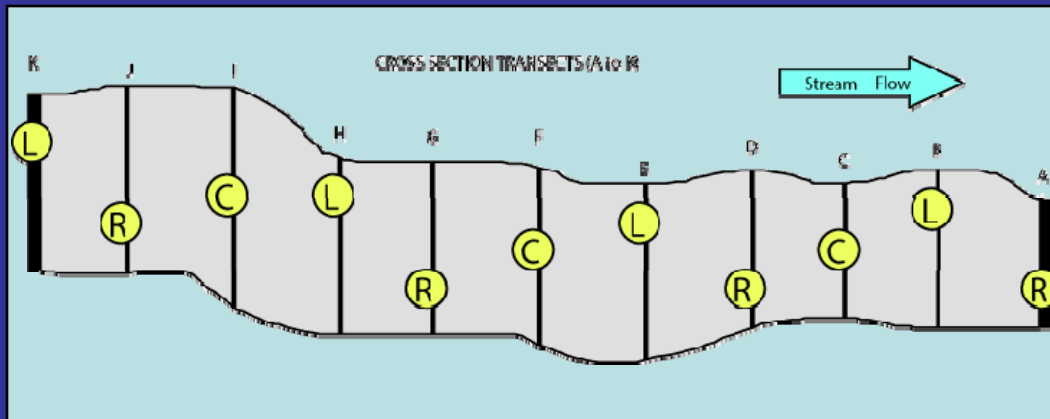


## ❖ USGS-HDOH Environmental Monitoring and Assessment Program (EMAP) on Oahu

- 2006-2007: Sampled 40 randomly selected sites on 28 streams representing a range of land uses
- Habitat Characteristics
- Water Chemistry
- Invertebrate samples
  - ✓ 36 Quantitative (Abundances)
  - ✓ 45 Qualitative (Presence/Absence)



# Qualitative Multihabitat Invertebrate Sampling: D-Frame Net - EMAP



- 500-micron mesh net
- Standardized methods
- Multihabitat Transect
- Used for Richness Only (presence/absence)



