

Evolving Science and Policy to Restore Streams Using Instream Obstructions and Beaver Dam Analogues

A Workshop at the 34th Annual Salmonid Restoration Conference held in Fortuna, CA from April 6-9, 2016.



Session Overview

- Session Coordinator:
 - Eli Asarian, Riverbend Sciences

Instream structures such as beaver dams, wood jams, living vegetation, and other obstacles that slow the downstream movement of water and sediment are essential to the restoration of streams. These obstructions can be used to accelerate the development of "stage zero" channels (Cluer and Thorne 2013) which are increasingly recognized as having intrinsic high value because of the multiple and synergistic ecosystem goods and services that such systems provide. Stage zero channels have well connected floodplains with elevated water tables, spatially variable hydrologic regimes and structurally complex aquatic and riparian habitat. As such, they provide incredibly valuable habitat for a suite of terrestrial and aquatic taxa, including several Pacific salmon species that are in decline.

This workshop will provide a state-of-the science overview of recent innovations in the construction of instream obstructions in California and their use in stream restoration, particularly for building stage zero fluvial ecosystems. Following the presentations there will be in-depth group discussions about how restorationists and permitting agencies can move forward together to improve the process for permitting innovative and adaptive restoration projects in California.



Presentations

(Slide 5) Streams evolve and habitat and ecosystem benefits accrue Brian Cluer, Ph.D. NOAA Fisheries

(Slide 70) Using Ecologically Functional Dams and other Instream Obstructions to Restore Complex Fluvial Ecosystems Michael Pollock, Ph.D. NOAA Fisheries

(Presentation not included) Post Assisted Woody Structures: Implementing California's First Beaver Dam Analogues
Betsy Stapleton, Scott River Watershed Council

(Slide 117) A Demonstration of the Carbon Sequestration and Biodiversity Benefits of Beaver and Beaver Dam Analogue Restoration Techniques in Childs Meadow, Tehama County CA Sarah Yarnell, UC Davis

(Presentation not included) Fish Passage at Natural and Constructed Channel Spanning Obstructions: Preliminary Observations from Klamath Basin Tributaries Rocco Fiori, Fiori Geosciences

(Presentation not included) Beaver Restoration in the Sierra Nevada: U.S. Fish and Wildlife Service Applications
Damion Ciotti, U.S. Fish and Wildlife Service



Presentations

(Slide 130) The Beaver Restoration Guidebook: Are Beavers Too Good to be True for Stream Restoration?

Gregory Lewallen, Portland State University

(Slide 158) How to Streamline Permitting of Restoration Projects that Makes Streams less Streamlined

Gordon Leppig, California Department of Fish and Wildlife

(Presentation not included) Regulatory Challenges to Restoring Complex Fluvial Ecosystems in California
Michael Pollock, Ph.D., NOAA Fisheries

(Presentation not included) Panel Discussion on Improving the Restoration Permitting Process, all presenters

Streams Evolve, and Habitat and Ecosystem Benefits Accrue

Brian Cluer, NOAA-NMFS, West Coast Region – Santa Rosa CA Michael Pollock, NOAA NWFSC Seattle WA Colin Thorne, Univ. of Nottingham UK



Outline:

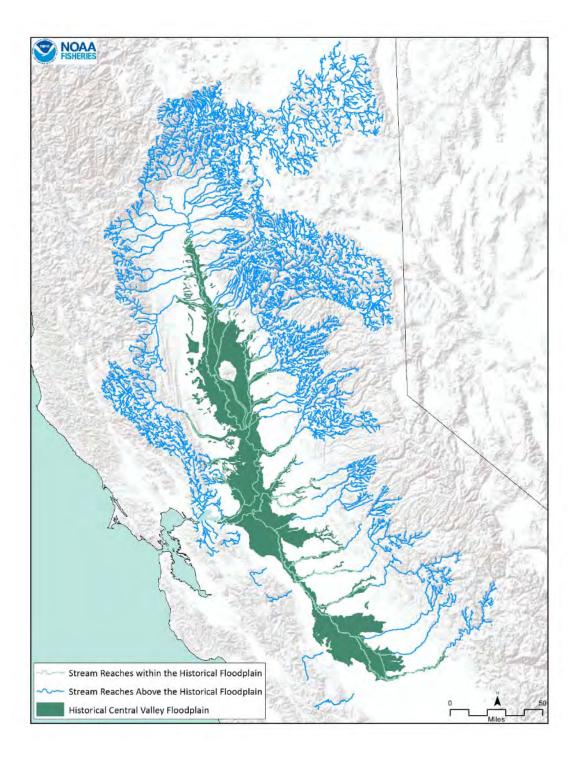
- History of land & water development
 - Scale of impacts to habitat and ecosystem
- SEM overview, linking habitat to processes
 - Applying the SEM to your watershed
- Implications
 - Functional restoration, standard practices
- Conclusions
 - Many stable forms, we have choices
- Recommendations
- Q and A

