Ecohydrology Research Vision

SCCWRP Commission Meeting

December 4, 2015

Roadmap for Today

- What is Ecohydrology?
- Why is Ecohydrology important?
- How does SCCWRP's Ecohydrology research vision relate to policy and management decisions?
- What comes next?

What is Ecohydrology?

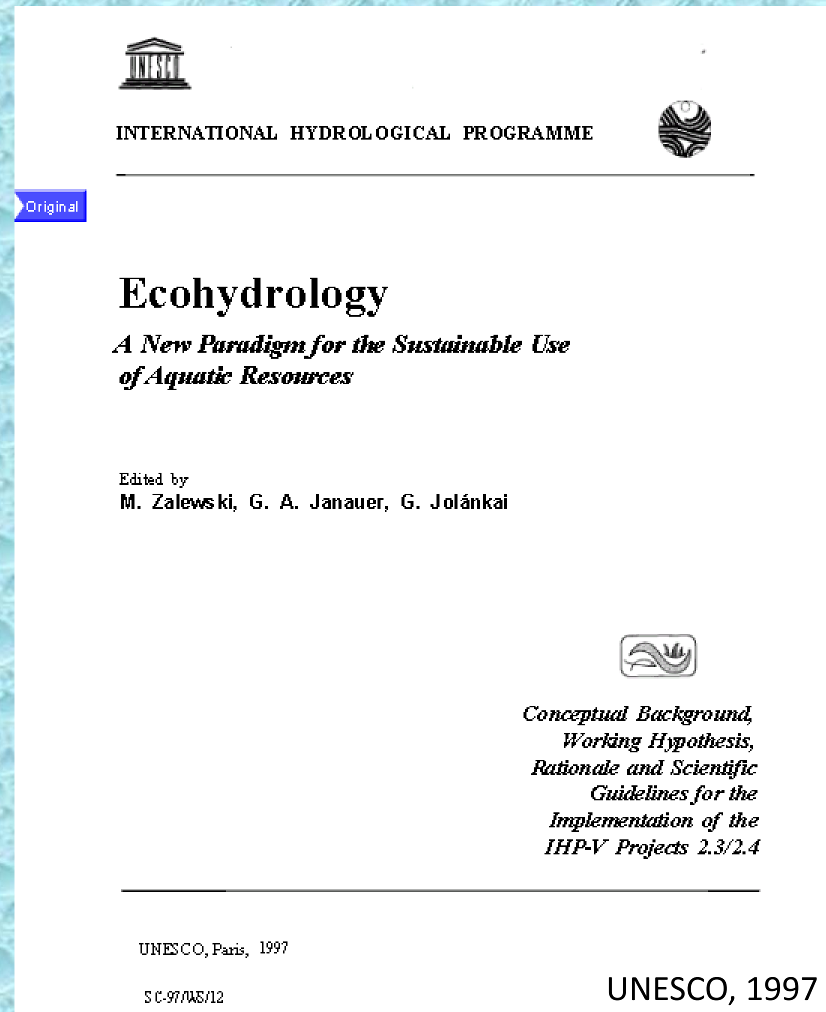
Ecohydrology is an interdisciplinary field studying the interactions between water and ecosystems.

The principles of Ecohydrology are expressed in three sequential components:

1. Hydrological: integration of hydrological and biological processes.

2. Ecological: ecosystem services and beneficial uses.

3. Ecological engineering: regulation of hydrological and ecological processes as a key management tool/approach


INTERNATIONAL HYDROLOGICAL PROGRAMME

Original

Ecohydrology

A New Paradigm for the Sustainable Use of Aquatic Resources

Edited by
M. Zalewski, G. A. Janauer, G. Jolánkai

Conceptual Background, Working Hypothesis, Rationale and Scientific Guidelines for the Implementation of the IHP-V Projects 2.3/2.4

UNESCO, Paris, 1997

SC-97/WS/12

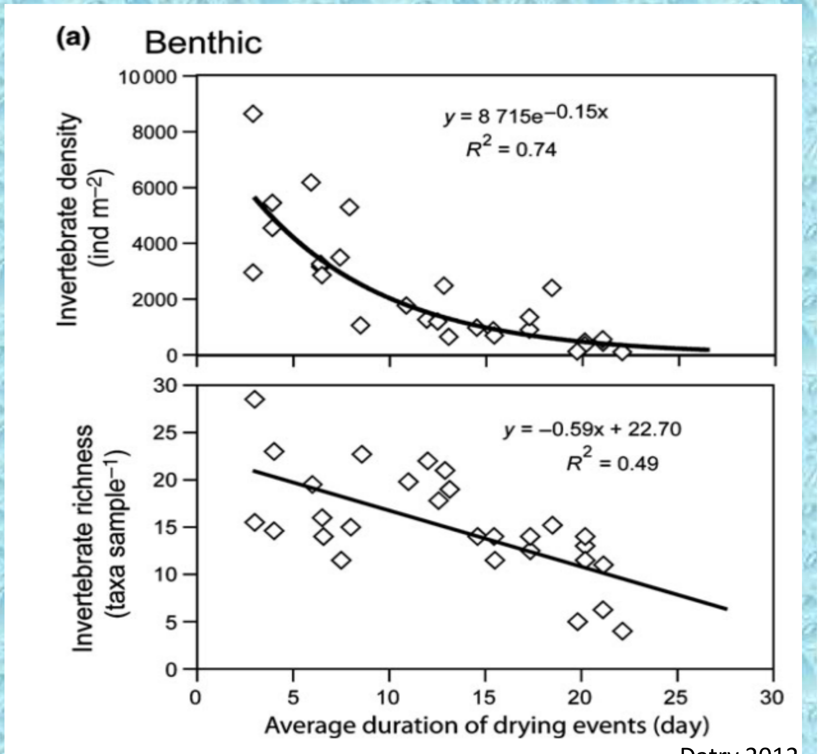
UNESCO, 1997

Why Do We Care About Ecohydrology?

- Biological endpoints are increasingly used for ambient and compliance monitoring in streams
  - *Bio-integrity*
  - *Nutrient numeric endpoints*
  - *Hydromodification*
  - *Stormwater compliance monitoring*

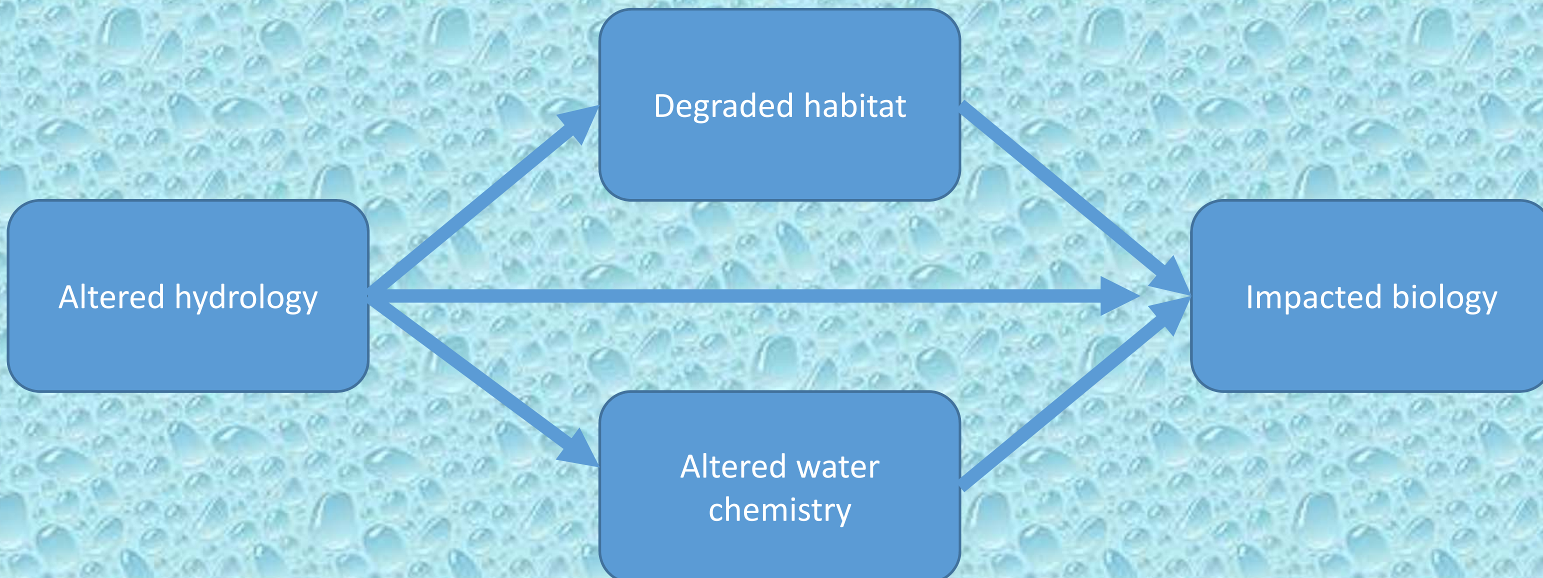
- Instream biological communities are sensitive to changes in flow and physical structure of streams

