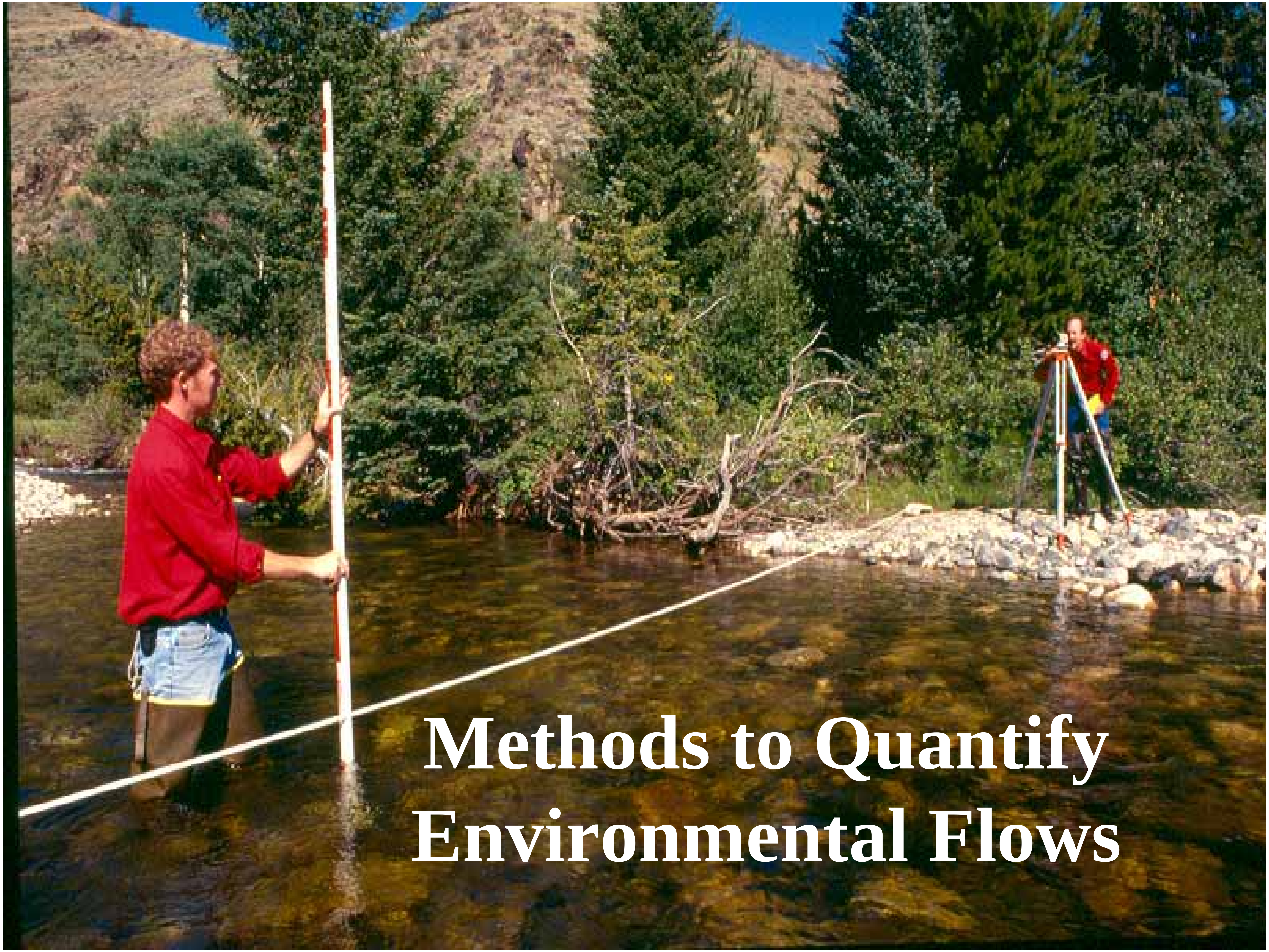

Methods to Quantify
Environmental Flows

So Far . . .

- Environmental flows aren't simple . . . but we can figure things out
- Water works hard
- Many key issues with river management
  - Crustaceans and invertebrates are important
  - Riparian management is as important as flow
  - Connectivity is key
  - Emphasis so far has been on <u>survival</u> of orgs.

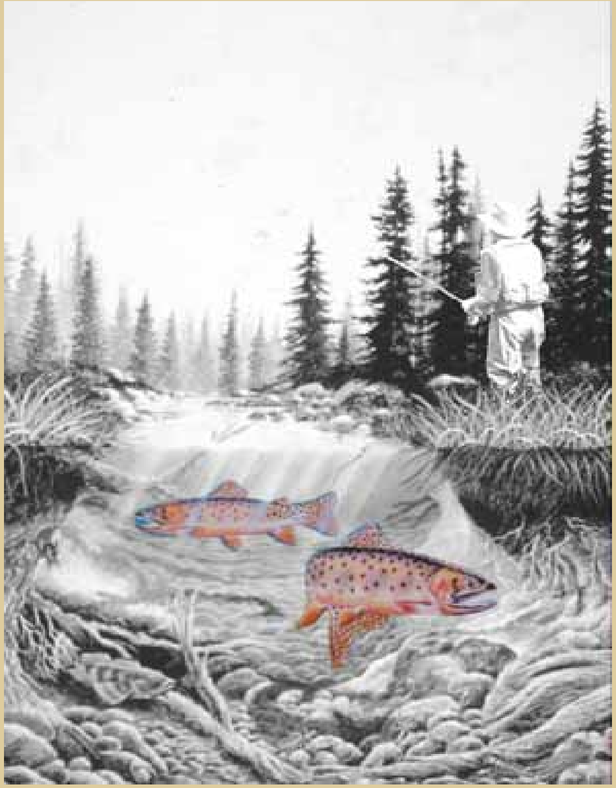
What can models tell us?

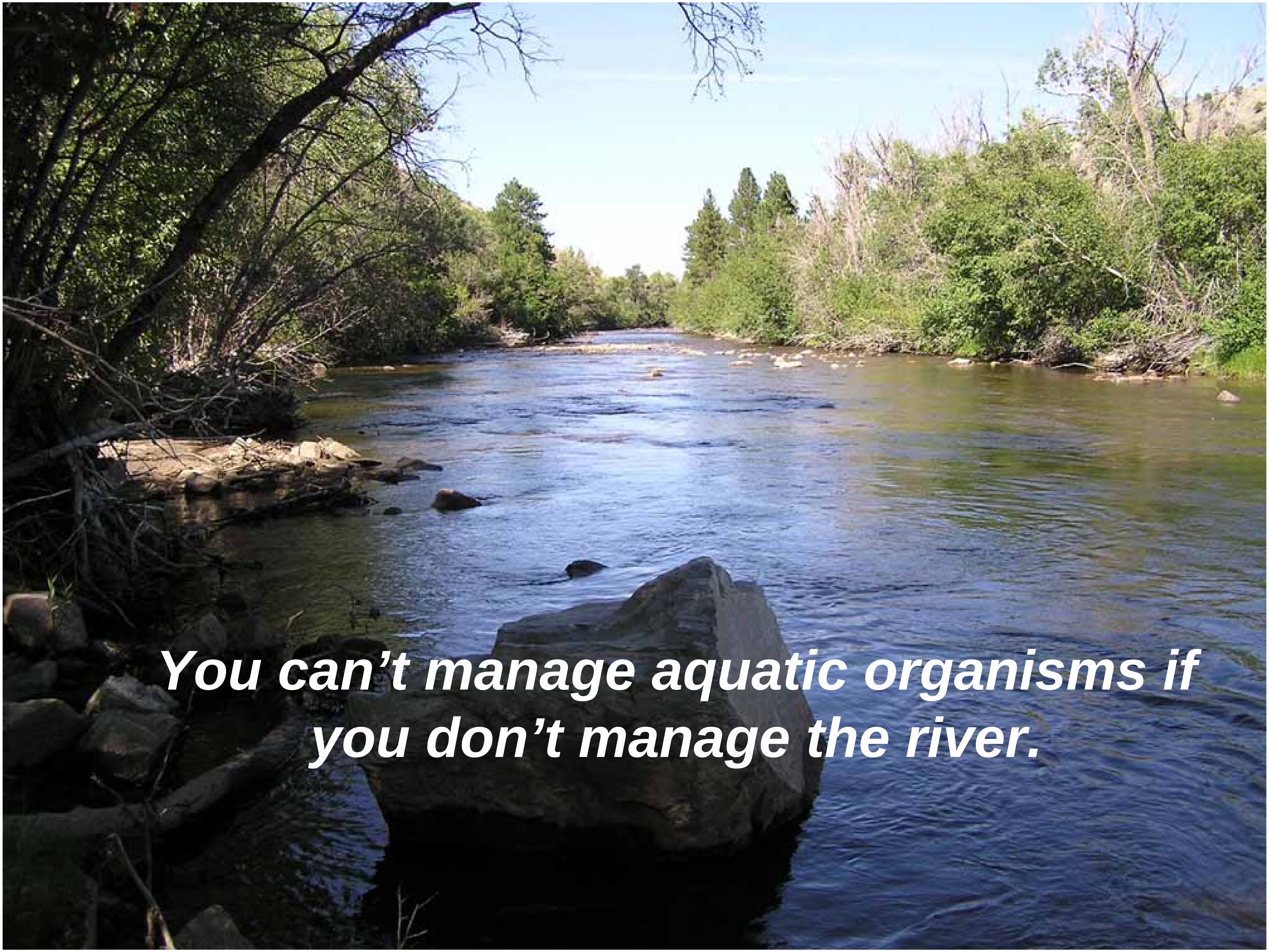
- Short term survival of organisms
- Long-term persistence of habitat
- Long-term persistence of organisms

