

Effectiveness of habitat restoration techniques at mitigating for habitat degradation and flow alteration



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A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds

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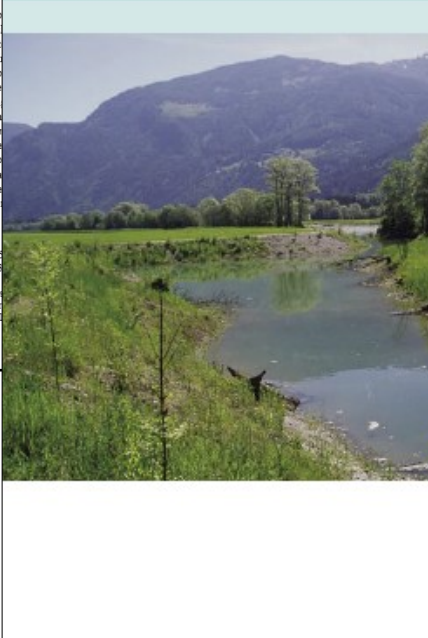
Abstract.—Millions of dollars are spent on improvement in the U.S. Pacific Northwest in accepted that watershed restoration should maintain habitat rather than manipulating instream site-specific, that is, conducted on a unique into a process-based watershed restoration techniques at improving fish habitat them. The hierarchical strategy we present is processes, (2) protecting existing high-quality of specific techniques. Initially, efforts cesses and high-quality habitat. Following a focus on reconnecting isolated high-quality fish made inaccessible by culverts or other artificial within a basin has been restored, efforts should delivery and routing), and riparian processes exclusion of livestock, and restoration of riparian of wood, boulders, or nutrients) should where short-term improvements in habitat are existing research and monitoring is inadequate comprehensive physical and biological evaluation needed.

Watershed restoration is a key component of many land management plans and endangered fish species recovery efforts on public and private lands. Millions of dollars are spent annually in individual river basins in an effort to enhance or restore habitat for salmonids and other fish species (NRC 1996). This increased interest and funding is, in part, due to increased listings of Pacific salmon on *Oncorhynchus* spp. and steelhead *Oncorhynchus mykiss* stocks as threatened or endangered under the U.S. Endangered Species Act. The majority of this money is being allocated to local citizen watershed groups for watershed restoration and recovery. Unfortunately, local citizen groups often

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Received September 14, 2000; accepted April 8, 2001

Habitat rehabilitation for inland fisheries
Global review of effectiveness and guidance for rehabilitation of freshwater ecosystems



FAO
FISHERIES
TECHNICAL
PAPER
484

North American Journal of Fisheries Management 22: 1-20, 2002
American Fisheries Society 2002
0161-7531/02/2201-0001

[Article]

Global Review of the Physical and Biological Stream Habitat Rehabilitation Techniques

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Abstract.—The degradation of inland aquatic habitats caused by decades worldwide efforts to rehabilitate freshwater habitats for fisheries and a published evaluation of stream rehabilitation techniques from throughout and improvement: riparian rehabilitation, floodplain connectivity and improvement, nutrient addition, and other, less-common techniques. We assess the effectiveness of these techniques for improving physical habitat and water biotic production. Despite locating 345 studies on effectiveness of stream about many specific techniques were difficult to make because of the physical habitat, water quality, and biotic and because of the short time published evaluations. Rehabilitation of inland habitats, floodplain and improvement has, however, proven effective for improving habitat and under many circumstances. Techniques such as species rehabilitation, siltation, dam removal, and restoration of natural flood regimes have the processes that create and maintain habitats, but no long-term studies discuss published. Our review demonstrates that the failure of many rehabilitation, attributable to inadequate assessment of historic conditions and factors understanding of watershed-scale processes that influence local site projects, spatial and temporal scale. We suggest an iterative approach to responding to address those needs through promoting high-quality habitat and water processes before implementing human habitat improvement projects.

In response to aquatic habitat degradation from a variety of human activities, rehabilitation of these habitats has become commonplace throughout the world (NRC 1992; Cowx and Welcomme 1998). Rehabilitation efforts are often undertaken to restore or improve natural resources that are of economic, cultural, or spiritual importance. Rehabilitation typically occurs in a single reach or in reaches spread throughout a watershed; this includes both riparian and upland activities as well as activities in the lowlands, such as reconstruction of floodplains and addition of habitat structures (e.g., logs, boulders, and weirs) in streams. The vast majority of such efforts have been undertaken to restore fisheries resources; in some cases, large sums of money are spent on a single species or group of species. For example, hundreds of millions of dollars are spent annually in western North America in an effort to increase runs of Pacific salmon *Oncorhynchus* spp. that once sustained large fisheries but are now threatened with extinction. Other ecosystem restoration programs have been initiated in the

Florida Everglades, Sacramento river Bay, the Great (Northeast Midwest) Europe to rehabilitate large systems, basins (Brazuca a increasing because increased frequent practices, or dense streamflows (Part an underway to wetlands, and meadows, China, and and has desertification and 30% reforestation of the Mambas in Iraq, extensive draining (Richardson et al. Restoration in A

* Corresponding author: phil.roni@noaa.gov
Received June 20, 2001; accepted August 8, 2001
Published online June 16, 2002

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Review of Literature

NOAA Technical Memorandum NMFS



Fish-Habitat Relationships and the Effectiveness of Habitat Restoration

June 2014

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

Pagination not final (cite DOI) / Pagination provisoire (citer le DOI)



PERSPECTIVE

Wood placement in river restoration: fact, fiction, and future direction

Philip Roni, Tim Beechie, George Pess, and Karrie Hanson

Abstract. Despite decades of research on wood in rivers, the addition of wood as a river restoration technique remains controversial. We reviewed the literature on natural and placed wood to shed light on areas of continued debate. Research on river ecology demonstrates that large woody debris has always been a natural part of most river systems. Although a few studies have reported high structural failure rates (>50%) of placed instream wood structures, most studies have shown relatively low failure rates (<20%) and that placed wood remains stable for several years, though long-term evaluations of placed wood are rare. The vast majority of studies on wood placement have reported improvements in physical habitat (e.g., increased pool frequency, cover, habitat diversity). Studies that have not reported improvements in physical habitat often found that watershed processes (e.g., sediment, hydrology, water quality) had not been addressed. Finally, most evaluations of fish response to wood placement have shown positive responses for salmonids, though few studies have looked at long-term watershed-scale responses or studied a wide range of species.

Résumé. Malgré des décennies de recherche sur le bois dans les rivières, l'ajout de bois comme technique de restauration demeure controversé. Nous avons passé en revue la documentation sur le bois naturel et mis en place pour faire la lumière sur les enjeux qui font toujours l'objet de débat. La recherche en écologie fluviale démontre que les grands débris ligneux ont toujours constitué une composante naturelle de la plupart des réseaux fluviaux. Si quelques études ont signalé des taux élevés de défaillance structurelle (>50 %) des structures en bois mises en place dans des cours d'eau, la plupart des études ont noté des taux de défaillance assez faibles (<20 %) et montré que le bois mis en place dans les cours d'eau demeurait stable pendant plusieurs années, les évaluations à long terme du bois mis en place étant toutefois rares. La grande majorité des études sur la mise en place de bois font état d'améliorations de l'habitat physique (p. ex. fréquences accrues de moutilles, couvert, diversité des habitats). Bon nombre des études n'ayant pas constaté d'amélioration de l'habitat physique notaient que les processus hydrographiques (p. ex. sédiments, hydrologie, qualité de l'eau) n'avaient pas été pris en considération. Enfin, si la plupart des évaluations de la réaction des poissons à la mise en place de bois ont relevé des réactions positives en ce qui concerne les salmonides, peu d'études ont examiné les réactions à long terme à l'échelle du bassin versant ou étudié un grand éventail d'espèces. [Traduit par la Rédaction]

Introduction

Placement of large woody debris (wood) and other structures in streams is one of the most widespread and common techniques to improve riverine fish habitat. Techniques for wood placement range from simply falling, pushing, or hauling trees from the riparian zone into the active stream channel to construction of highly engineered structures such as log weirs or engineered logjams (Roni and Beechie 2013). In part due to the popularity and variety of wood placement techniques, whole books and technical manuals have been developed over the years to guide restoration practitioners and local sportsmen on how to design and implement instream wood projects (e.g., Hunt 1993; Hunter 1991; Tarzwell 1934; White and Bryndilsson 1967).

The number of projects historically and currently being implemented using various wood placement techniques is staggering. In just one 3-year period from 1933 to 1935, the United States Civilian Conservation Corps constructed more than 30 000 instream structures in more than 400 streams (Hunter 1991; Thompson and Stull 2002). In a database compiled of more than 37 000 river restoration projects implemented in the United States (US) from

these were wood placement or other instream habitat improvement projects. In the Columbia River Basin of the Pacific Northwest, the focus of a large habitat restoration program, at least 2000 wood placement projects have been implemented since 1980 (National Oceanic and Atmospheric Administration (NOAA), unpublished data). Wood placement has also become commonplace in Europe, Japan, Australia, and other parts of the world (Brooks 2006; Nagayama and Nakamura 2010; Reich et al. 2003).

