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

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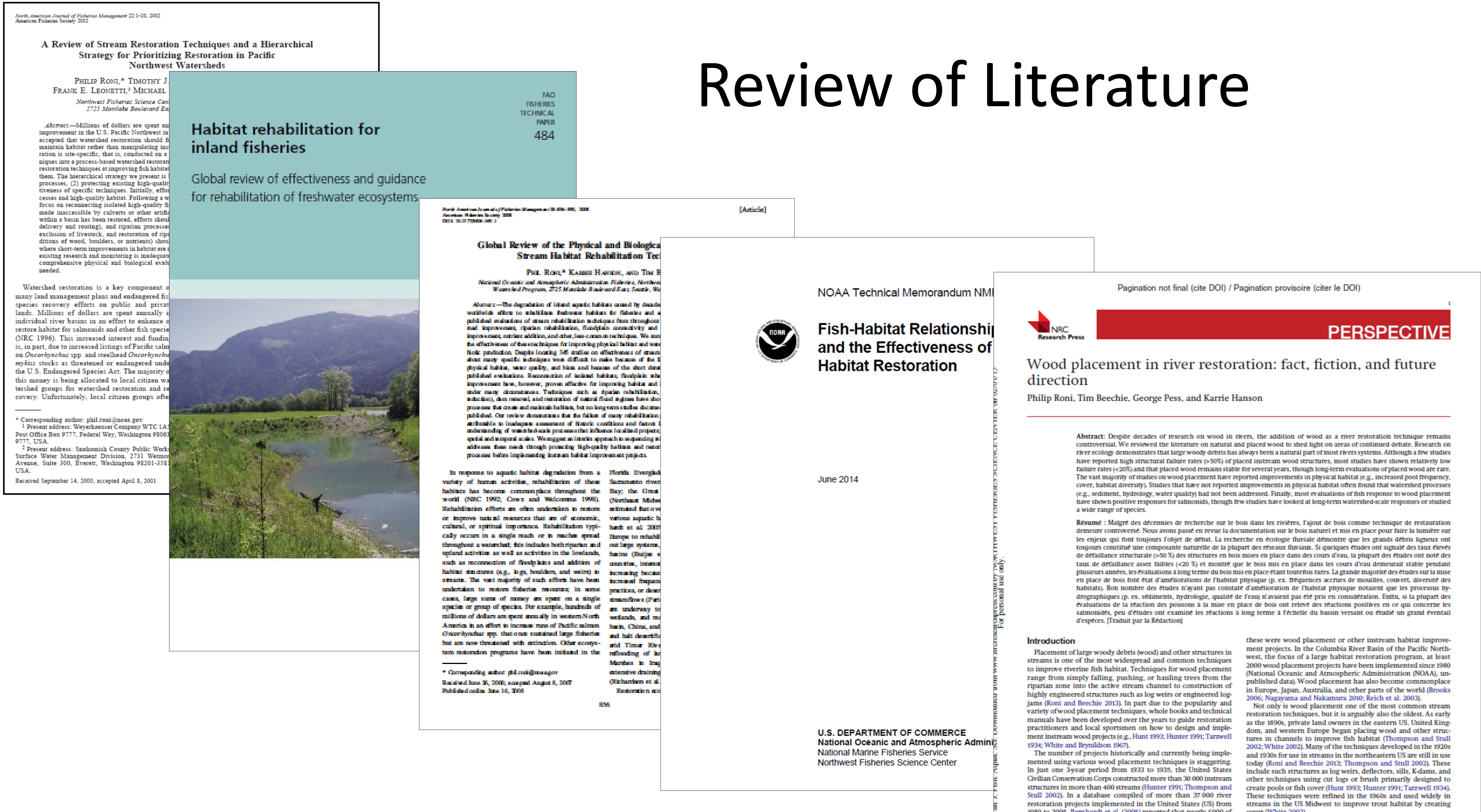
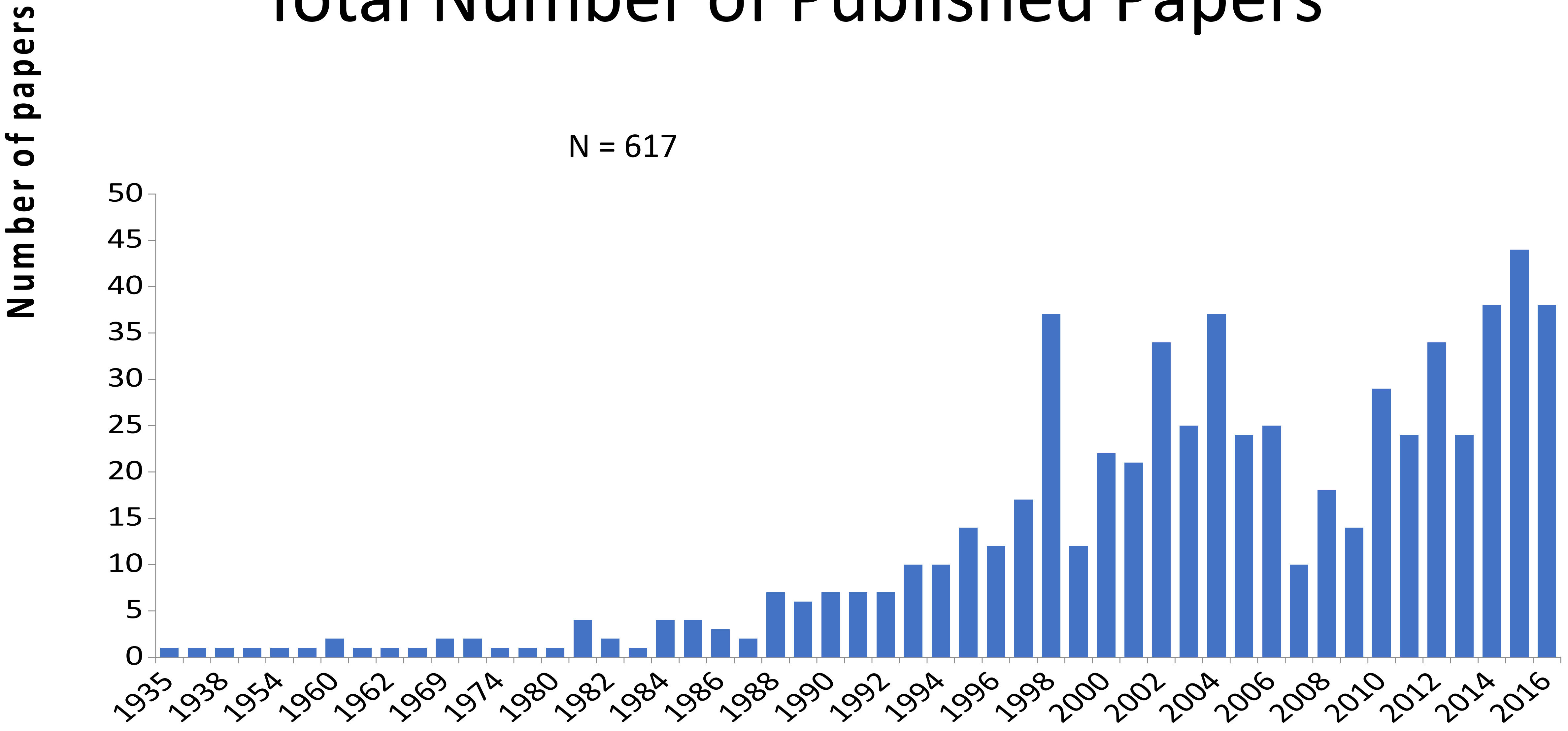
Review of Literature

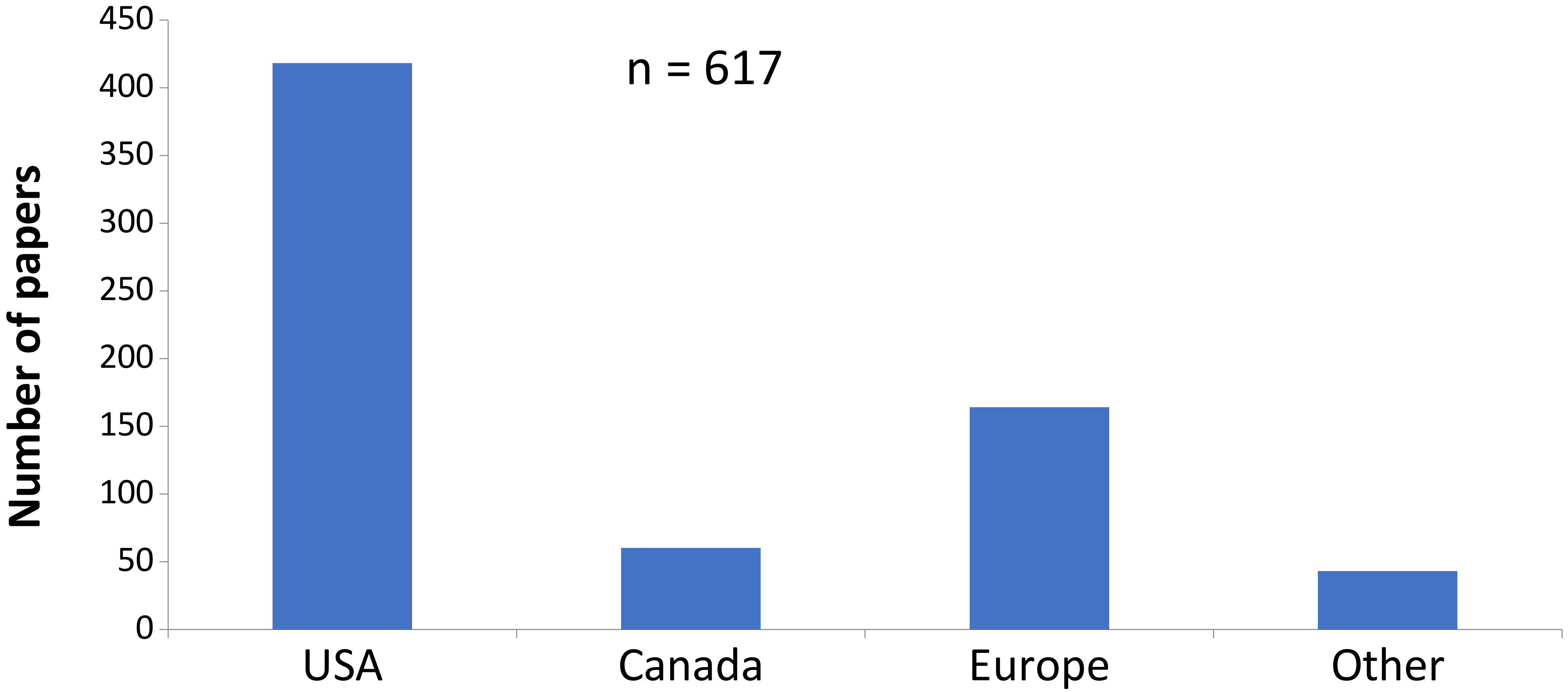


Total Number of Published Papers*



* Published papers and grey literature

Where are those paper from?