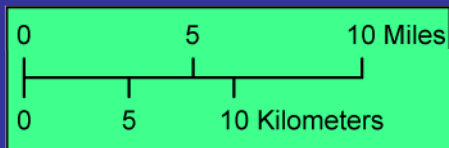
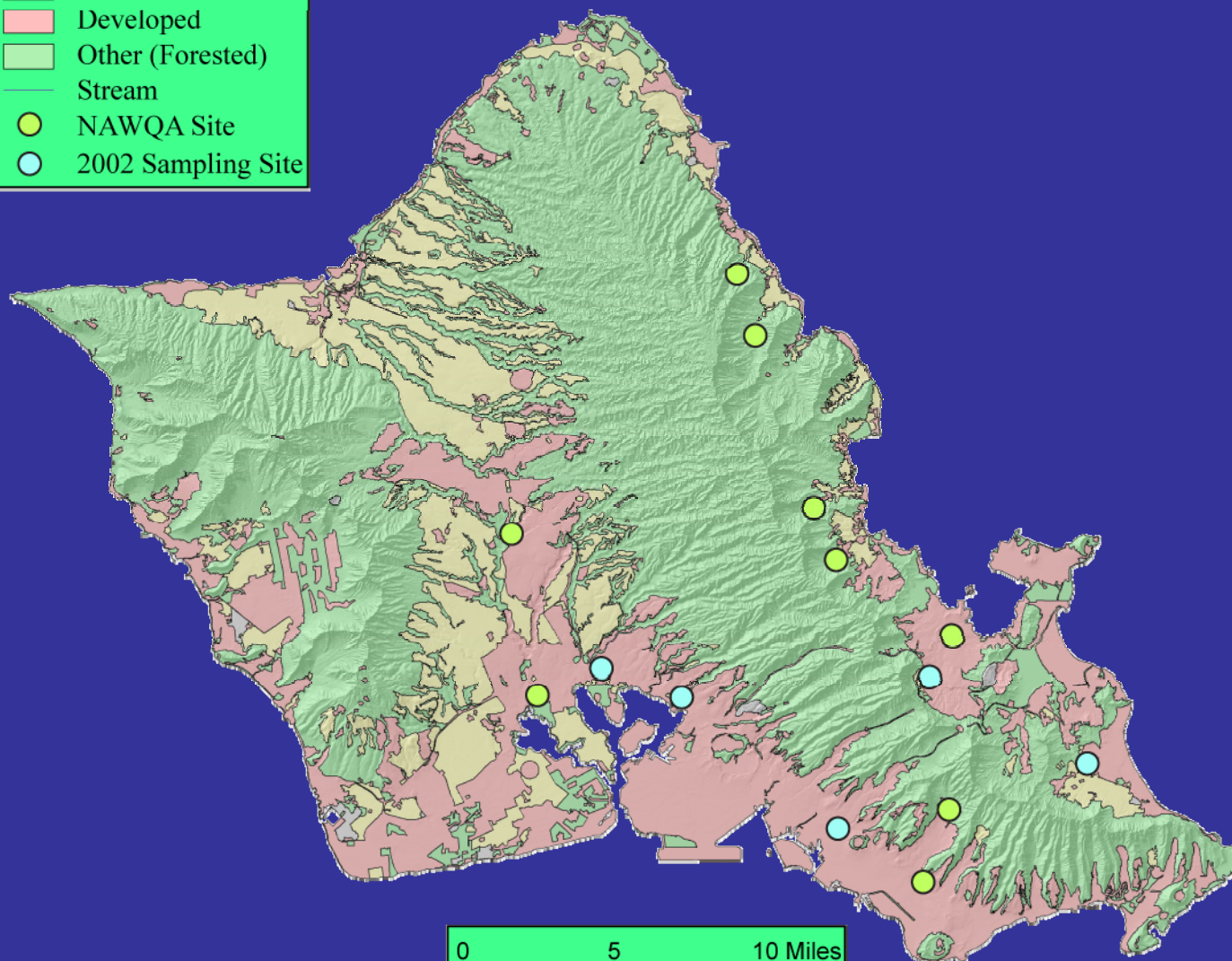


## EXPLANATION

### Land Use









- Agriculture
- Barren
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- Other (Forested)
- Stream
- NAWQA Site
- 2002 Sampling Site