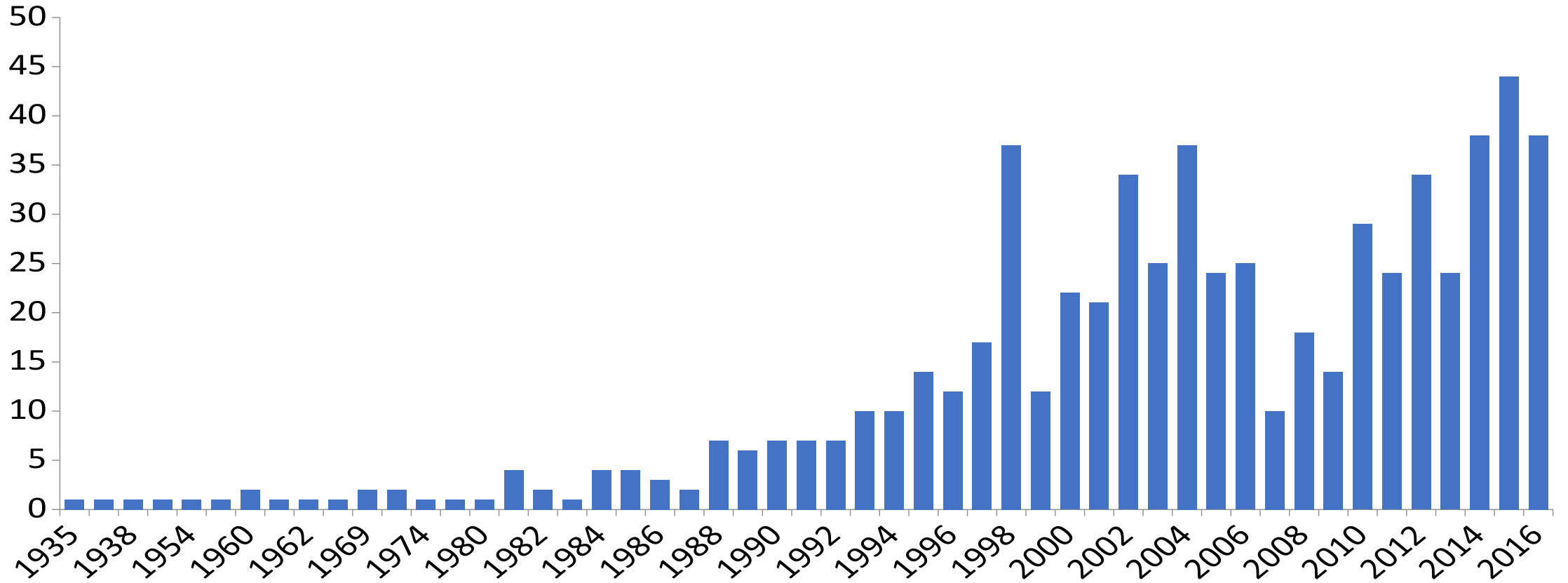
Not only is wood placement one of the most common stream restoration techniques, but it is arguably also the oldest. As early as the 1890s, private land owners in the eastern US, United Kingdom, and western Europe began placing wood and other structures in channels to improve fish habitat (Thompson and Stull 2002; White 2002). Many of the techniques developed in the 1920s and 1930s for use in streams in the northeastern US are still in use today (Roni and Beechie 2013; Thompson and Stull 2002). These include such structures as log weirs, deflectors, sills, K-dams, and other techniques using cut logs or brush primarily designed to create pools or fish cover (Hunt 1993; Hunter 1991; Tarzwell 1934). These techniques were refined in the 1960s and used widely in streams in the US Midwest to improve trout habitat by creating

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Total Number of Published Papers*

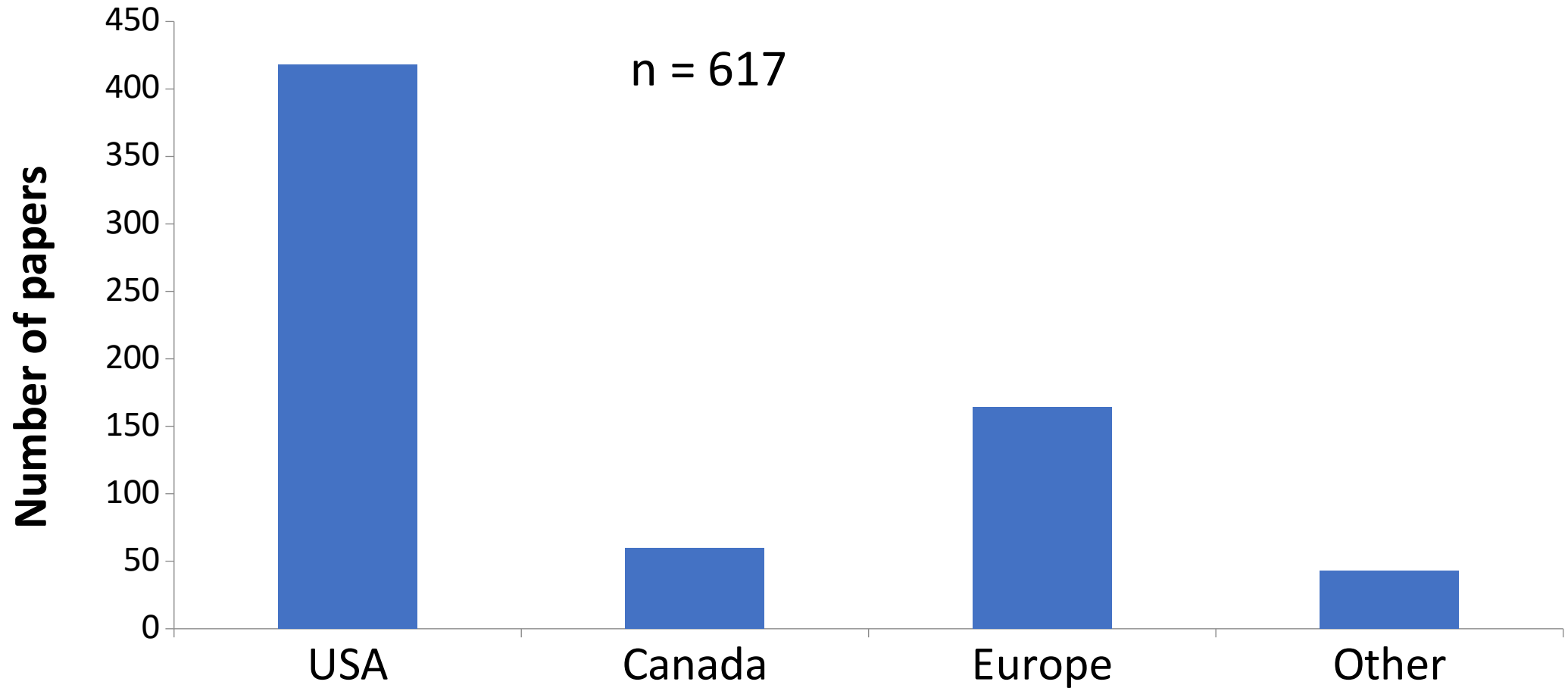
Number of papers

N = 617



* Published papers and grey literature

Where are those paper from?



* 160 from BC, WA, OR or ID

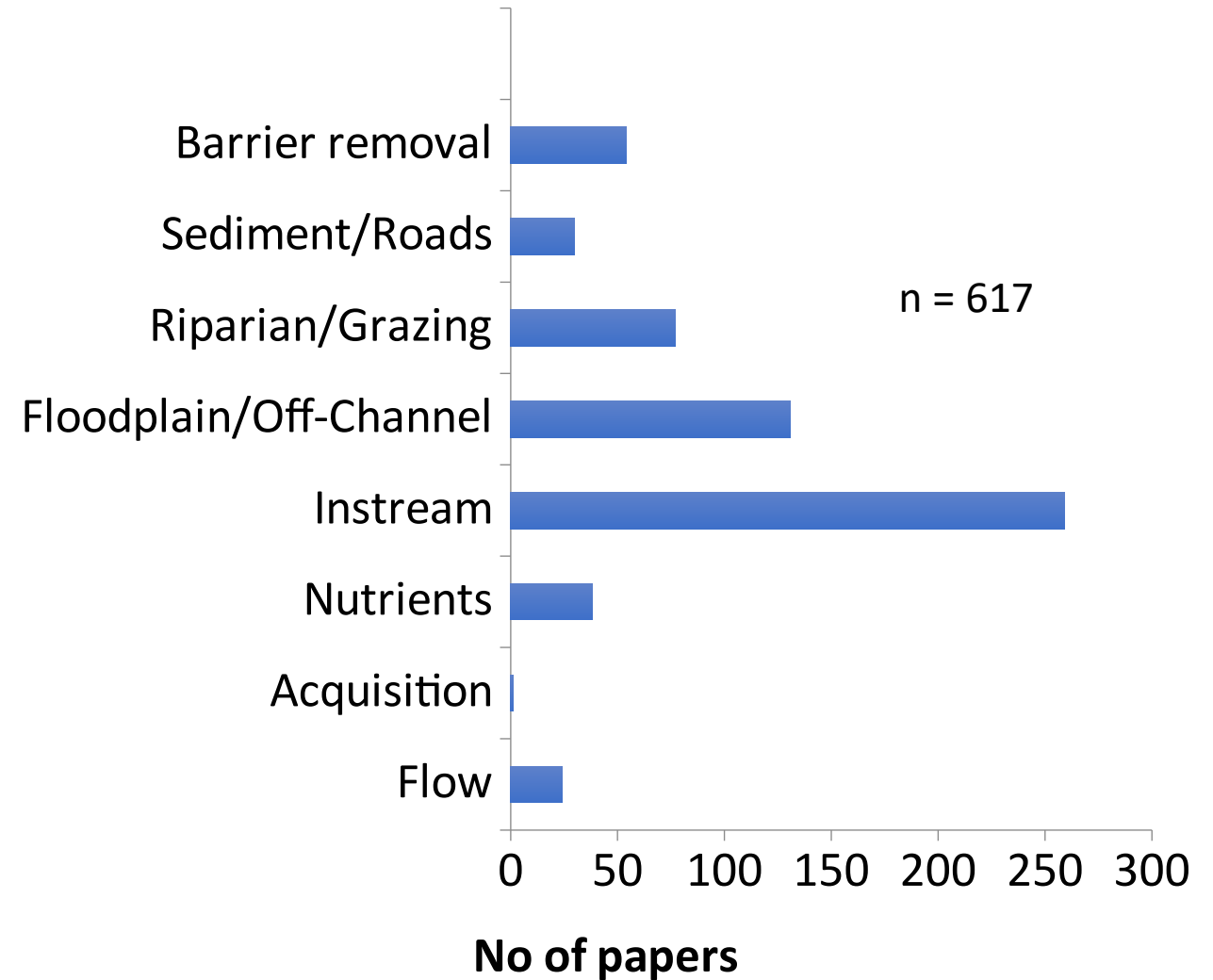
What I'll Cover Today

- Overview of each technique
 - What we know in general about effectiveness
 - Can they mitigate for flow reduction?
- Approaches to quantify benefit from restoration
 - Based on capacity
 - Restoration effectiveness