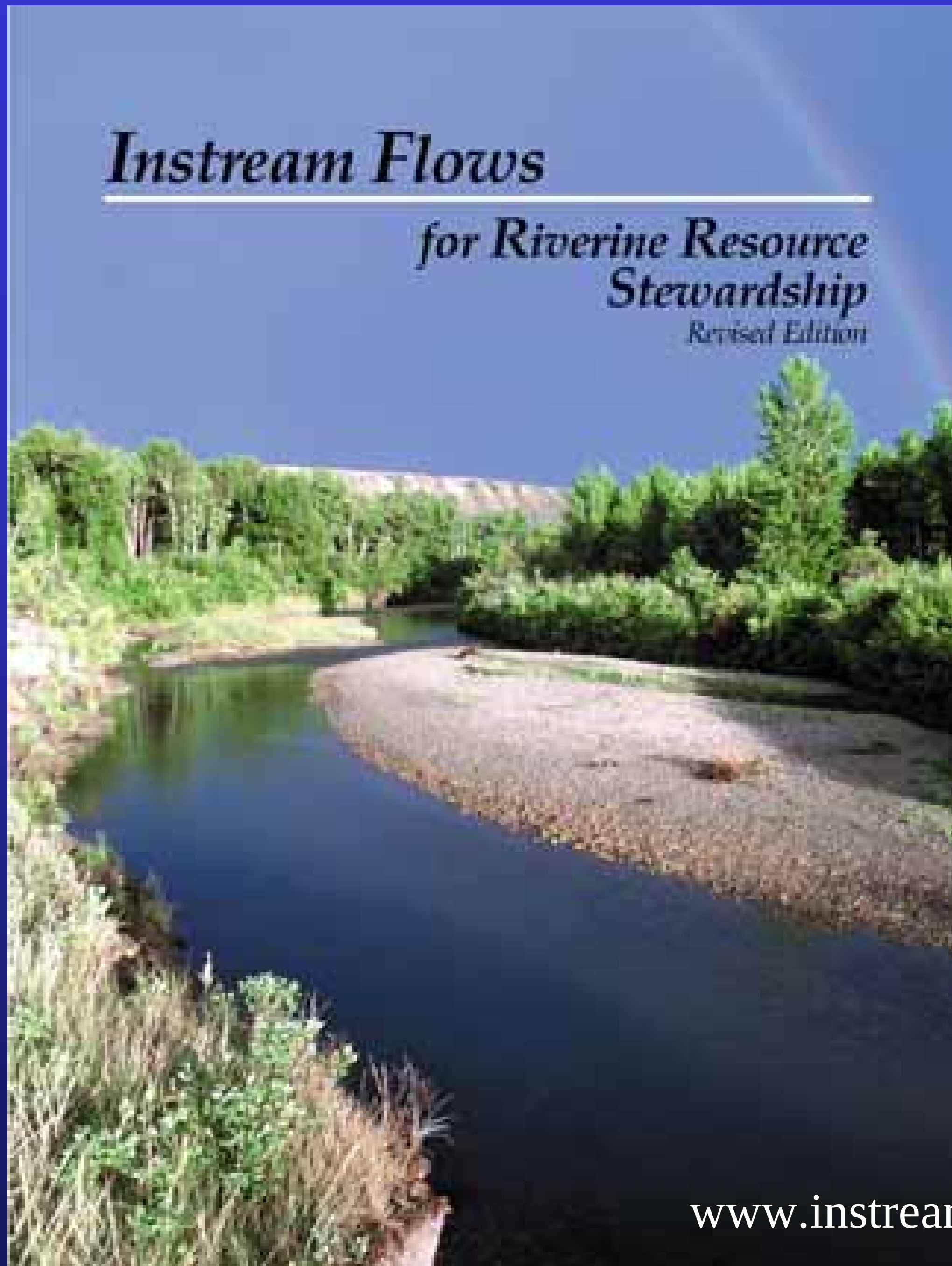
Models can tell us about:

- Hydrology (short and long-term water availability)
- Biology (short-term physical habitat availability)
- Geomorphology (long-term physical habitat maintenance or restoration)
- Connectivity (short and long-term)
- Water quality (short and long-term)

Manage organisms or ecosystems?