- Improved understanding of the relationship between flow and biological assessment indicators will aid in development of management strategies



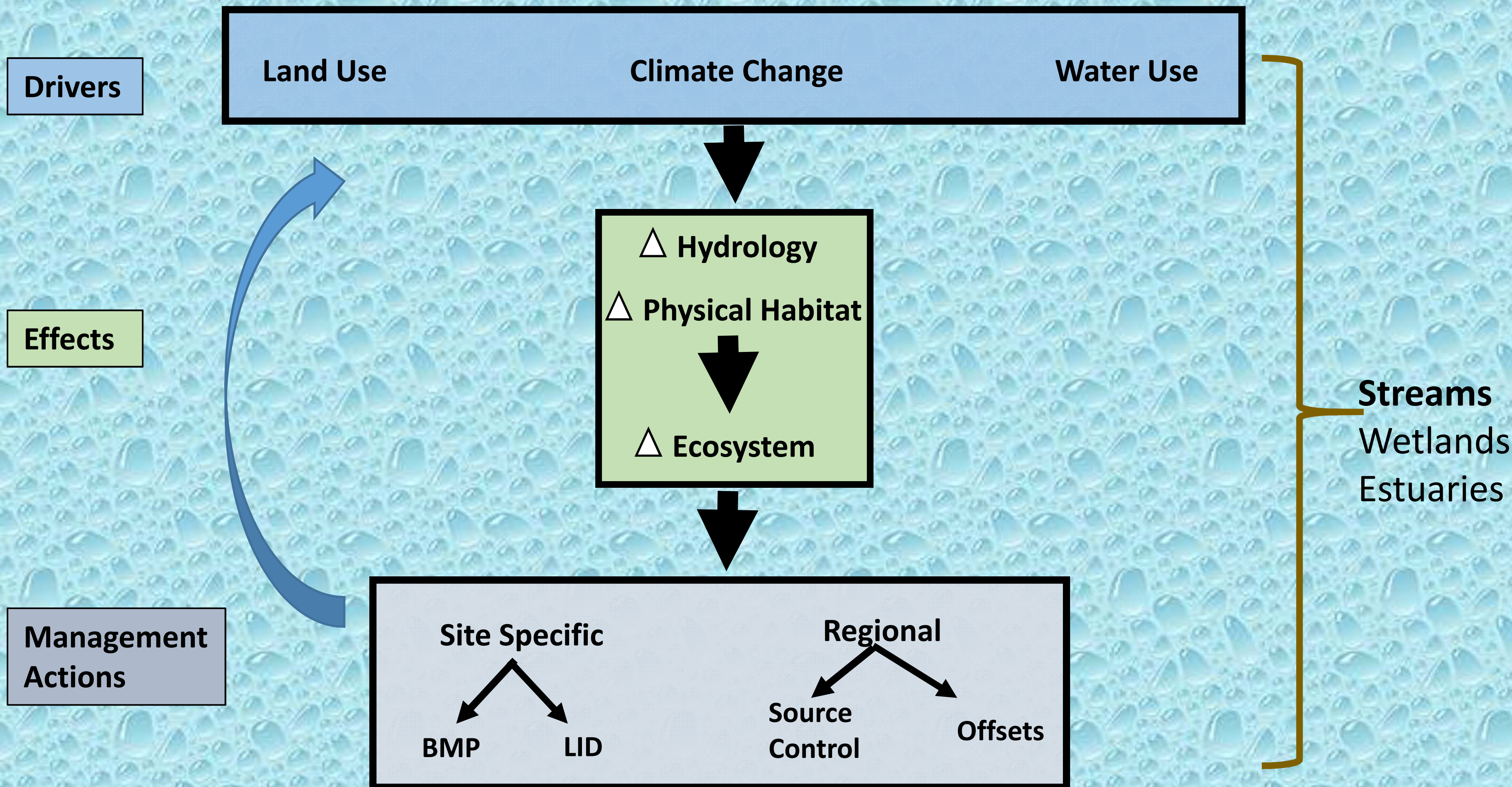
Datry 2012

Hydrology is an Integrator



If you can mitigate hydrologic alteration, you'll solve a lot of other problems

Conceptual Model



Drivers

What are the expected patterns in key hydrologic/ecosystem drivers?

✓ ***Tools to improve our ability to predict changes in drivers***

How might we affect drivers to achieve ultimate desired outcomes?

- Land Use
  - Changes in land use patterns → *largely done by others*
  - **Relationship between connected and disconnected impervious**
- Climate Change
  - Downscaling global climate models → *largely done by others*
  - Statistical analysis of medium-scale (decadal) climate signals
- Water Use
  - Quantification of reduced flow due to changing water use practices

Effective Imperviousness

Key metric for use in hydromodification compliance

- Effective (disconnected) impervious cover is a better predictor of hydrologic change
- No local relationships to relate total to effective imperviousness
- Programs currently rely on single study from Maryland (Sutherland 2000)
- ***Lot's of uncertainty for local use***

Table 1. Sutherland Equations to Determine DCIA (%)

Watershed Selection Criteria	Assumed Land Use	Equation *(where IA(%) ≥1)*
Average: Mostly storm sewered with curb & gutter, no dry wells or infiltration, residential rooftops not directly connected	Commercial, Industrial, Institutional, Open land, and Med. density residential	$DCIA=0.1(IA)^{1.5}$
Highly connected: Same as above, but residential rooftops are connected	High density residential	$DCIA=0.4(IA)^{1.2}$
Totally connected: 100% storm sewered with all IA connected	--	DCIA=IA
Somewhat connected: 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	Low density residential	$DCIA=0.04(IA)^{1.7}$
Mostly disconnected: Small percentage of urban area is storm sewered, or 70% or more infiltrate/disconnected	Agricultural; Forested	$DCIA=0.01(IA)^{2}$

Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit

Small MS4 Permit Technical Support Document, April 2011

Draft NPDES Permit Focuses on DCIA

The 2010 NPDES Small MS4 draft permits for Massachusetts require regulated communities to estimate the number of acres of **impervious area** (IA) and **directly connected impervious area** (DCIA) that have been added or removed each year due to development, redevelopment, and or retrofitting activities (Draft North Coastal Permit Section 2.4.6.9). Beginning with the

Accepted Methods for Estimating IA & DCIA

Step 1. Establish Baseline IA/DCIA — Use the estimates of existing IA and DCIA provided by EPA to establish the baseline acreage from which future additions or reductions of impervious cover can be tracked and measured.

For each regulated municipality in Massachusetts, EPA will provide graphical and tabular estimates of IA/DCIA ordered by land use type and subbasin. **Permittees may simply use these baseline estimates as is, or develop more accurate estimates when justified.** This may include using local data to refine EPA's estimates or the direct measure of IA (**Figure 1**). If the EPA estimates are not used for the baseline, permittees must provide in the annual report a description of the alternative methodology used.

Figure 1. EPA will use IA extrapolated from 2005, 1-meter orthoimagery provided by MassGIS (upper). A comparison of a MassGIS-derived IA estimate (shown in purple) vs. a refined direct measurement (shown in green) by the Town of Reading,

Effects - Overview

Hydrology

- How do changes in key landscape drivers affect hydrology?

Physical Habitat

- What is the relationship between hydrologic change and physical habitat response?

Ecosystem Response

- How are key biological indicators or communities affected by changes in hydrology and physical habitat?