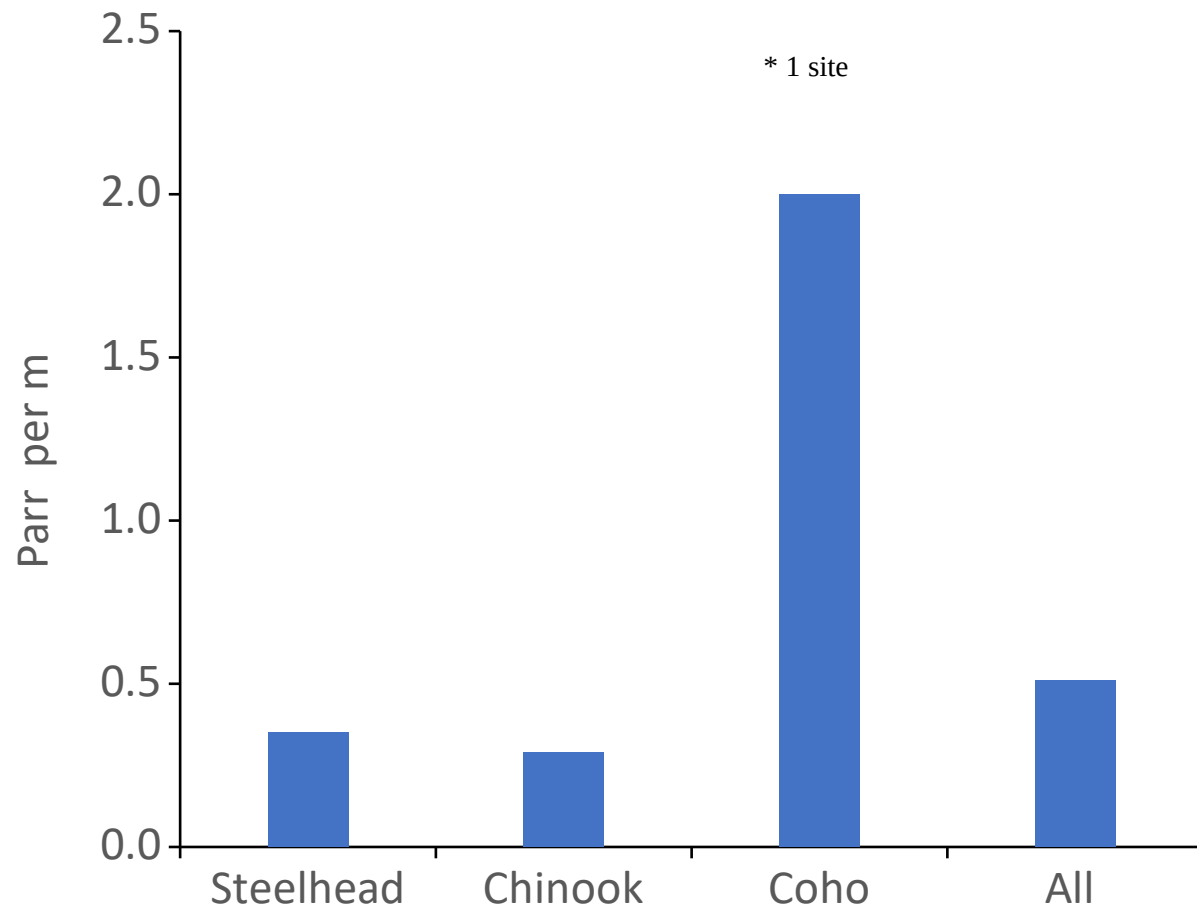
Habitat Restoration Techniques

- **Barrier removal**
- **Sediment Reduction**
- **Riparian Improvement**
- **Off-Channel/Floodplain Habitat**
- **Instream Structures**
- Nutrient Enrichment
- Acquisition and Protection
- **Flow Augmentation**



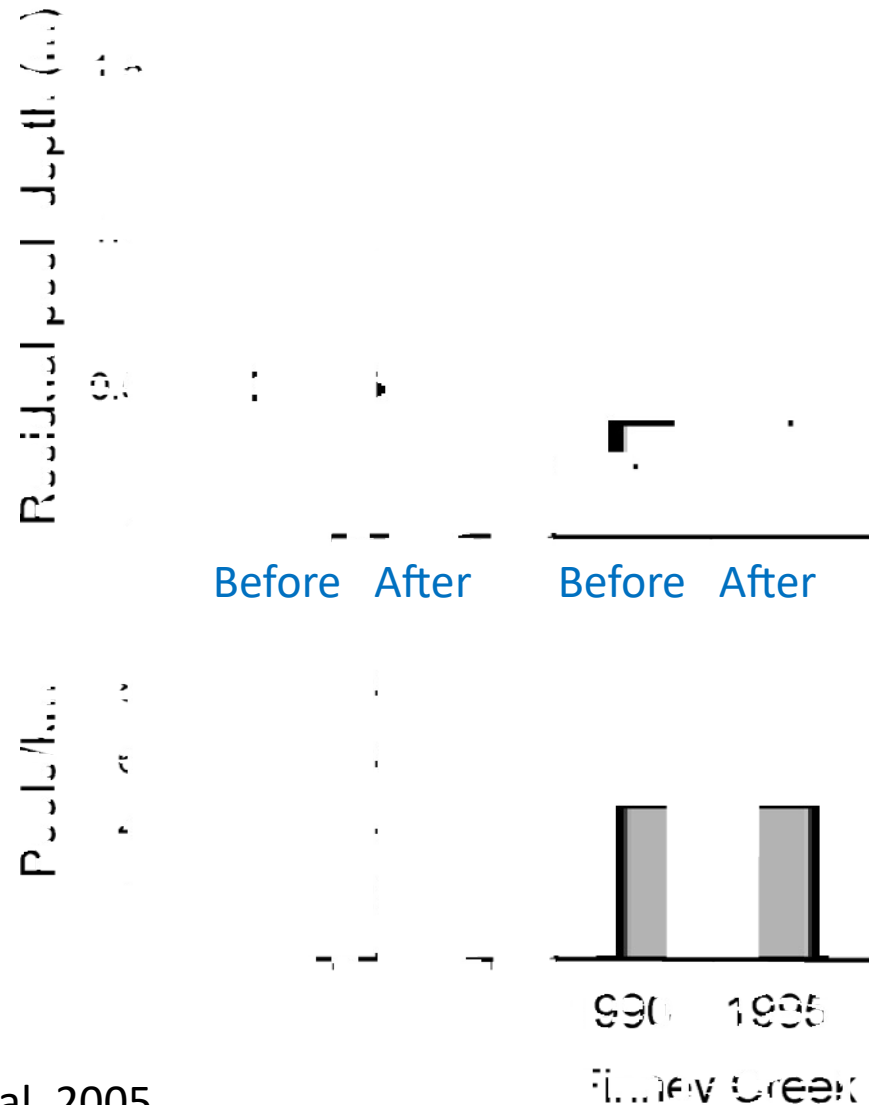
Barrier Removal – 60 Studies

BPA AEM Barrier Removal Monitoring
n = 32 projects



- What we know
 - Rapid recolonization
 - Some don't meet passage success criteria
 - Surprisingly few studies on fish response to culverts
- Success depends upon
 - Nearby fish populations size
 - Design and maintenance
- What we need to know
 - Fish response

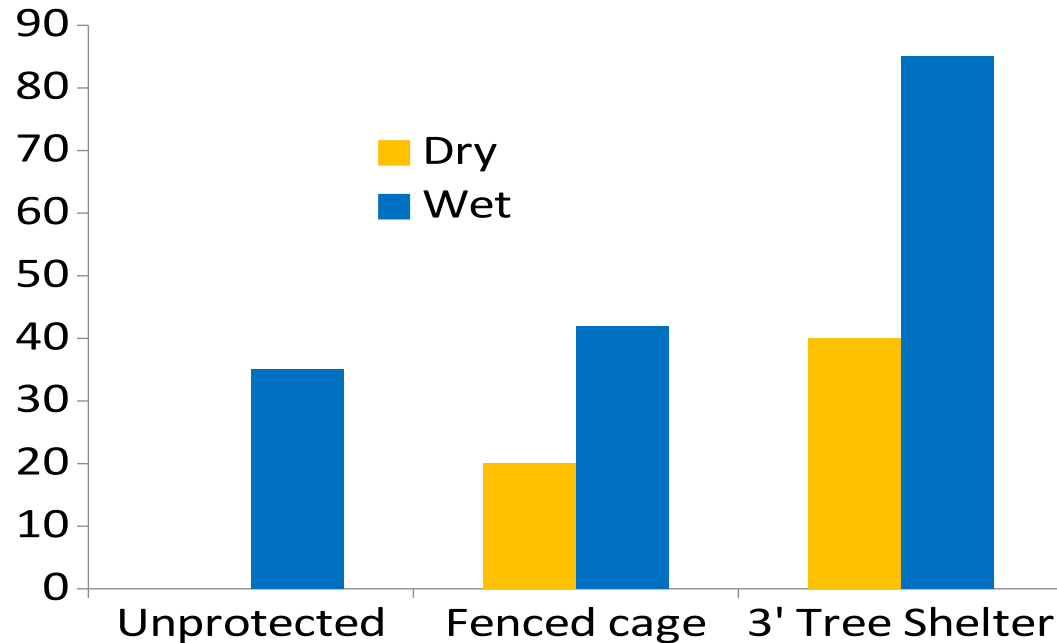
Sediment Reduction/Road Improvements – 36 Studies



- What we know
 - Most reduce fine sediment
 - Reduce mass wasting
- Success depends upon
 - Technique used
 - Number of stream crossings
 - Replanting/site prep
 - Area treated
- What we need to know
 - Watershed-scale response
 - Fish or biological response
 - Improved spawning success