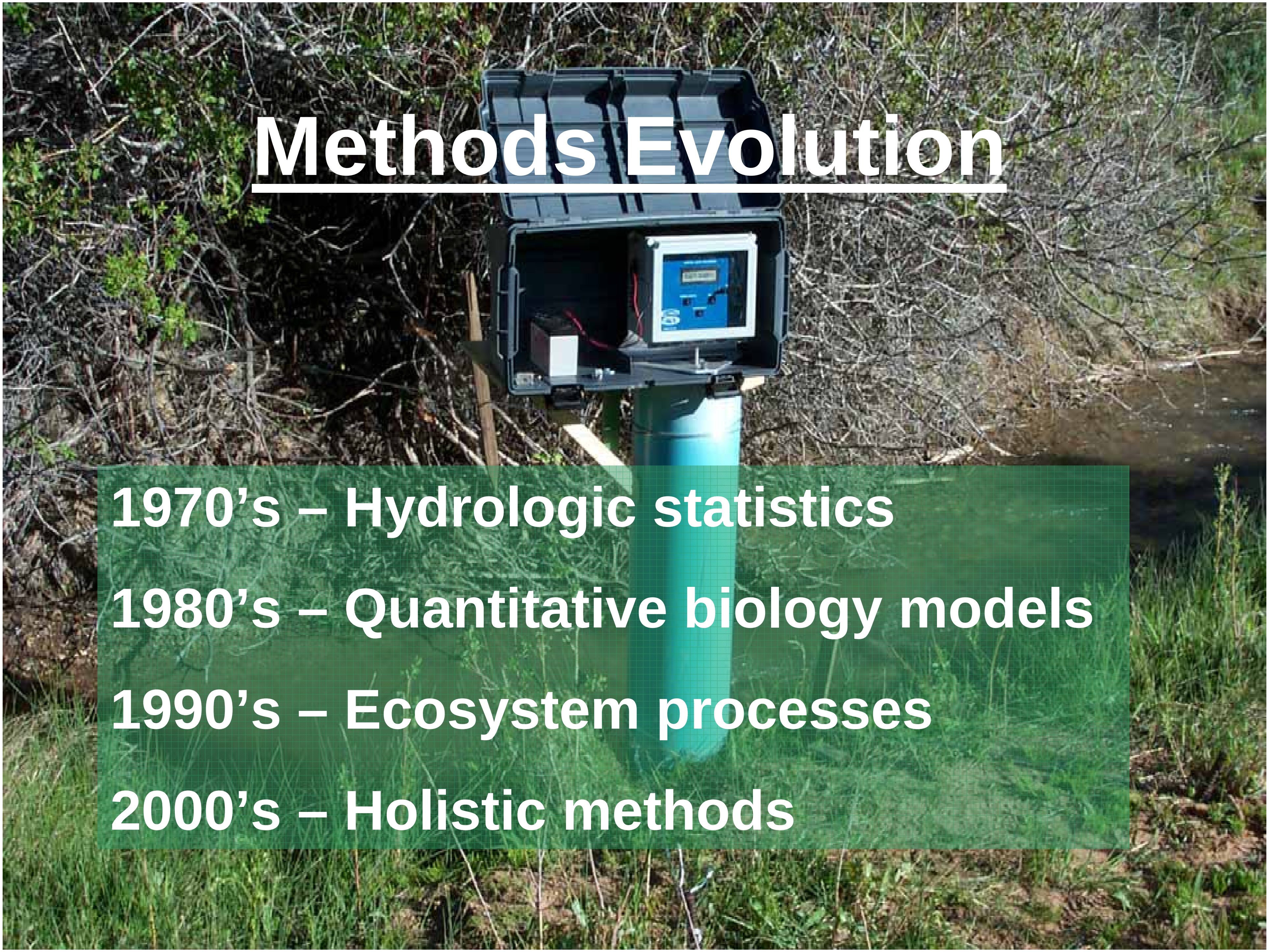

You can't manage aquatic organisms if you don't manage the river.



www.instreamflowcouncil.org

Traditional Approach

- One species
- One method / tool
- One flow (minimum)



Methods Evolution

1970's – Hydrologic statistics

1980's – Quantitative biology models

1990's – Ecosystem processes

2000's – Holistic methods

Flow quantification methods

- Standard-setting methods
  – Estimate single level or threshold of flow
- Incremental methods
  – Evaluate habitat value vs. flow relationship
  – Relate to a single riverine element at a time
- Multiple component methods
  – The next generation

Habitat Modeling Caveats

- There isn't a straight-line relationship between flow and habitat.
- A flow that's good for one species may be detrimental to others.
- A flow that maximizes habitat in one stream segment may not provide much in another.
- There isn't a single "best" flow – think flow regimes.

All models are wrong,
but some are useful.

George Box

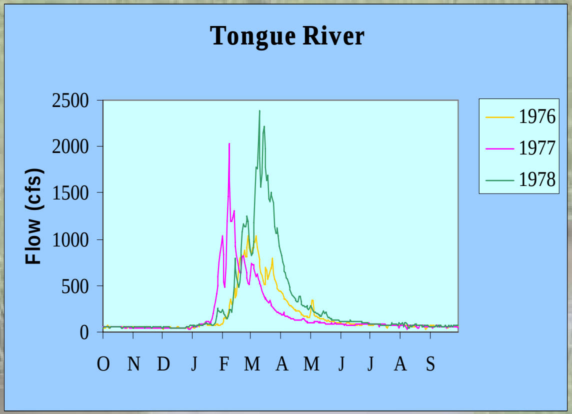
Selecting Methods

- Each situation is different so each has a unique solution
- Document what questions need answered
- Document what questions DON'T need answered.

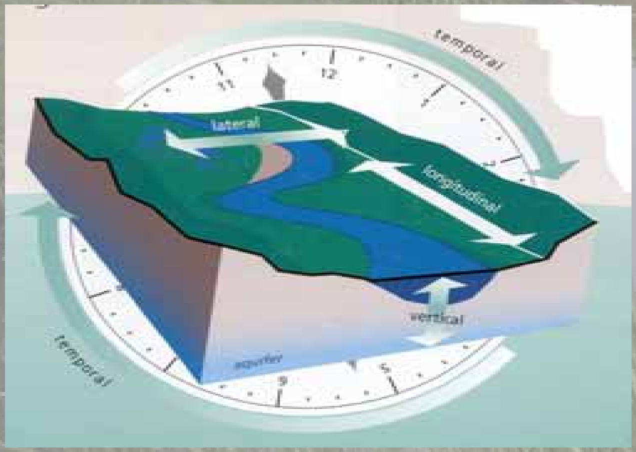
Geomorphology

Biology

Hydrology



Connectivity



Water Quality

Hydrology Methods

- Indicators of Hydraulic Alteration (IHA)
- Range of Variability Approach (RVA)
- Flow duration curves (Q_{98})

Hydrology Model Considerations

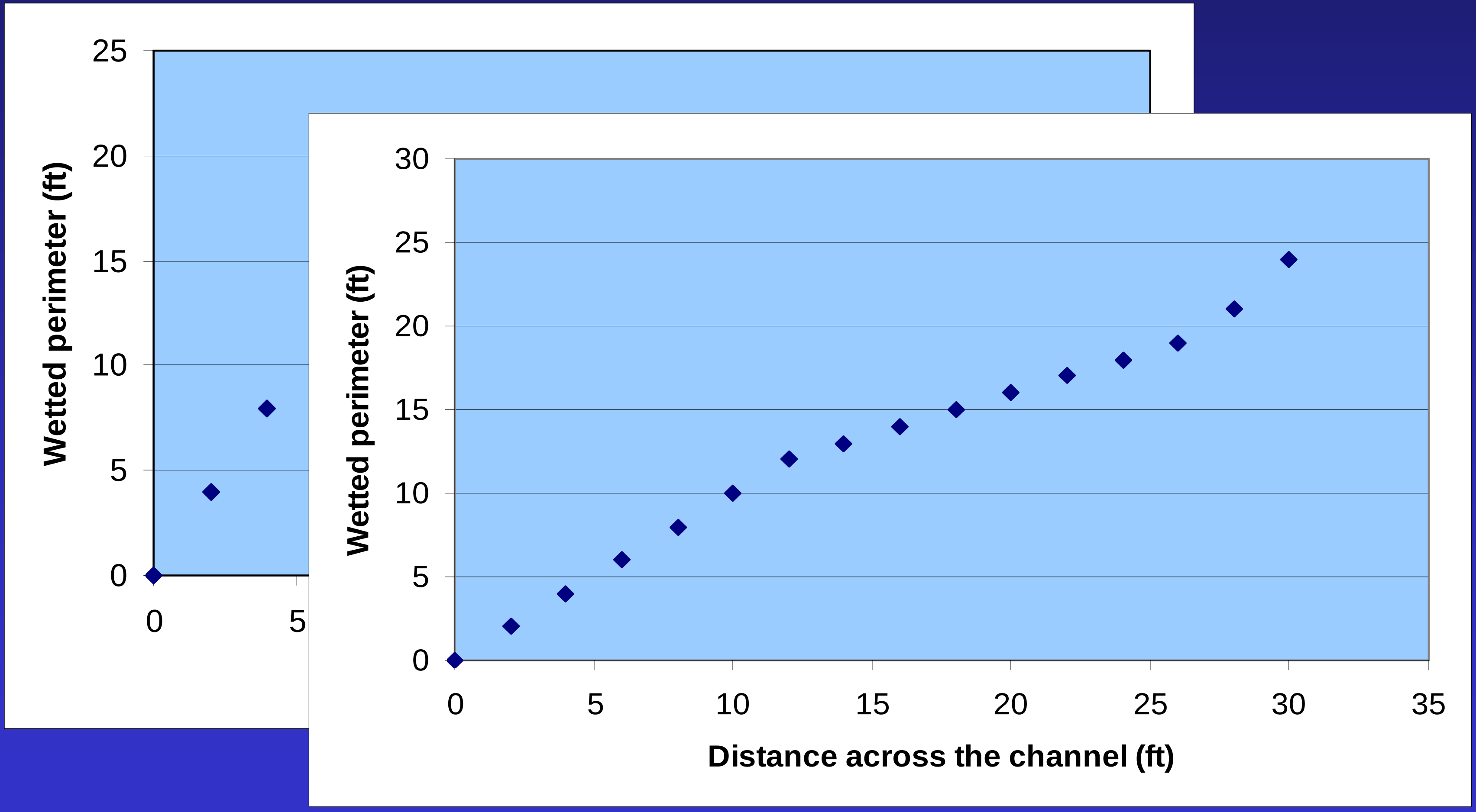
- Good for describing hydrology (planning)
- Need long-term gage data
- Low to moderate effort
- Long history of use - acceptance
- Assumes a relationship with biology
- May have different relationships on different streams
- Need other tools to assess needs for other riverine elements