How might program and policies affect management at each of these levels (e.g. hydrologic targets vs. biological targets)

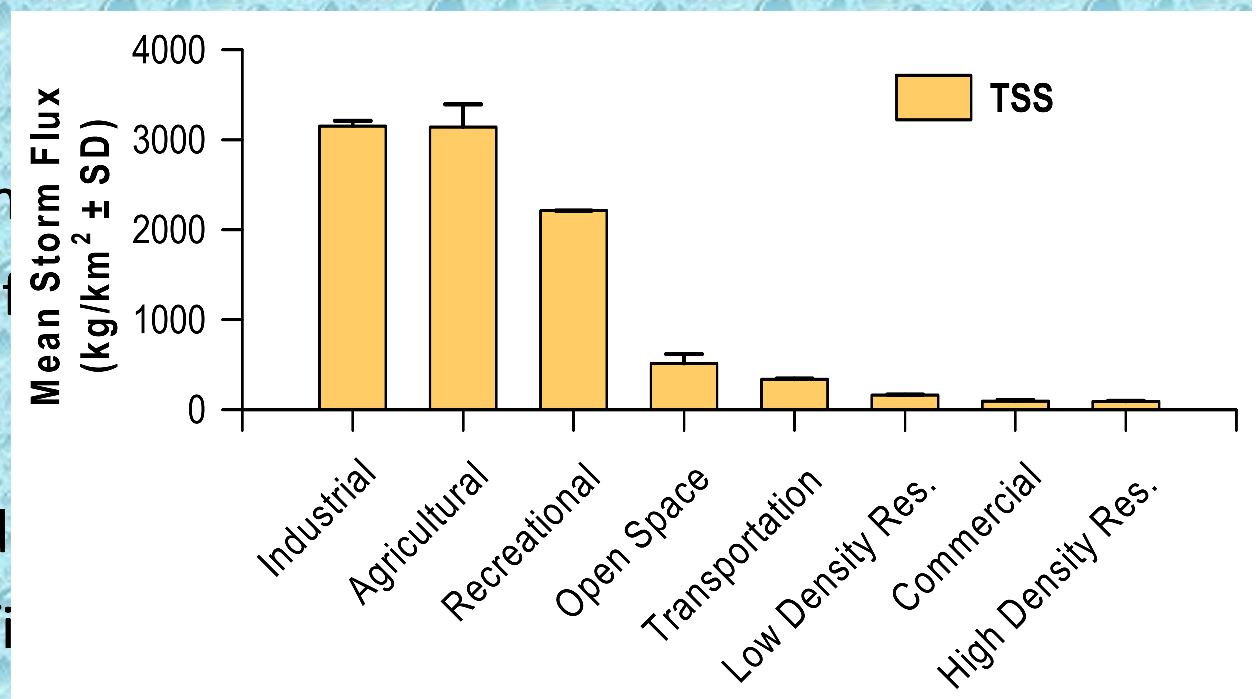
Effects - Hydrology

Past work focused on developing watershed models

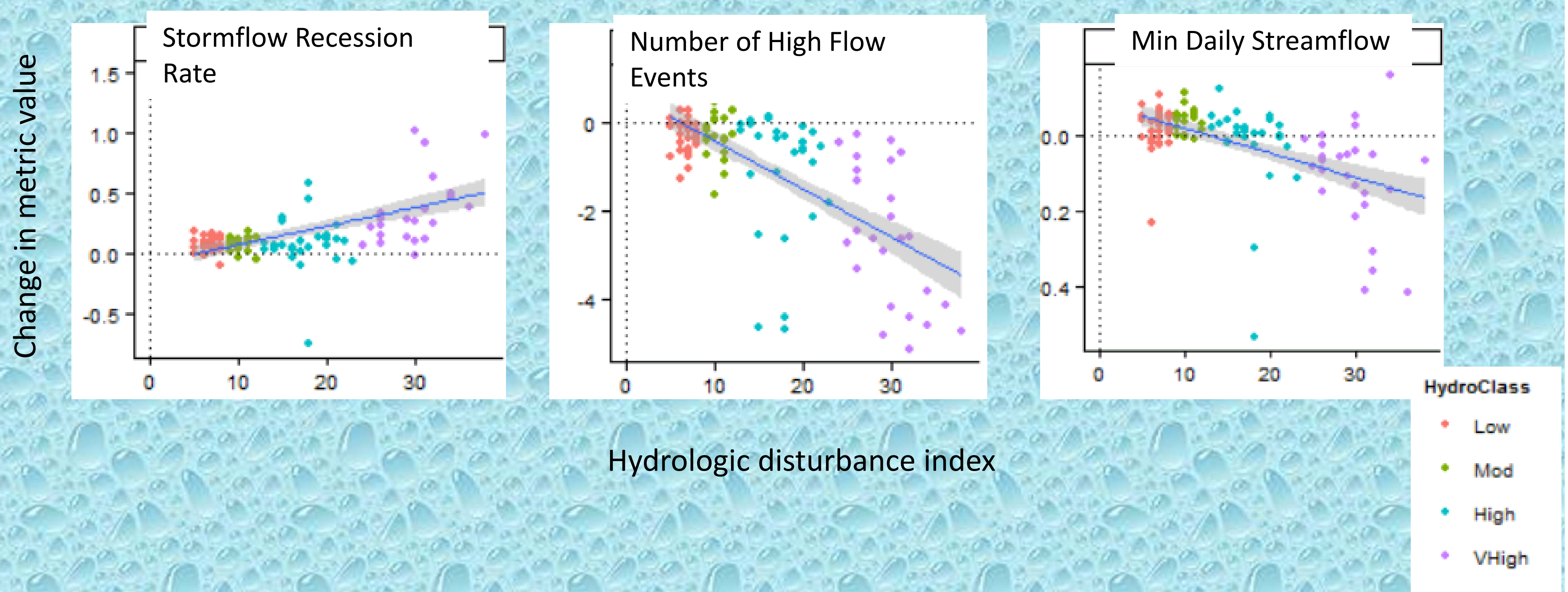
- Modeling framework for many water quality programs (e.g. TMDL)
- SCCWRP land-use runoff coefficients still provide the foundation of most local models

Future research needs

- Update land use – run
- Improved modeling of
  - Statistical models
  - Mechanistic models
- Surface-water ground
- Long term effects of fi



Modeling Biologically Meaningful Metrics



Which flow metrics should we manage toward?

Drivers → **Effects** → Management Actions

Effects – Physical Habitat

Past work

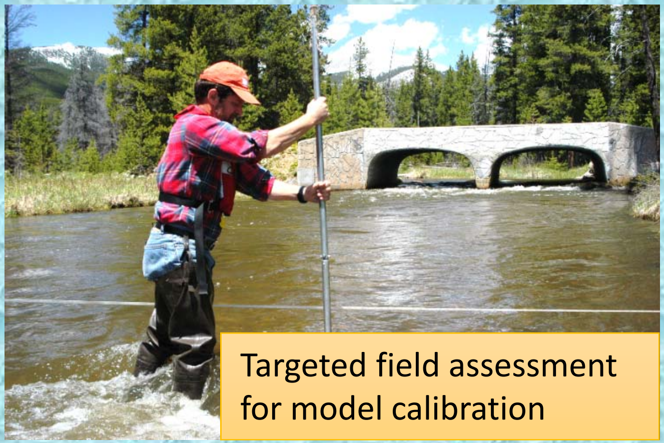
- Robust research program on hydromodification has influenced stormwater management statewide

Future research needs

- Continued work on evaluation of *effectiveness of hydromodification management strategies* → feedback to improve assessment tools

- Improved ability to predict sediment yield
  - Potential compliance endpoint

- Predicting hydraulic responses in channels
  - PHAB metrics and assessment
  - Hydraulic modeling



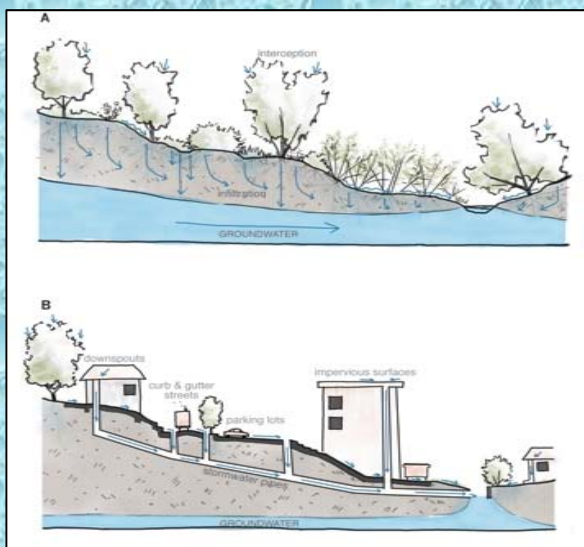
Targeted field assessment for model calibration

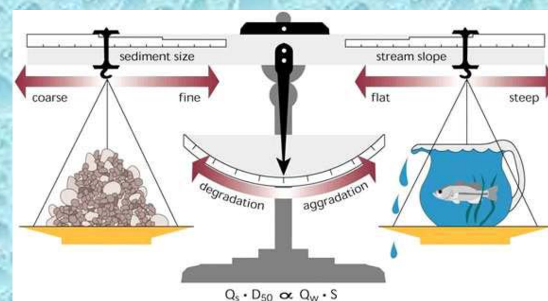
How do we gage "success" of hydromodification management?