Riparian Planting – 39 Studies

% Planting Survival



Hall et al. 2011

➤ What we know

- shade and bank stability increase relatively rapidly

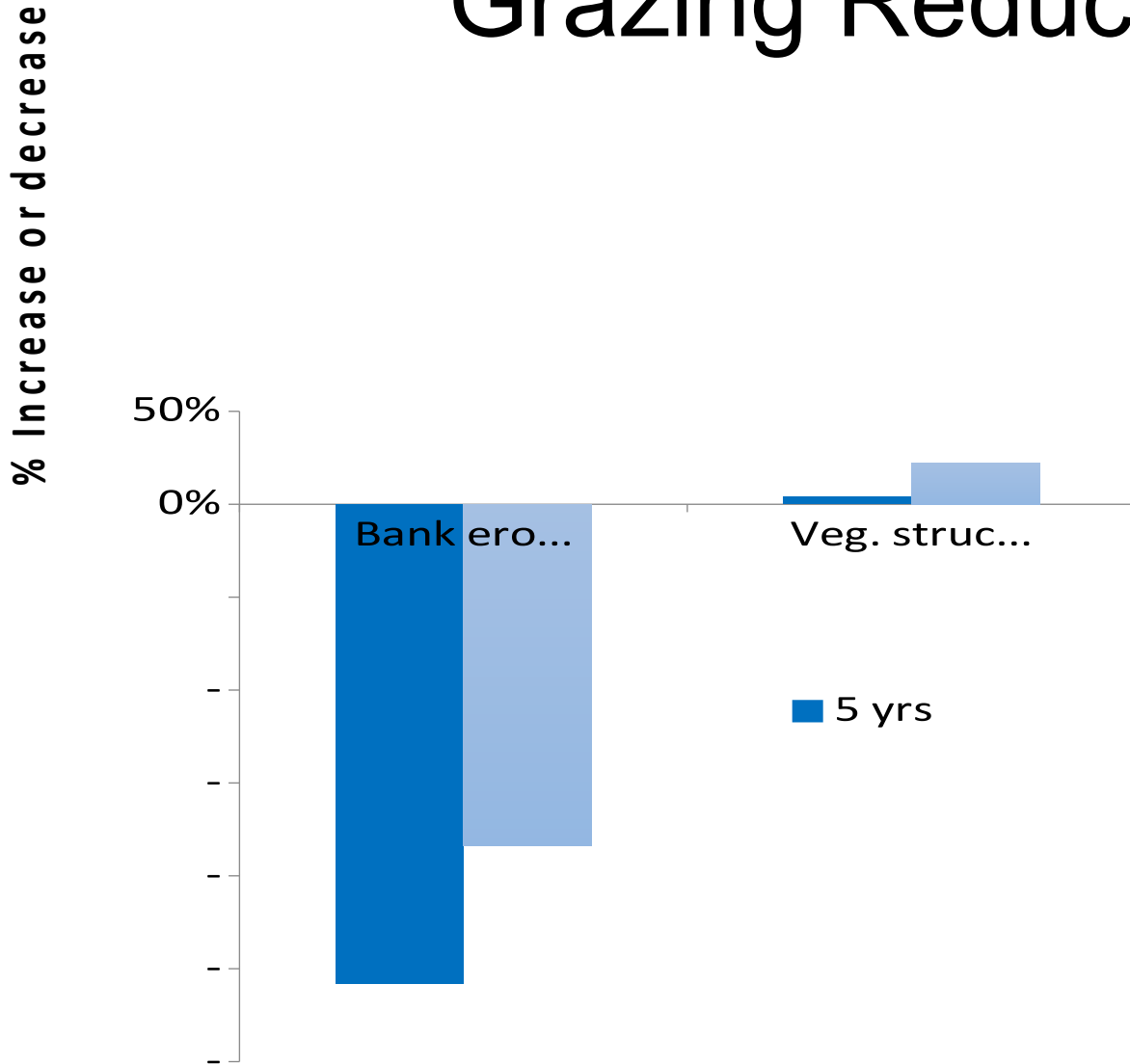
➤ Success depends on

- site prep & conditions
- protection from herbivores
- competition with other plants
- technique
- planting depth

➤ What we need to know

- time needed to restore LWD.
- effects on stream habitat/biota
- long-term response (10+ yrs.)

Grazing Reduction – 44 Studies



SRFB unpublished data

➤ What we know

- Livestock removal consistently effective
- Quick recovery of veg., sediment, channel width, shade

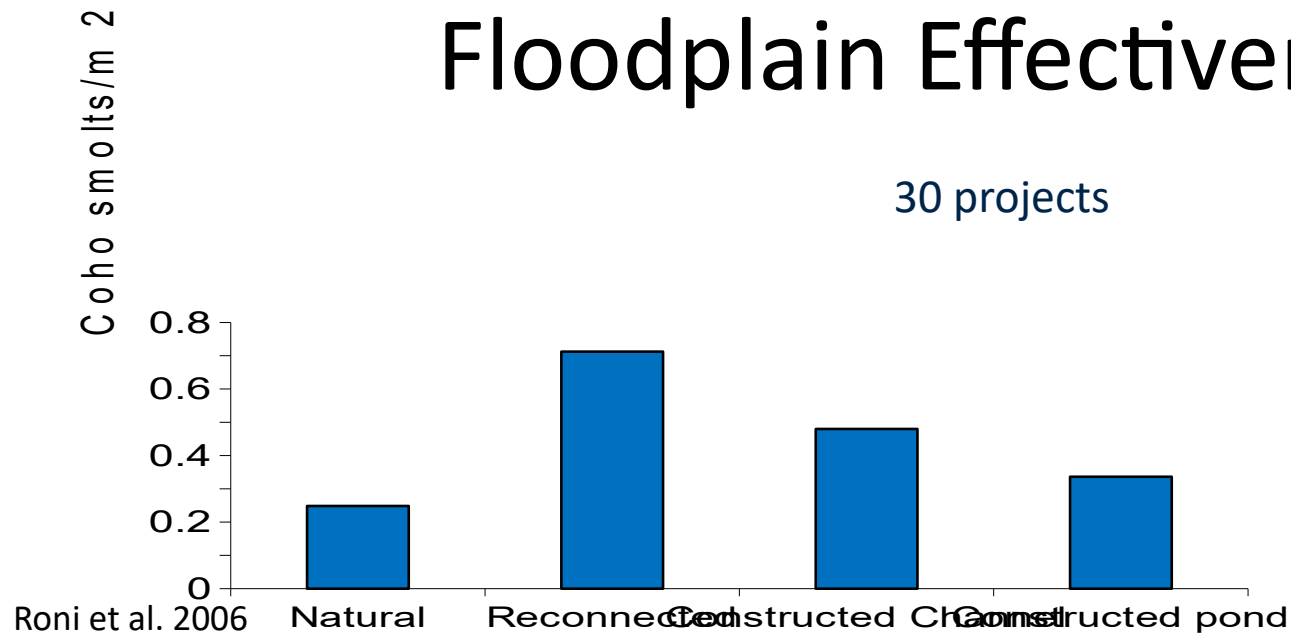
➤ Success depends on

- Upstream conditions
- Grazing duration
- Rest. of flooding & processes
- Scale of project

➤ What we need to know

- Fish & instream response?

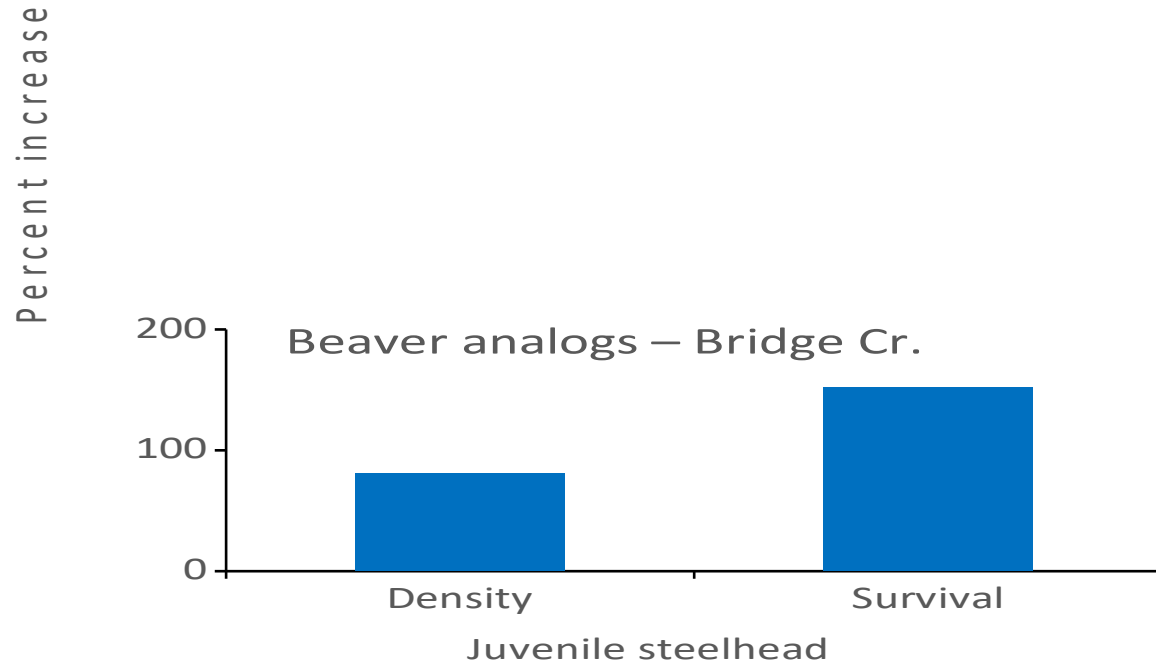
Floodplain Effectiveness – 159 Studies



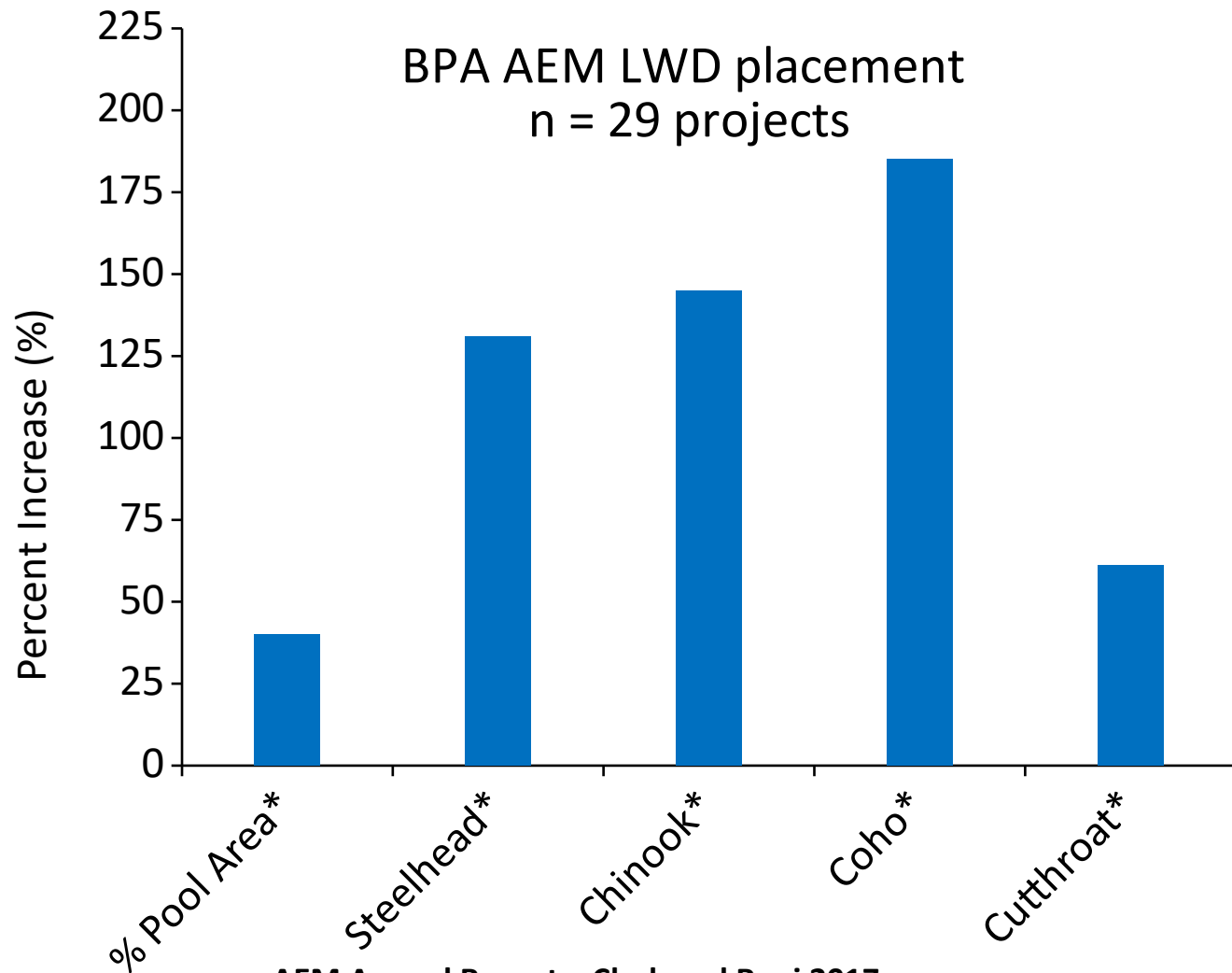
- What we know
 - Reconnecting existing habitats highly successful
 - Other techniques show variable success rates
 - Little long-term monitoring
 - Good data for Coho

