Effective watershed restoration:

key considerations for planning, prioritizing, and evaluation

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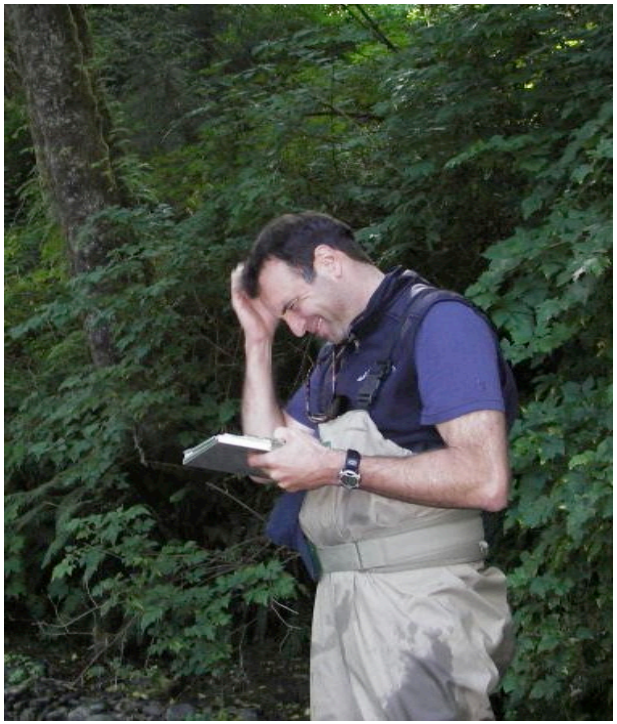
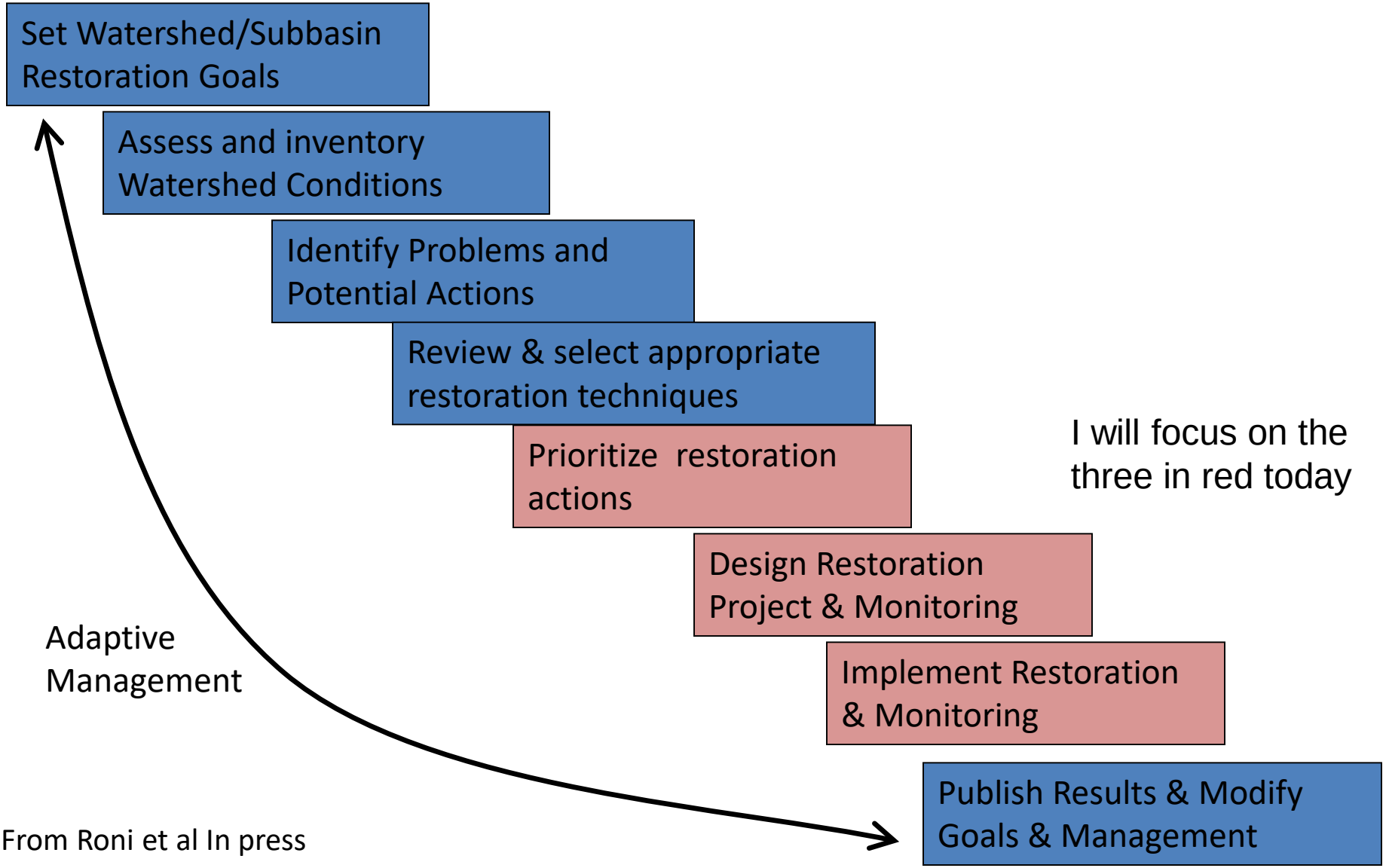
Some common problems

- Inadequate habitat assessments
- Ecosystem processes
- Limiting factors
- Design of projects
- Prioritization of projects
- Monitoring and evaluation
- Total amount of restoration



Key Steps in Restoration



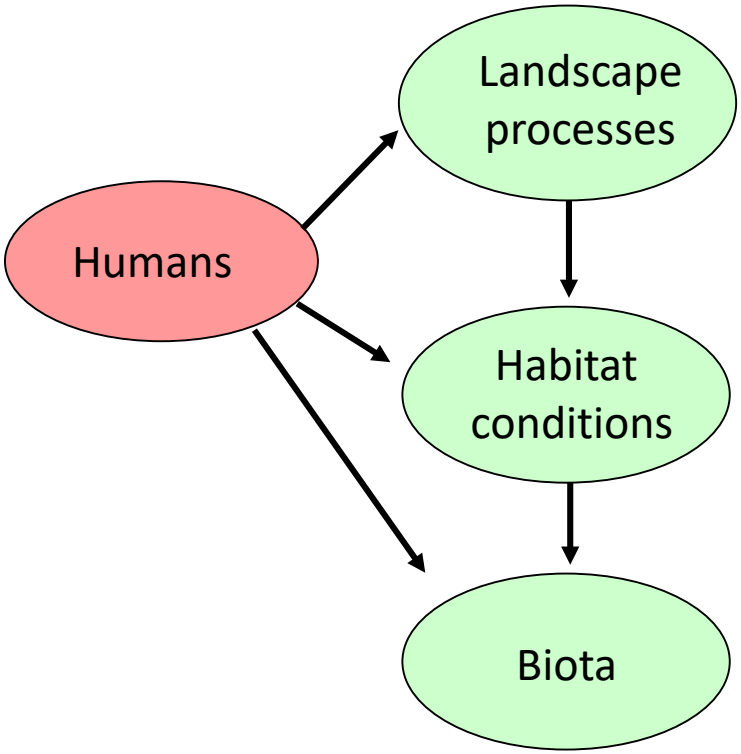
From Roni et al In press

Goals & Objectives

- For restoration
- For assessment
- For restoration design
- For prioritization
- For monitoring & evaluation

Assessments – identifying problems & actions

- Historical habitat
- Current habitat
- Habitat loss
- Disrupted processes
  - Connectivity
  - Hydrology
  - Riparian
  - Sediment
  - Nutrients



Beechie et al 2003

Scales of processes

- Basin scale
  - Non-point processes

- Sediment supply
- Hydrologic processes
  - Urban
  - Rain-on-snow
- Water quality
- Riparian functions
- Floodplain dynamics
- Inaccessible habitat
  - Stream blockages

Scales of processes

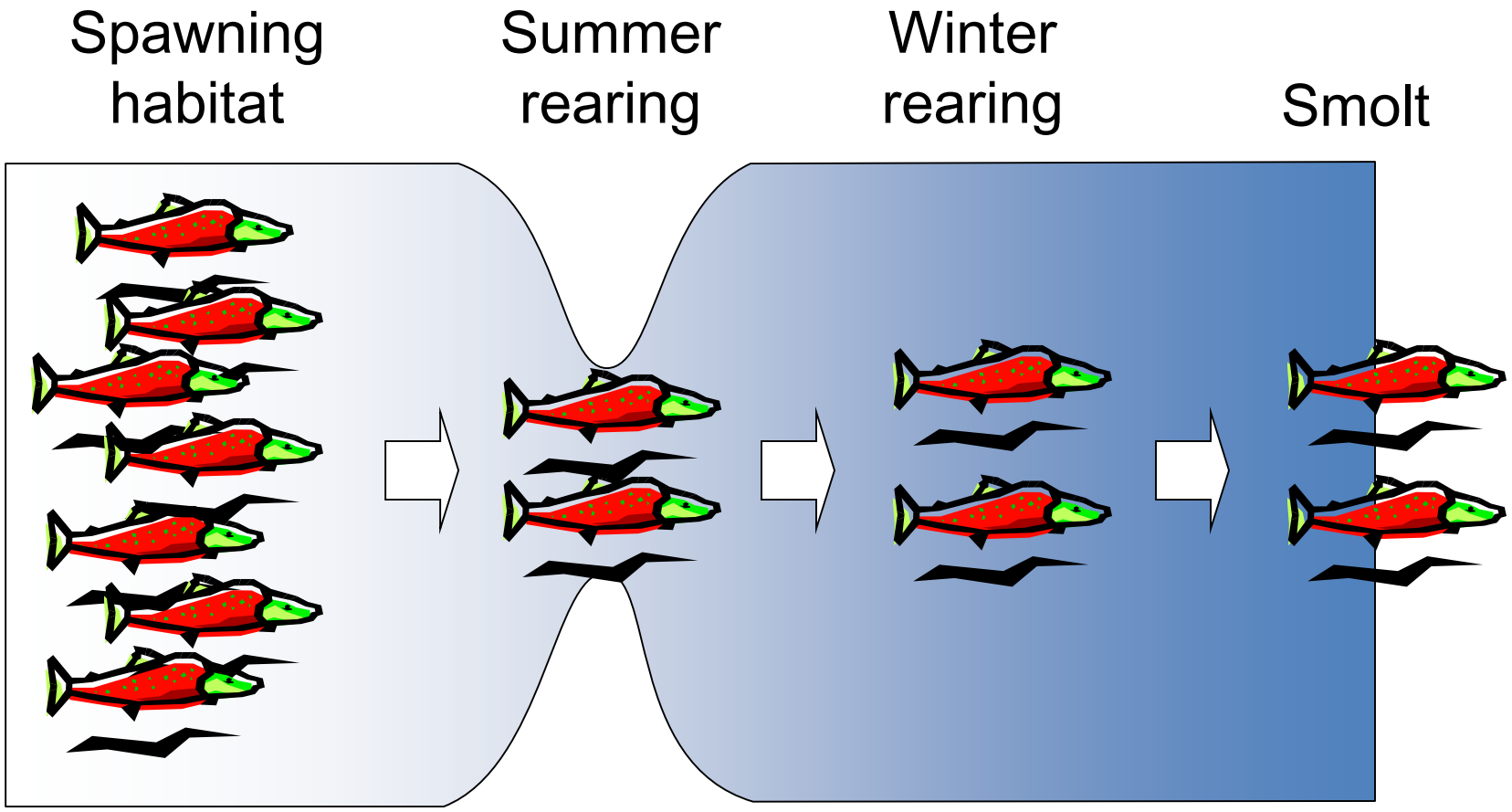
- Reach scale
  - Localized effects

- Sediment supply
- Hydrologic processes
  - Urban
  - Rain-on-snow
- Water quality
- Riparian functions
- Floodplain dynamics
- Inaccessible habitat
  - Stream blockages