* 160 from BC, WA, OR or ID

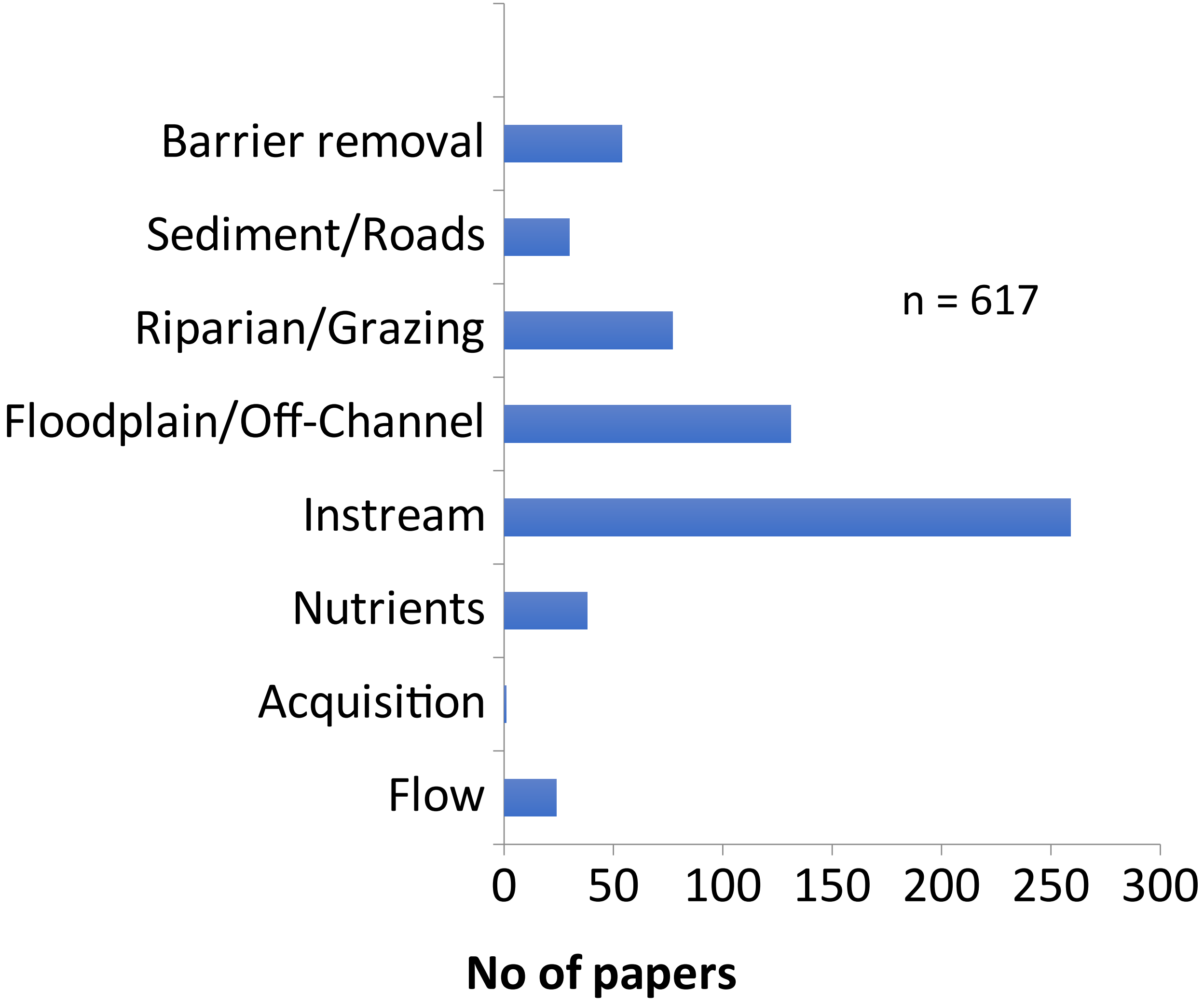
What I'll Cover Today

- Overview of each technique
  - What we know in general about effectiveness
  - Can they mitigate for flow reduction?

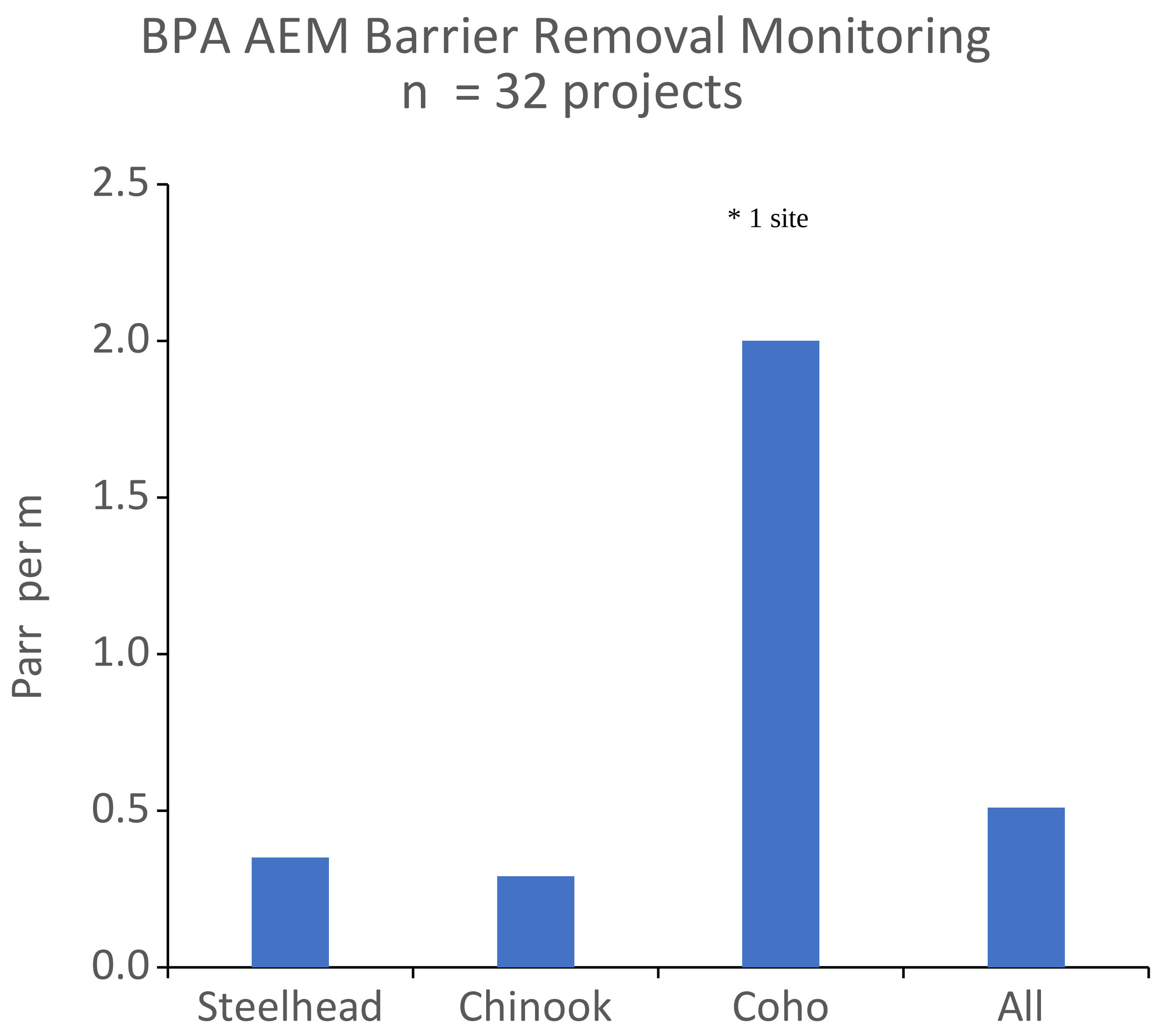
- Approaches to quantify benefit from restoration
  - Based on capacity
  - Restoration effectiveness