- Success depends on
 - Access, WQ, sediment
 - Design issues

- What we need to know
 - Response of Chinook & steelhead



Instream Structures – 258 Studies



AEM Annual Report – Clark and Roni 2017

- What we know
 - Physical response well documented
 - Response well documented for most species (minus Chinook)
 - Fish response varies among species, regions, watersheds
- Success depends upon
 - Addressing WQ, sediment, riparian and other processes
 - Intensity and amount of restoration***
 - Design
- What we still need to know
 - More info in larger rivers (>20 meters wide)
 - More info on Chinook

Flow Enhancement – 24 Studies



- What we know
 - Fish abundance and diversity generally increase
 - Biggest response for dewatered reaches and reconnected floodplain habitats
 - Few studies in PNW
- Success depends upon
 - Amount and timing of flow addition
 - Addressing WQ, sediment, riparian, connectivity and instream habitat
- What we still need to know
 - More info on fish
 - Hard to quantify how many more fish for unit of flow

Other Considerations on Effectiveness

TECHNIQUE	RESPONSE TIME (YEARS)	LONGEVITY IN YEARS	Reduces Impacts of Climate Δ
Connectivity (barriers)	1 to 5	>50	Yes (temp)
Floodplain restoration	1 to 5	>50	Yes (flow, temp)
Sediment reduction	5 to 20	>50	Unlikely
Instream flows	1 to 5	>50*	Yes (flow, temp)
Riparian replanting	>50	>50	Yes (temp)
Fencing/grazing	1 to 5, 5 to 20	>10 to 50*	Yes (temp)
Instream (LWD etc.)	1 to 5	10 to 50	Unlikely

Two Simple Methods for Quantifying Ecological Benefit

- Capacity/Limiting Factors

- Reeves et al. 1989; Beechie et al. 1994 ,2015

**Habitat Data by
Season & Life Stage**

X

**Seasonal Fish
Density**

X

Smolt Factor

=

**Smolt Production
Potential**

- Restoration Effectiveness

- Roni et al. 2010

**Area, length, and type of
restoration**

X

**Known Fish
Response (density)**

=

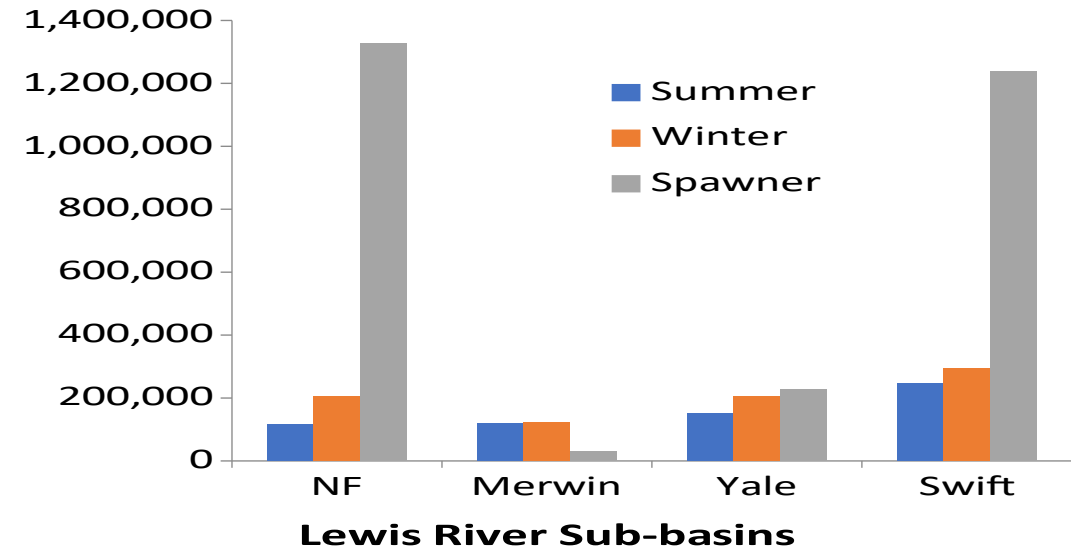
**Mean Increase in
Parr or Smolts**

* Other methods include more complex life cycle models

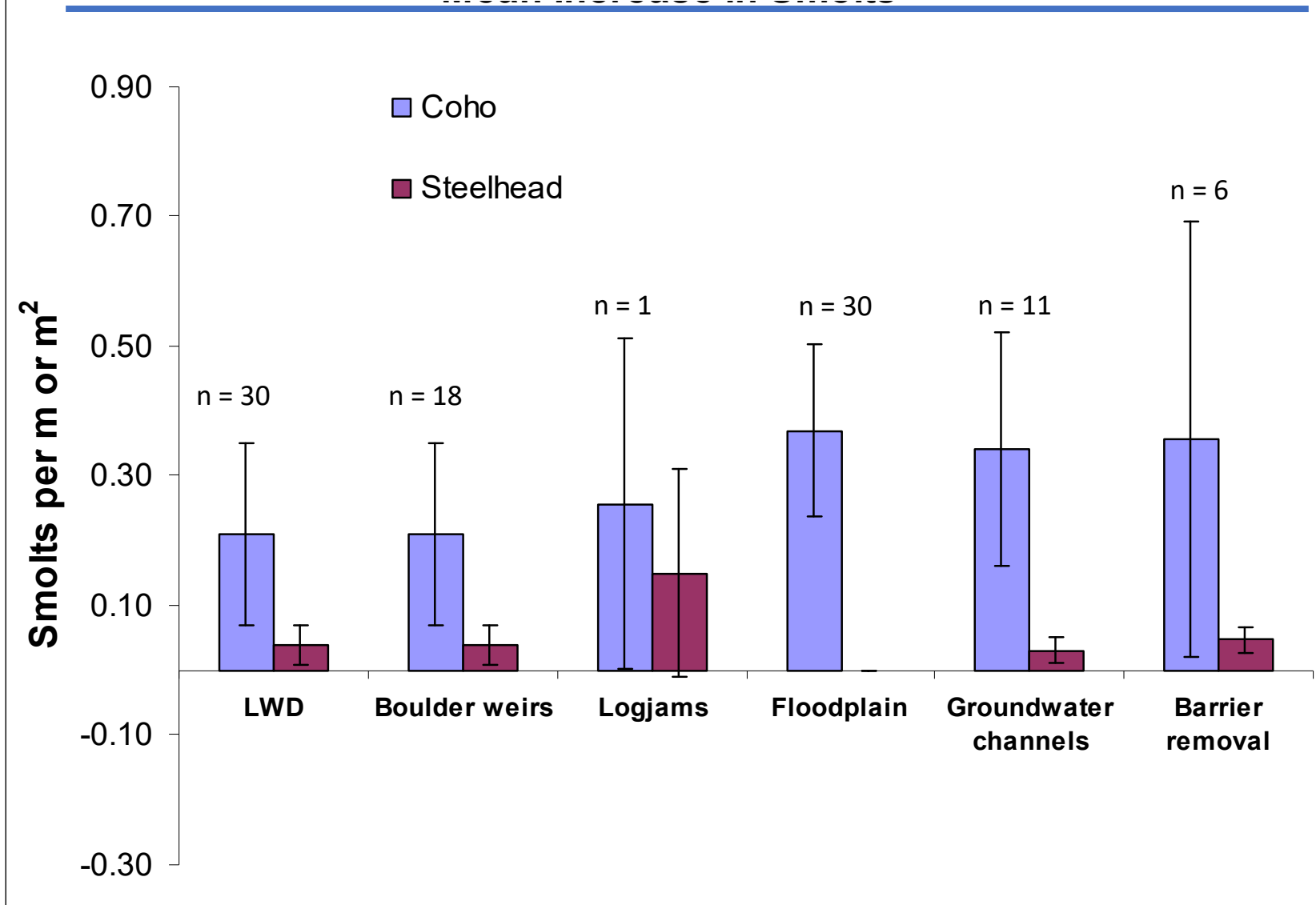
Based on Available Habitat and Capacity

Habitat Type	Smolt Production Potential (fish/m ²)		
	Coho	Steelhead	Spring Chinook
<u>Side channel</u>			
Summer	0.32	0.05	0.11
Winter	0.78	0.19	NA
<u>Tributaries</u>			
Summer pool	0.43	0.06	0.13
Summer Glide		0.06	0.03
Summer riffle	0.21	0.05	0.02
Winter pool	1.09	0.02	N.A.
Winter Glide		0.01	N.A.
Winter riffle	0.00	0.00	N.A.
<u>Mainstem</u>			
Summer		0.01	0.02
Winter		0.01	
<u>Pond/Lake</u>			
Summer pond	0.38	0.00	0.01
Winter pond	0.78	0.00	NA
Summer reservoir	0.003	0.00	0.02
Winter reservoir	0.003		NA
<u>Spawning habitat</u>			
Spawning habitat	60.00	8.08	52.40