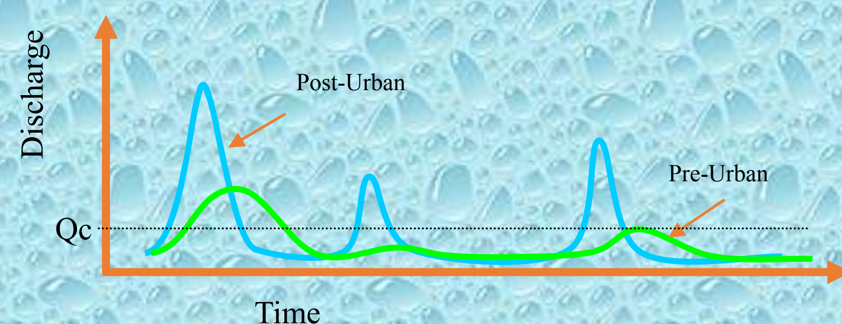
Past Focus: Hydromodification

How can we assess extent of impact?

Hydromodification = changes to the runoff hydrograph and sediment supply resulting from land use modifications

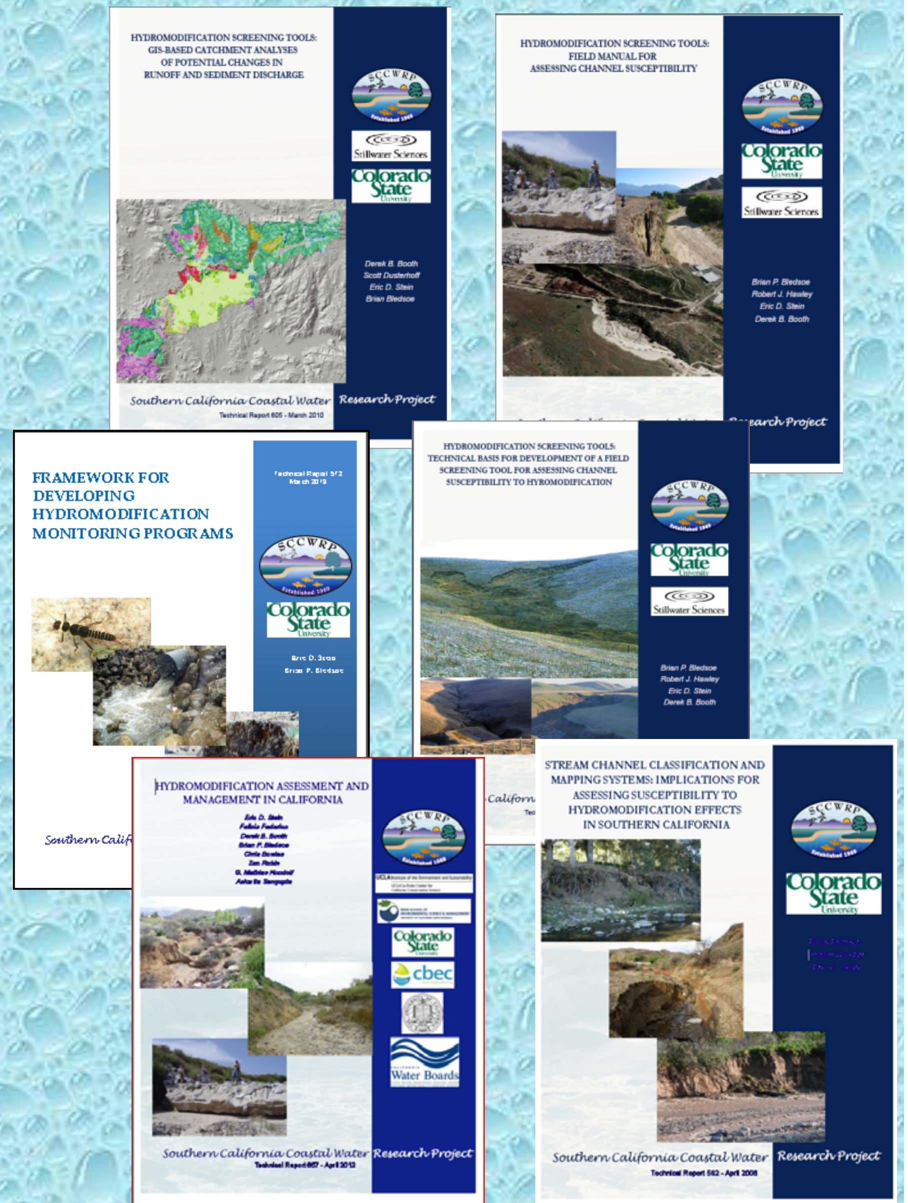






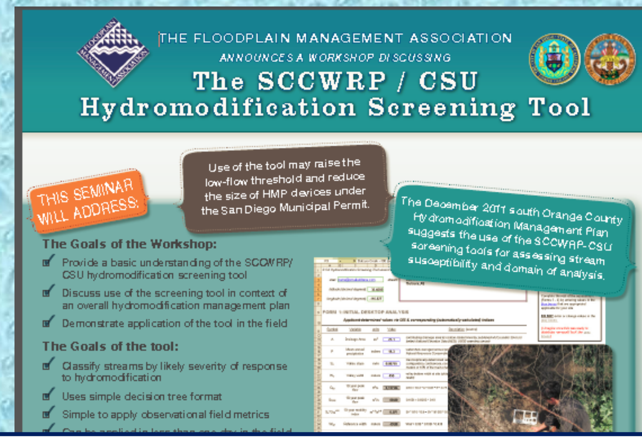
SCCWRP Products Responded to Management Needs

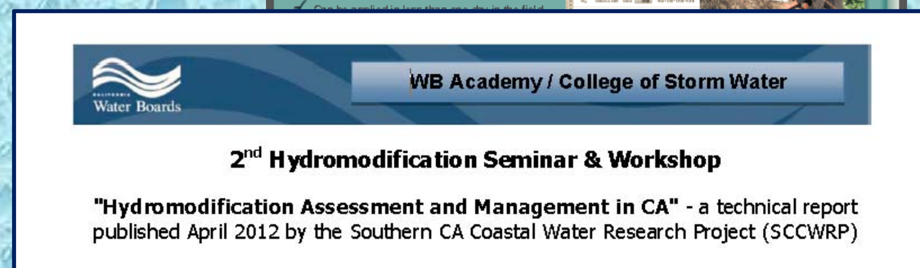
- Classification system
- GIS screening tool
- Field susceptibility assessment
- Model selection guidance
- Management approaches
- Monitoring framework



Ongoing Implementation Support

- Technical advisory committees
- Stakeholder outreach
- Training and technical support
- Automated tools





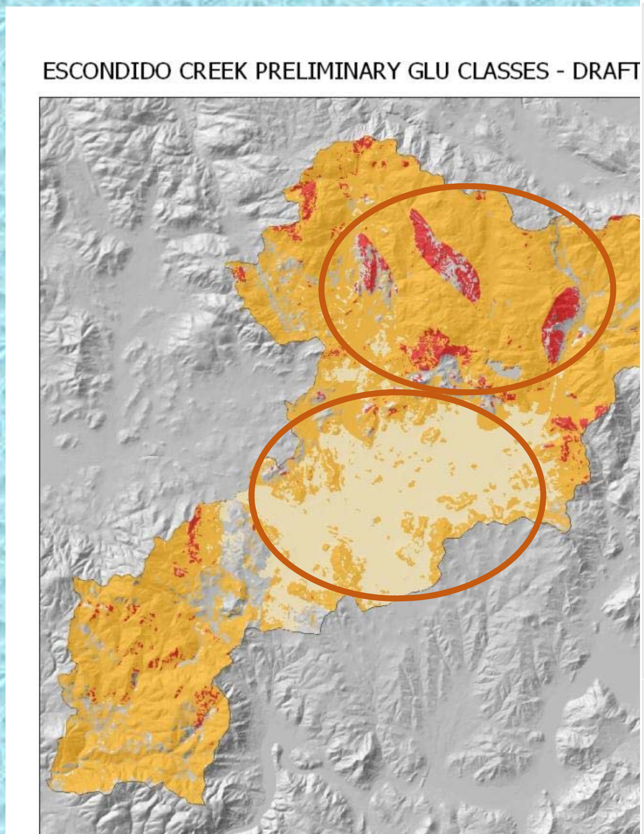
Future Needs for Hydromodification Management