Habitat Restoration Techniques

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

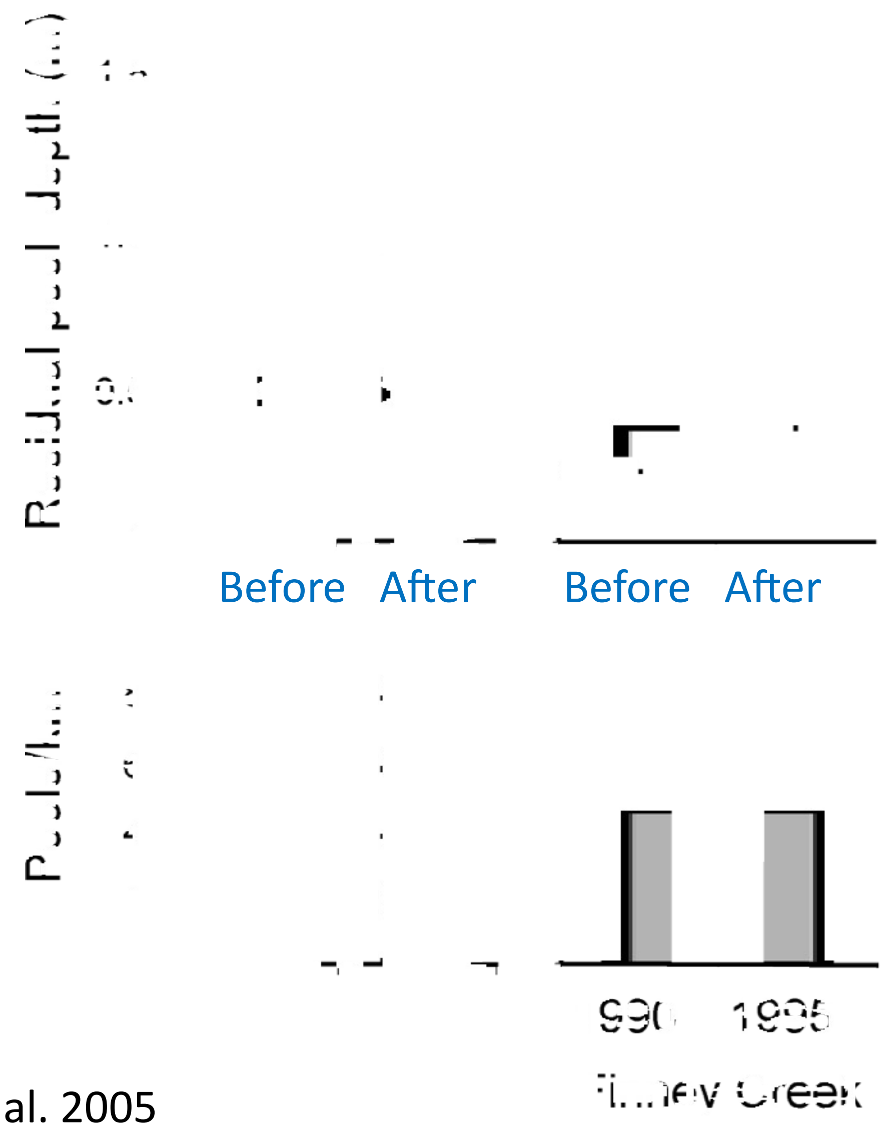


Barrier Removal – 60 Studies



- 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

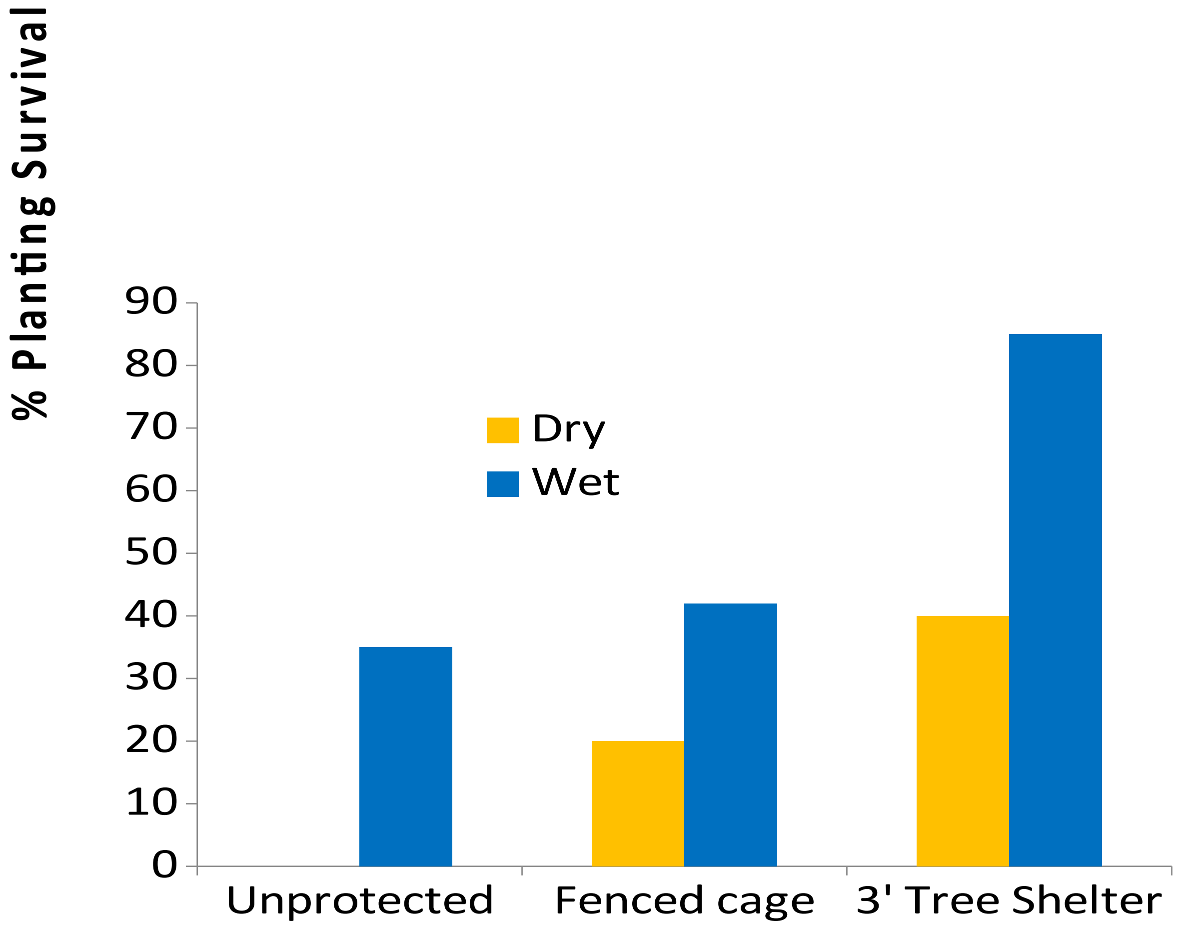
Sediment Reduction/Road Improvements – 36 Studies



Beechie et al. 2005

- 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

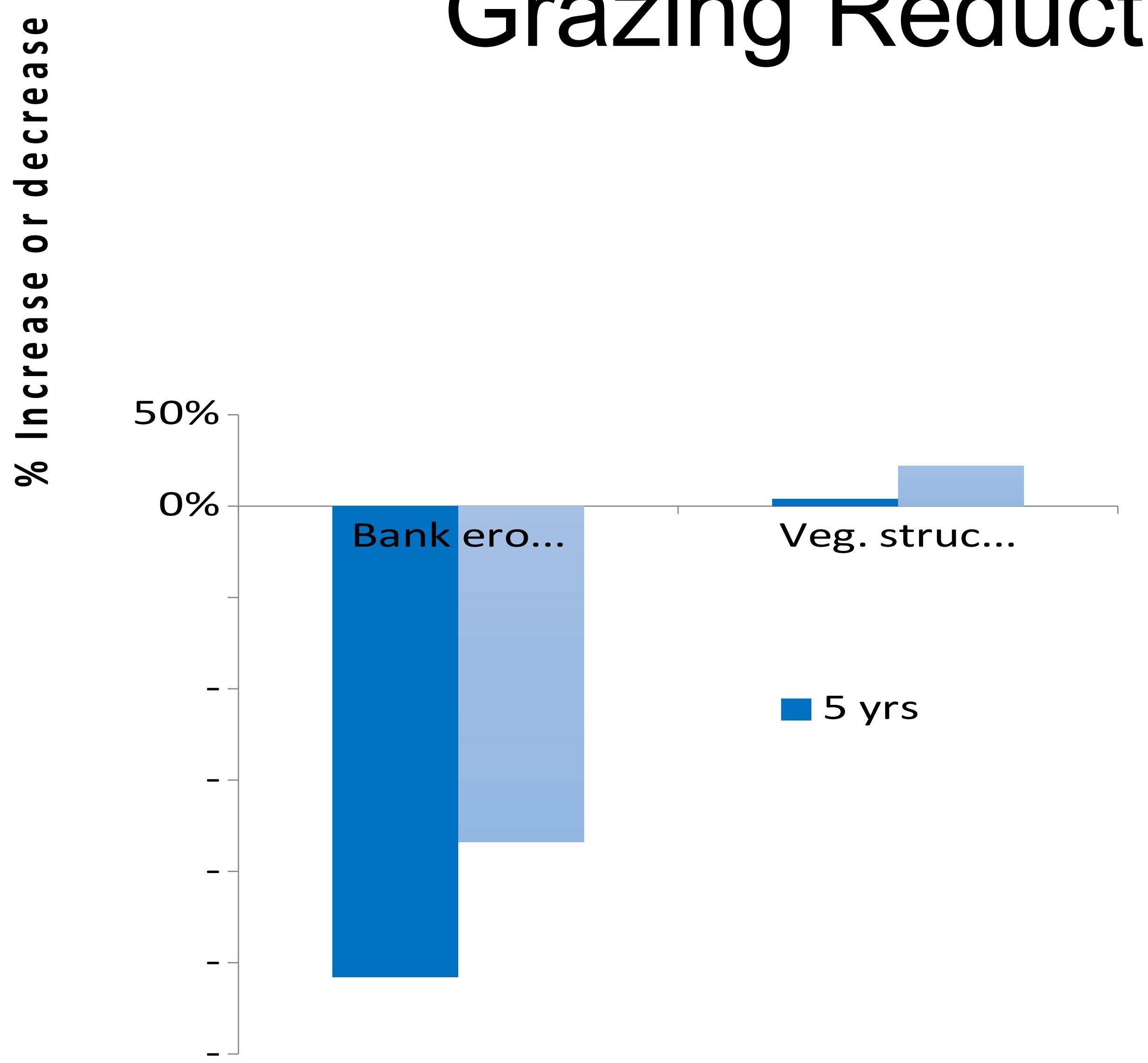
Riparian Planting – 39 Studies



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.)