Historic Habitat

Conditions that existed before human modifications represent an integration over centuries or longer the physical processes and disturbance histories of that place. An historic understanding is therefore a valid perspective even though we do not understand all of the processes that shaped that system

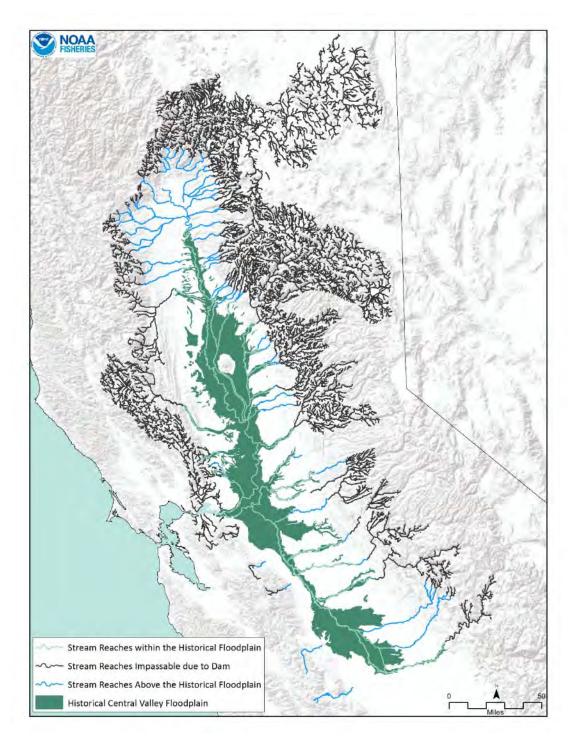
Data from the SWFSC IP model (streams)

The Bay Institute "From the Sierra to the Sea -The Ecological History of the San Francisco Bay Delta Watershed" 1998 (floodplain)

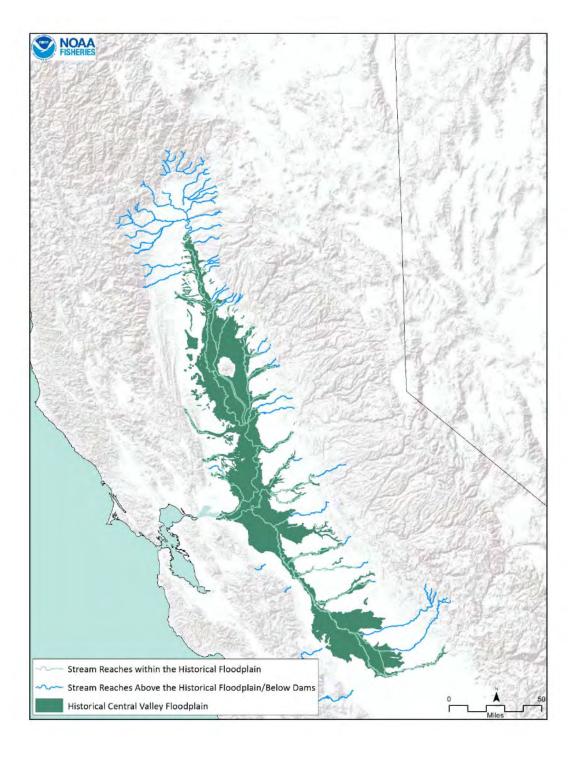


Historical Central Valley with Intact Floodplain and Streams

Rim Dams



Historical Central Valley with Intact Floodplain and identification of Stream Reaches blocked by dams



Historical Central Valley with Intact Floodplain and identification of Stream Reaches currently accessible