Scales of processes

- Sediment supply
- Hydrologic processes
  - Urban
  - Rain-on-snow
- Water quality
- Riparian functions
- Floodplain dynamics
- Connectivity → Inaccessible habitat
  - **Migration pathways** → Stream blockages

Limiting Factors Analysis to Identify Restoration



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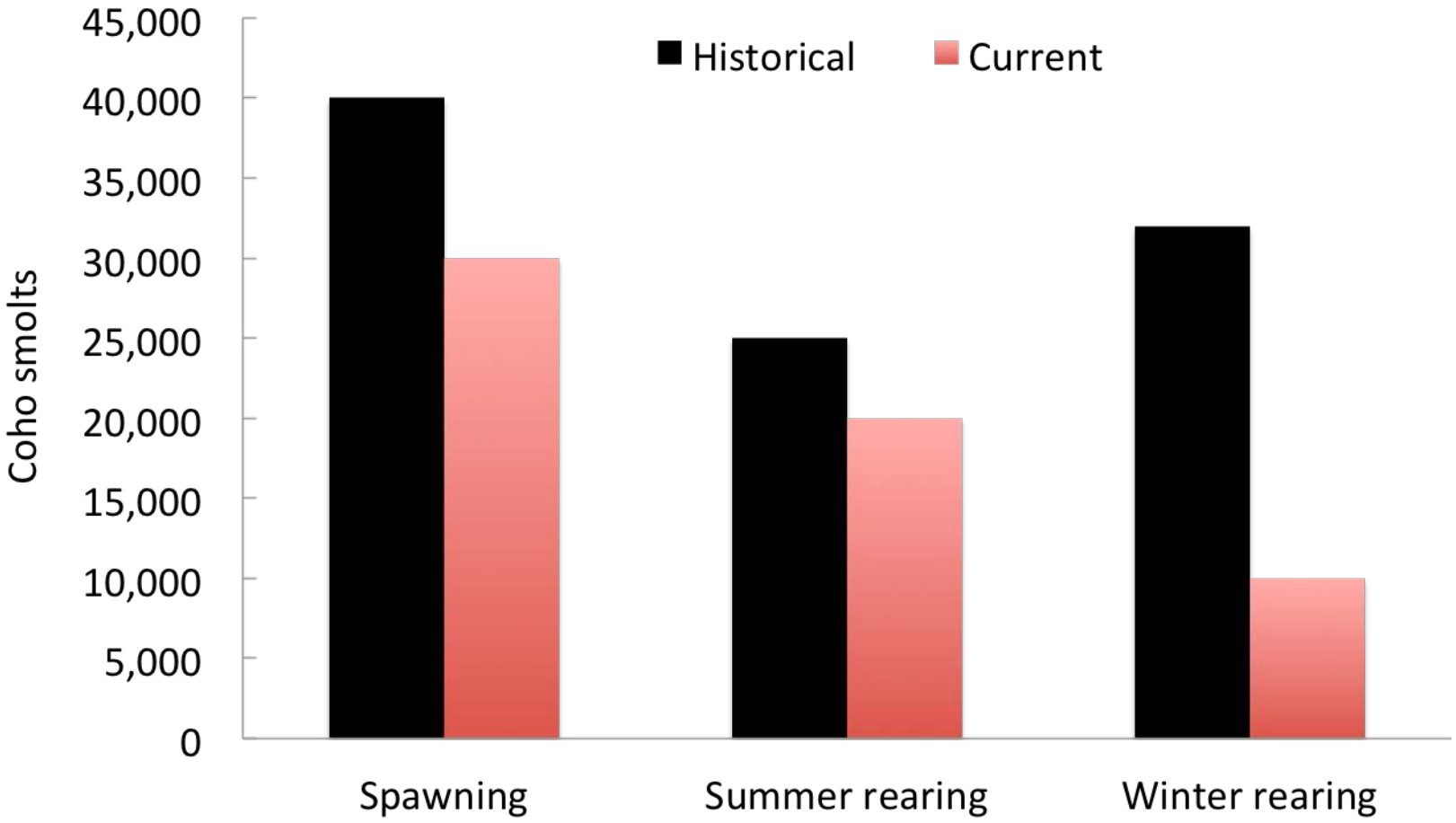
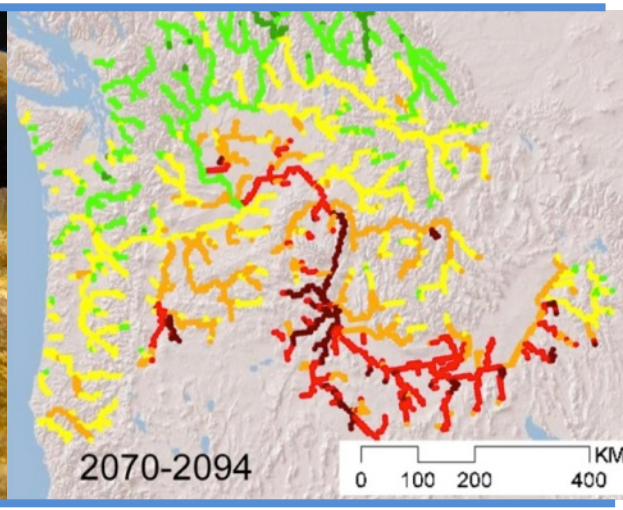
What Habitat is Limiting?



Selecting Restoration Techniques

- Process-based restoration vs. improvement
- Effectiveness of different techniques
- Restoration and Climate change

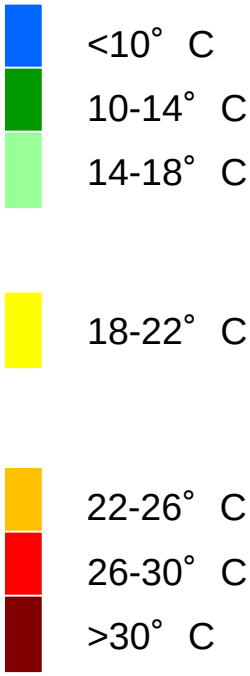


Time and Duration of Restoration

Restoration action	Restores Processes	Years till response	Duration of action
Barrier removal	Yes	<1	50+
Floodplain connectivity	Yes	<1	50+
Restore in-stream flow	Yes	<1	50+
Riparian planting	Yes	25-50	100+
Road removal	Yes	10-50	100+
*In-stream habitat	N	1-5	20-30
*Nutrient enrichment	N	<1	?

*** NEED TO BE COUPLED WITH PROCESS BASED RESTORATION** Roni et al. In press

Summer rearing sensitivity



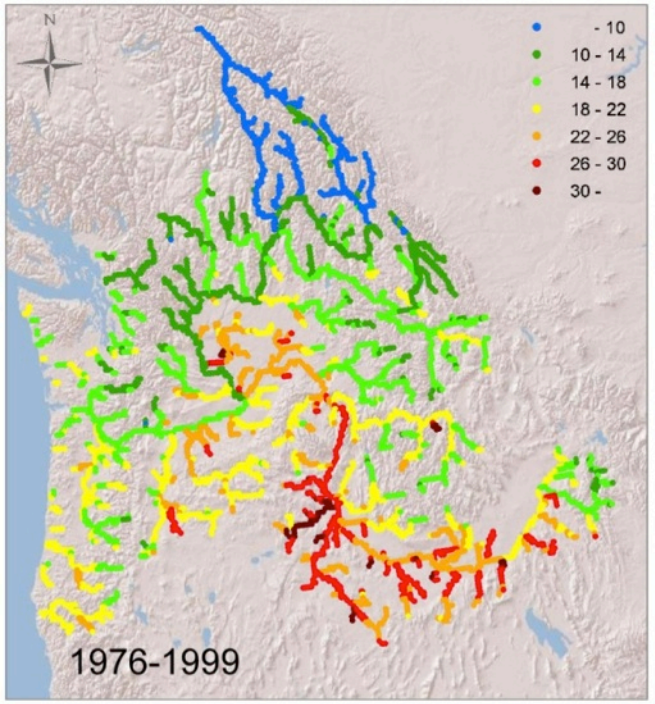
Below threshold

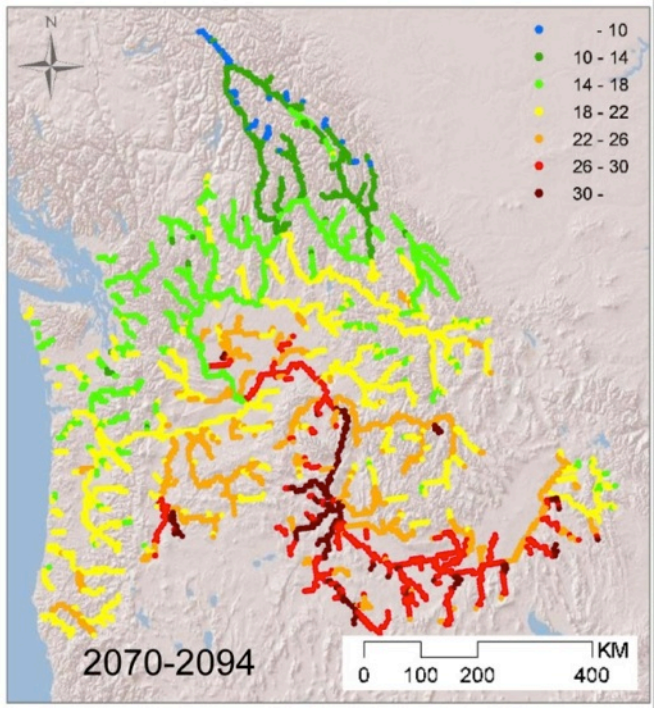
Near threshold

Above threshold

Average increase in stream temperature ~1.5° C

Beechie et al. In press





Restoration Actions & Climate change

	Does Project Ameliorate -			
Restoration action	**Temperature increase**	**Low flow decrease**	**Peak flow increase**	**Increase resilience**
Barrier removal	Y	Y	N	Y
Floodplain connectivity	Y	N	Y	Y
Restore in-stream flow	Y	Y	N	M
Riparian rehabilitation	Y	M	N	N
Road removal	M	N	Y	N
In-stream habitat	M	N	N	M
Nutrient enrichment	N	N	N	N

Beechie et al. In press

Prioritizing Restoration

Protect High Quality Habitats

↓

Water Quality and Quantity

↓

Habitat Connectivity

↓

Restoration of Processes

↓

Habitat improvement

Roni et al. 2002, 2008

Prioritization or Sequencing Restoration

- A variety of approaches
  - Project type
  - Location
  - Complex models
  - Multi-criteria scoring systems