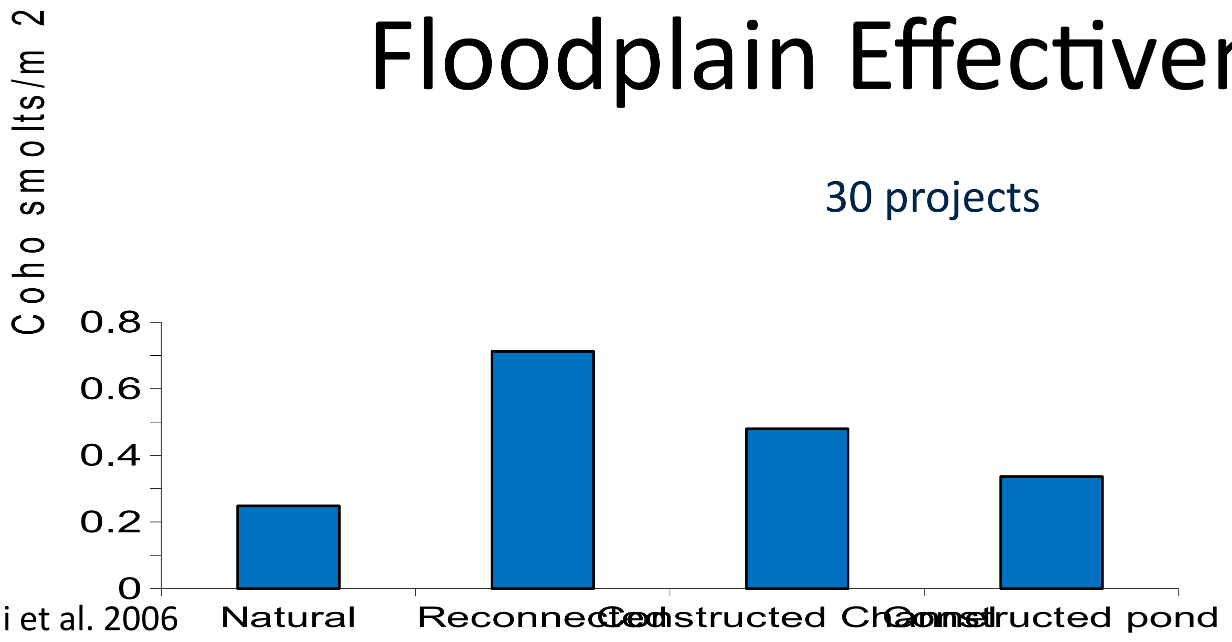
Grazing Reduction – 44 Studies



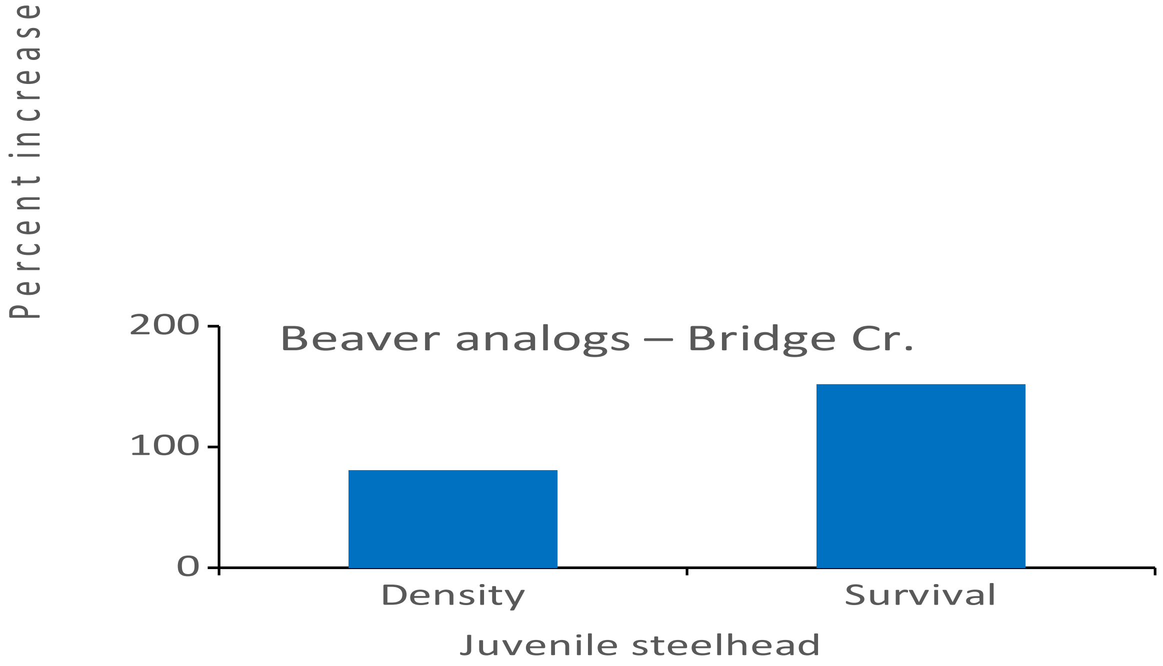
SRFB unpublished data

- 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



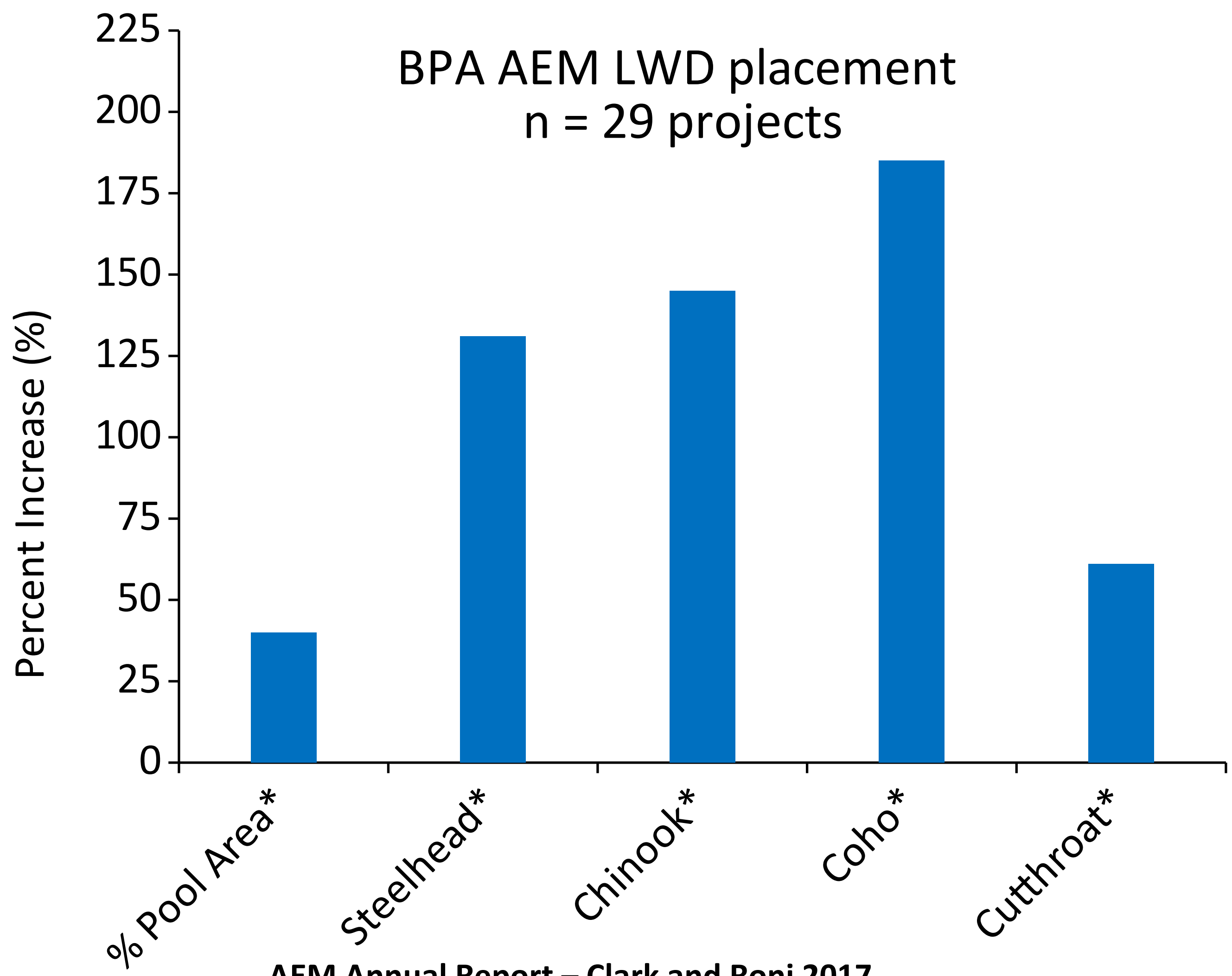
Roni et al. 2006



Bouwes et al 2016

- 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

Roni et al. 2013

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)