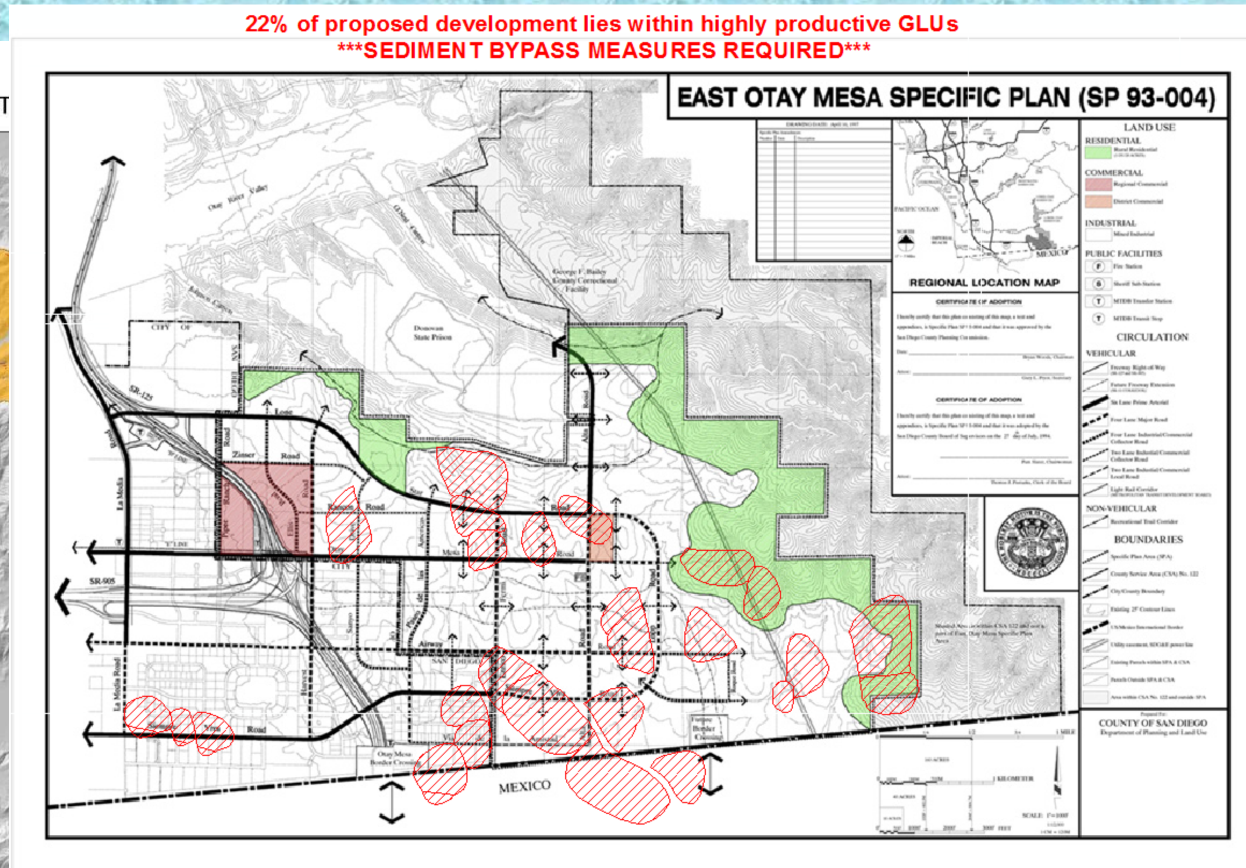
- **Assessment** – *setting appropriate targets based on anticipated effects*
  - Link hydromodification to biological endpoints / support causal assessment
  - Improve models for predicting physical habitat response
  - Inform flow criteria based on ecological endpoints

- **Management** – *what will be the most effective management strategies*
  - New management approaches, such as restoring stream processes
  - Use alternative compliance provisions to support more holistic management

- **Monitoring** – *improving the effectiveness of monitoring tools*
  - Use monitoring and retrospective analysis to inform causal assessment
  - Establish sentinel monitoring to better separate anthropogenic effects from natural variability
  - New monitoring technologies
  - Focused monitoring to provide data to improve model calibration

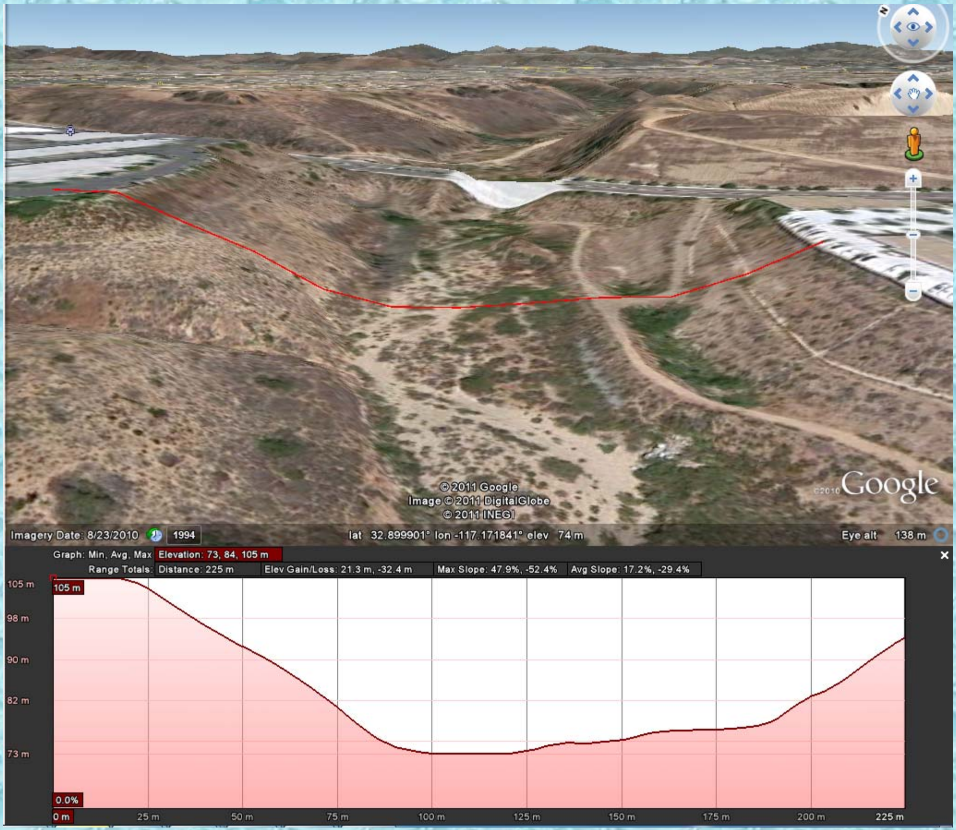
Management: Control of Critical Coarse Sediment Yield





- How can you map these areas?
- What type of BMPs are needed to protect sediment yield?
- How do you monitor/assess effectiveness?
- Resolving apparent conflicts between TMDLs and hydromodification