# Oahu NAWQA Sampling Sites

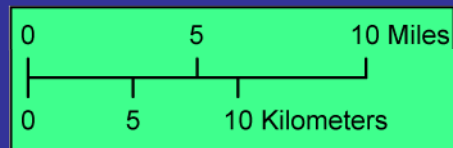
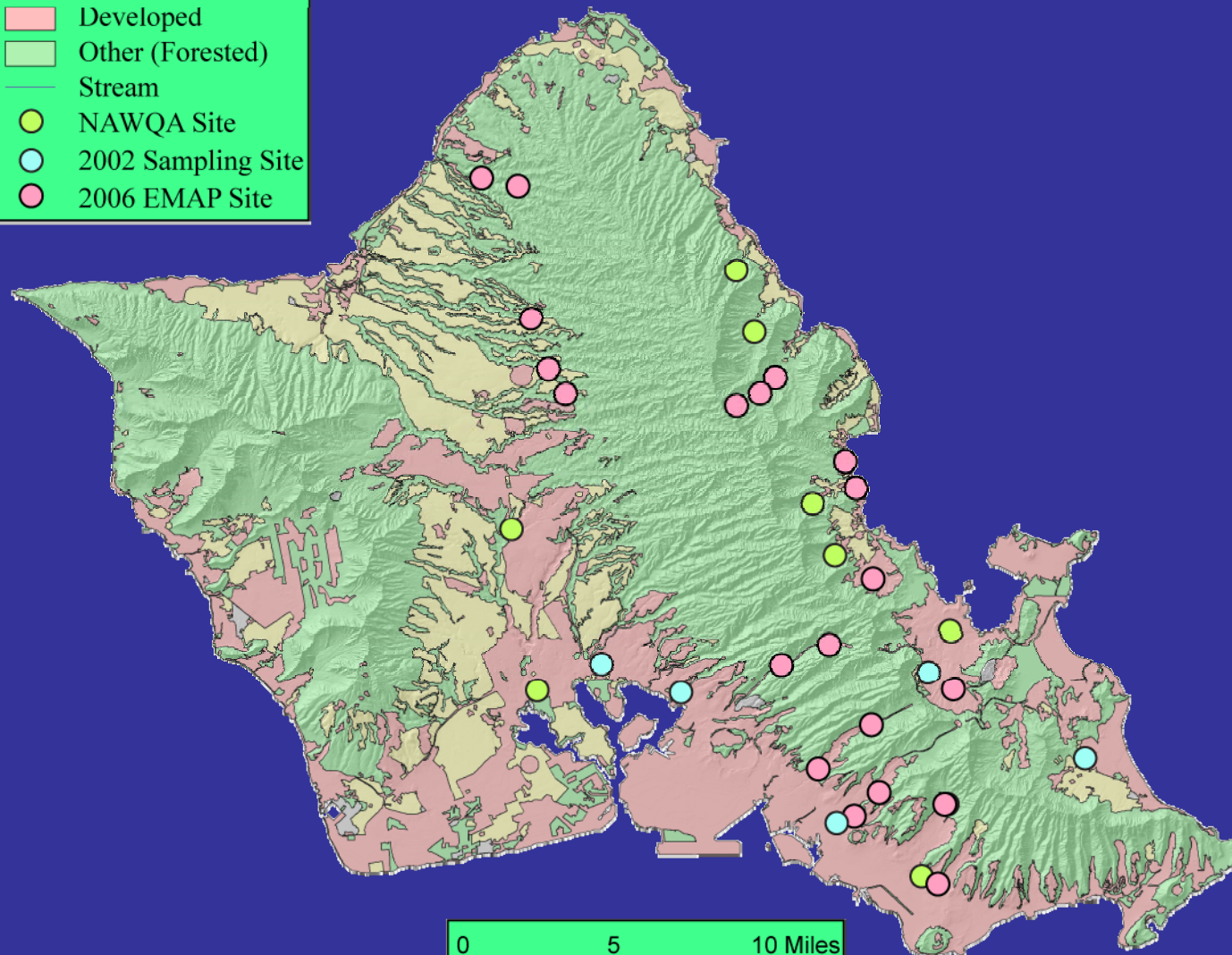


## EXPLANATION

### Land Use










-  Agriculture
-  Barren
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-  Other (Forested)
-  Stream
-  NAWQA Site
-  2002 Sampling Site
-  2006 EMAP Site