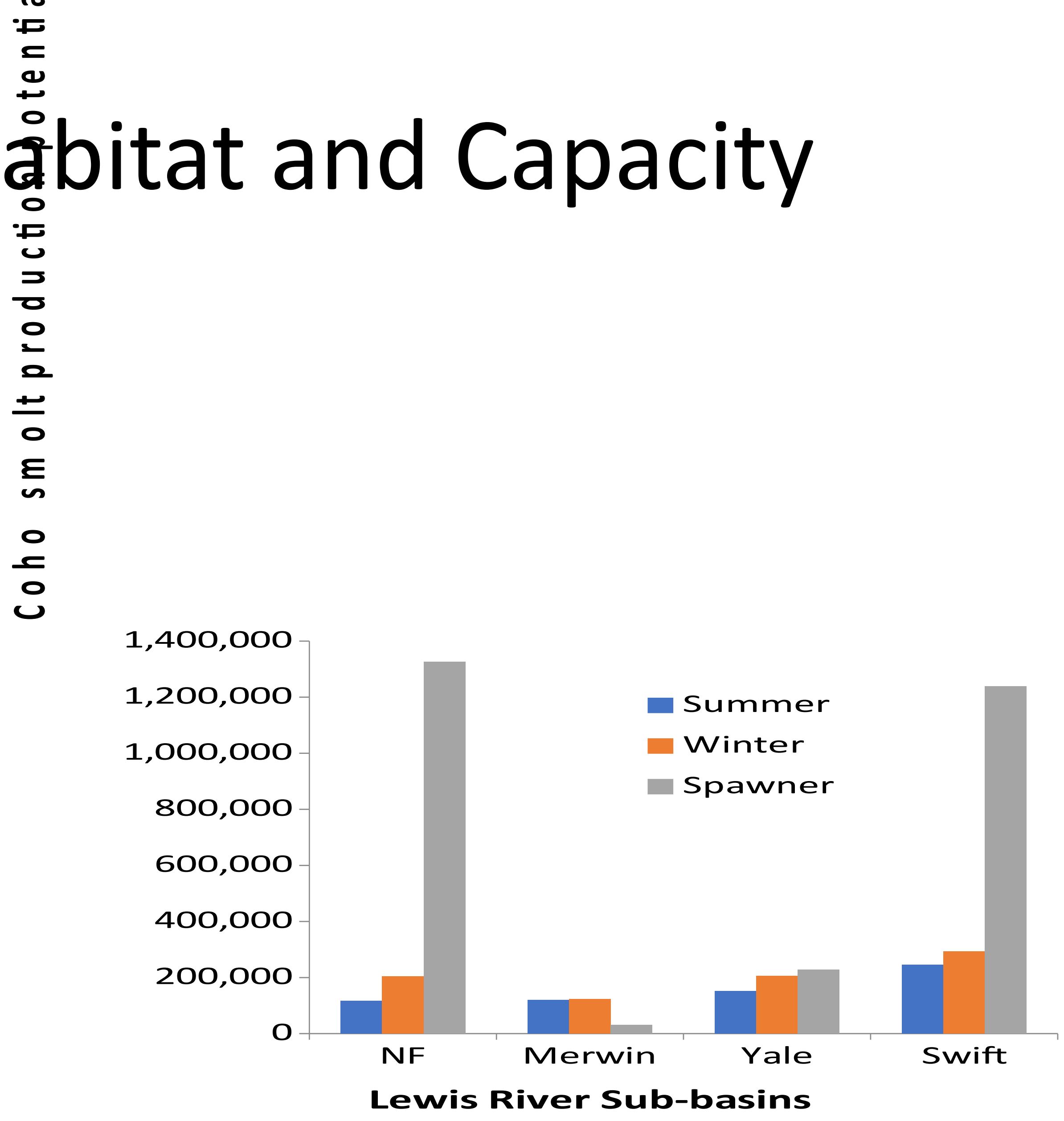
=

Mean Increase in Parr or Smolts

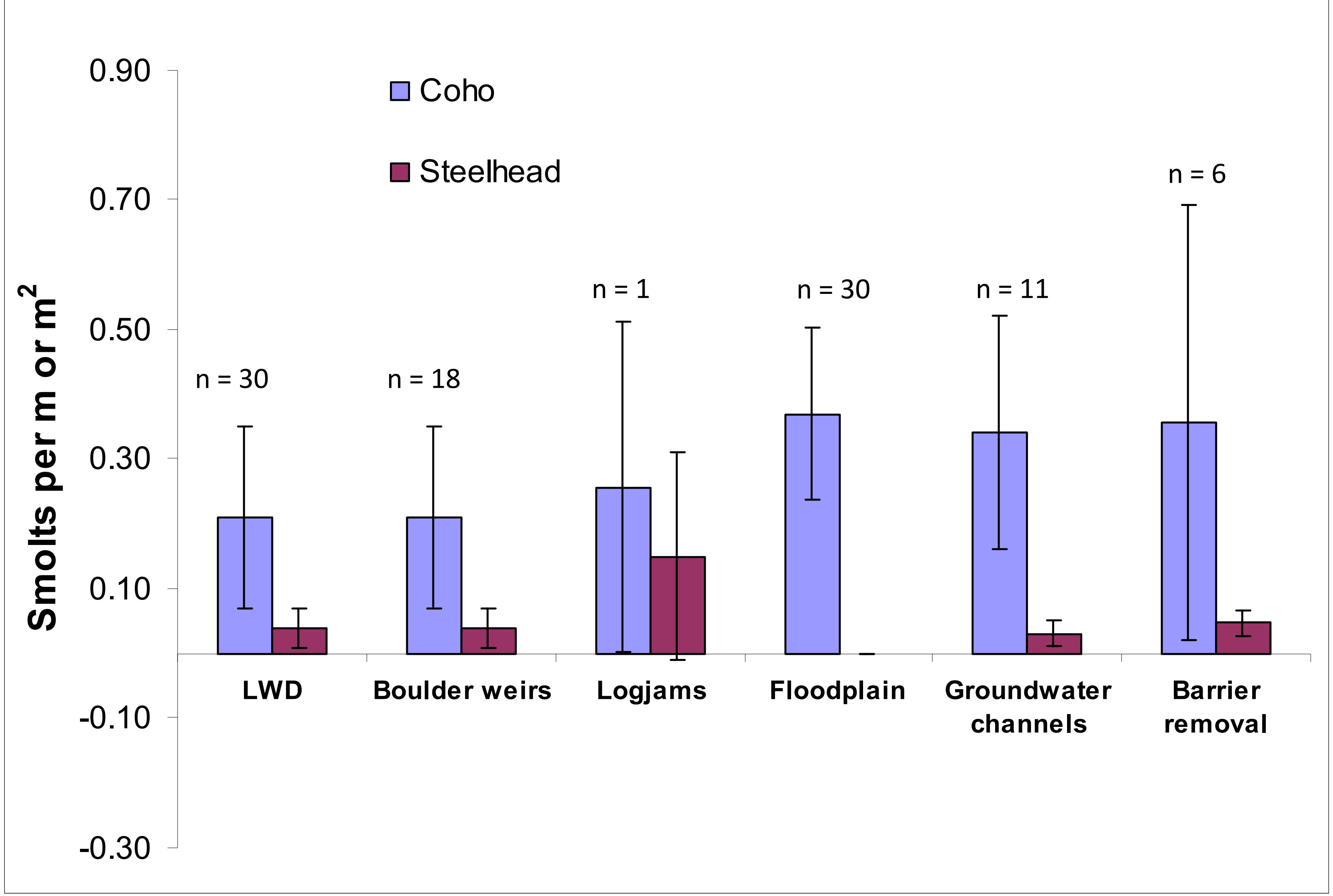
* Other methods include more complex life cycle models

Based on Available Habitat and Capacity

	Smolt Production Potential (fish/m²)		
Habitat Type	Coho	Steelhead	Spring Chinook
Side channel			
Summer	0.32	0.05	0.11
Winter	0.78	0.19	NA
Tributaries			
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.
Mainstem			
Summer		0.01	0.02
Winter		0.01	
Pond/Lake			
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
Spawning habitat			
Spawning habitat	60.00	8.08	52.40



Increase in smolts by project type



Roni et al. 2010. NAJFM

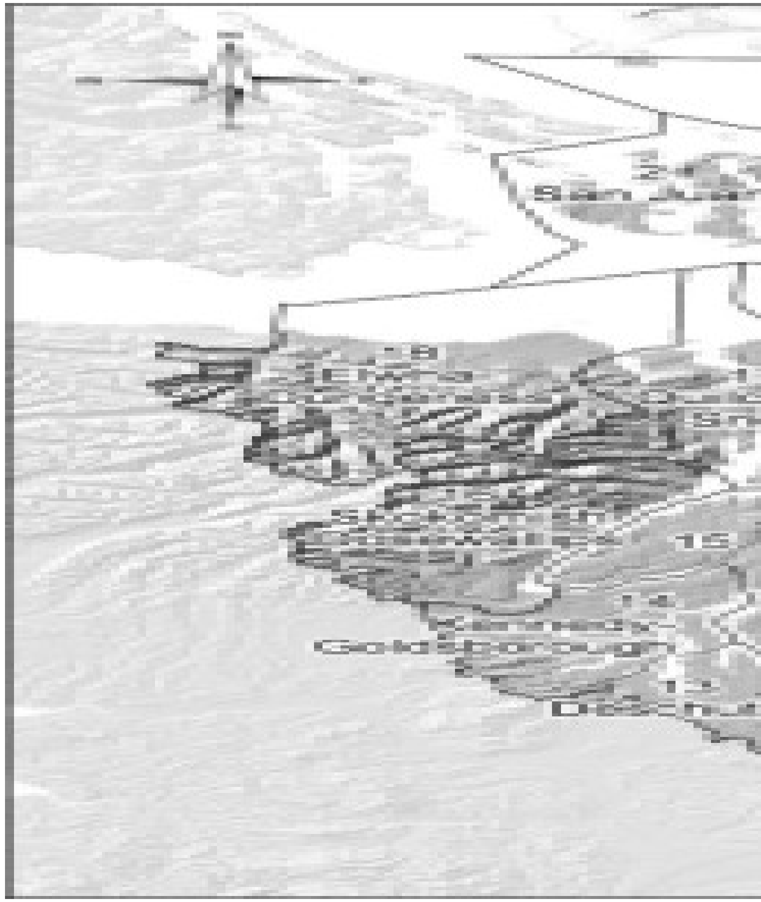
Restoration Actions Applied to Watershed