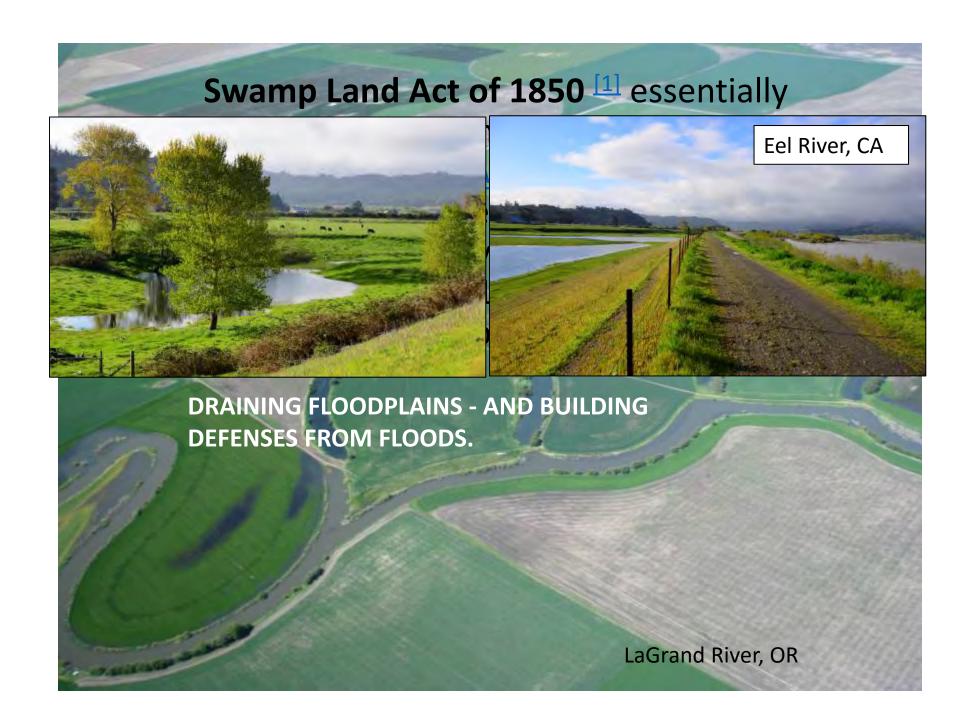
FLOODPLAINS History and Development

For 1-2 centuries in US and several more centuries in Europe there has been an all-out effort to maximize agricultural land



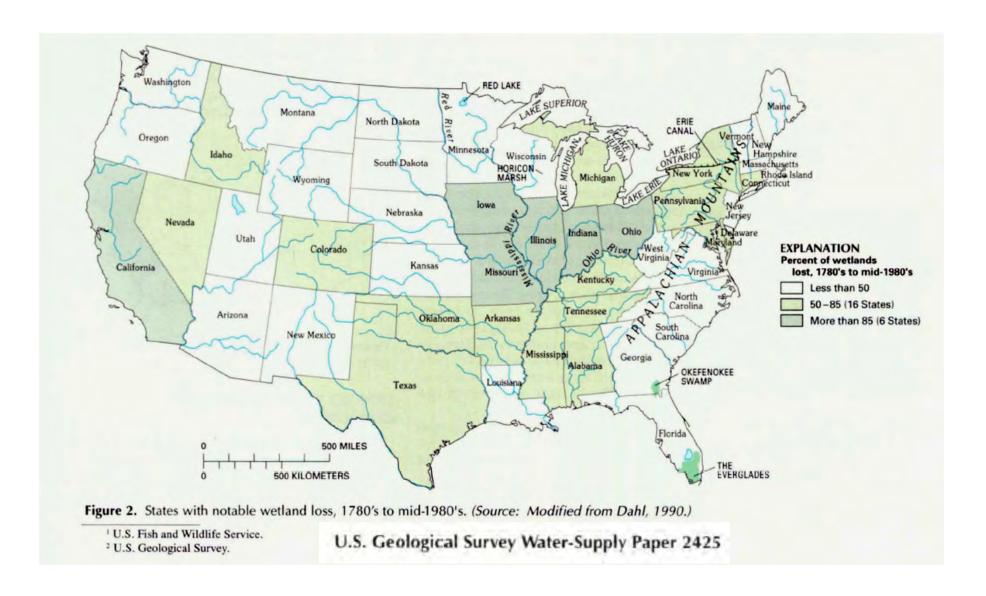


Oil-powered dredge digging a 30-foot-wide ditch to drain wetlands near Carroll, Iowa. (Photograph courtesy of National Archives, 8–D–2214–2570.)