- Most straightforward and transparent
  - Multi-criteria scoring systems

Prioritization – Common Approaches

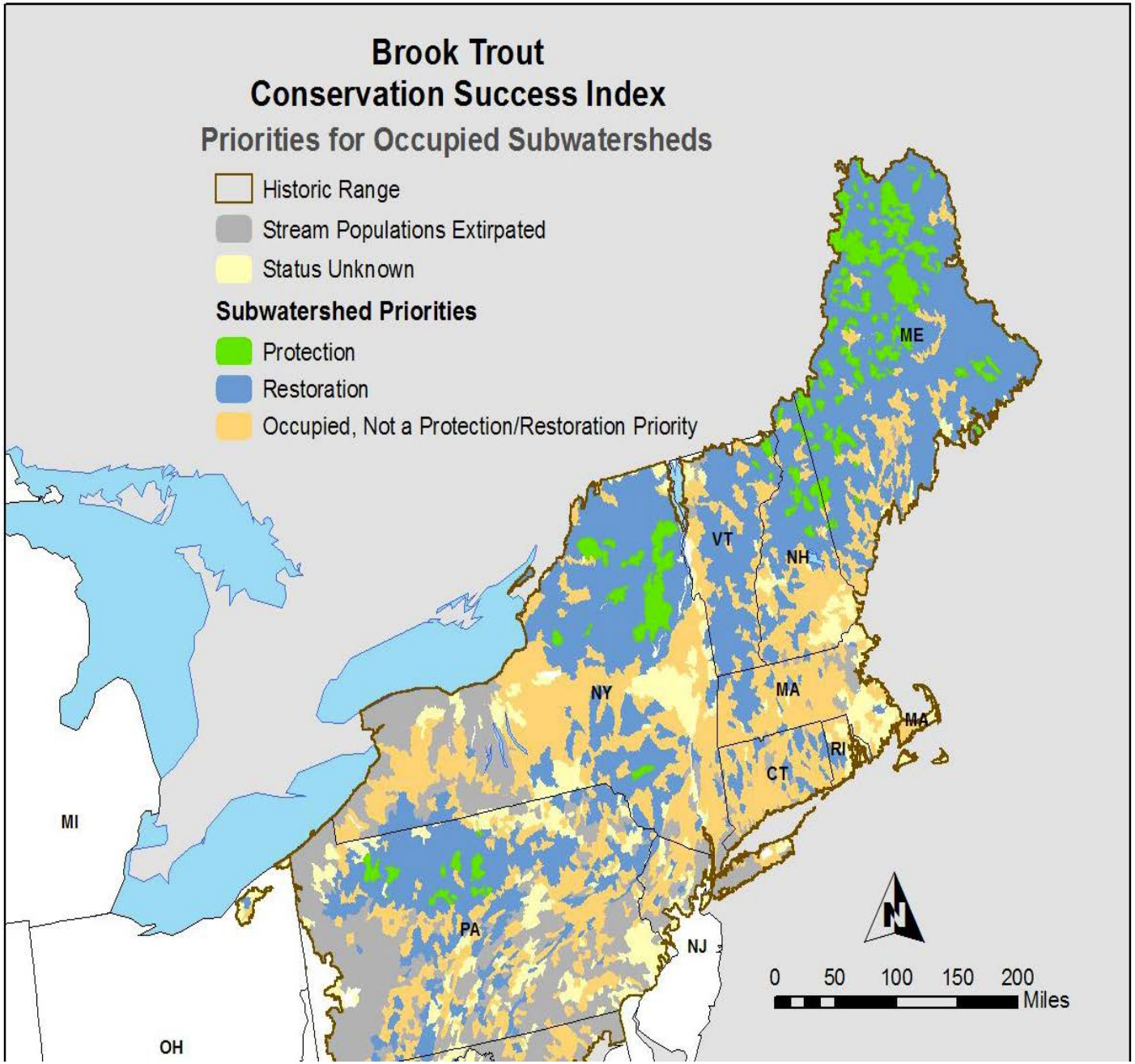
Technique	Length treated	Increase in fish #s	Cost	Cost/fish	# of species present	Restores disrupted process
LWD placement	2 km	500	$100,000	$200	2	no
Floodplain reconnection	1 km	5,000	$500,000	$100	5	yes
Riparian planting	5 km	?	$10,000	?	4	yes
Road removal	8 km	?	$750,000	?	4	yes

Roni et al. 2002, Beechie et al. 2008

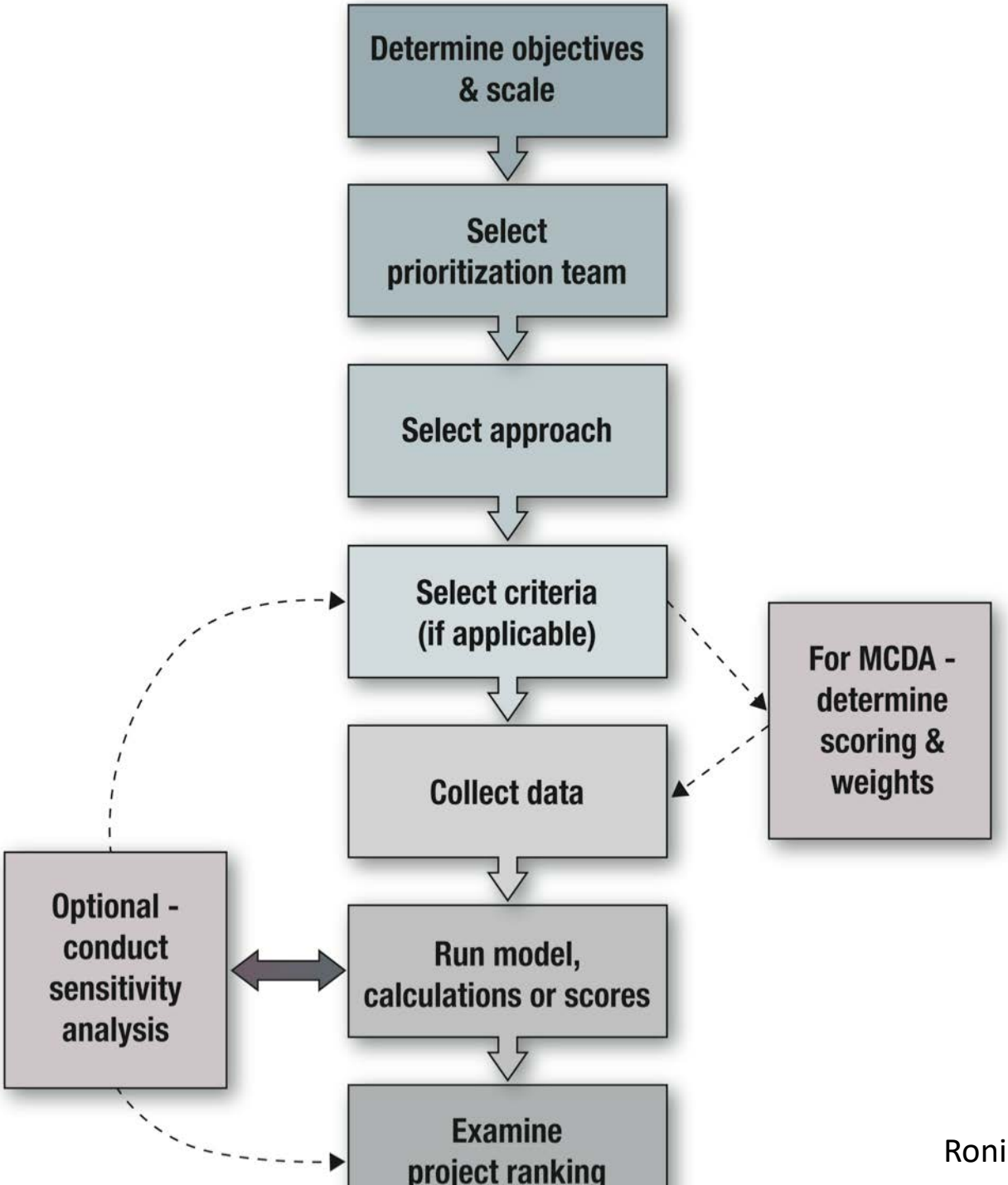
Prioritization – Scoring System

Technique	Length treated	Increase in fish #s	Cost	Cost/fish	# of species present	Restores disrupted process	Total score
LWD placement	2	4	3	3	2	1	**15**
Floodplain reconnection	1	5	2	4	5	5	**18**
Riparian planting	5	2	5	1	4	5	**23**
Road removal	5	2	1	1	4	5	**18**

Score of 1 to 5 – five being highest score



Williams et al. 2007 Trout Unlimited



Roni et al In press

Restoration Design Steps

1. Problem Identification
2. Context & assessment
3. Project goals & objectives
4. Alternatives evaluation
5. Project design
6. Implementation
7. Monitoring & Evaluation

RiverRAT – Design Tool

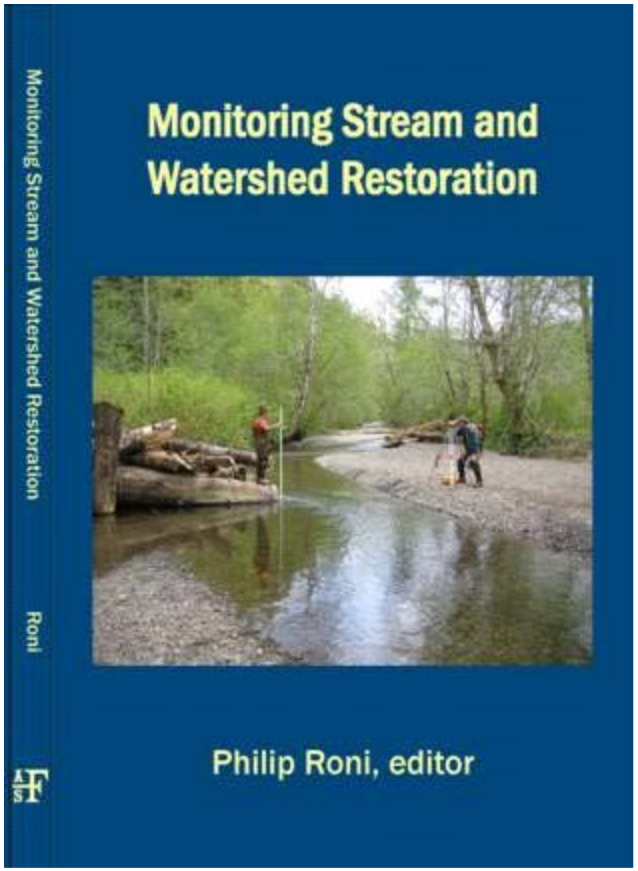
http://www.restorationreview.com/

“Additional evaluation studies on stream improvement, especially with reference to the effect on the abundance of fish, are still urgently needed.”