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

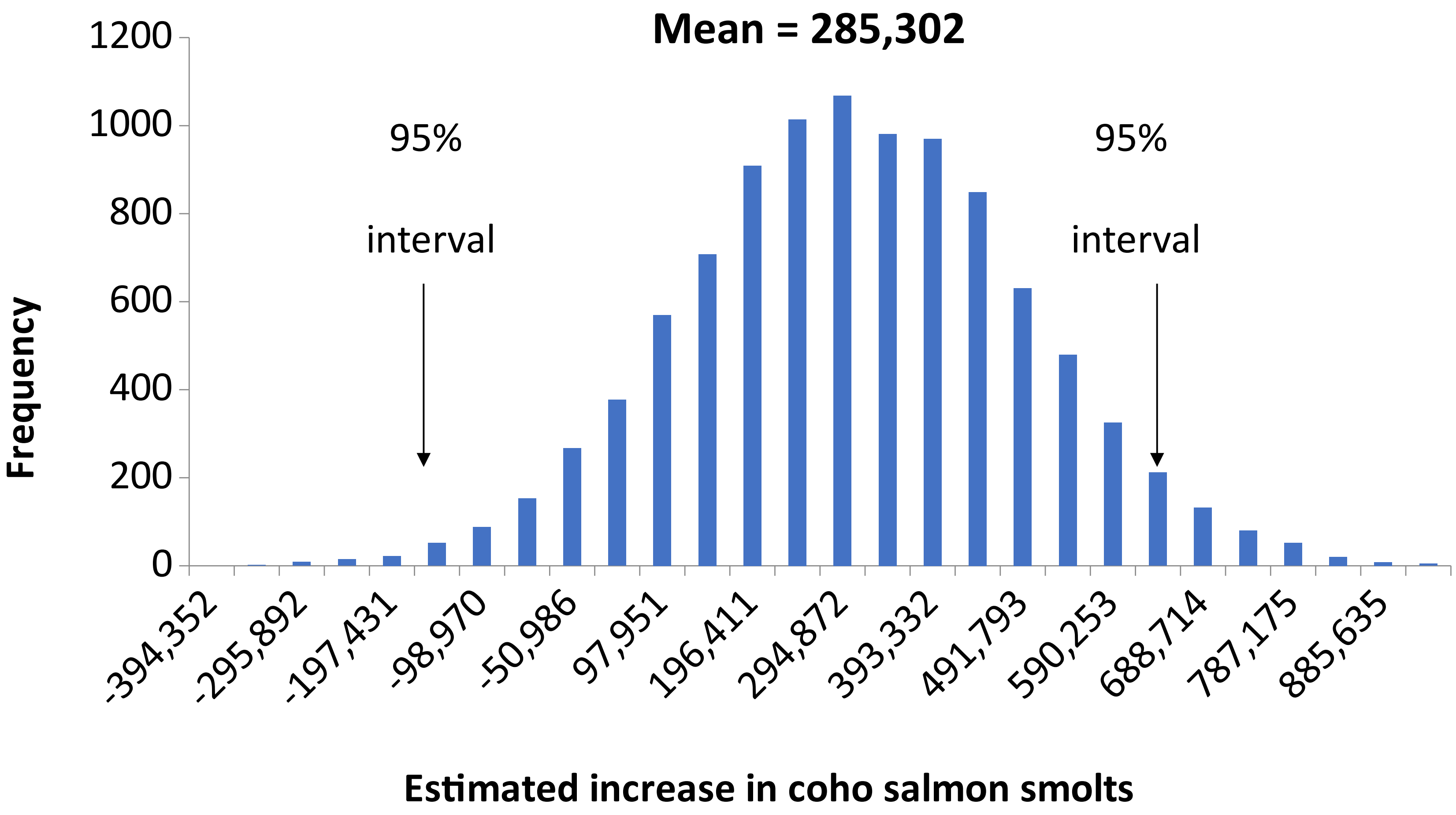
Typical Puget Sound Watershed

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



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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

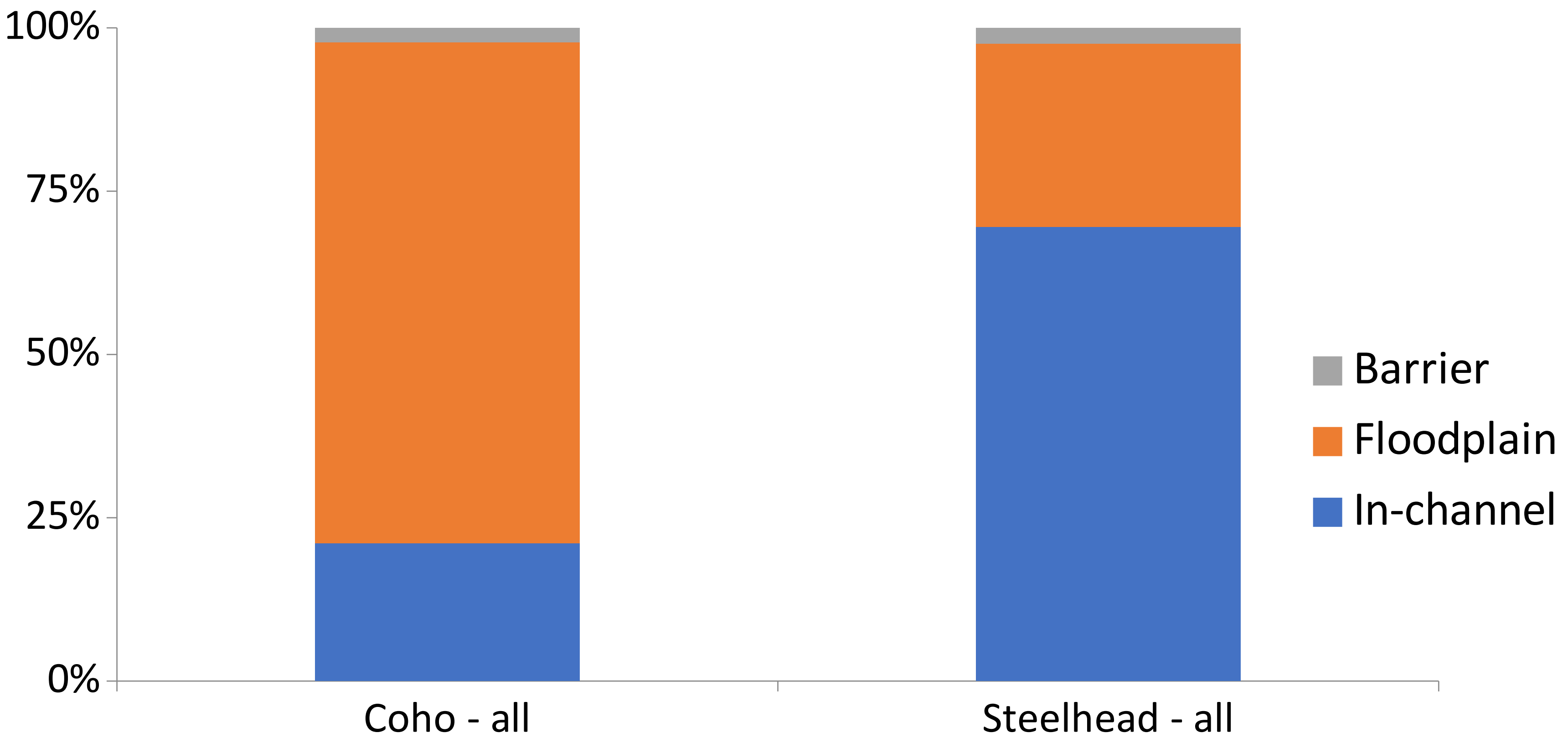
- There are few basic approaches that have been used to determine fish response to restoration which may be useful for estimating net ecological benefit of offset projects

Questions?

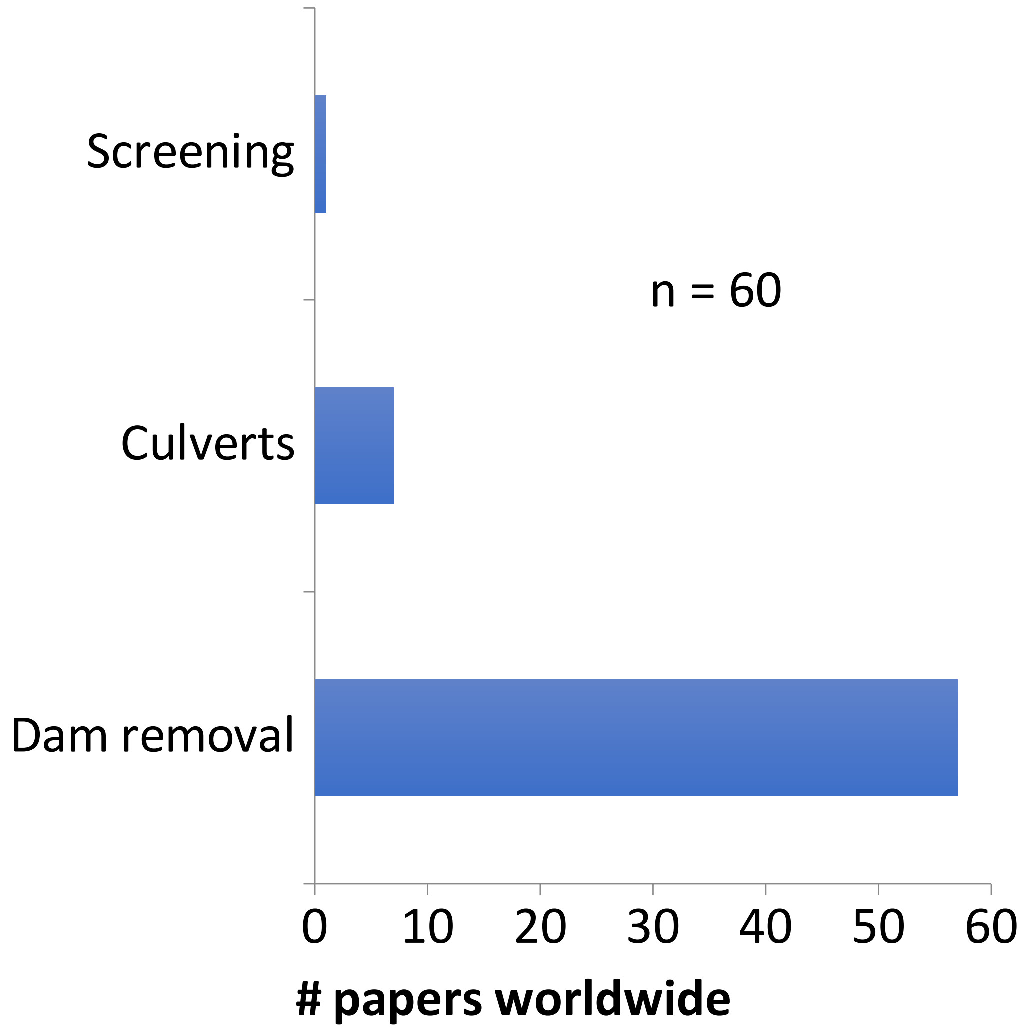
Summary of Restoration Techniques and Ability to Mitigate for Flow