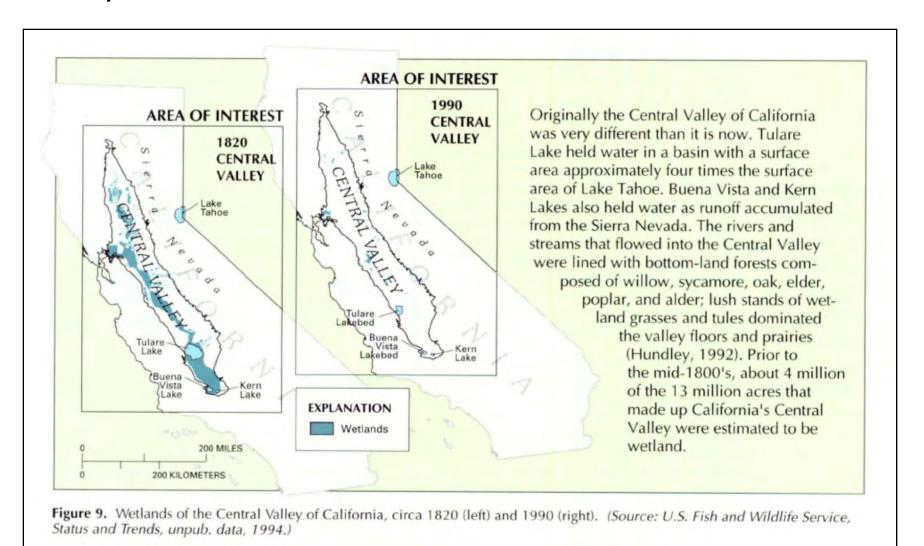


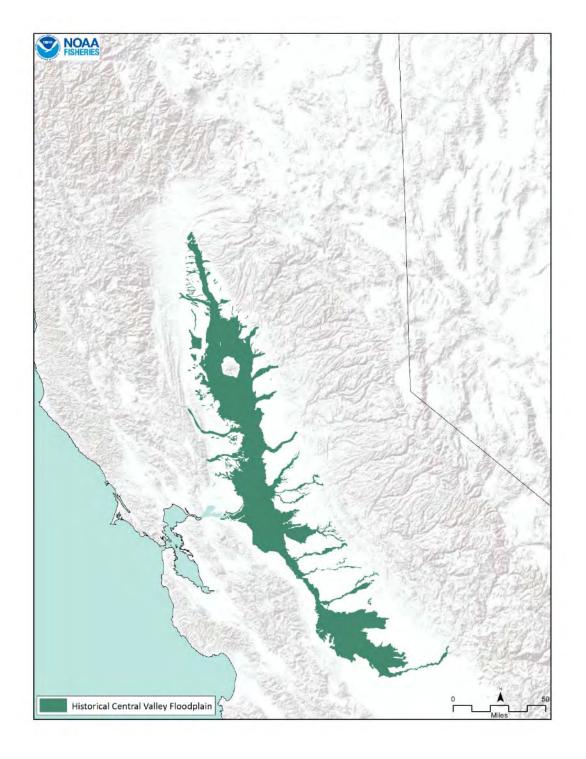
Scale of hydromodification is difficult to grasp.