Coho smolt production potential



Increase in smolts by project type

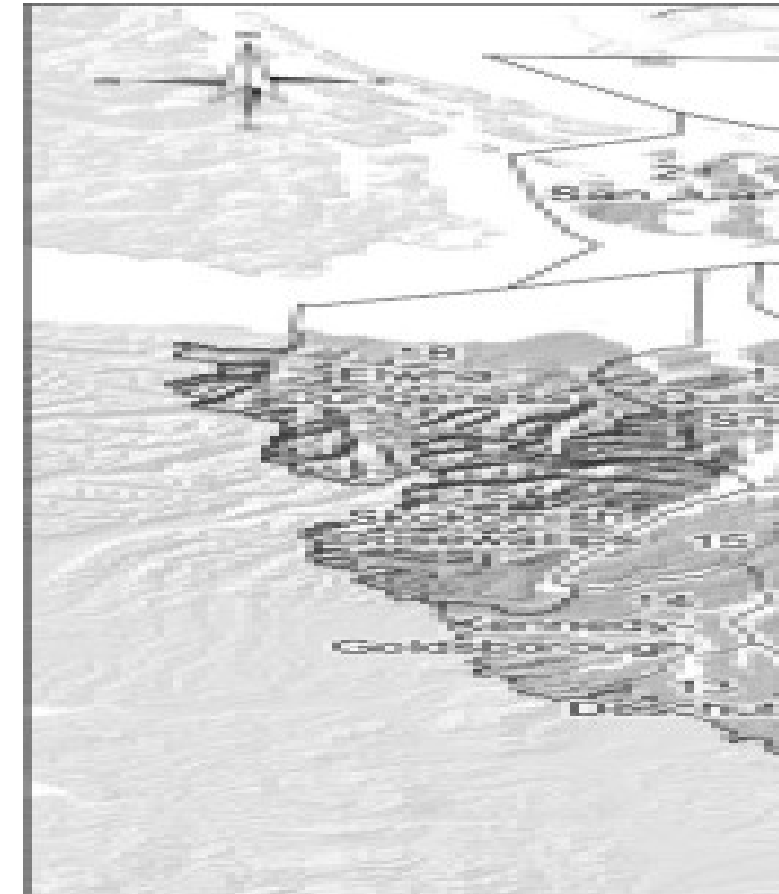


Restoration Actions Applied to Watershed

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

Typical Puget Sound Watershed

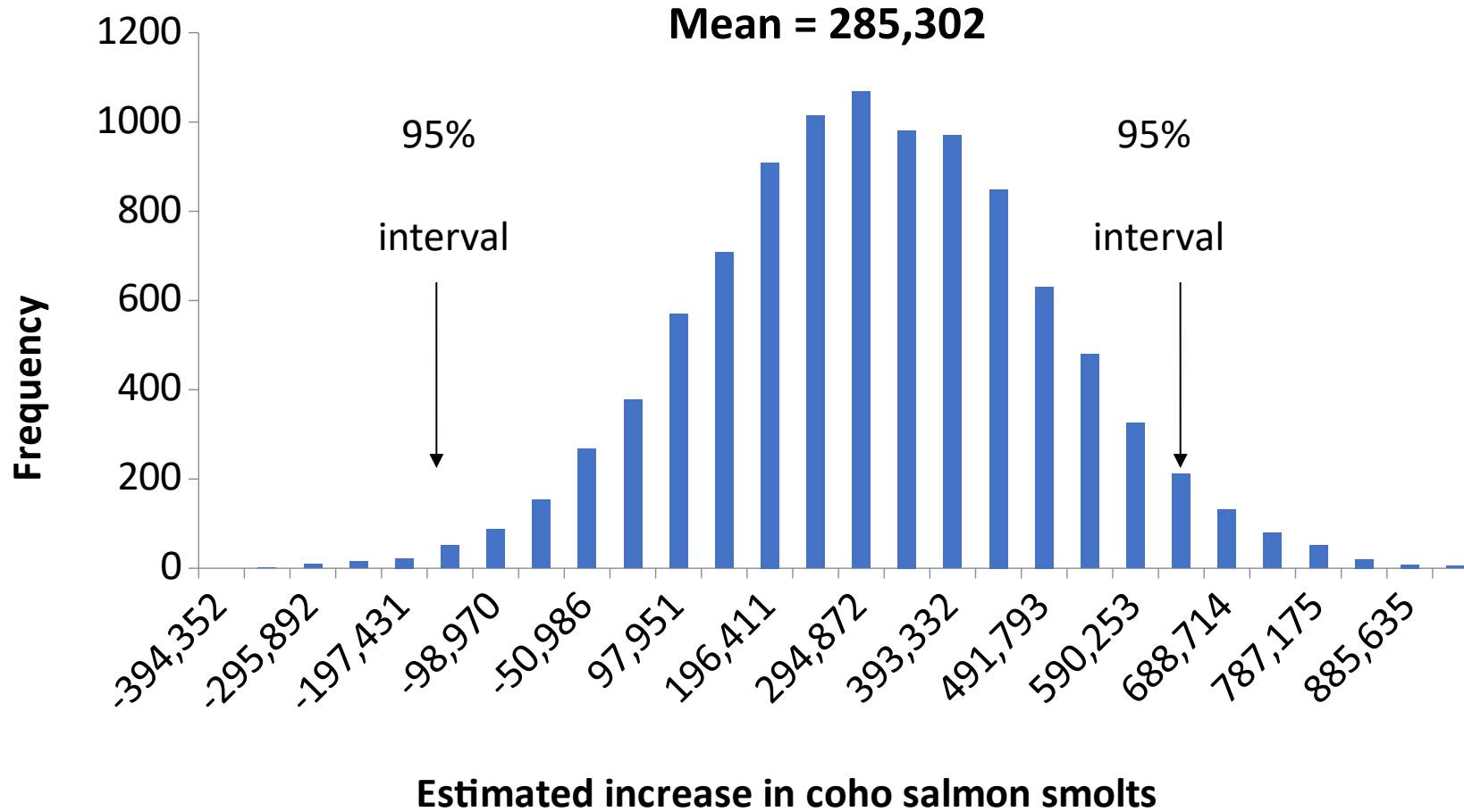
Salmon Habitat	Typical Watershed
Streams/Rivers (km)	
small* – inaccessible	13
small* – accessible	126
medium*	58
large*	118
Floodplain habitat (ha)	
Side channels existing	213
Side channels lost	307
Sloughs existing	77
Sloughs lost	320



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

Increase in Coho Smolts

Scenario 1 – Restore All Habitat



Summary

- We know a fair amount about fish response to some techniques
 - Instream and floodplain
- Very little about fish response for others (riparian, roads, flow)
- Some directly and indirectly may mitigate for flow
- There are few basic approaches that have been used to determine fish response to restoration which may be useful for estimating net ecological benefit of offset projects

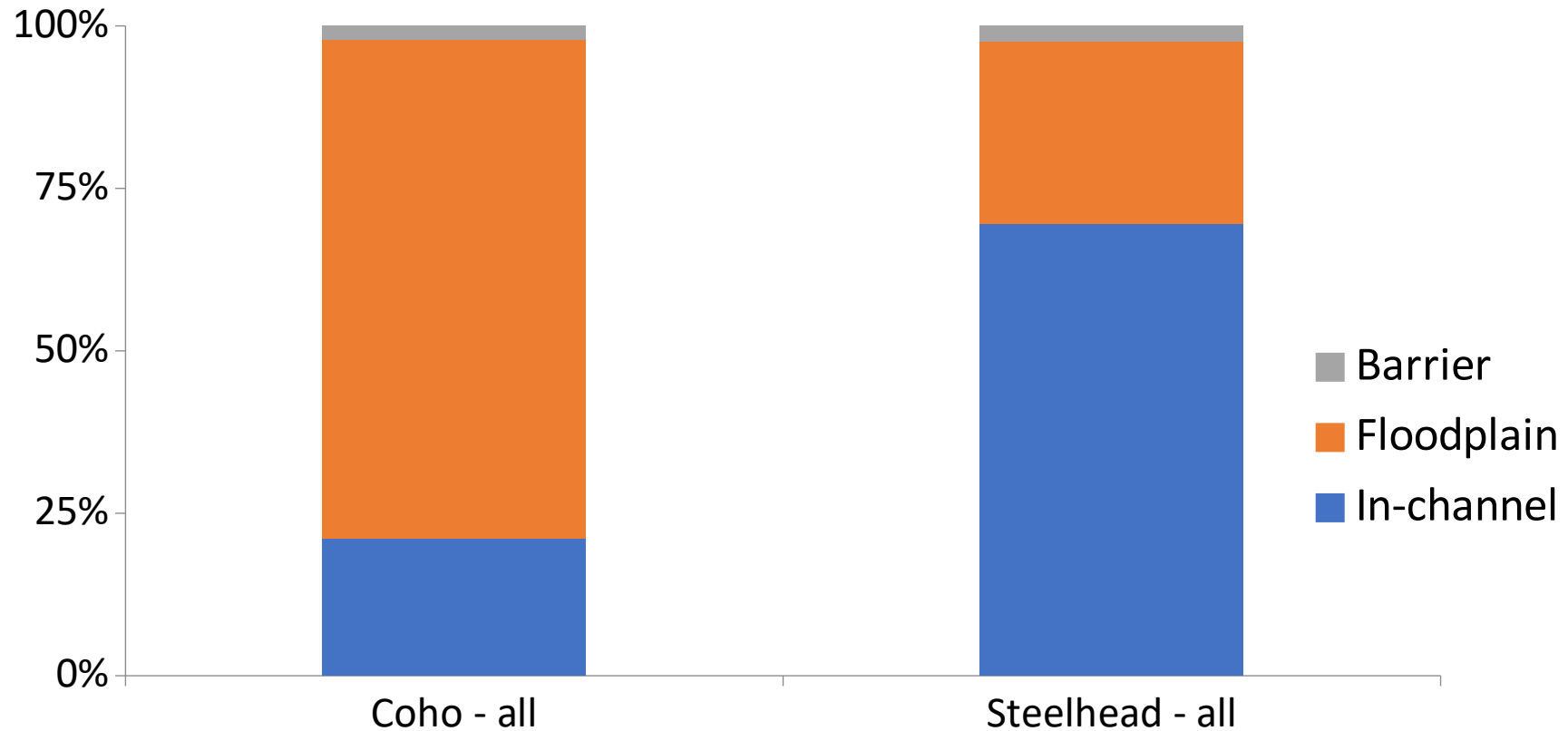
Questions?