Clarence M. Tarzwell, U.S. Bureau of Fisheries, 1937

Steps for Designing a Effectiveness Monitoring Program

- Define project goals and objectives
- Define scale
- Define questions/hypotheses
- Determine monitoring design
- Spatial and temporal replication
- Select parameters
- Selecting sampling scheme/protocol
- Implement monitoring



Key Questions or Hypotheses

Reach or Project Scale

- **What is effect of project x on local habitat conditions or fish?**
- **What is effect of project like x on local conditions or fish?**

Watershed Scale

- **What is effect of project x on watershed conditions or a fish population?**
- **What is effect of a suite of projects on watershed conditions or a population?**

Key Questions or Hypotheses

Reach or Project Scale

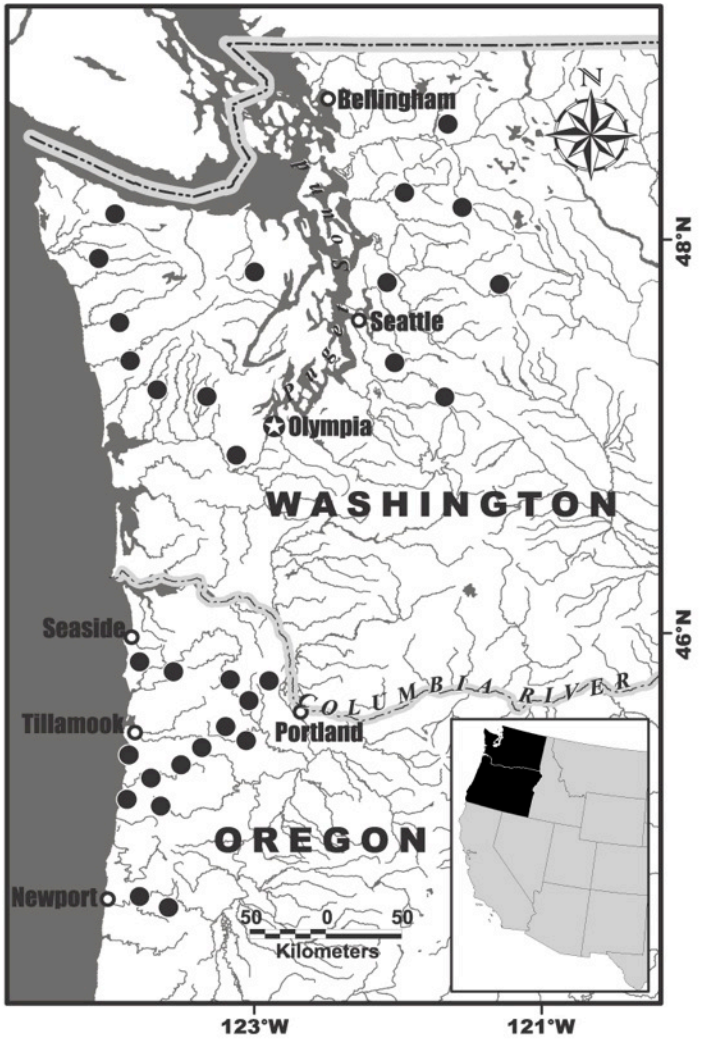
- **What is effect of project like x on local conditions or fish?**
  - **Sample many projects**

Watershed Scale

- **What is effect of a suite of projects on watershed conditions or a population?**
  - **IMW**

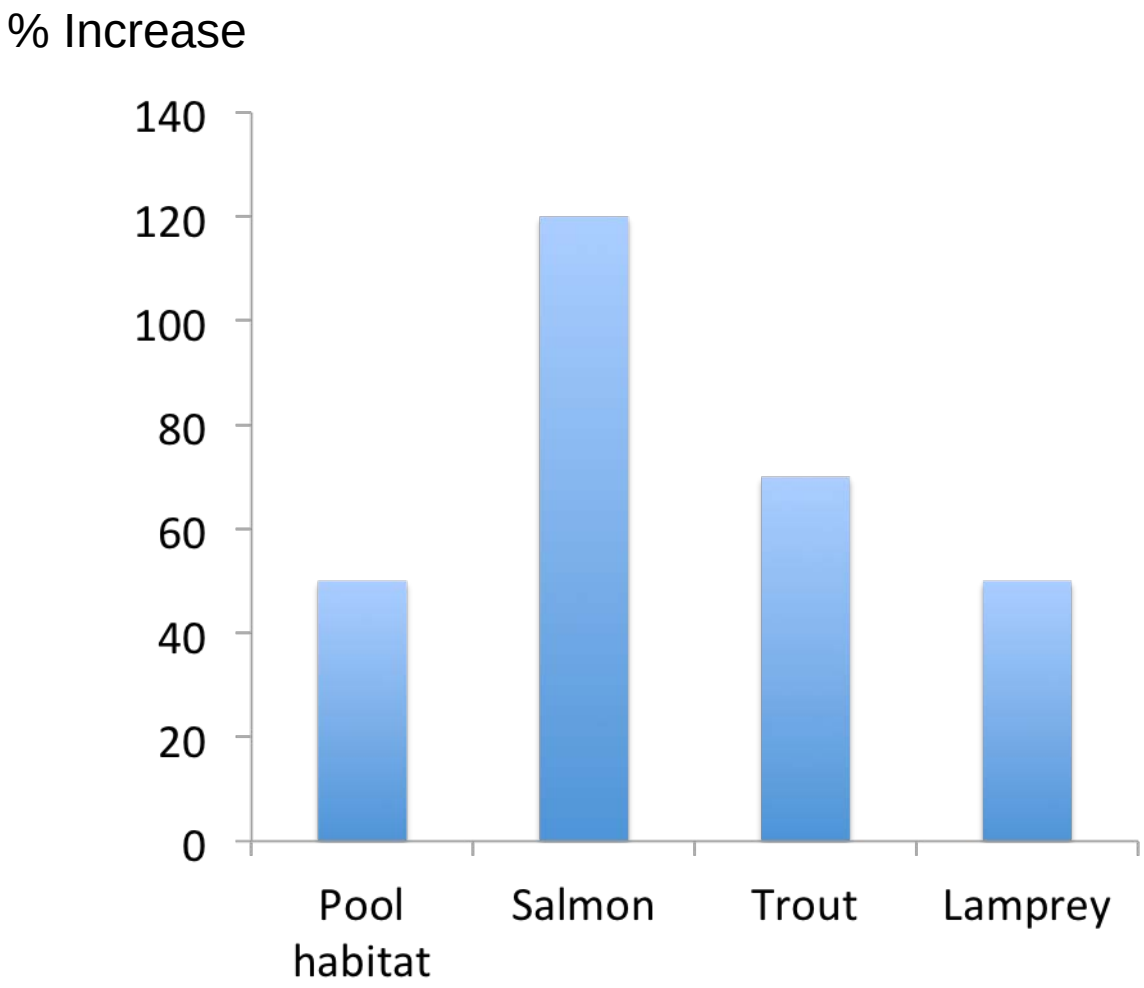
Effectiveness of LWD Placement

- H_0 What is the effect of existing large wood placement projects on local habitat and fish abundance in western Washington and Oregon?
- Post-treatment design
- 30 treatment & controls
- Parameter
  - fish
  - habitat
  - macroinverts