History of Valley Modifications

CA, formerly 4 million acres wetland, most accessible to fish

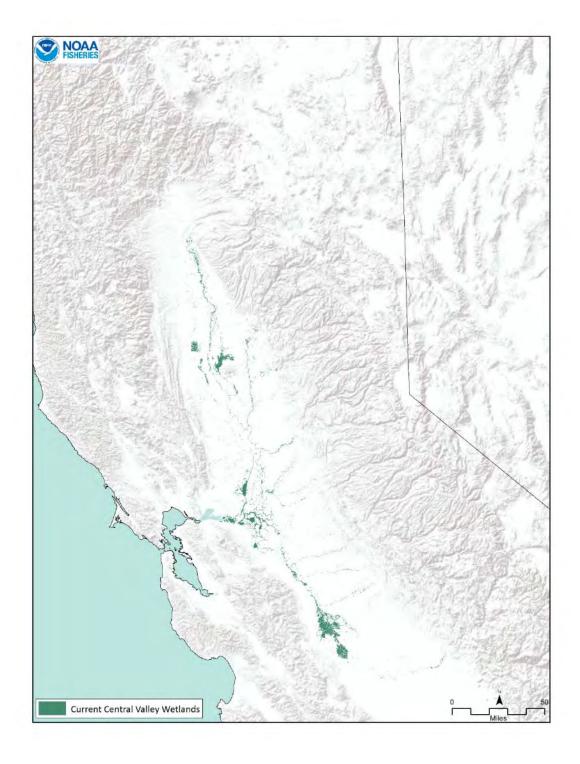




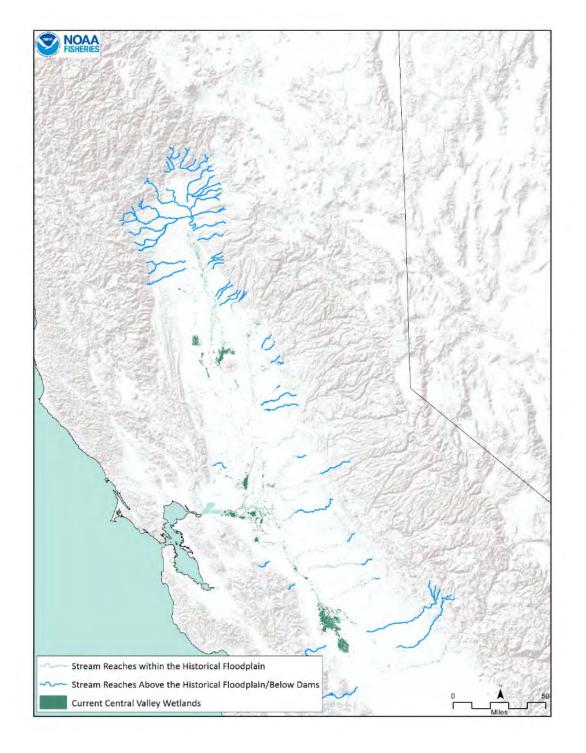
Historical Central Valley with Intact Floodplain



Historical Central Valley with identification of Stream Reaches currently accessible



Current Central Valley Floodplain

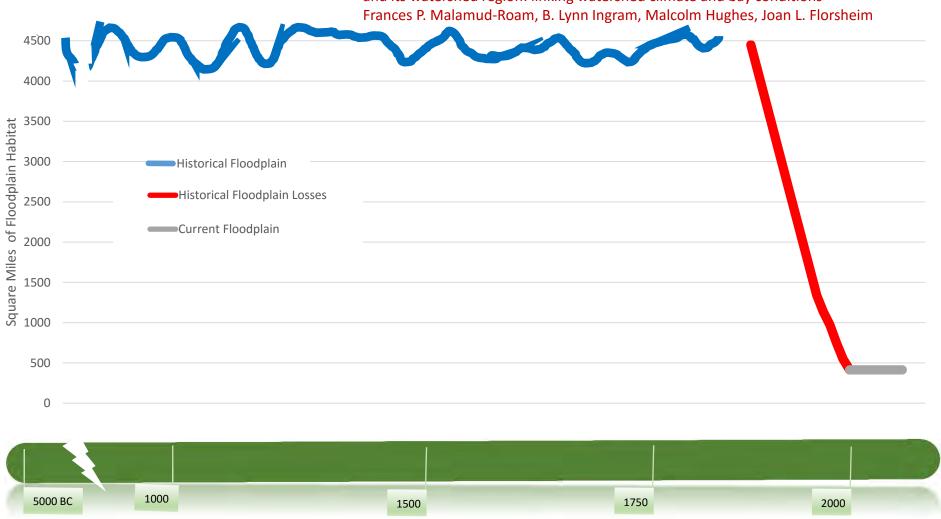


What's Left

~5% of original habitat

History of Central Valley Floodplains

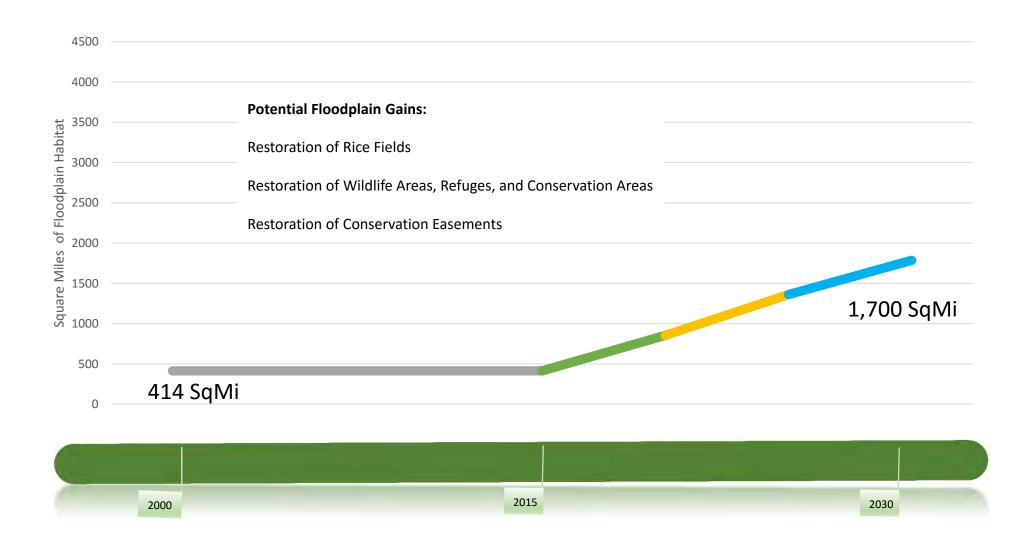
Historical Floodplain baseline graph from Meko et a. 2002 in Quaternary Science Reviews 25 (2006) 1570–1598 Holocene paleoclimate records from a large California estuarine system and its watershed region: linking watershed climate and bay conditions Frances P. Malamud-Roam, B. Lynn Ingram, Malcolm Hughes, Joan L. Florsheim