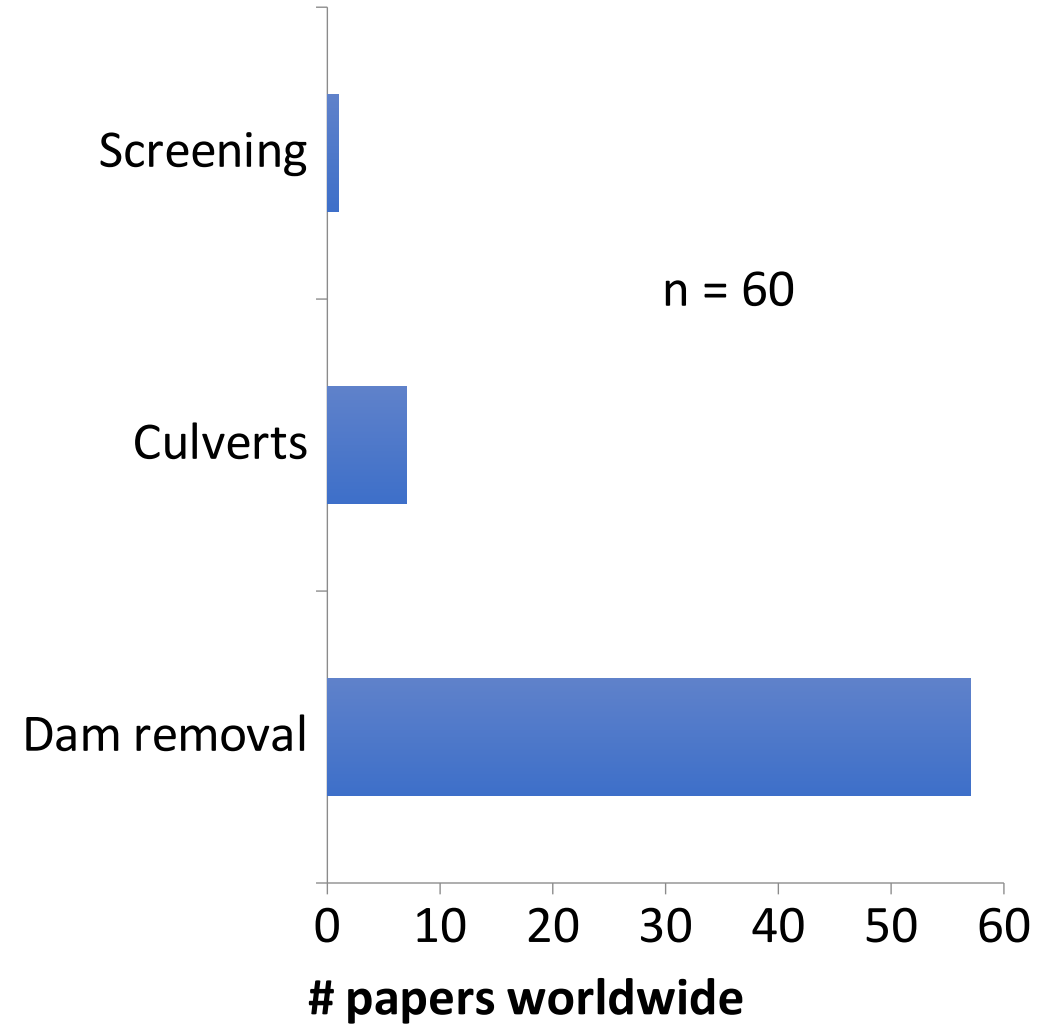
Summary of Restoration Techniques and Ability to Mitigate for Flow

Restoration Technique	Directly Mitigate for Flow Reduction	Possible to quantify benefits for fish
Barrier removal	No	Yes
Sediment Reduction	No	No
Riparian Planting	No	No
Grazing reduction	No	No
Off-channel/Floodplain	Maybe	Yes
Instream	No	Yes
Flow augmentation	Yes!	No

Contribution by restoration type



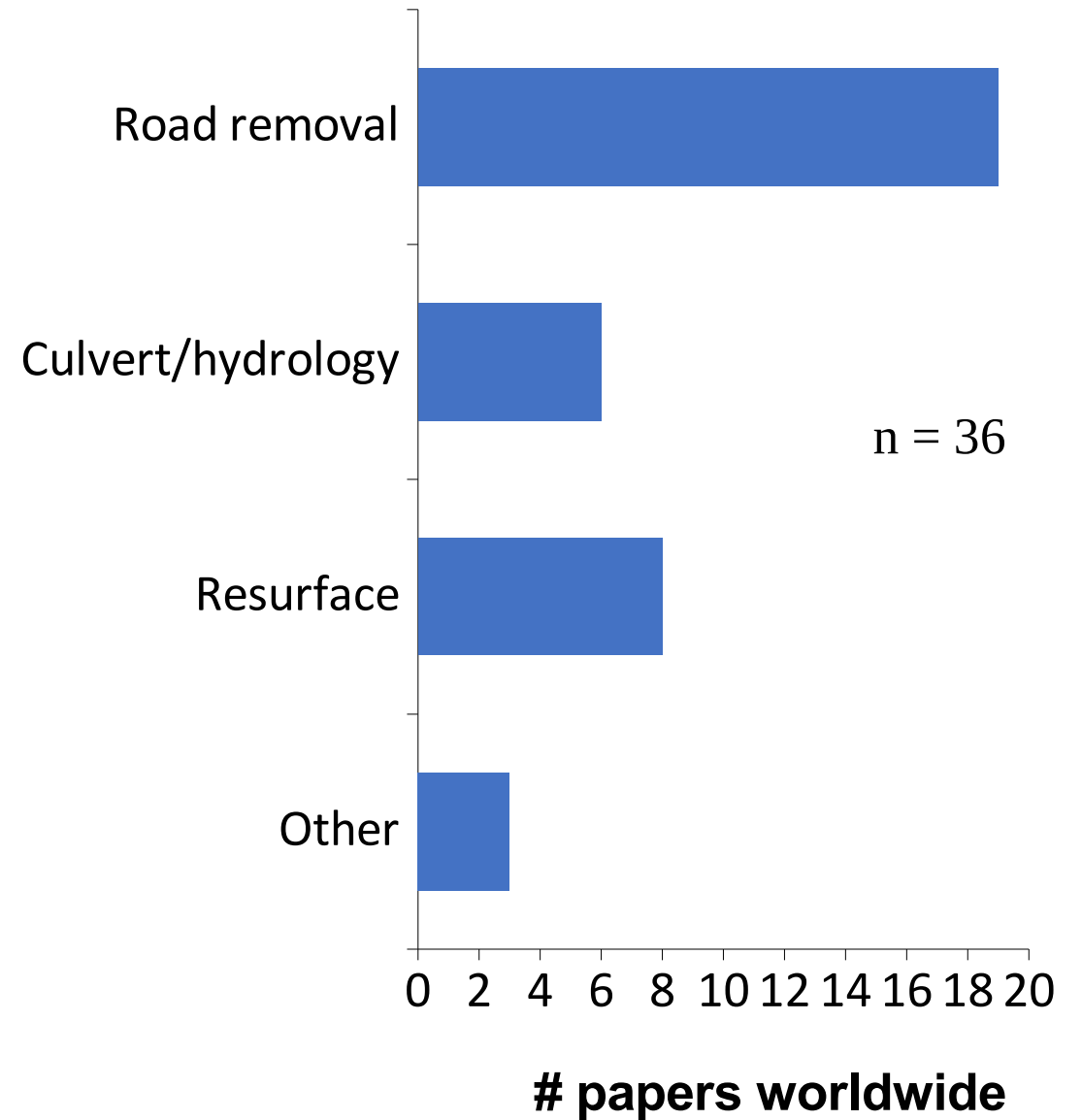
Barriers to Fish Passage



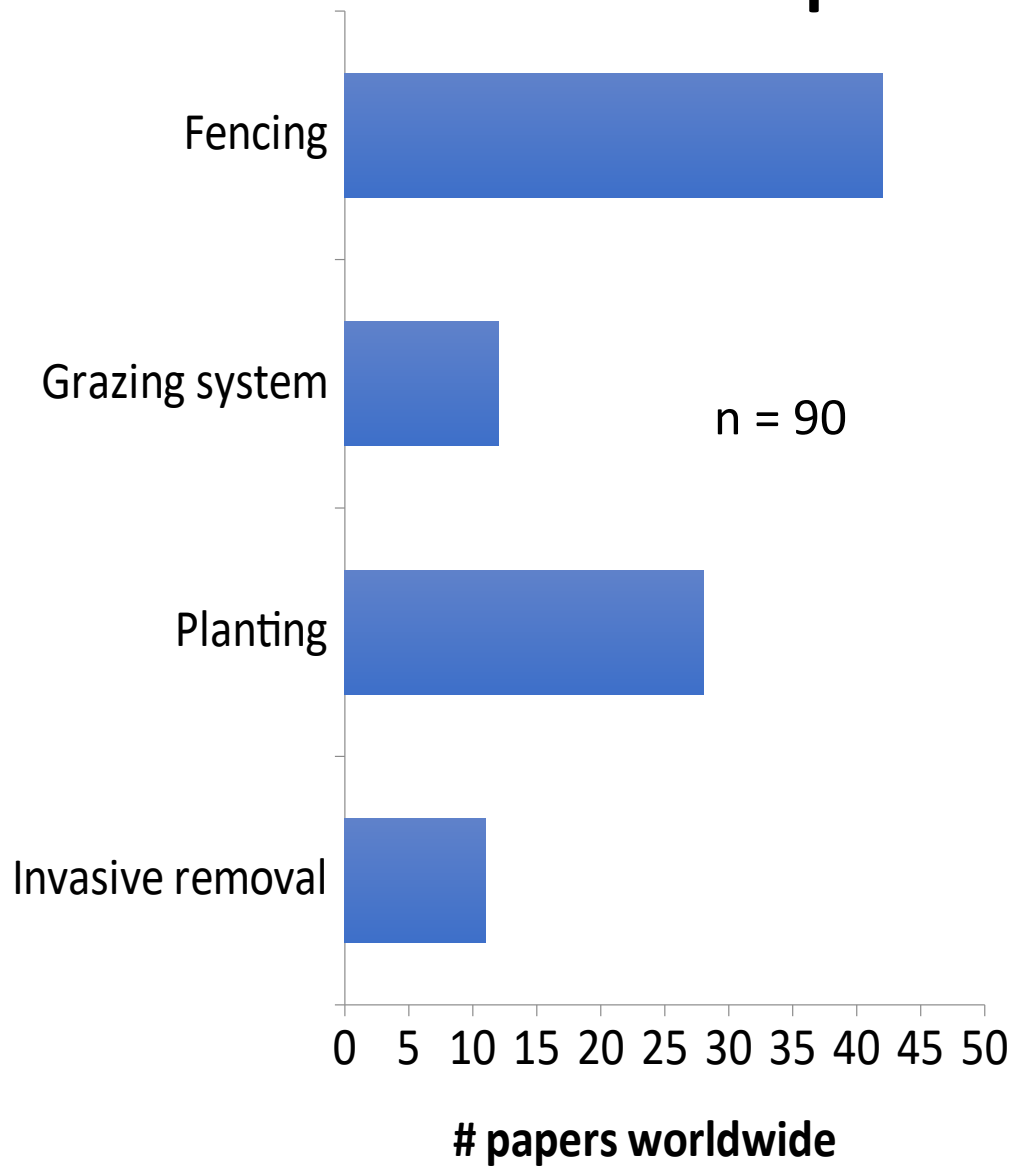
Sediment Reduction – Road Treatments



PCFWWRA, & PWA photos.