# Oahu EMAP 2006 Sampling Sites

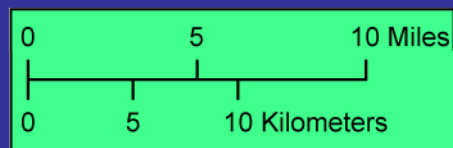
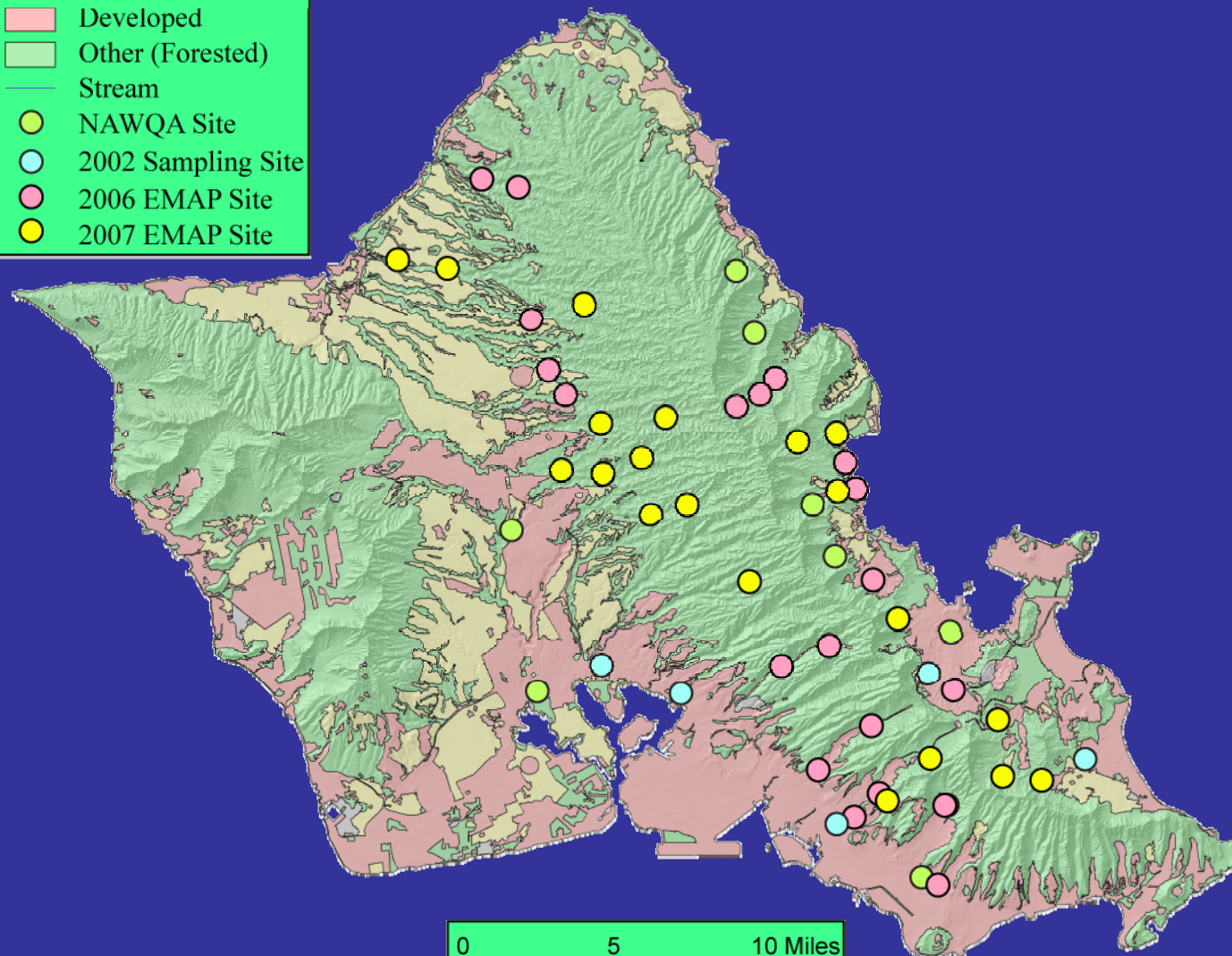


## EXPLANATION

### Land Use

-  Agriculture
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-  2006 EMAP Site
-  2007 EMAP Site

# Oahu EMAP 2007 Sampling Sites





# What's Next?

- ❖ **Secure Funding Sources**
- ❖ **Incorporate Oahu EMAP data into the Invertebrate Metrics**
  - **Test Existing Metrics**
    - ✓ **Preliminary testing appears to support findings**
  - **Develop and Integrate New Metrics**
- ❖ **Sample Other Islands**
  - **Test State-wide vs Island-wide metrics**

# Thank You