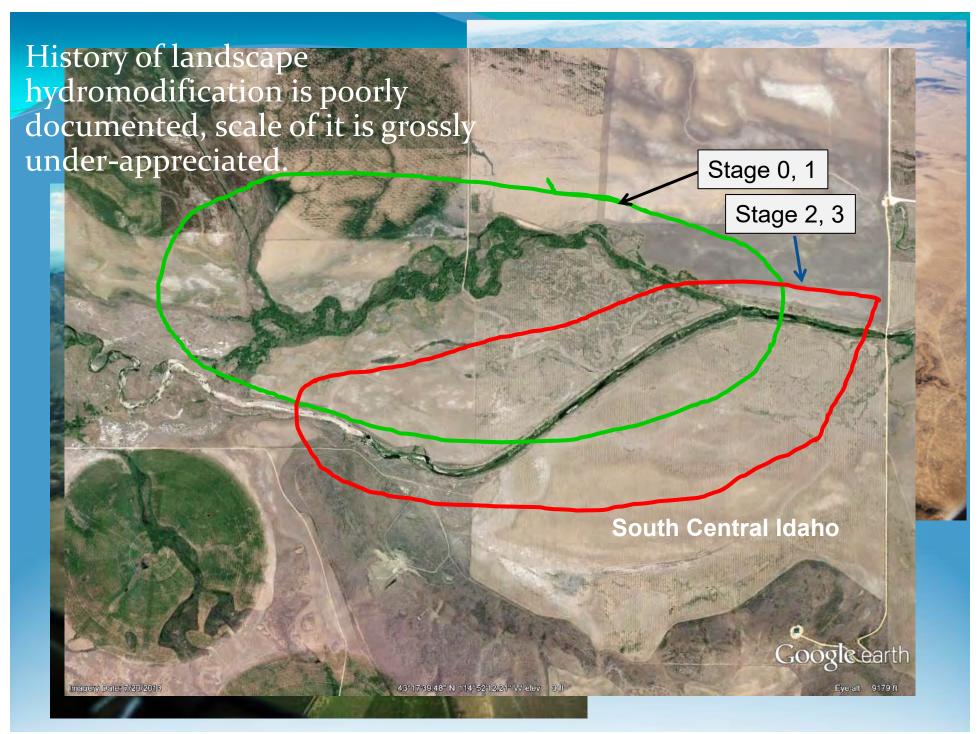


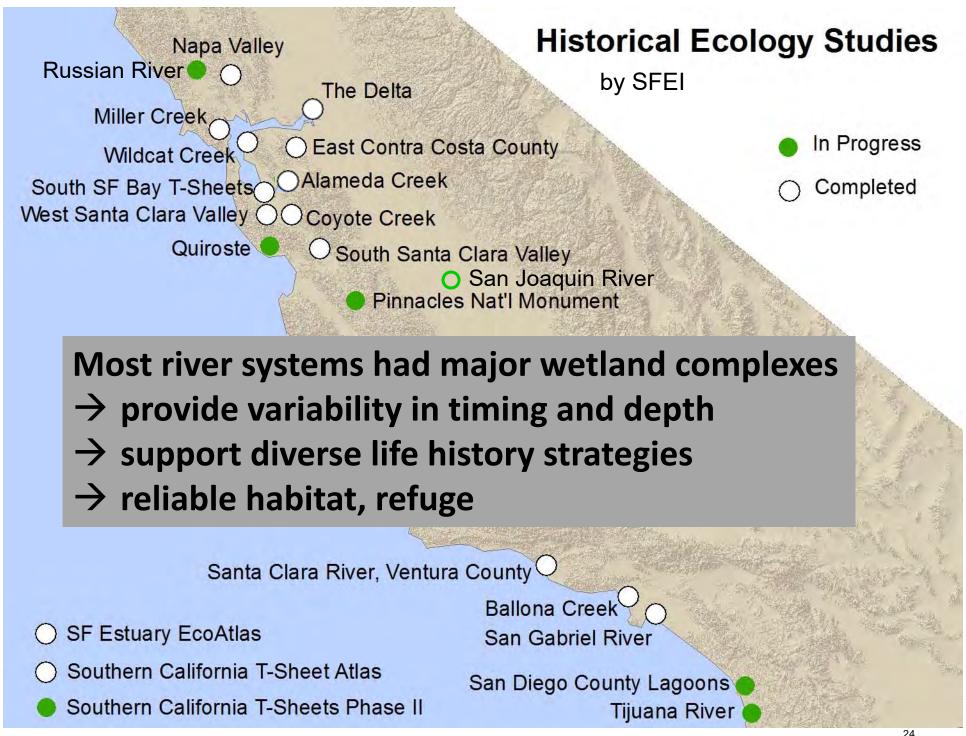
History of Central Valley Floodplains



History of Central Valley Floodplains









Jeffres et al. 2008

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. (2013)

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A STREAM EVOLUTION MODEL INTEGRATING HABITAT AND ECOSYSTEM BENEFITS

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* Fluvial Geomorphologist, Southwest Region, NOAA's National Marine Fisheries Service, Santa Rosa, California, USA
b Chair of Physical Geography, University of Nottingham, Nottingham, UK

ABSTRACT

For decades, Channel Evolution Models have provided useful templates for understanding morphological responses to disturbance associated with lowering base level, channelization or alterations to the flow and/or sediment regimes. In this paper, two well-established Channel Evolution Models are revisited and updated in light of recent research and practical experience. The proposed Stream Evolution Model includes a precursor stage, which recognizes that streams may naturally be multi-threaded prior to disturbance, and represents stream evolution as a cyclical, rather than linear, phenomenon, recognizing an evolutionary cycle within which streams advance through the common sequence, skip some stages entirely, recover to a previous stage or even repeat parts of the evolutionary cycle.

The hydrologic, hydraulic, morphological and vegetative attributes of the stream during each evolutionary stage provide varying ranges and qualities of habitat and ecosystem benefits. The authors' personal experience was combined with information gleaned from recent literature to construct a fluvial habitat scoring