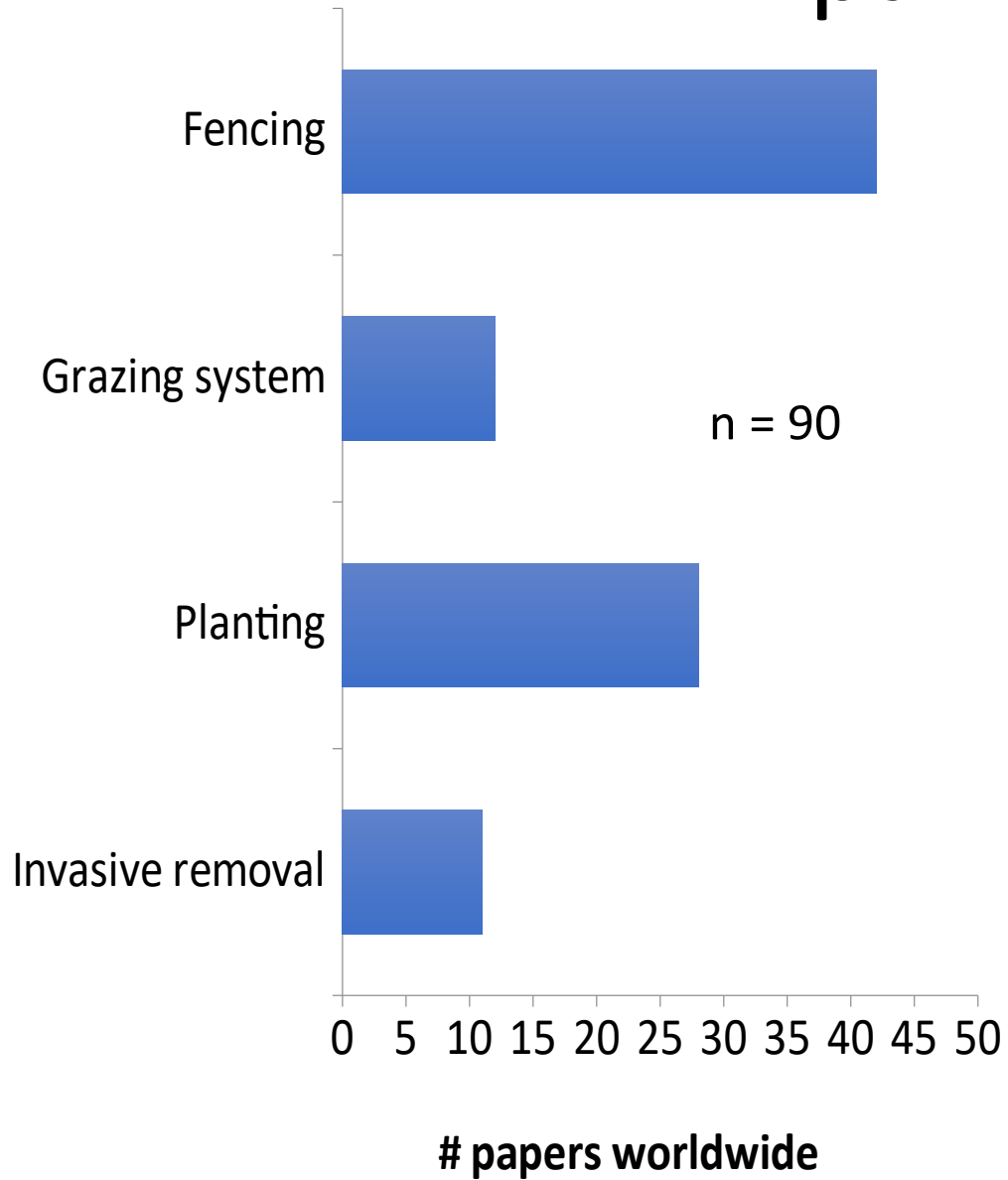


Riparian - Planting

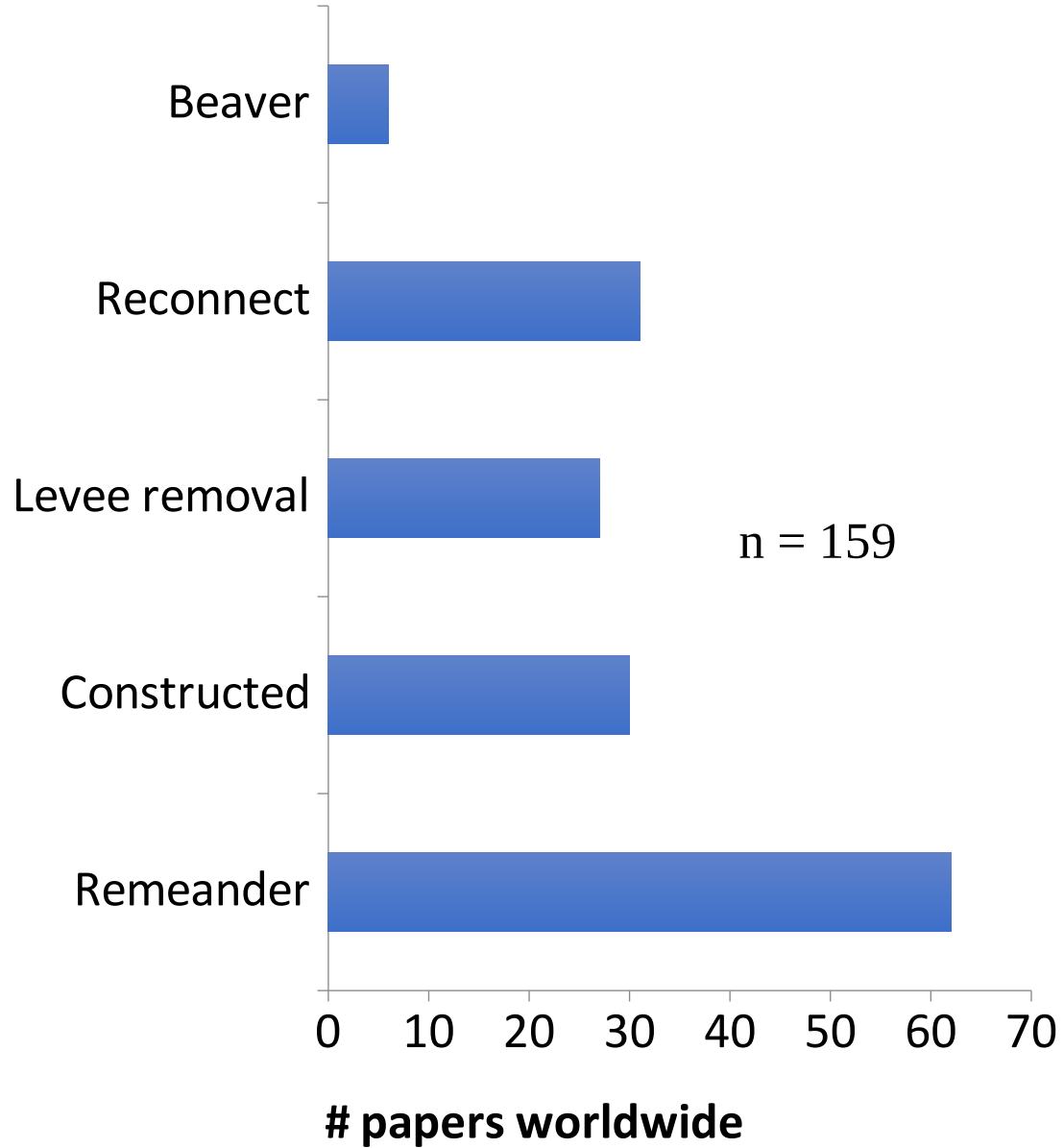


J. Hall NOAA photos

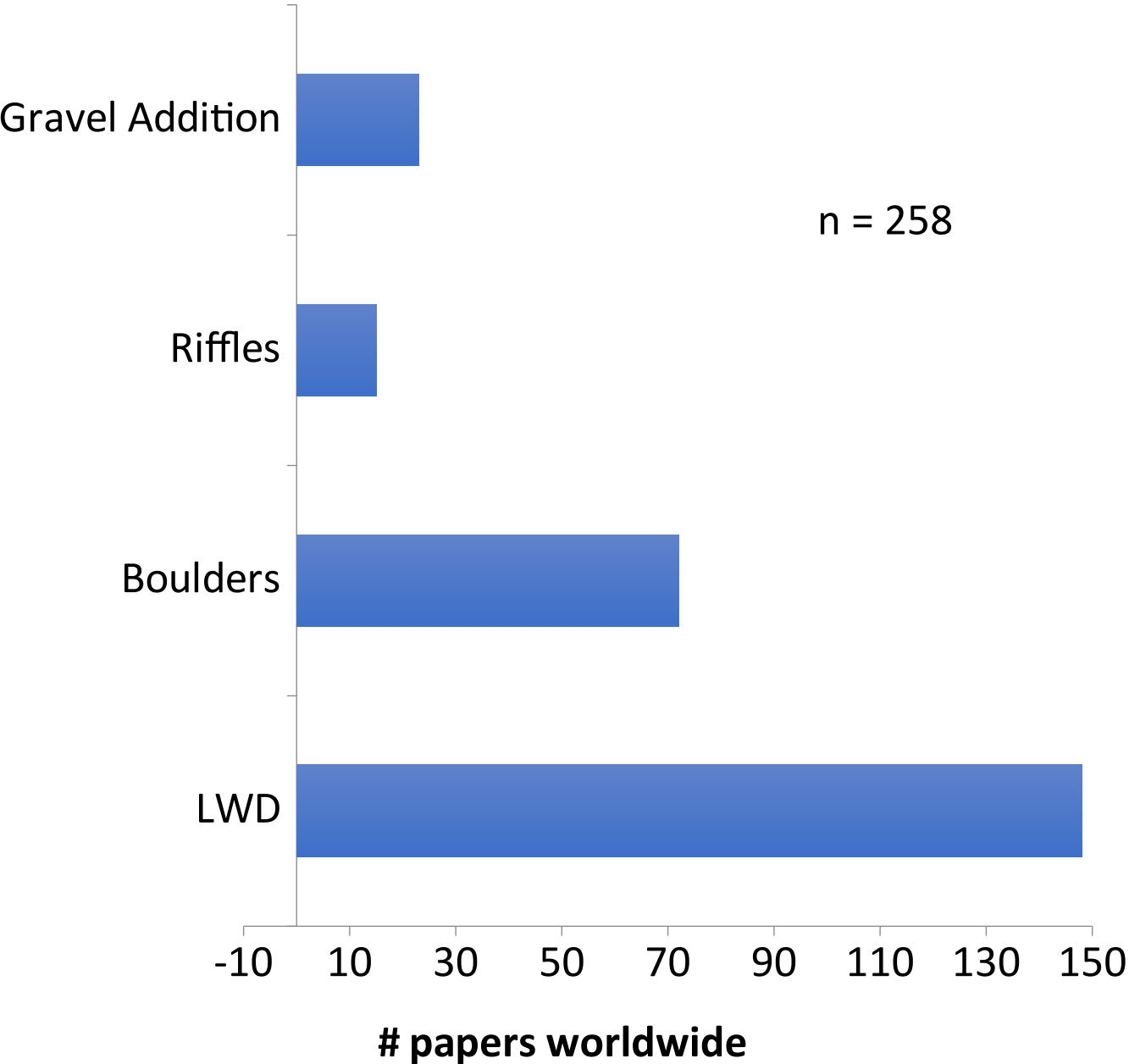
Riparian - Grazing



Floodplain Restoration



Instream Habitat Improvement



Instream Habitat Improvement

Physical and Biological Response