Biology

- Single Transect Methods
- Tennant Method (and variations)
- Physical Habitat Simulation HABSIM
- MesoHABitat SIMulator (MesoHABSIM)
- Two Dimensional Models (River 2-D)

Single Transect Methods

Single Transect Methods
(Wetted Perimeter)



Single Transect Methods

- Low to moderate effort
- Long history of use
- Only useful for setting threshold flows
- Limited ability to identify trade-offs
- Doesn’t address flow variability needs
- Need other tools to assess needs for other riverine elements

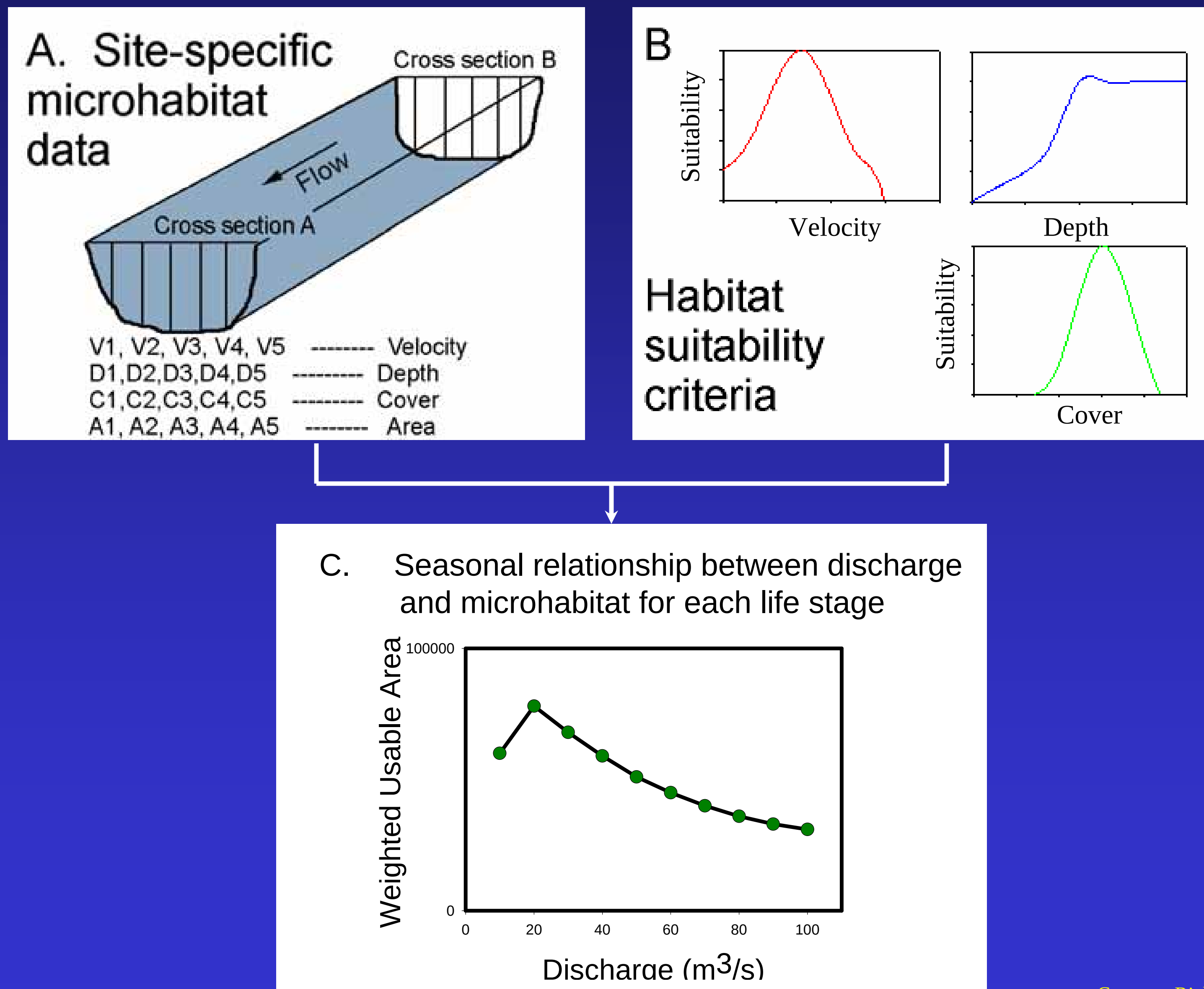
Tennant Method

Narrative Description of Flow	April to September	October to March
Flushing or maximum flow	200% from 48 to 72 hours	
Optimum range of flow	60-100%	60-100%
Outstanding habitat	60%	40%
Excellent habitat	50%	30%
Good habitat	40%	20%
Fair or degrading habitat	30%	10%
Poor or minimum habitat	10%	10%
Severe degradation	<10%	<10%

Tennant Method

- Can set threshold flows or regimes
- Need long-term gage data
- Limited ability to identify trade-offs
- Majority of challenges have been successfully defended
- Need other tools to assess needs for other riverine elements

Physical Habitat Simulation (PHABSIM)

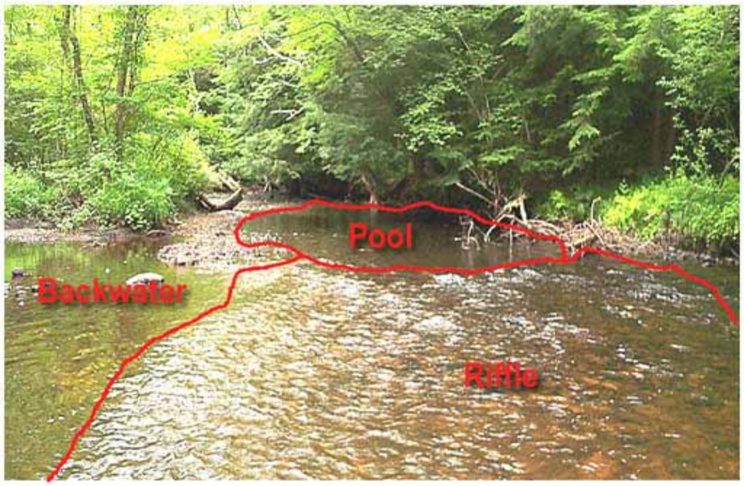


Courtesy Rick Anderson, CDOW

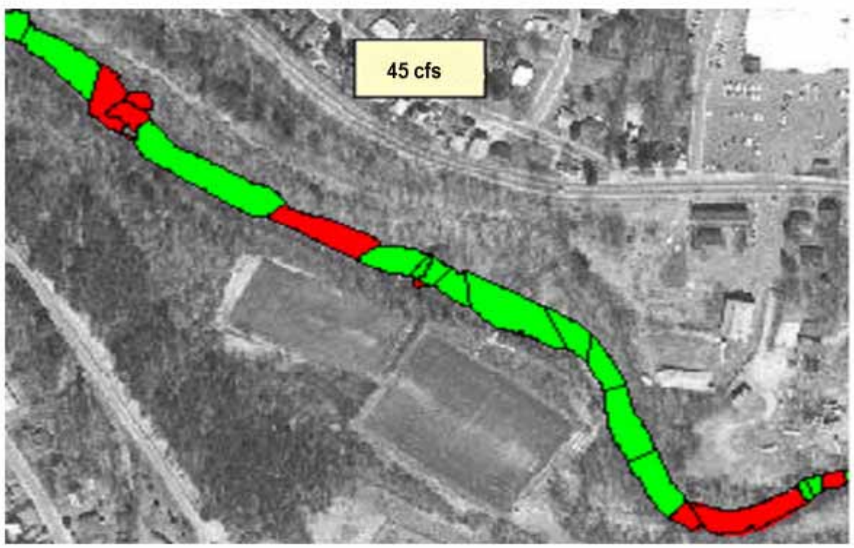
PHABSIM Concerns

- 1-D hydraulic models straighten and simplify the channel
- Physical habitat suitability isn't the same as habitat
- Unknown relationship between WUA and fish biomass
- Need other models to quantify needs for other riverine purposes