scheme that distinguishes the relative, and substantial differences in, ecological values of different evolutionary stages. Consideration of the links between stream evolution and ecosystem services leads to improved understanding of the ecological status of contemporary, managed rivers compared with their historical, unmanaged counterparts. The potential utility of the Stream Evolution Model, with its interpretation of habitat and ecosystem benefits includes improved river management decision making with respect to future capital investment not only in aquatic, riparian and floodplain conservation and restoration but also in interventions intended to promote species recovery. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS: Stream Evolution Model (SEM); channel evolution; freshwater ecology; habitat; conservation; river management; restoration; climate resilience

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Paper Outline:

- PART I Geomorphology
 - Channel pattern continuum:
 - Channel evolution models:
 - Stream Evolution Model:
- PART II Linkages:
 - Hydrogeomorphic attributes
 - Habitat and Ecosystem Benefits
- Management and Restoration Implications

SEM based on

- continuum of channel patterns, and
- 2. CEM concepts.

Channel patterns reflect the processes that created them. There exists a continuum of patterns because there is a continuum of processes.

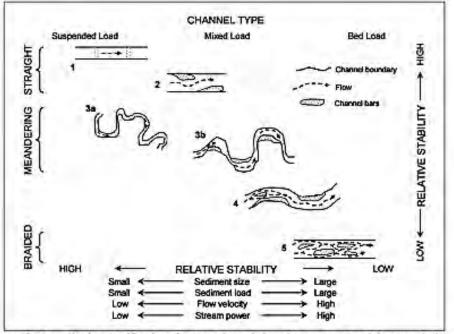
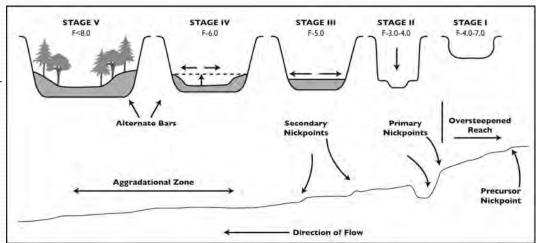


Figure 13. A qualitative classification of stream channels based on pattern (straight, meandering, or braided) and type of sediment load, along with flow and sediment variables and relative stability with regard to average erosional activity. From Schumm (1981).