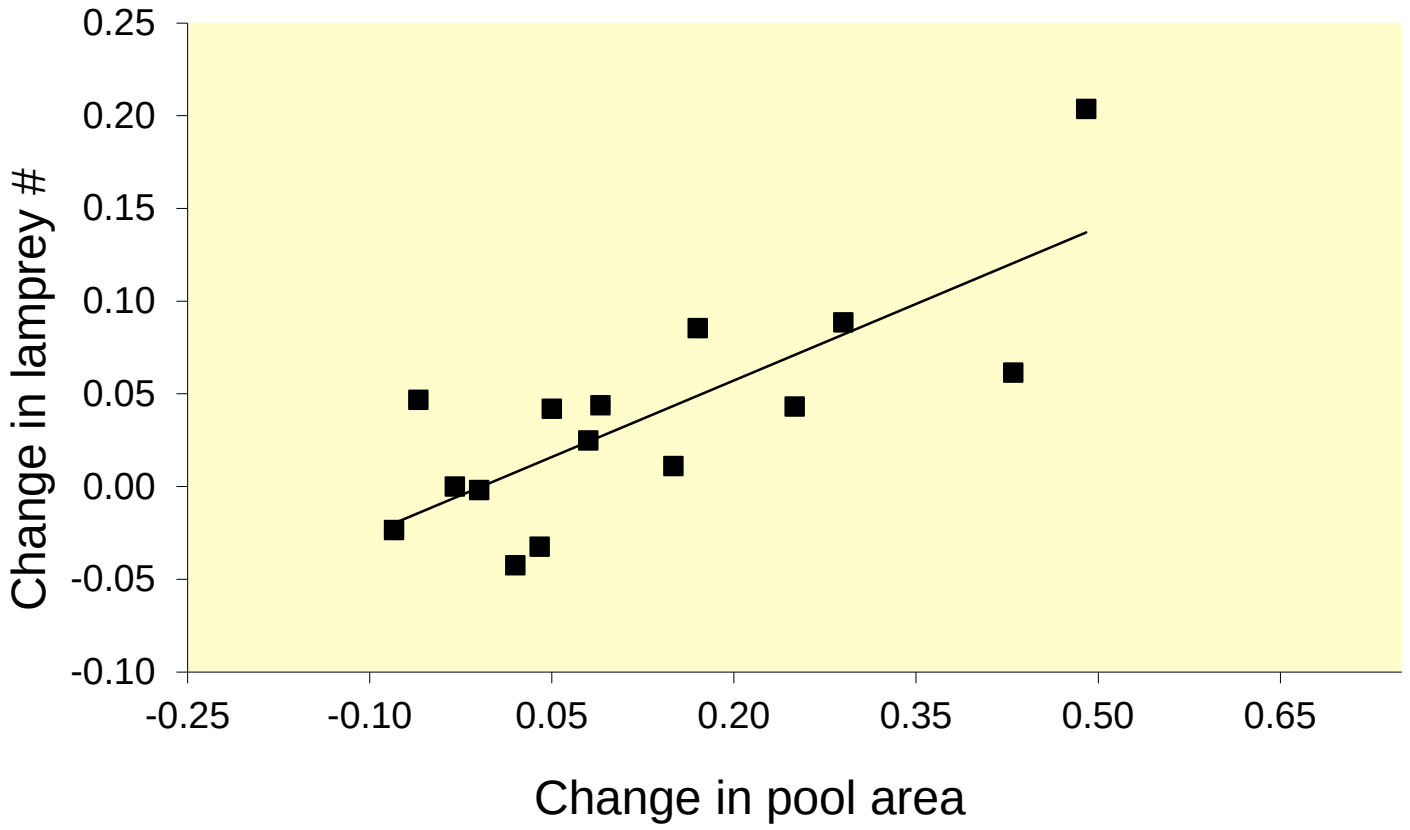


Roni & Quinn 2001

Average Response to Wood Placement



Fish Response vs. Restoration Intensity



Roni & Quinn 2001

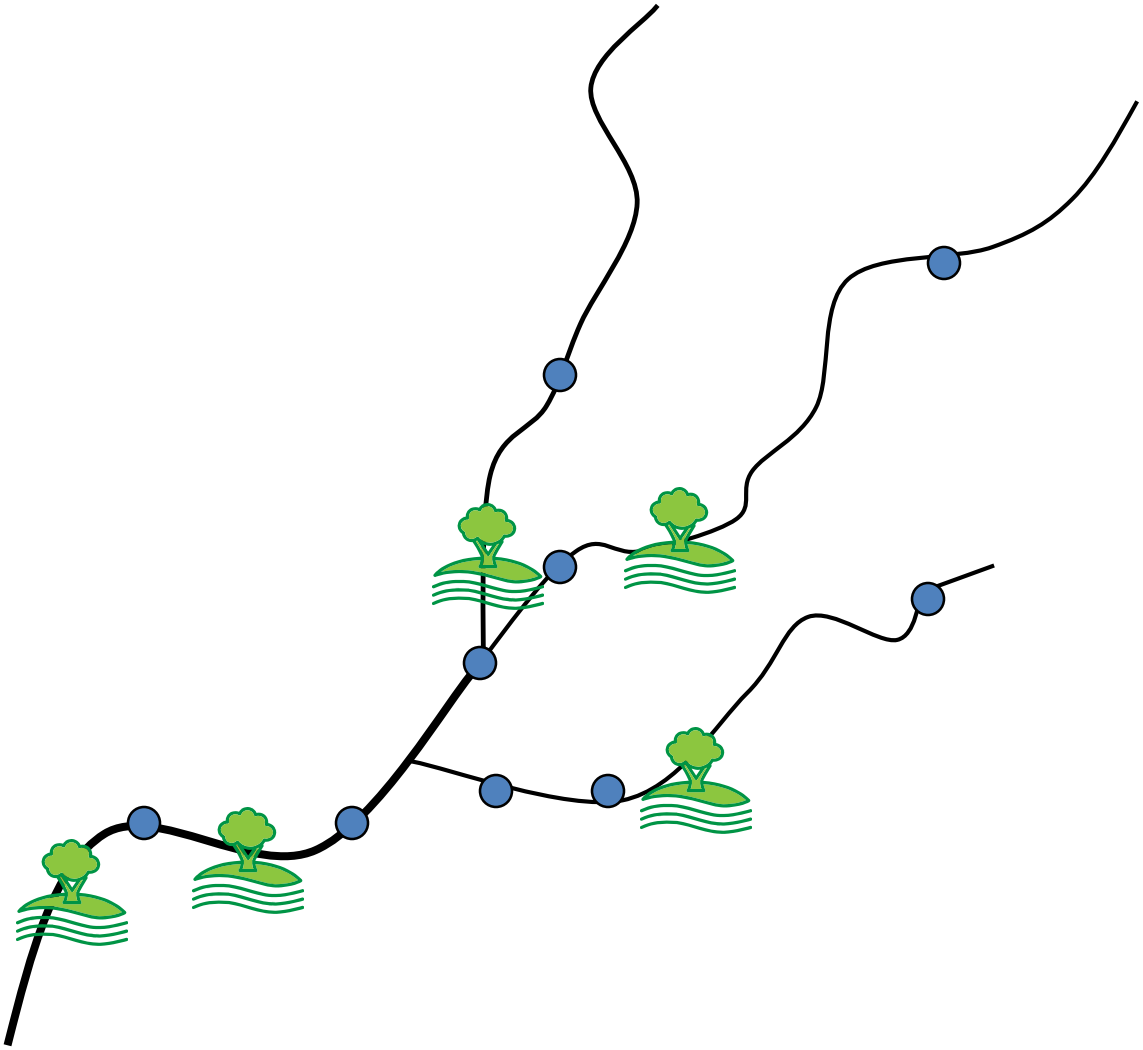
Key Questions or Hypotheses

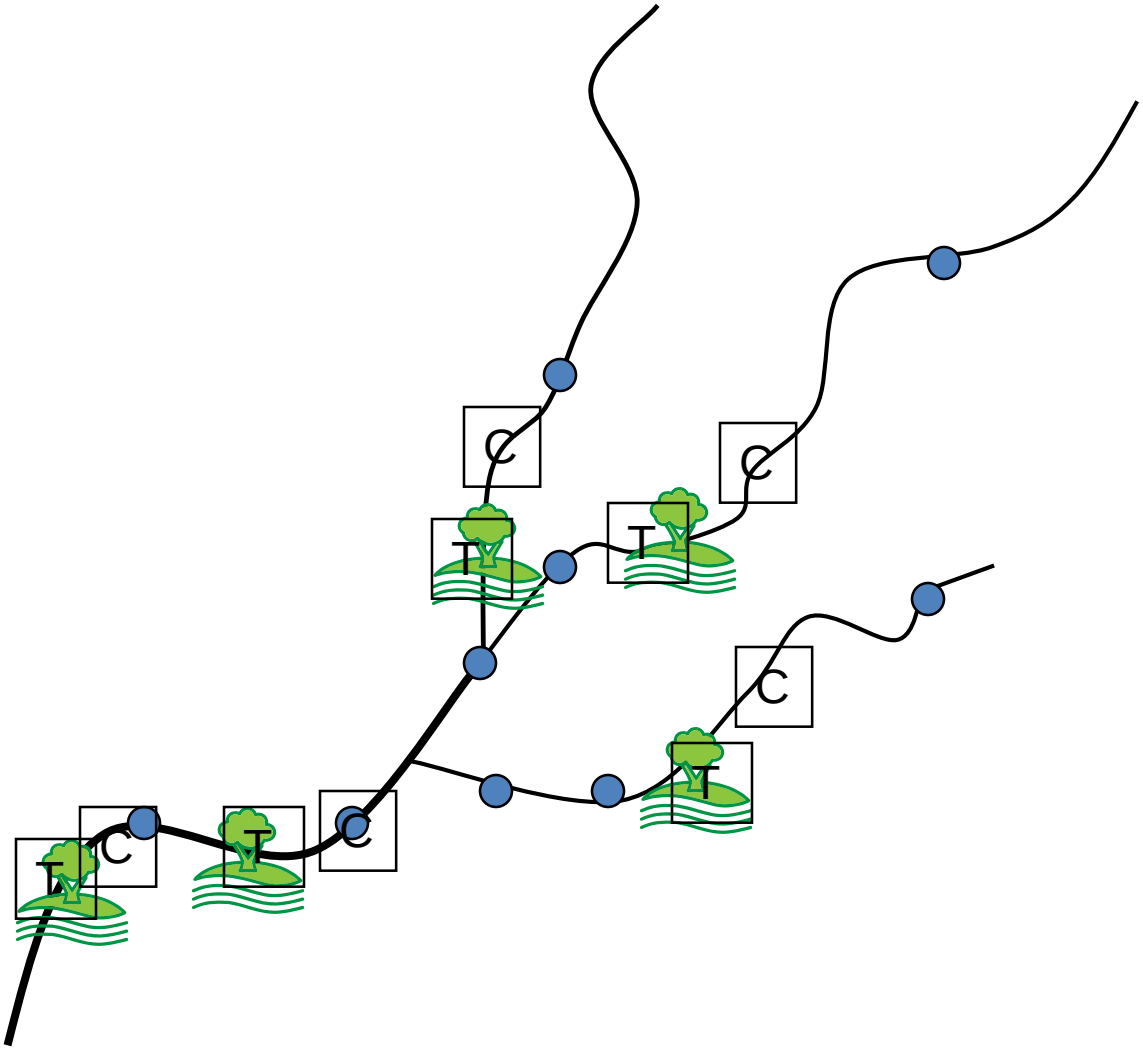
Reach or Project Scale

- What is effect of project like x on local conditions or fish?
  - Sample many projects

Watershed Scale

- **What is effect of a suite of projects on watershed conditions or a population?**
  - **IMW**
  - **Several challenges**
    - **Design**
    - **Implementation**

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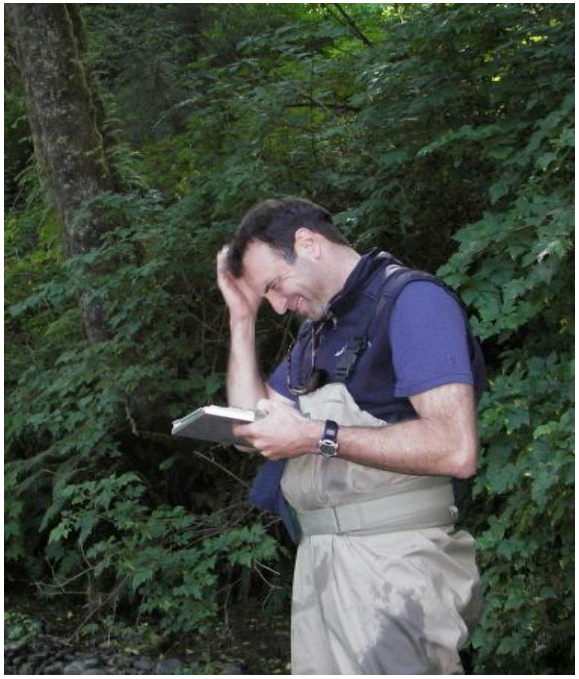
Spatial and Temporal Replication

- How sites?
- How many years?

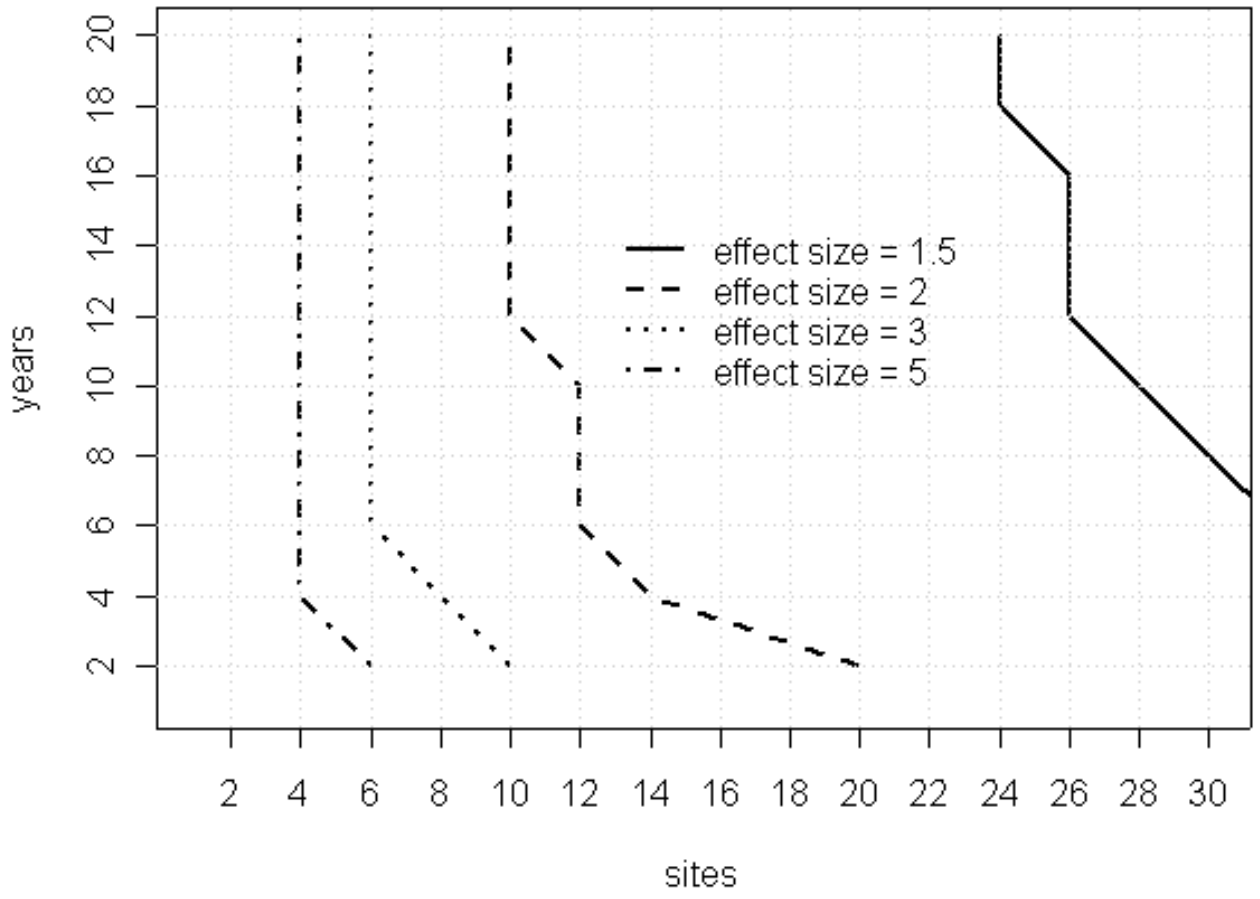
5 years?

25 years?

>45 years?