Monitoring Hydromodification Using UAVs



Drivers → **Effects** → Management Actions

Effects – Ecosystem Response

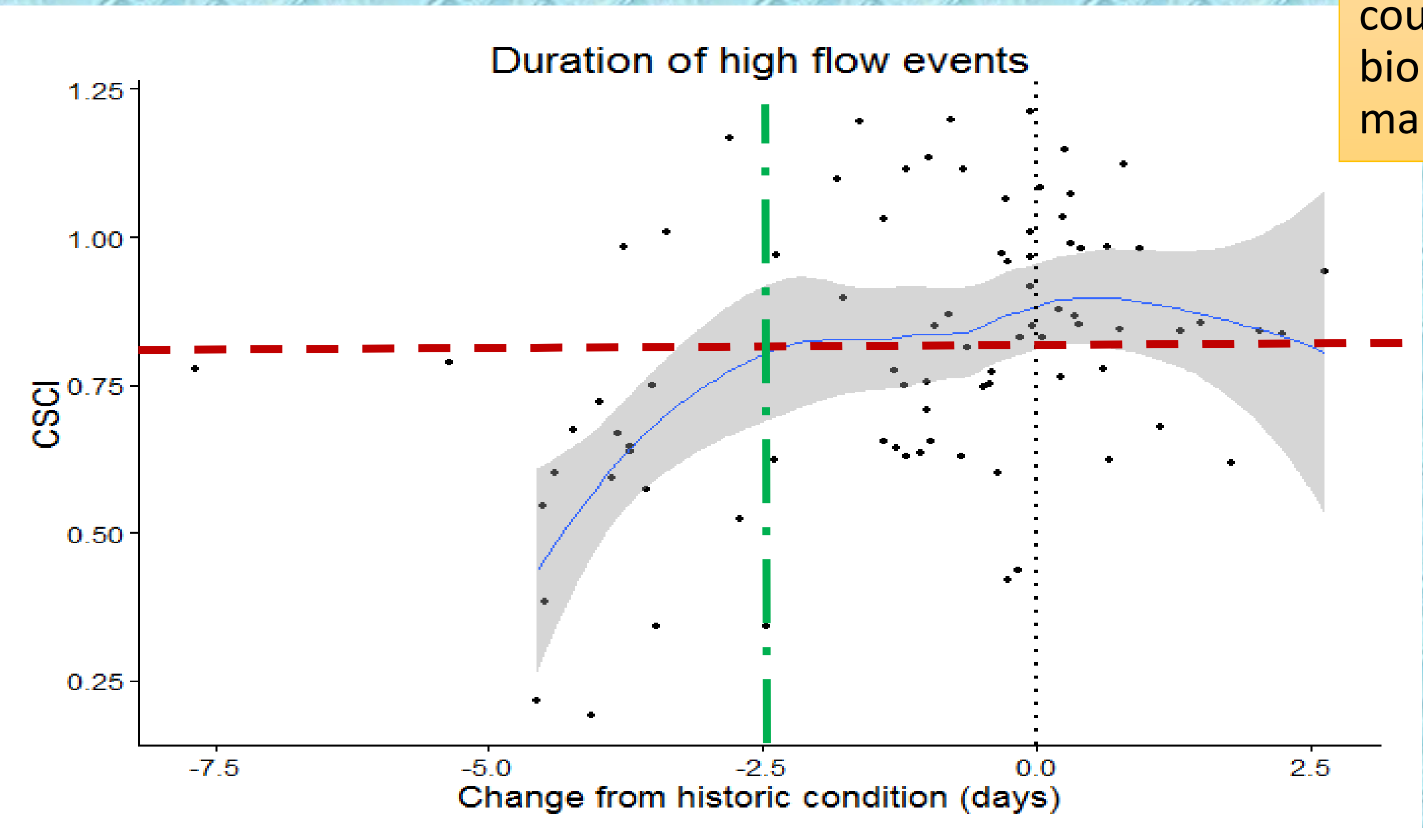
Implications of current work

- **What might "flow criteria" look like in the future?**
- **How might flow criteria affect water management, use, and reuse?**
  - Relationship between changing hydrology/physical habitat and biological endpoints

Future research needs

- How to identify desired ecological assessment endpoints
  - What are the biological community targets we want to maintain? →shifting baselines
- Flow ecology analysis
  - Response of multiple biological endpoints (e.g. algae, fish, birds)
  - Improved modeling and assessment tools
- Development of physical habitat-ecology relationships

How are Flow Criteria Developed?



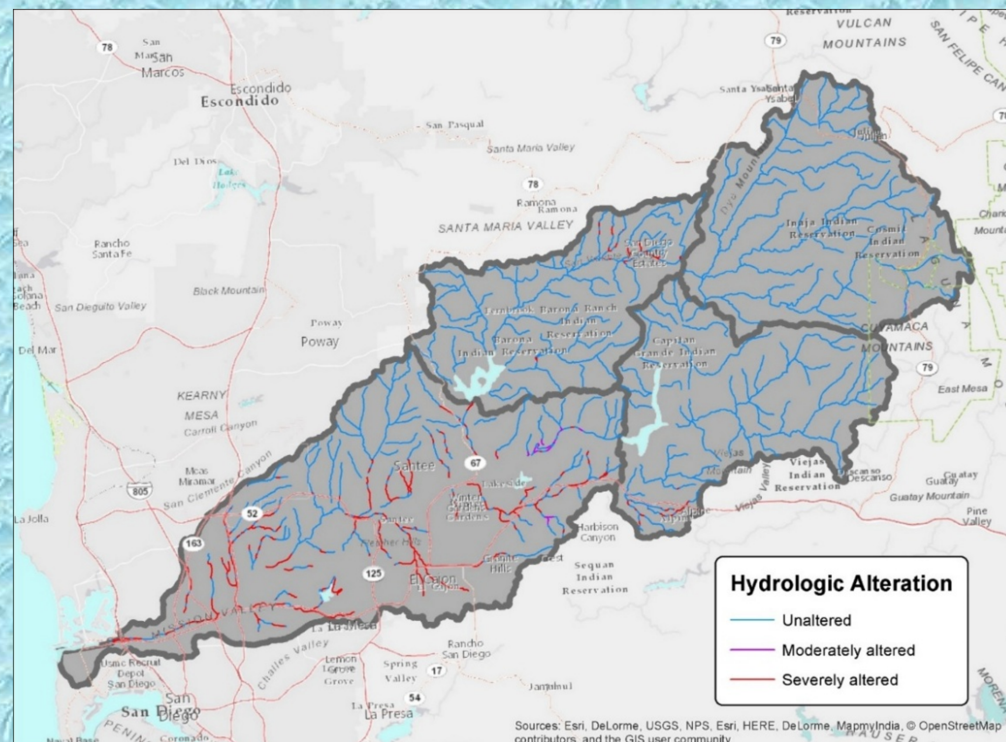
Relationships that could be used to set biologically-based management targets

Drivers → **Effects** → Management Actions

Demonstrating Application of Flow-Ecology Targets

Goal = To demonstrate how flow-ecology relationships can be implemented at a watershed scale to guide management targets/decisions

- Explore how flow ecology tools can support local decision
- Build capacity for implementation
- Summarize lessons learned and transferability to other areas of the State
- Summarize data and information needs
- Identify needs for additional tools and resources to aid in implementation



Drivers → **Effects** → Management Actions

San Diego River Case Study: *Priority Management Questions*

- How might lower discharge of treated effluent due to increased demand for reclaimed water affect ability to meet biological targets?
- How might minimum flow requirements affect decisions regarding stormwater capture potential
  - Amount or location of capture
- How will BMPs affect flow conditions
  - ability to meet biological endpoints
  - evaluate different types of BMPs, including stream restoration
  - evaluate different locations of BMPs
  - prioritize potential alternative compliance areas →downstream effects on biology

Management Actions

Implications of future research

What management strategies can be used to help meet instream flow targets that are intended to protect beneficial uses?

Onsite

- Optimization of BMPs for hydromodification and flow management
- Quantifying benefits of floodplain and stream restoration