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

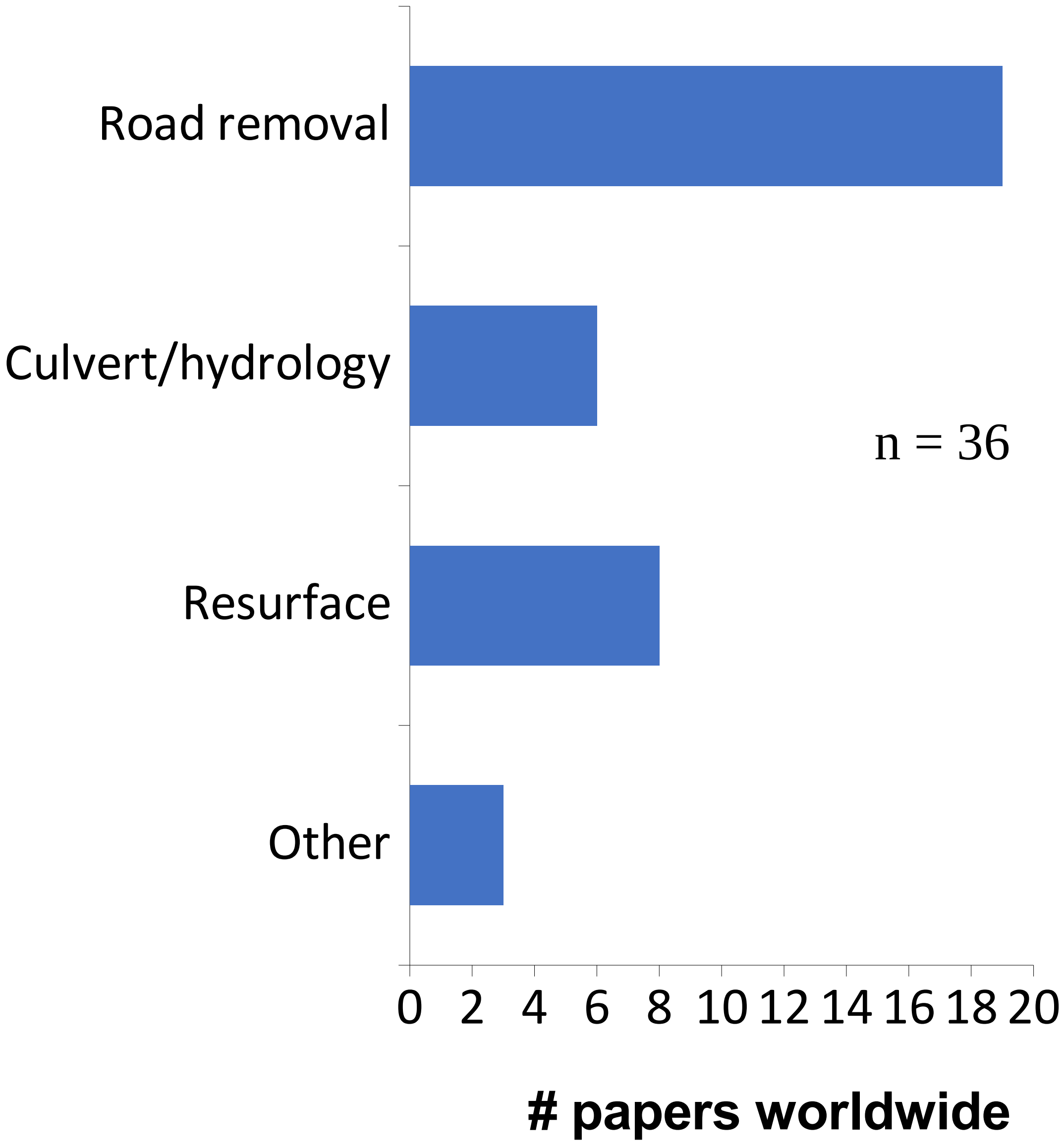


Barriers to Fish Passage

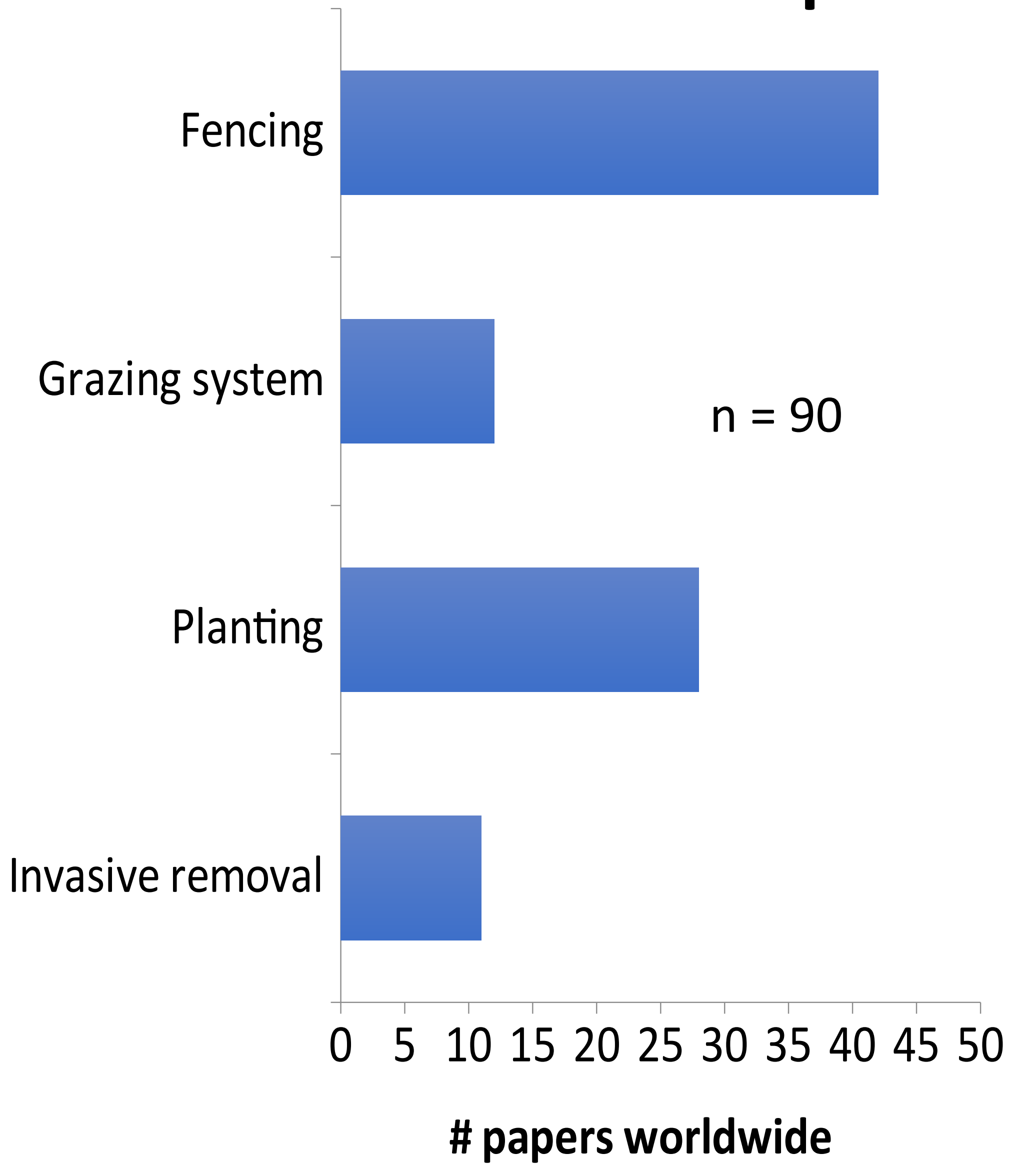


Sediment Reduction – Road Treatments

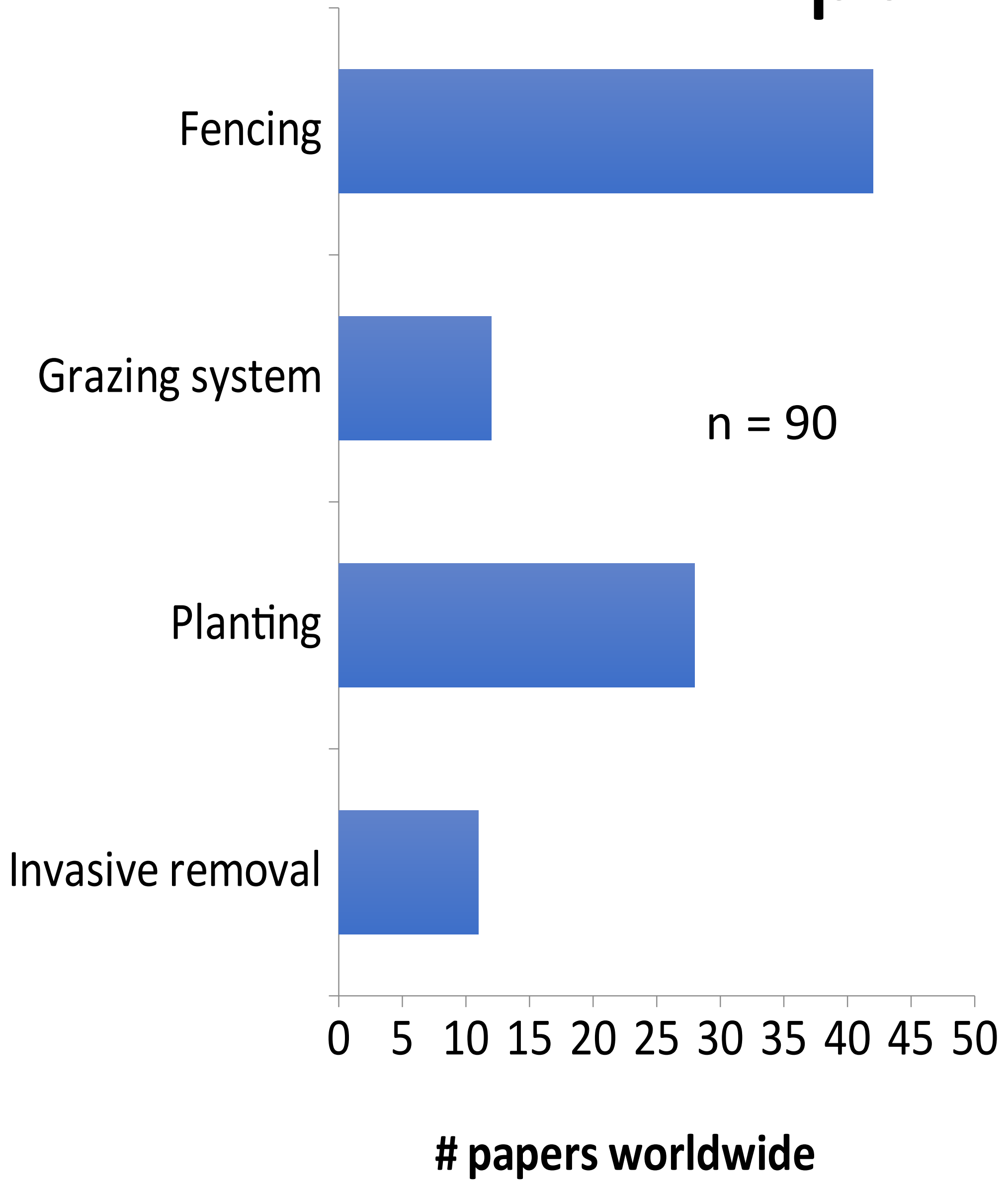
PCFWWRA, & PWA photos.