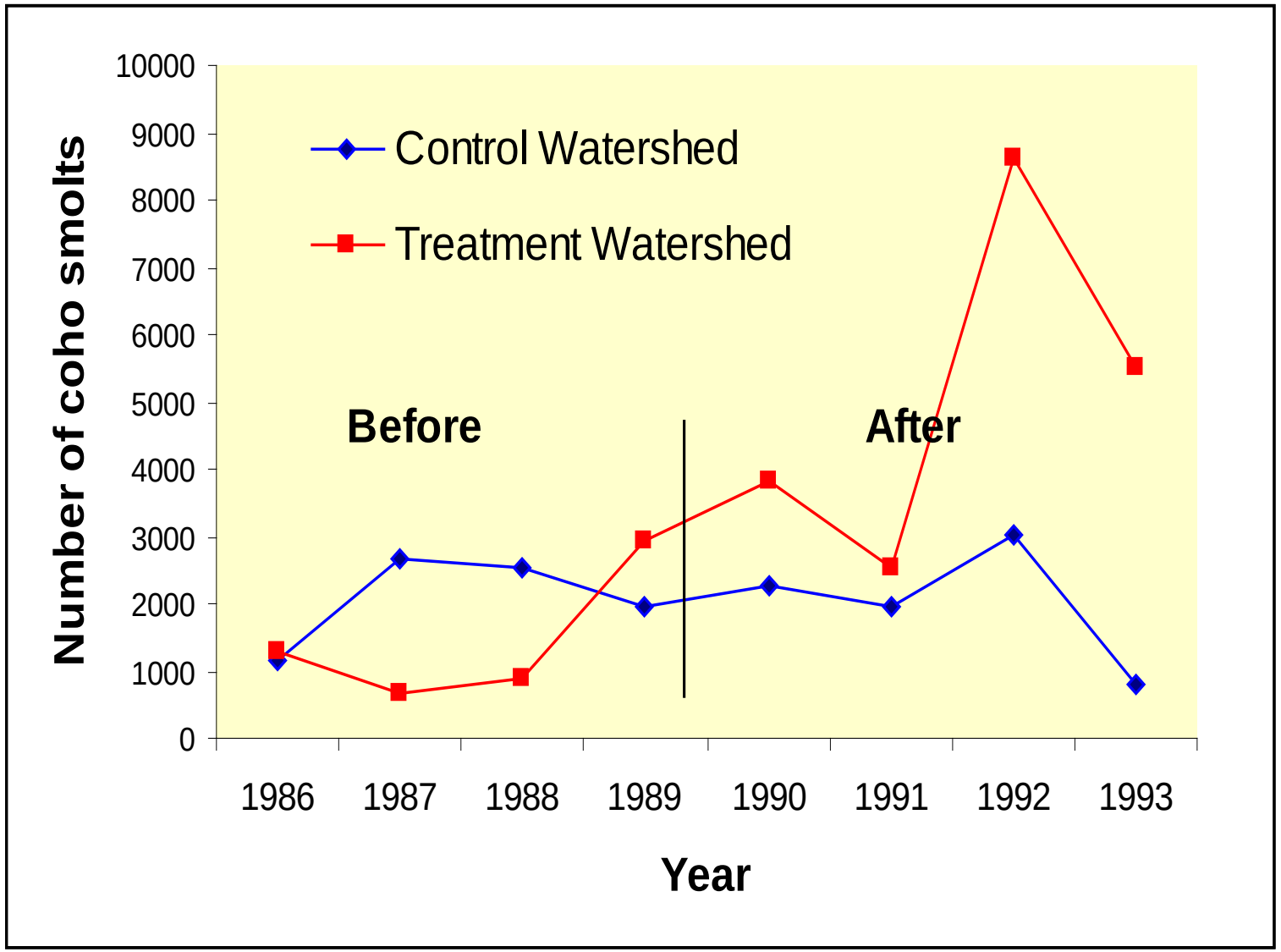
Sample Size – BACI Design



Liermann & Roni 2008

IMW Example - Alsea Basin

(from Solazzi et al. 2000)

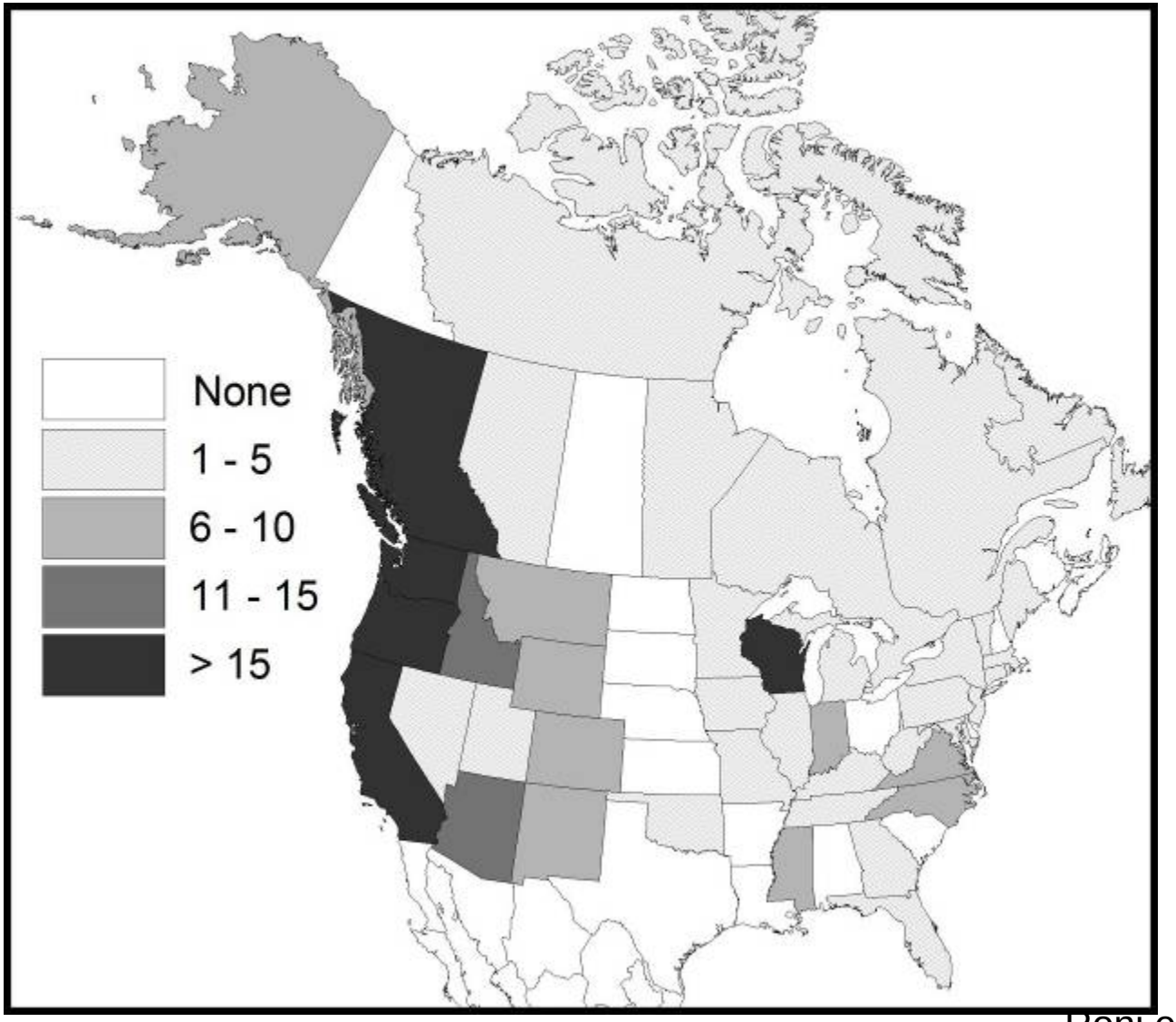


Monitoring Design

Restoration goal	Improve fish habitat and increase fish numbers
Specific objectives	Increase number of pools and trap gravel to improve coho spawning and rearing habitat
Hypotheses	What is the effect of boulder and wood placement in 500 meter reach on physical habitat, juvenile and adult fish abundance before and after restoration?
Study design and scale	Before after design, reach scale
Number of sites & years	1 treatment, 1 control, 5 years before & after
Parameters to monitor	Juvenile and adult fish numbers LWD, boulders, pools & riffles, gravel quantity and quality (spawning and rearing habitat)
Sampling scheme	Reach scale census

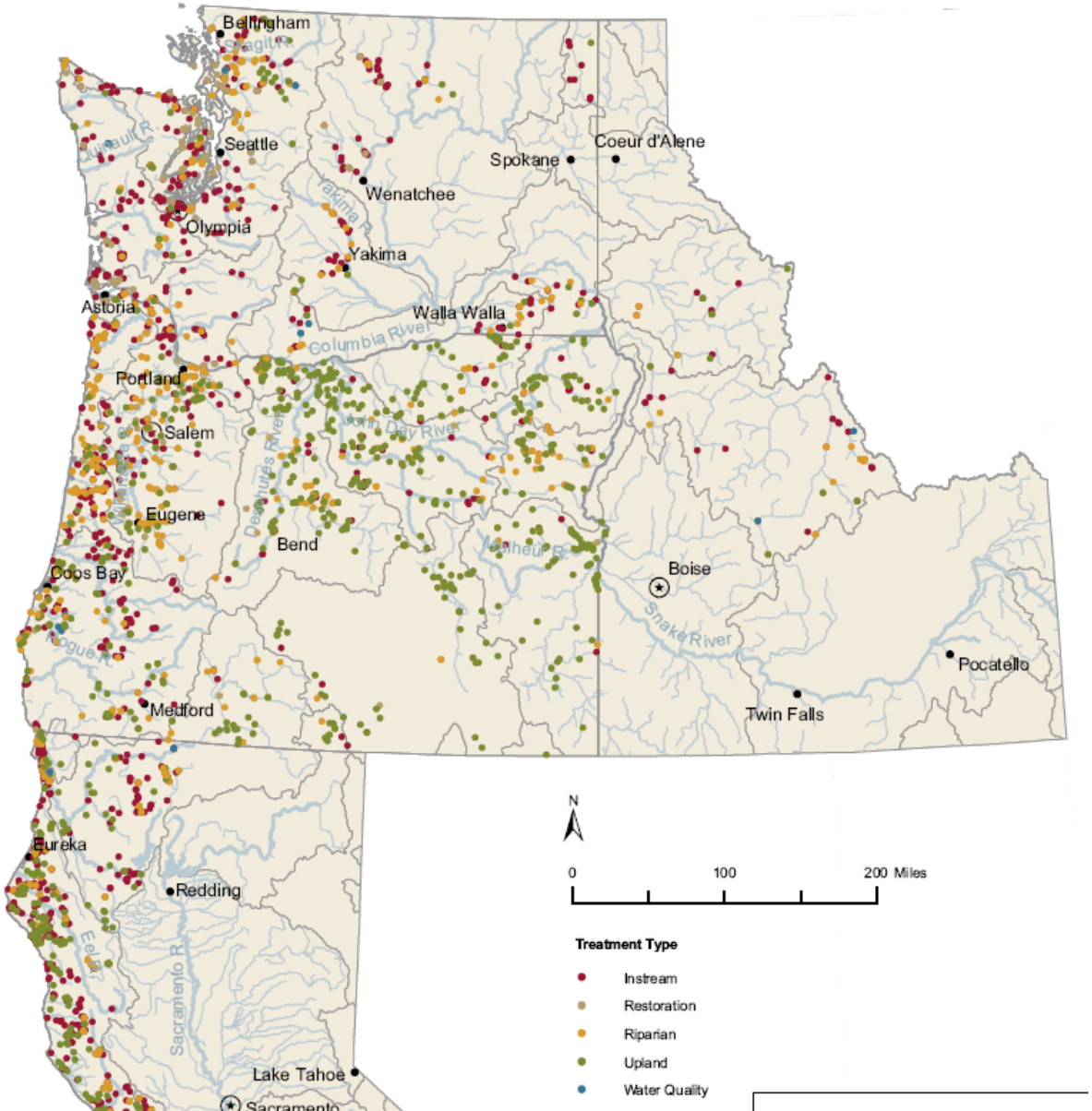
How much restoration is needed?

Published Studies Evaluating Restoration



Roni et al. 2008

How Much Restoration is Needed?