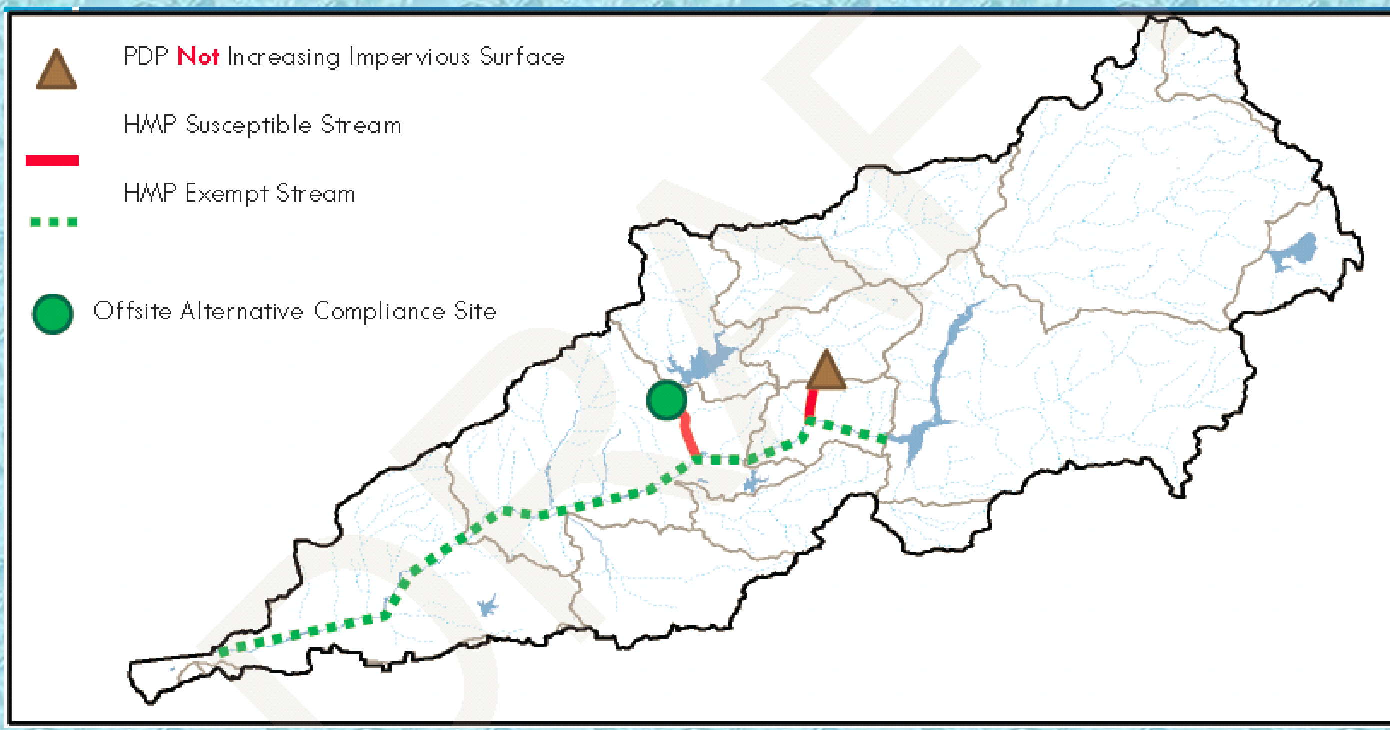
Regional

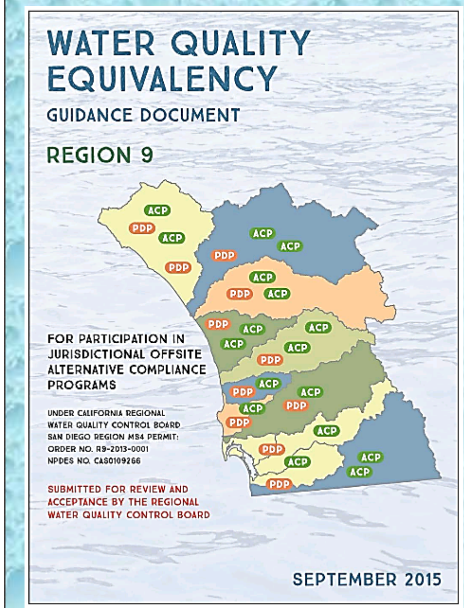
- Opportunities for water supply augmentation
  - Protection of source water and sediment supply areas
  - Stormwater capture opportunities
- Support development of integrated monitoring strategies

Offsets

- Designing optimal watershed management strategies
- Support development of equivalencies for flow, hydromodification, and water quality

Alternative Compliance: Hydromodification

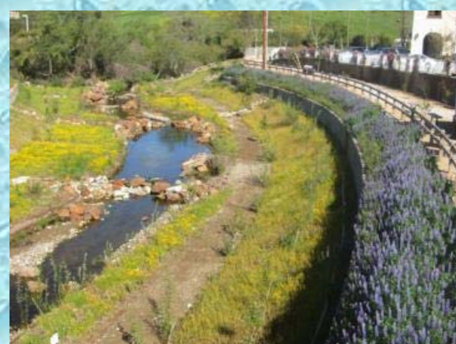


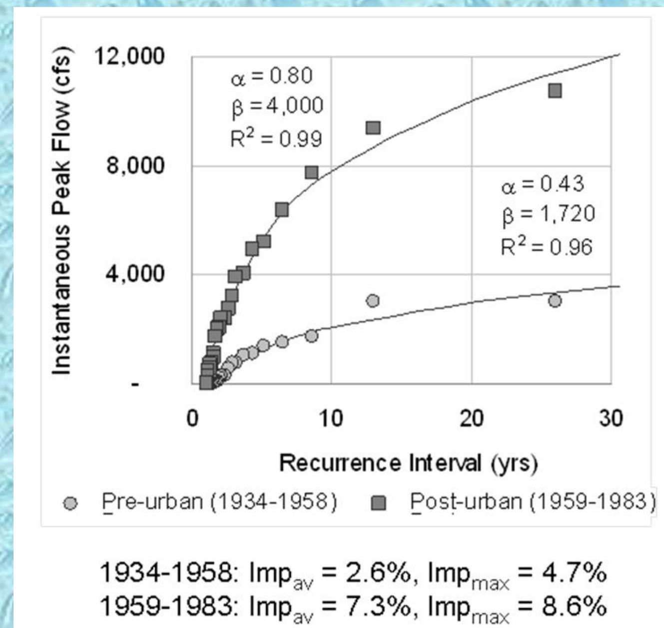


- **How to determine equivalencies for "offsite" mitigation ?**
  - ✓ **Size and location**
  - ✓ **Amount of offset needed to achieve compliance**