MesoHABSIM



COMMON SHINER		
Presence (*80%*)		Beta
	BOULDER	1.71
	RIPRAP	1.40
	SHADING	-1.48
	DEPTH 50-75 cm	-1.23
High abundance (*69%*)		
	BOULDER	1.68
	SHADING	-1.01

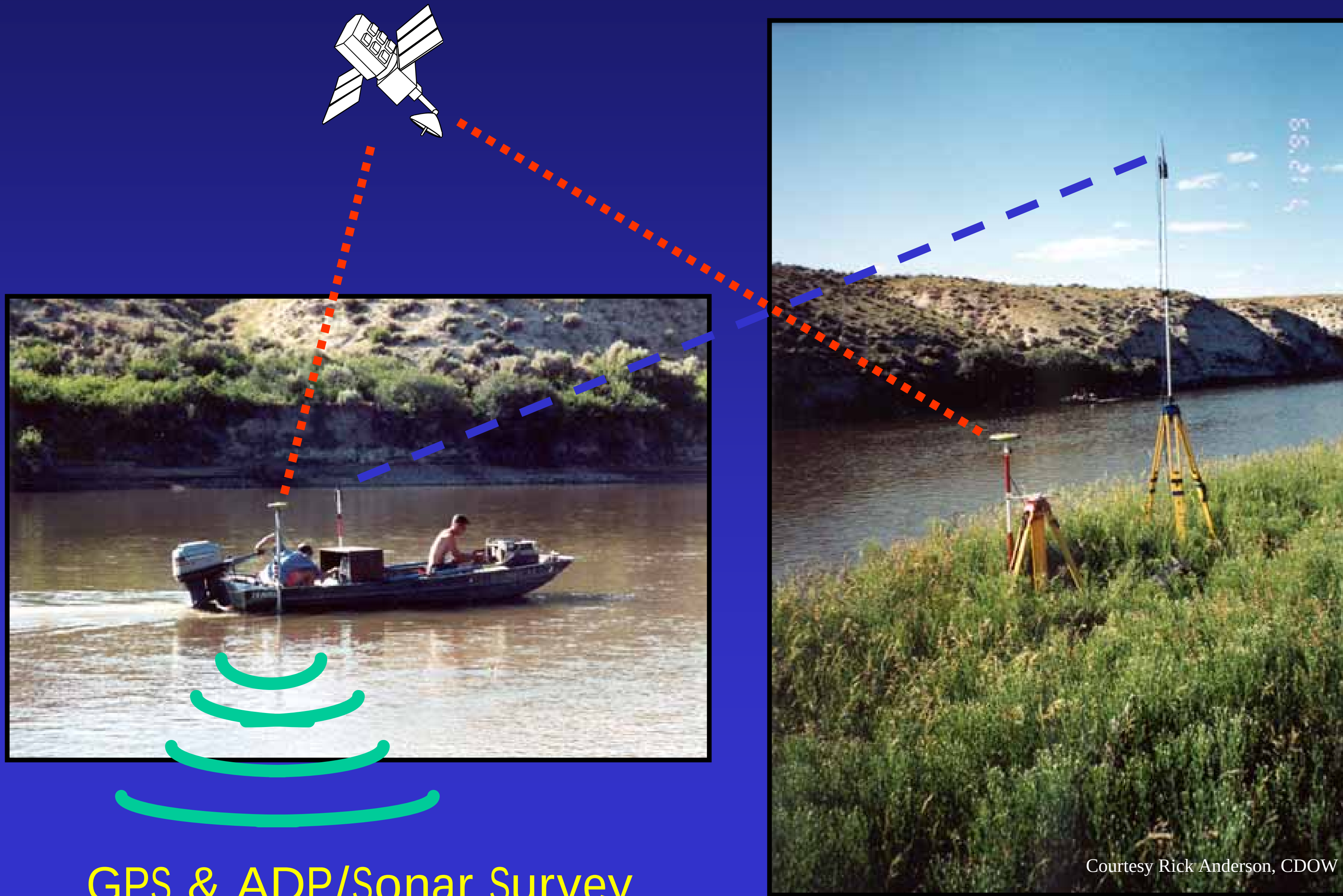


2-Dimensional Physical Habitat Models

Courtesy Rick Anderson, CDOW

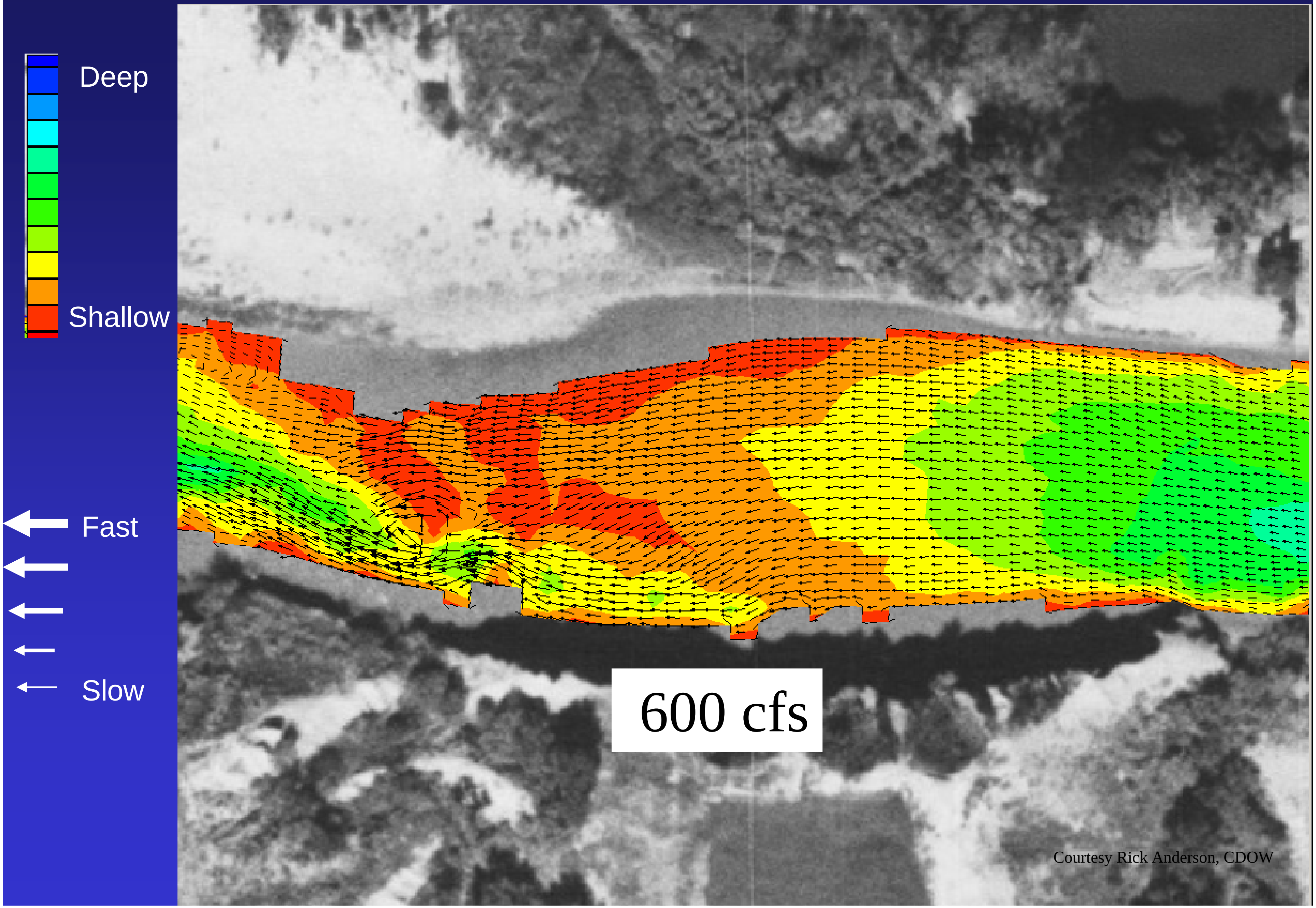
High-tech field equipment

RTK-GPS & ADP/sonar