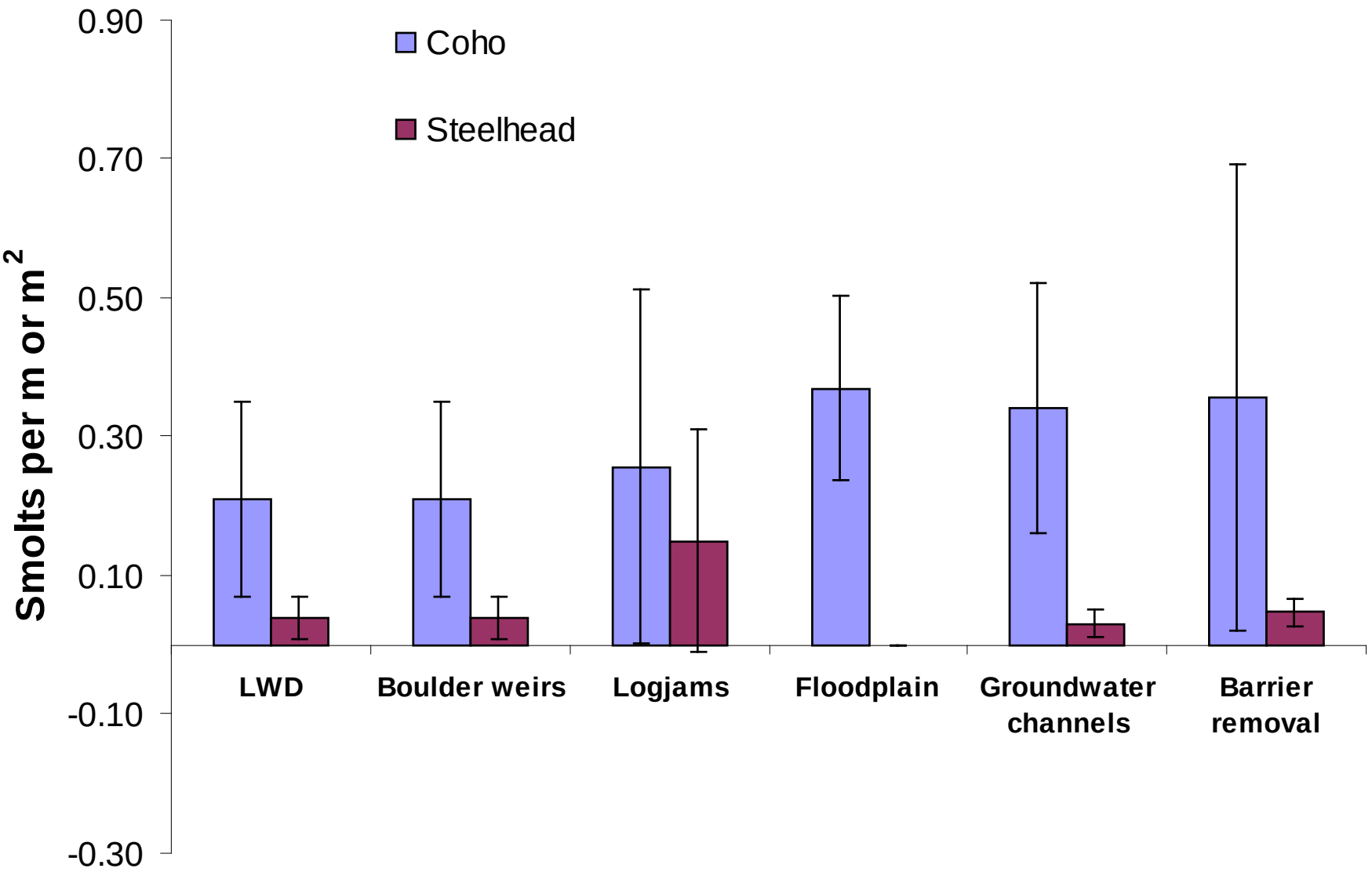
How Much Restoration Is Needed?

Restoration Activities PCSRF 2000 to 2009

Metric or Restoration Activity	All PCSRF	Per Watershed*
Instream kilometers treated	1,413	3
Floodplain hectares treated	4,938	3
Barrier removal (km)	6,918	17

*Puget Sound Basin
NOAA unpublished data

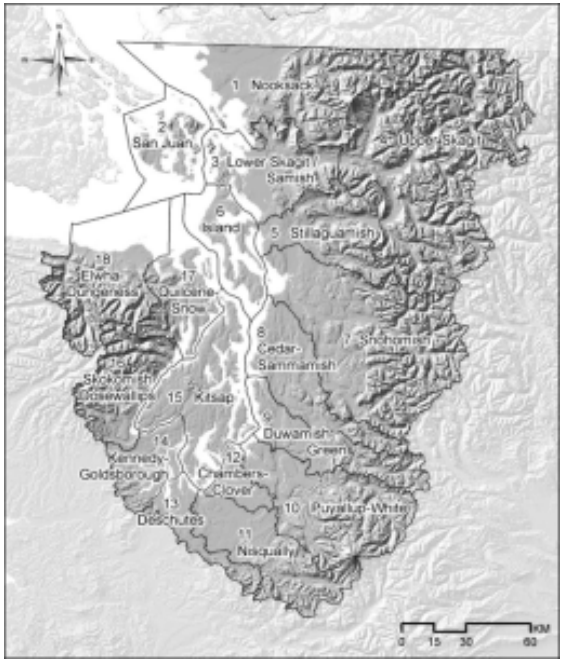
Mean Increase in Smolts



Roni et al. 2010

Typical Puget Sound Watershed

Salmon Habitat	Typical Watershed
Streams/Rivers (km)	
small* – inaccessible	13
small* – accessible	*126*
medium*	58
large*	118
Floodplain habitat (ha)	
Side channels existing	213
Side channels lost	307
Sloughs existing	77
Sloughs lost	320

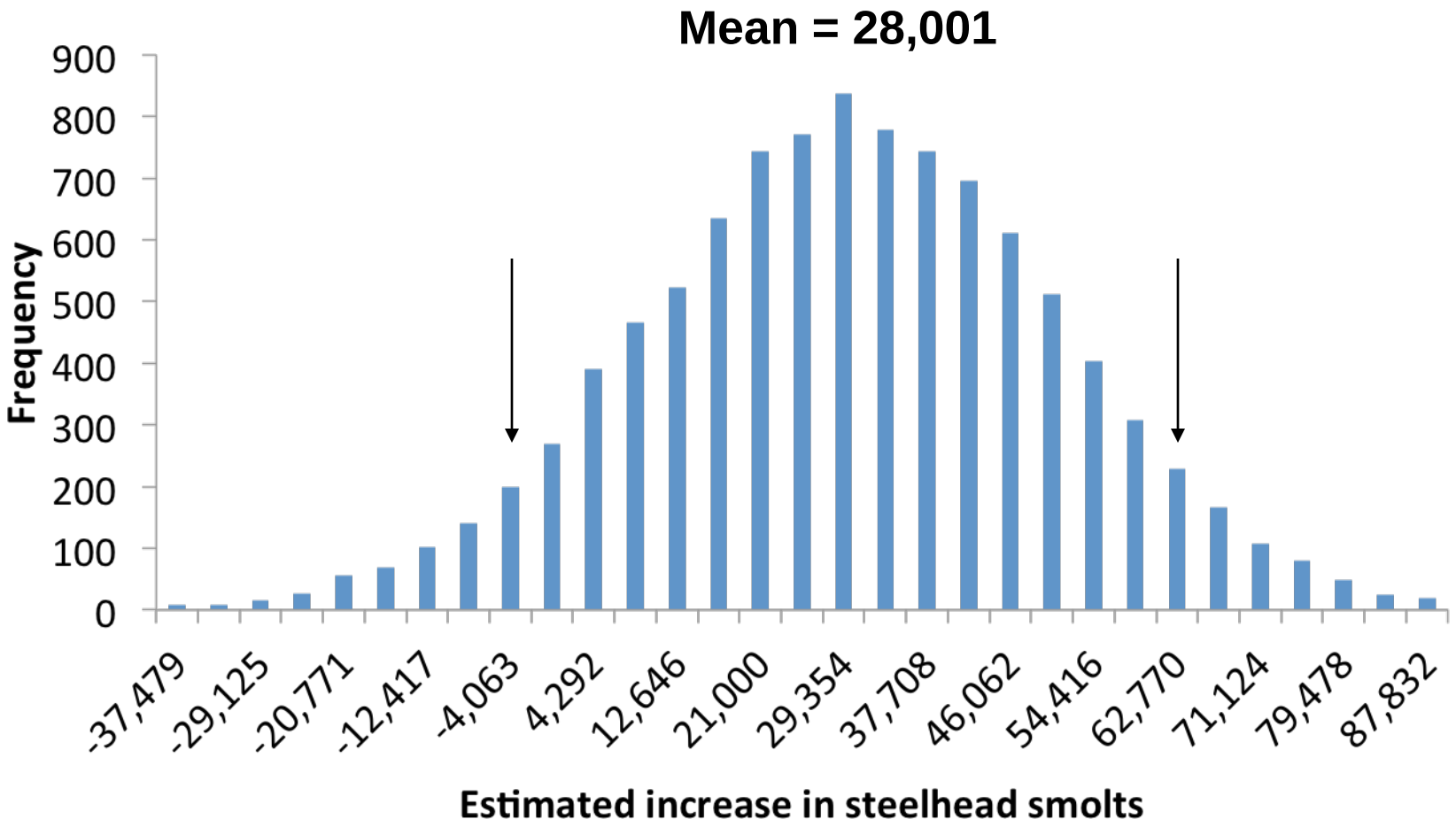


*Small = <15m bfw, medium = <25m bfw, large = >25m bfw

Restoration Actions Applied to Watershed

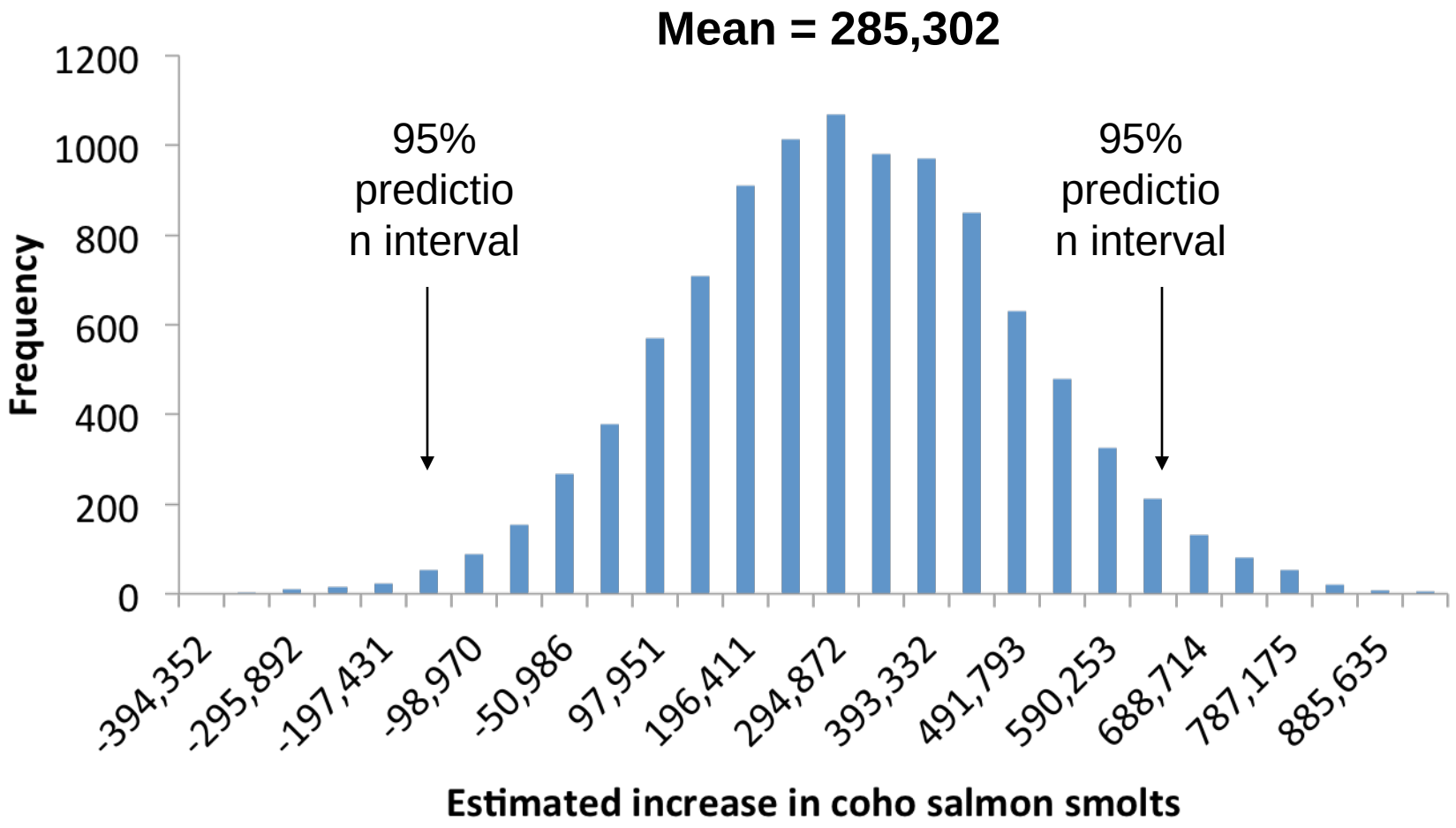
Salmon Habitat	Restoration type
Streams/Rivers	
small – inaccessible	Barrier removal
small - accessible	LWD addition
medium	Boulder weirs
large	Logjams
Floodplain habitat	
lost side channels	Groundwater channels
lost sloughs	Floodplain reconnection