New BMP Types:
Quantifying Benefits of Stream Rehabilitation

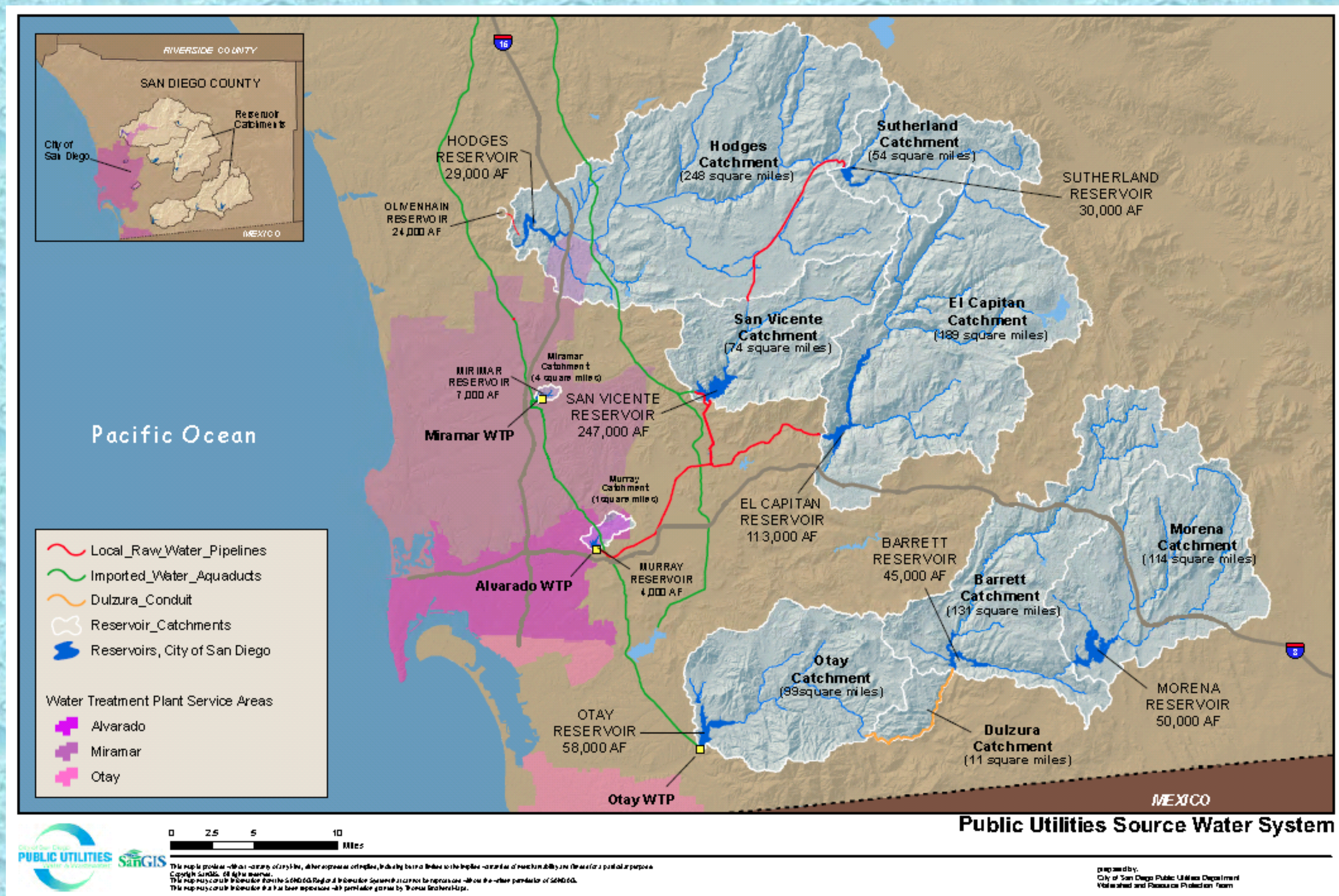




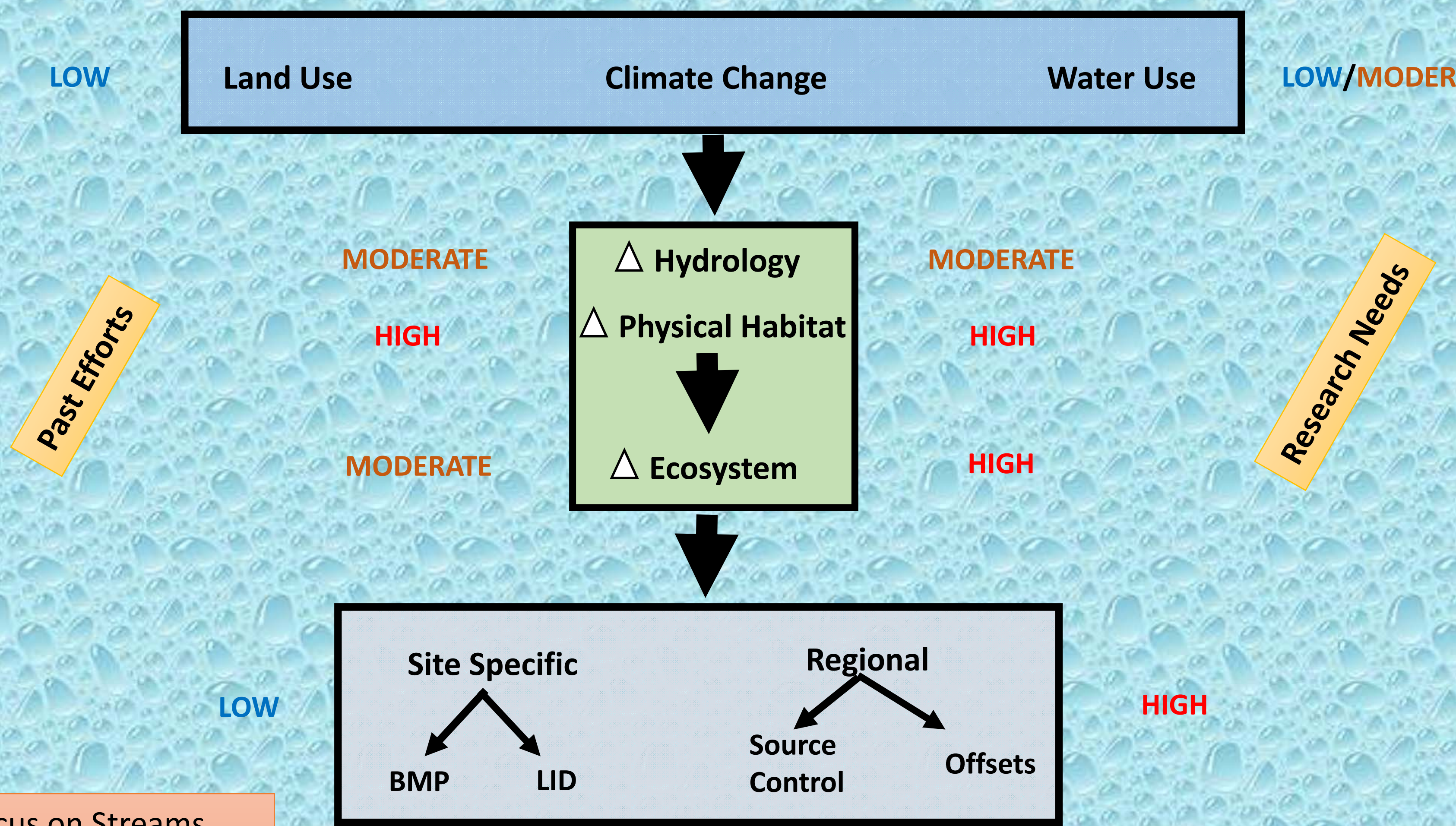
- **How much water quality or hydromodification credit ?**
  - ✓ **Allowable locations**
  - ✓ **When do credits "mature"**

Prioritizing Areas for Source Water Protection



Drivers → Effects → **Management Actions**

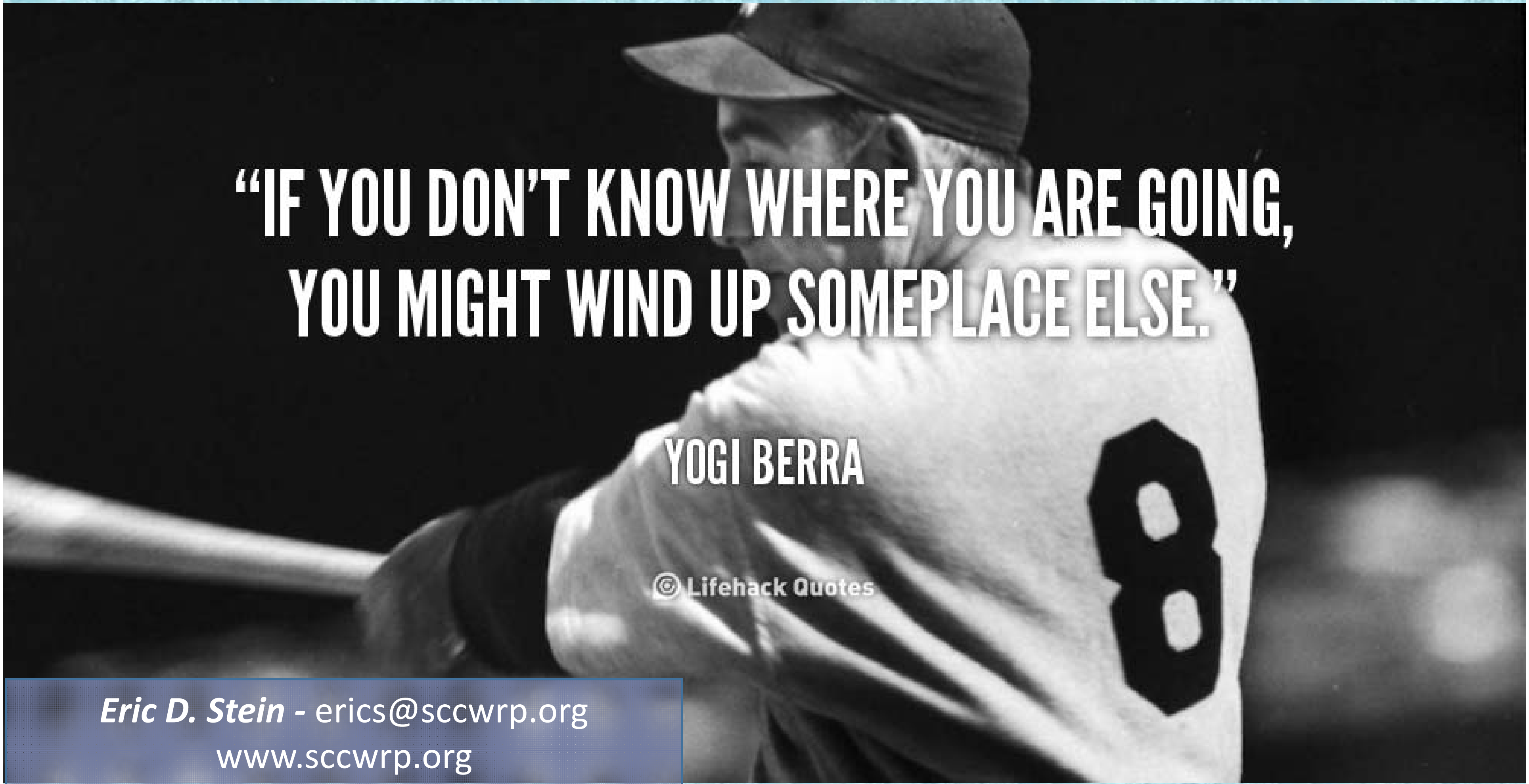
Conceptual Model – Status and Needs



- Focus on Streams
- Little effort in wetlands or estuaries

Development of research priorities

Research Planning



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