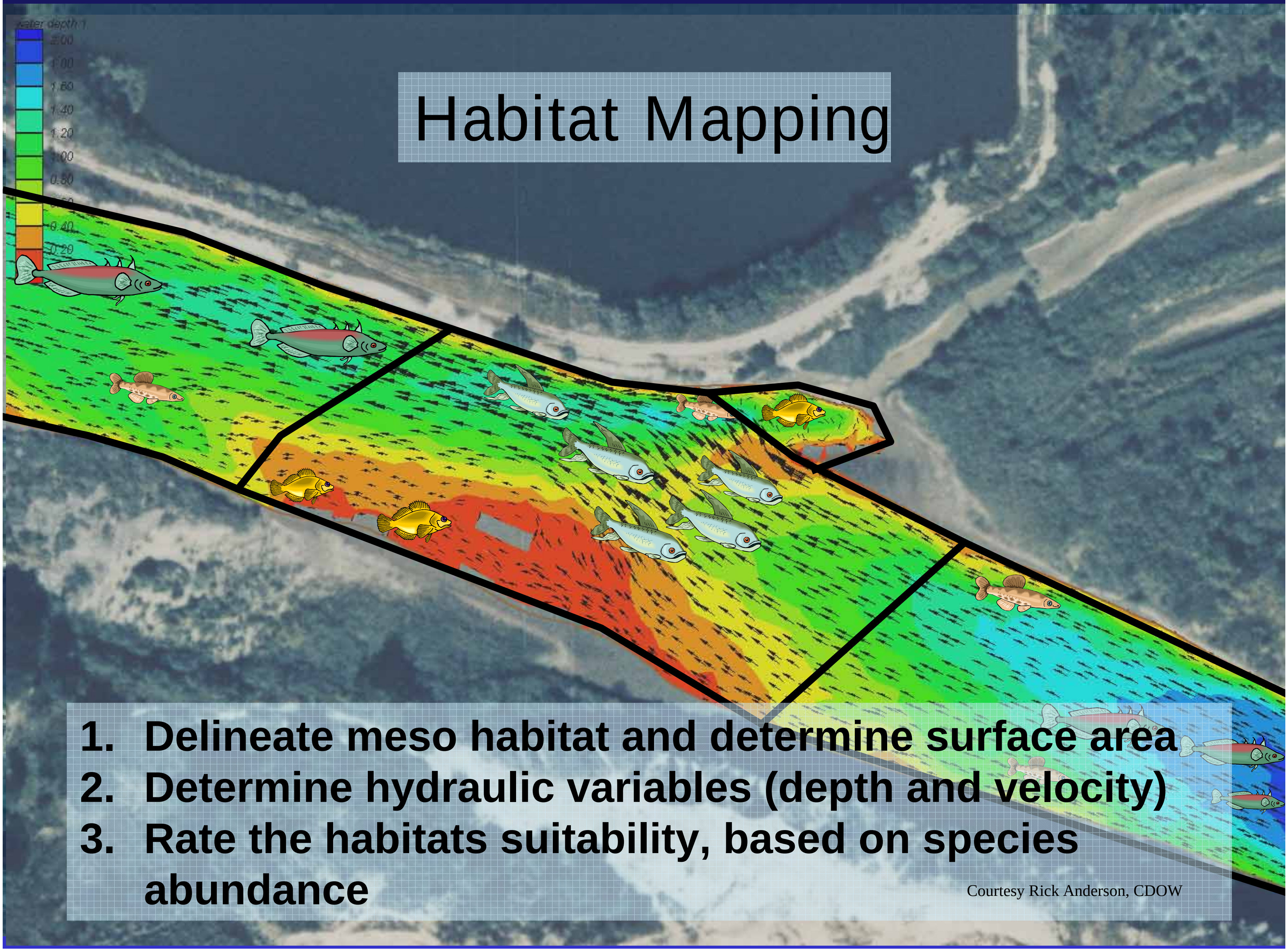


GPS & ADP/Sonar Survey

2D Modeling simulates river hydraulics for a flow range



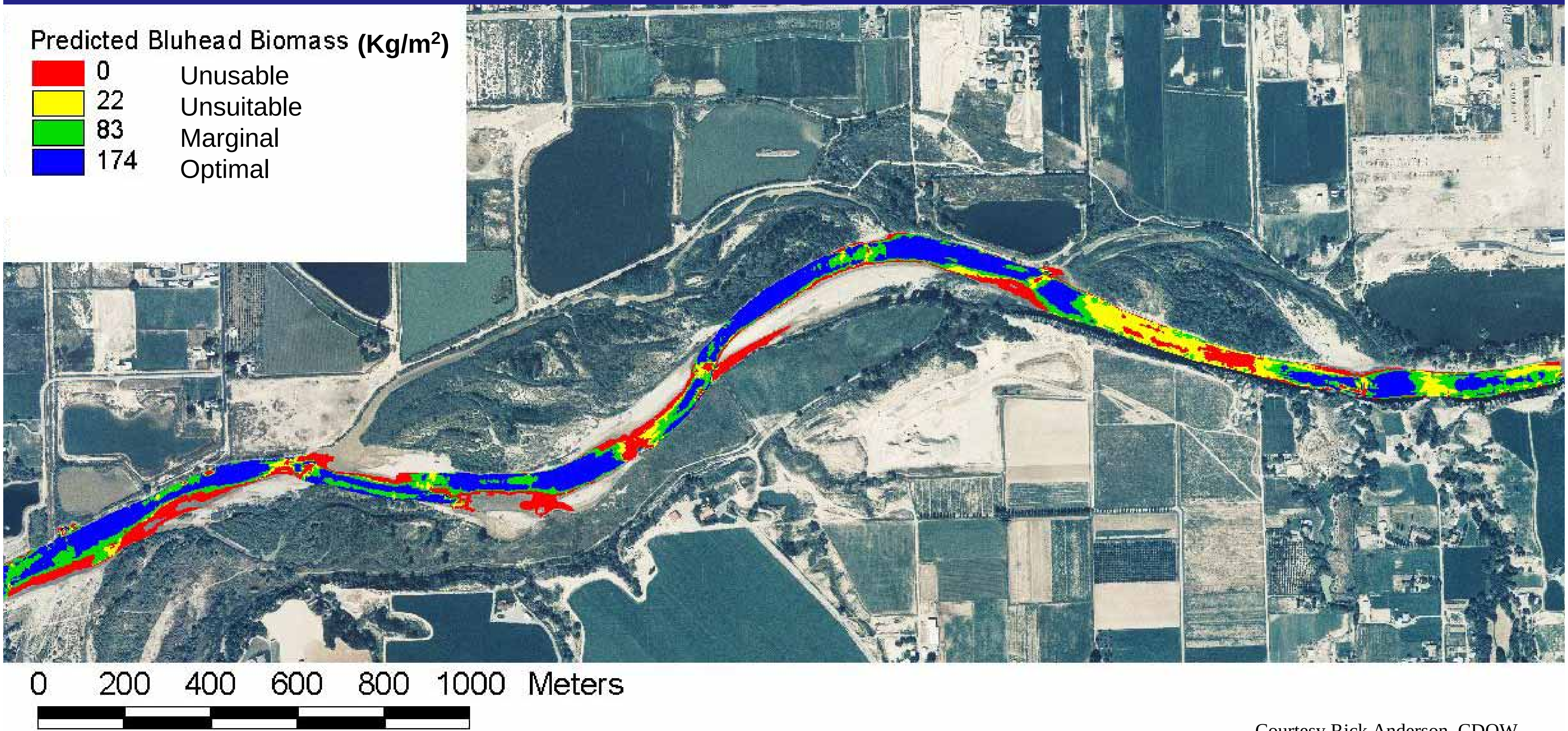
Habitat Mapping



1. **Delineate meso habitat and determine surface area**
2. **Determine hydraulic variables (depth and velocity)**
3. **Rate the habitats suitability, based on species abundance**