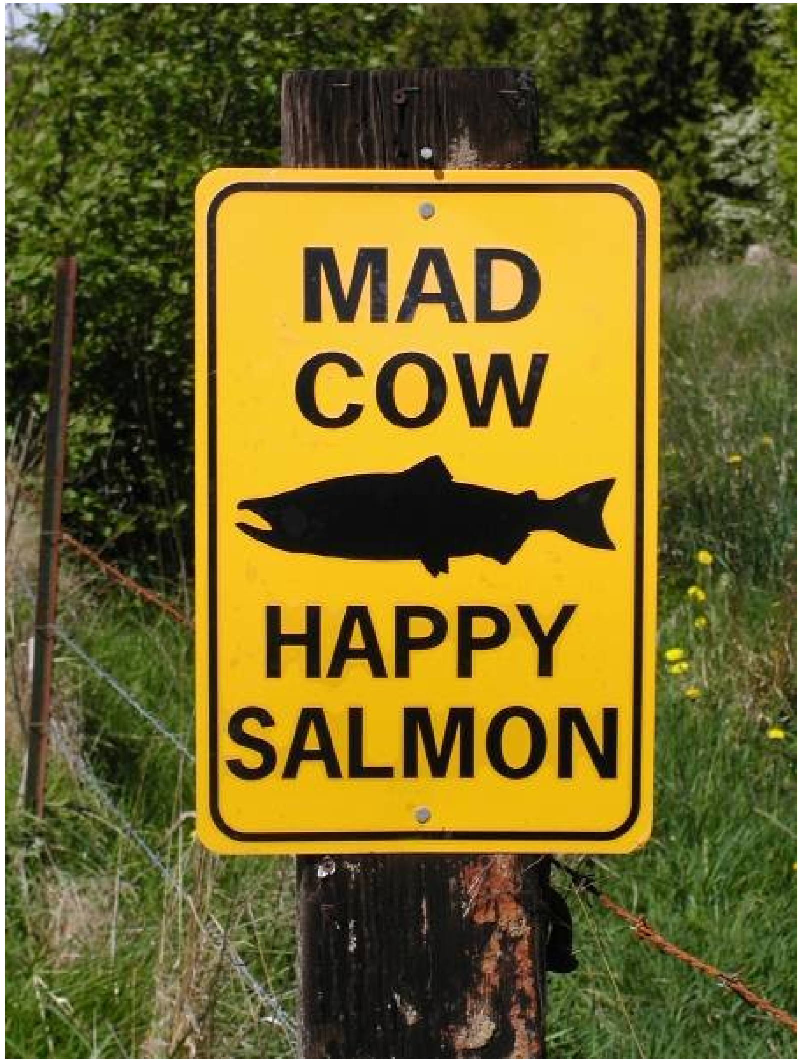


Riparian - Planting

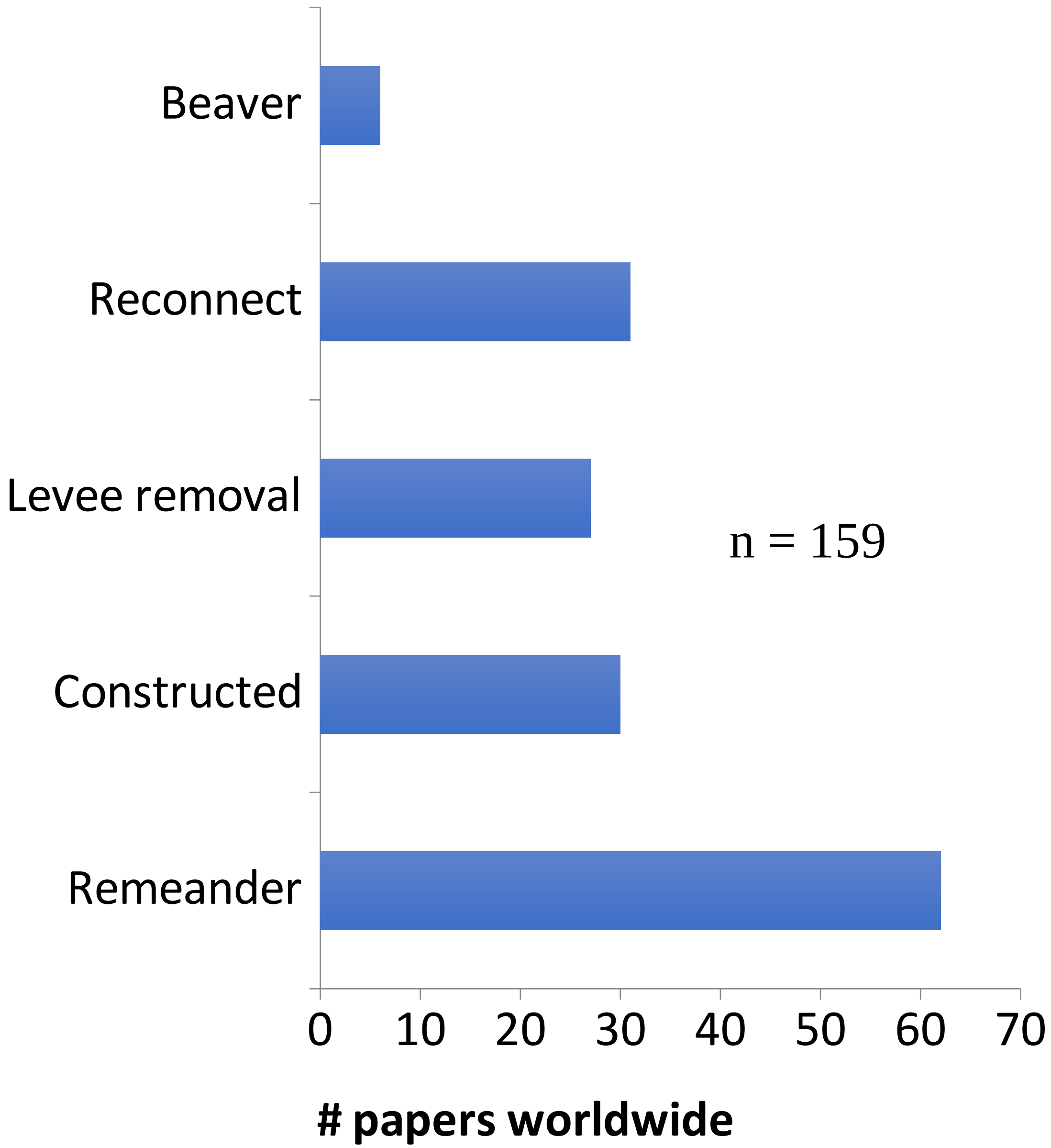


Riparian - Grazing





Floodplain Restoration



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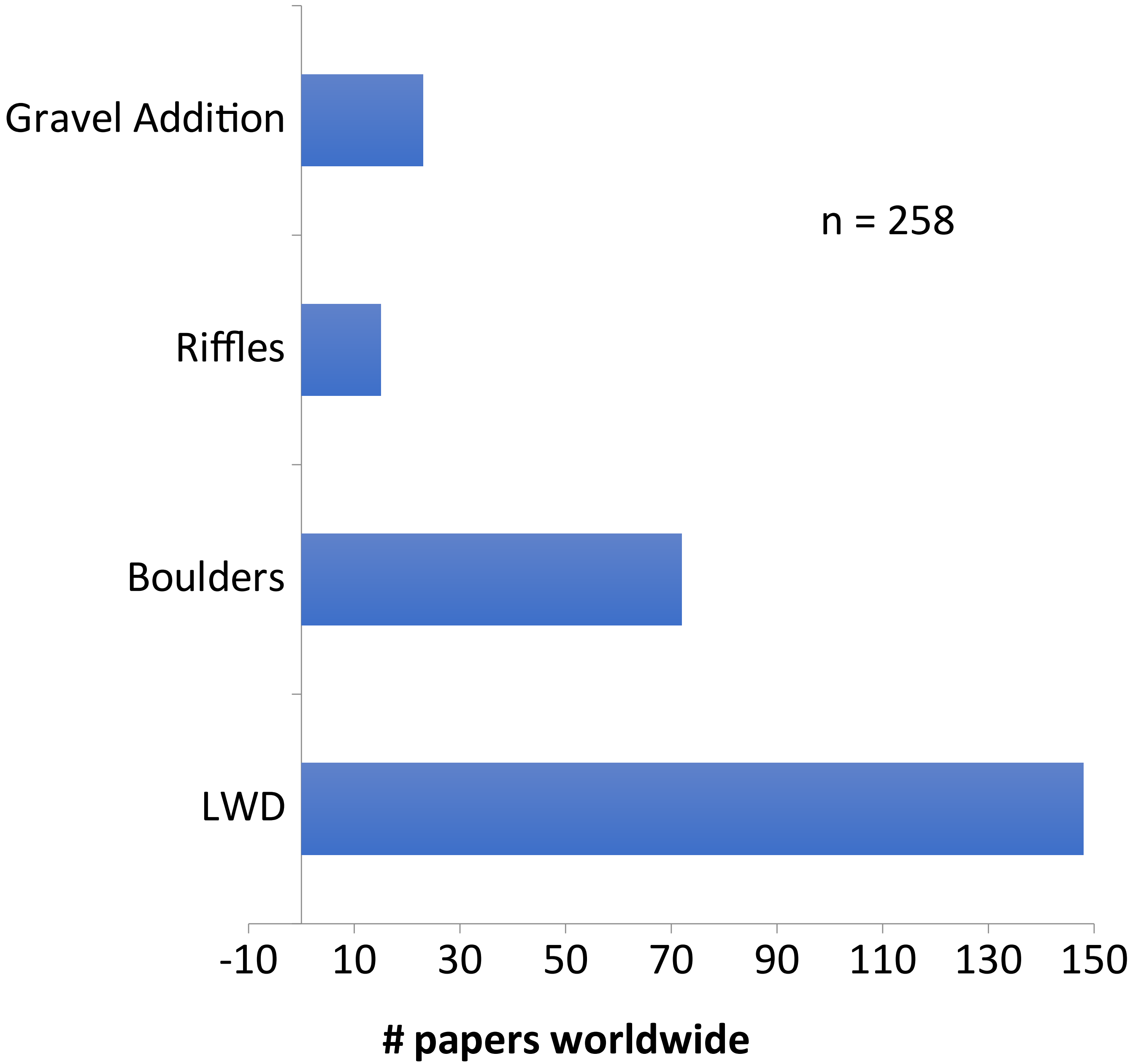
Instream Habitat Improvement



Instream Habitat Improvement
Physical and Biological Response