Increase in Steelhead Smolts
Scenario 1 – Restore All Habitat

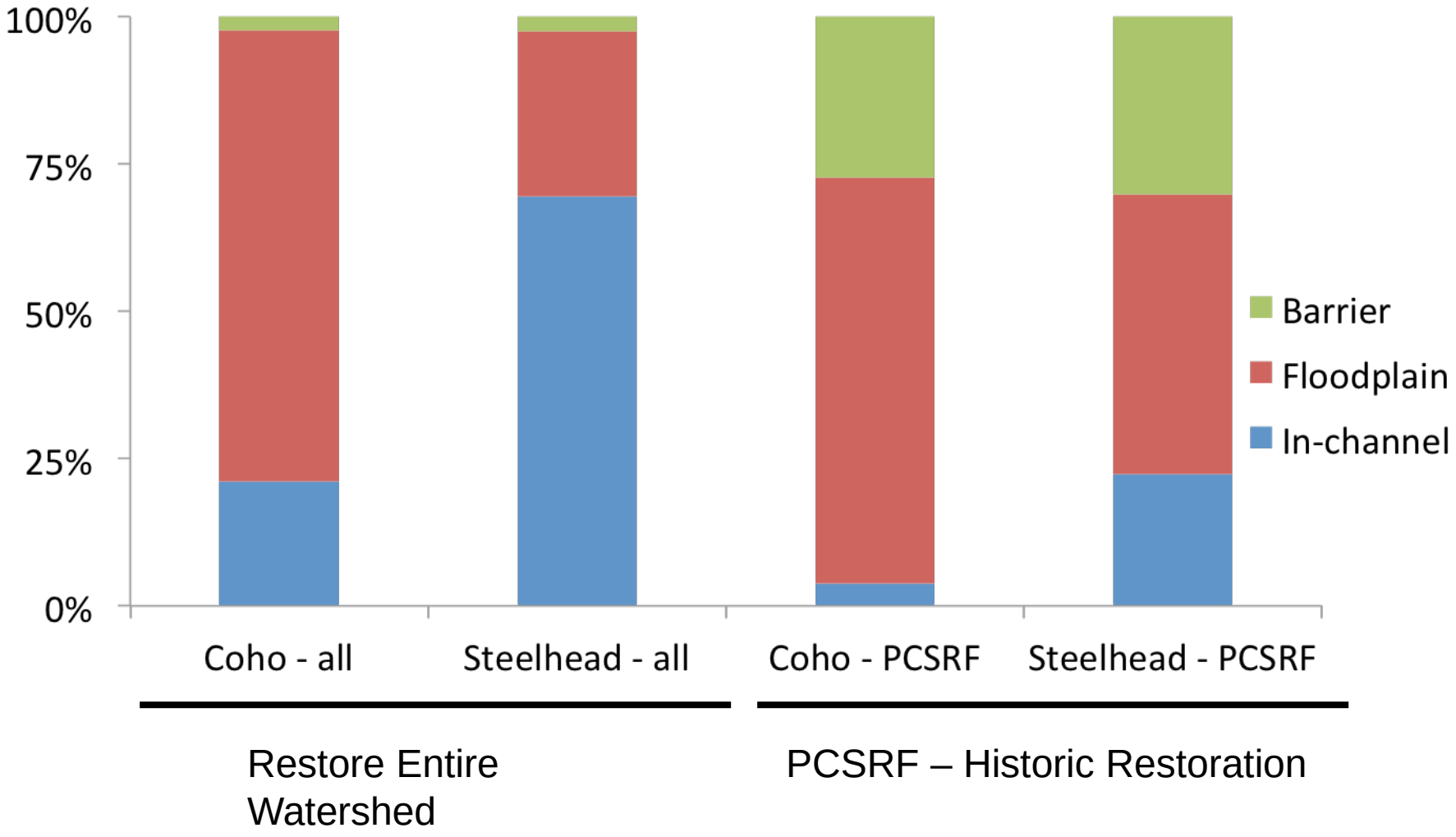


Roni et al. 2010

Increase in Coho Smolts
Scenario 1 – Restore All Habitat



Contribution by restoration action



Summary of Estimates in Model Watershed

Strategy	Coho smolts	Steelhead smolts
Pre-restoration smolt production	230,501	22,386
Scenario 1 – Restore All	285,302	28,001
Scenario 2 - Historic	15,022	1,195

How much restoration is needed to detect an increase in smolts with monitoring?

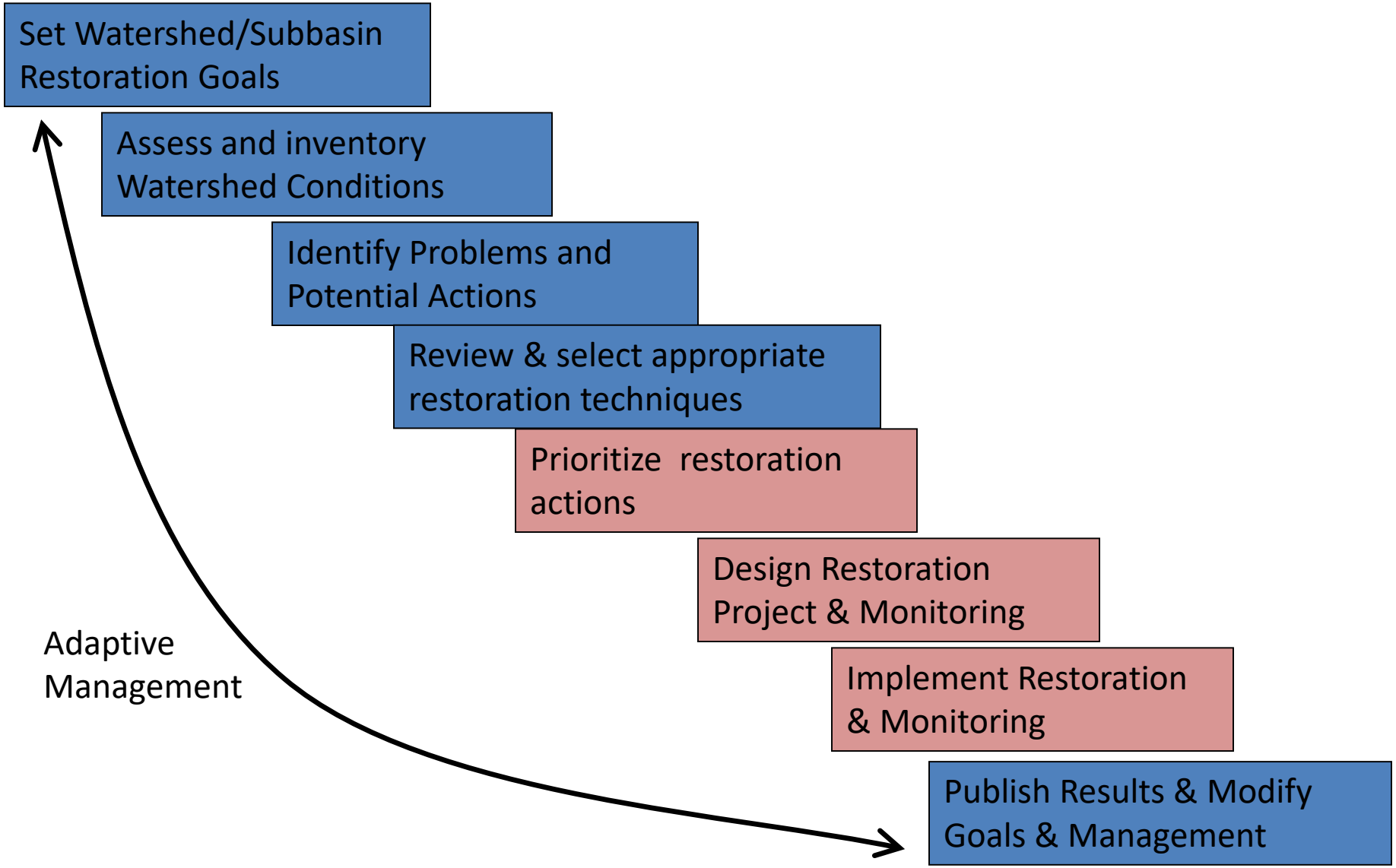
	Coho	Steelhead
Pre-restoration smolt production	230,501	22,386
Minimum detectable difference (25%)	57,625	5,596

How much restoration is needed to detect an increase in smolts with monitoring?

	Coho	Steelhead
Pre-restoration smolt production	230,501	22,386
Minimum detectable difference (25%)	57,625	5,596
Habitat restoration needed to increase smolts 25%	20%*	20%*

- 100% to be 95% certain

Key Steps in Restoration



Key Points

- **Several Steps to Restoration Process**
  - Successful restoration requires following all of them
- **Assessment of Watershed Conditions Critical**
  - Current, historic and habitat loss
  - Limiting factors
- **Project selection**
  - Processes, duration, longevity & climate change
- **Prioritization**
  - Multi-metric scoring systems most transparent

Key Points

- **M&E**
  - Defining questions/hypotheses
  - Type of monitoring needed
    - Effectiveness of categories of techniques
    - Watershed-scale effectiveness (IMWs)

- **Amount of Restoration**
  - Need to concentrate restoration and do a lot if we want to see a measureable response

Resources

Goals	Beechie et al. 2008. Setting river restoration priorities. NAJFM
Assessments	Beechie et al. 2003. Watershed assessments in recovery planning
Identify actions	Pess et al. 2003.. Watershed assessments and success for restoration Beechie et al. 1994. Estimating habitat and smolt production losses.
Restoration techniques	Roni et al. 2002. A review of restoration & a strategy for prioritizing. NAJFM Roni et al. 2008 Global review of effectiveness of restoration. NAJFM
Prioritization	Roni et al. 2002, Beechie et al.2008
Design	RiverRAT: science base and tools for analyzing stream restoration proposals. http://www.restorationreview.com/ Beechie et al. 2010. Process based restoration. Bioscience
Monitoring	Liermann & Roni 2008. Optimal study design for monitoring fish rest. NAJFM Roni 2005 Monitoring stream and watershed restoration. AFS Book

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