Courtesy Rick Anderson, CDOW

Habitat Suitability



Courtesy Rick Anderson, CDOW

Biology Model Considerations

- Many different models available
- Focus on survival or habitat suitability (short-term)
- Flow / habitat relationship may differ in different streams or stream segments
- Some address trade-offs
- Need other tools to assess needs for other riverine elements

Geomorphology

- Channel maintenance in gravel-bed streams
- Flushing flow
  - empirical
  - office-based
- Geomorphic classifications (Rosgen)
- HEC-6 and HEC-RAS

Geomorphology Model Considerations

- Usually have broad confidence intervals
- Address long-term physical habitat (not tied to one species)
- Need to specify timing, duration, ramping
- Need other tools to assess needs for other riverine elements

Water Quality

- QUAL2E
- Stream System Temperature (SSTEMP)
- Stream Network Temperature (SNTEMP)
- 7Q10

Water Quality

- Addressed long before water quantity
- Focus is on minimum flows (short or long-term needs)
- Don’t address intra- or inter-annually variable flows
- Don’t identify trade-offs
- Need other tools to assess needs for other riverine elements

Connectivity

- Two dimensional models can address this at the segment level
- Some groundwater models address this
- Estuary methods
  - Salinity based inflow method
  - Tidal distributary method
- Visual inspection

Connectivity

- Specify which of 4 dimensions you're using (lateral, vertical, longitudinal, time)
- Identify which elements are of interest (organisms, chemistry, bedload, energy)
- Specify time and duration when needed
- Need other tools to assess needs for other riverine elements

Holistic Methodologies

- Downstream Response to Imposed **Flow** Transformation (DRIFT)
- Ecological Limits of Hydrologic Alteration (ELOHA)
- Bayesian Decision Models
- Decision Flow Assessment (DFA)

Downstream Response to Imposed Flow Transformation (DRIFT)

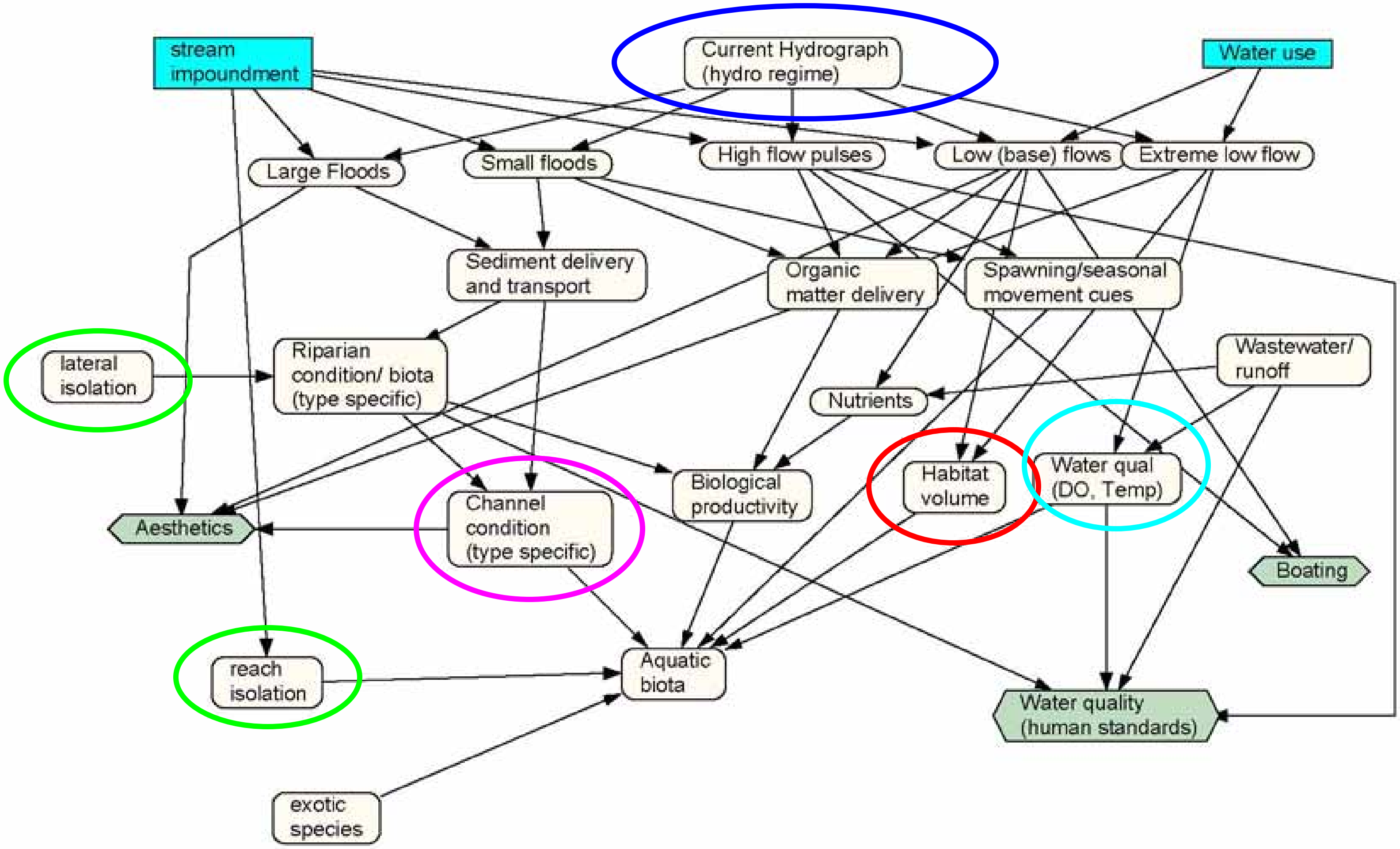
Four modules

- Biophysical
- Socio-economic (common users)
- Scenario building
- Economics (strict monetary assessment)

Ecological Limits of Hydrologic Alteration (ELOHA)

- Links hydrological alteration (IHA) with ecology
  - Requires reasonably good hydrological protocol
  - Also requires information about ecological processes

Bayesian Decision Models




Decision Flow Assessment

Holistic Model Considerations

- Still address limited range of elements
- Biological outcome is the weakest link
- Method development and refinement is a high priority

Reservoir Fishery Assessment Methods

- **Reservoir Quality Index**
- **Demonstration Drawdown**

Reservoir Model Considerations

- Few fishery models to chose from
- Most focus on fish production
- Emphasize balance between riverine and reservoir uses
- Need other tools to assess needs for riverine elements

Monitoring

- Typically focus on post-project monitoring
- Adequate pre-project monitoring is essential
- Can be a long-term commitment
- Monitoring is not mitigation (unless tied to a regulatory action)

Monitor What?

- Organism abundance?
- Community structure?
- Habitat form and function?
- Processes vs. snapshots?

More gage data are always needed

Adaptive management is a process

Establish Objectives

↓

Implement Management

↓

Monitor Effectiveness

↓

Evaluate Results

↓

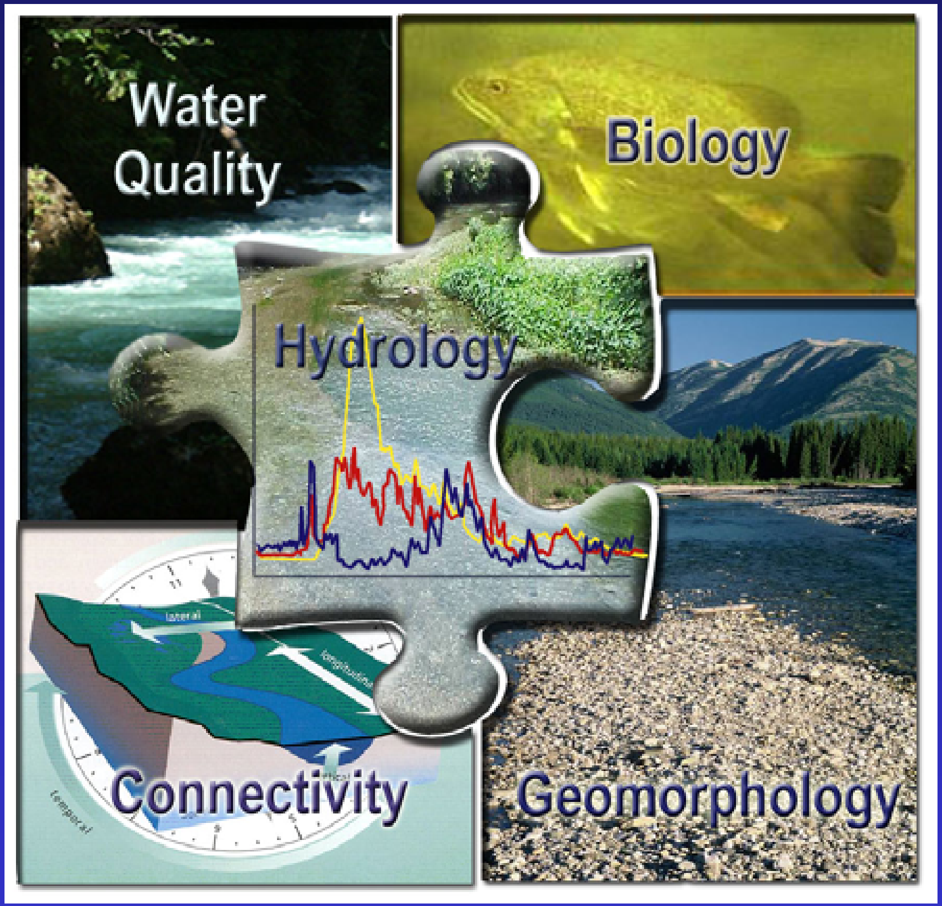
Revise Management

Adaptive management requires:

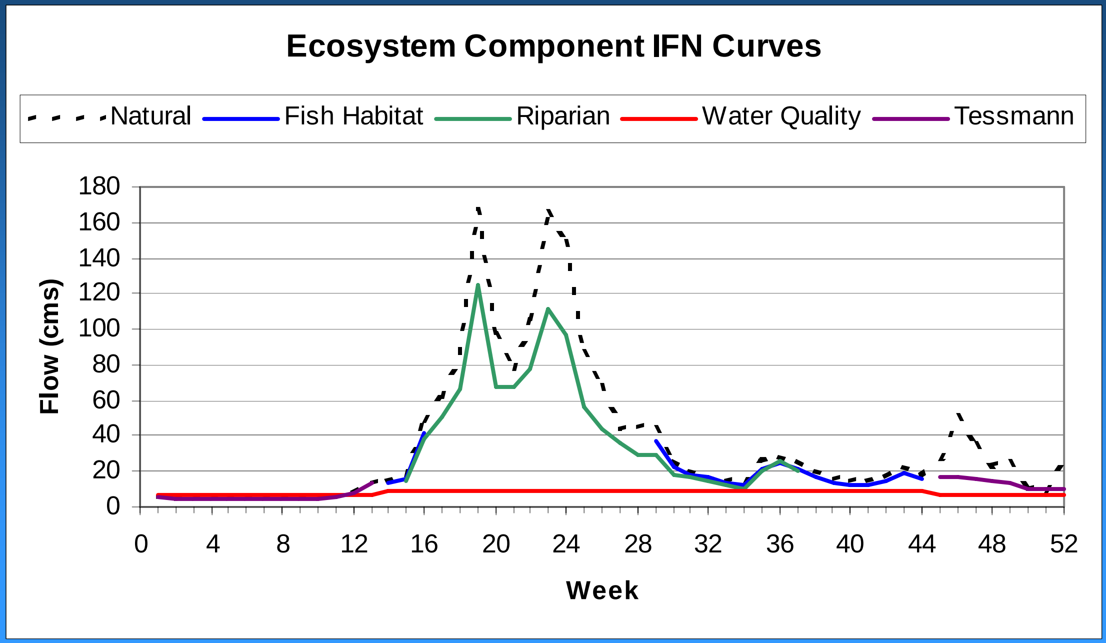
- Long-term commitment of all parties to a common (defined) goal,
- A clear definition of what success looks like (dynamic vs. static; habitat vs. population)
- Extensive monitoring before and after implementation of a flow prescription
- Ability and resources (formal commitment, water & money) to implement new strategies when information shows the need.

Putting it all together

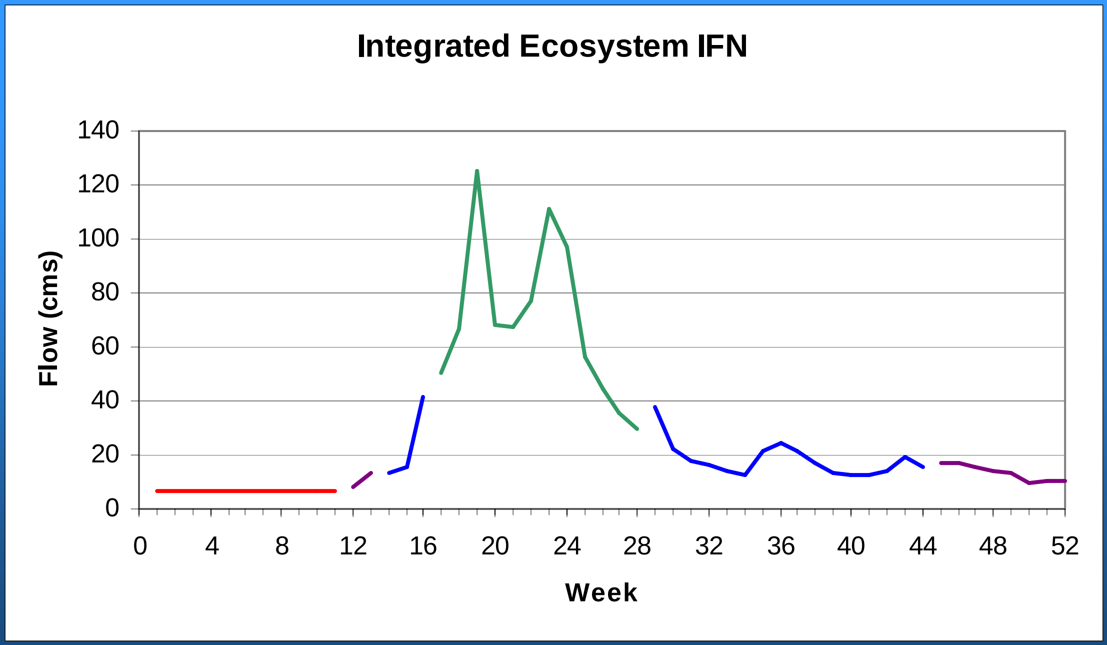
There is no single answer



Long-term persistence of organisms comes from long-term persistence of habitat and habitat processes



Ecosystem Component IFN Curves
Natural
Fish Habitat
Riparian
Water Quality
Tessmann
Flow (cms)
0
20
40
60
80
100
120
140
160
180
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Week



Integrated Ecosystem IFN
Flow (cms)
0
20
40
60
80
100
120
140
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Week

Science can ascertain what is, but not what should be, and outside of its domain value judgments of all kinds remain.

- *Albert Einstein*