CHANNEL EVOLUTION

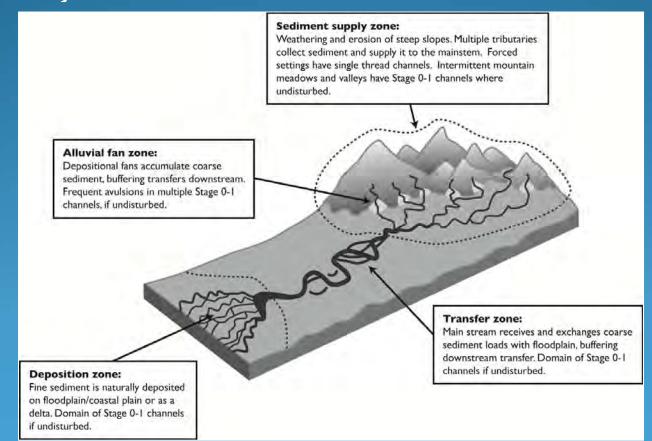
CONTINUUM

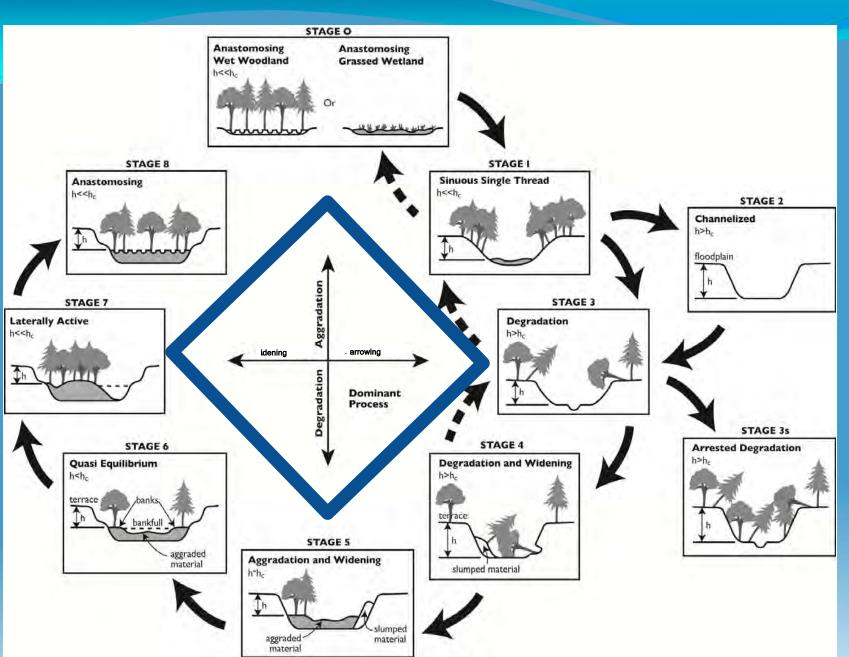
Alluvial channels, when disturbed, evolve through stages dominated by erosion, widening, aggrading, and relaxation to meta-stability.



SEM - basic idea is that there is a continuum of stream conditions across a watershed, and each condition is the result of the dominant physical processes driven by geology/hydrology/history.

Each condition is associated with characteristic habitat and ecosystem benefits.





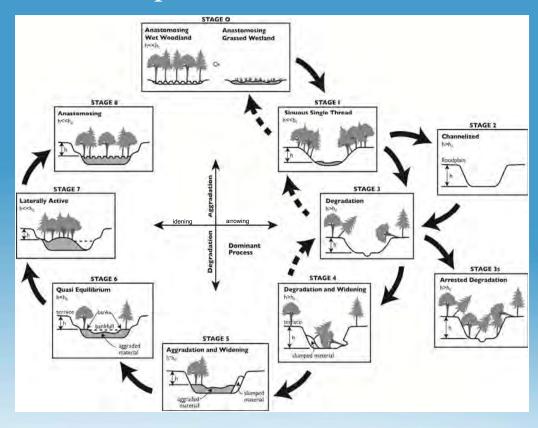
Multiple Paths Dead Ends

SEM highlights two ideas:

Stream systems are not represented by their channel; there is a web of bio-geo process interactions upstream, in the past, and nearby resulting in a dynamic stream corridor and a continuum of channel forms.

There is no "start point" or "end point" to channel

evolution.



PART II

Linking Habitat and Ecosystem Benefits to Hydrogeomorphic Attributes

Principles of functional ecology link the SEM Stages to habitat and ecosystem benefits.

- Stream morphology interacts with flow and sediment regimes, channel boundary characteristics, and water quality to produce, maintain and renew habitat.
- The potential for a stream to support resilient and diverse ecosystems increases with morphological diversity.
- Morphological adjustments (SEM Stage) have implications for diversity and richness of habitat and ecosystem services.

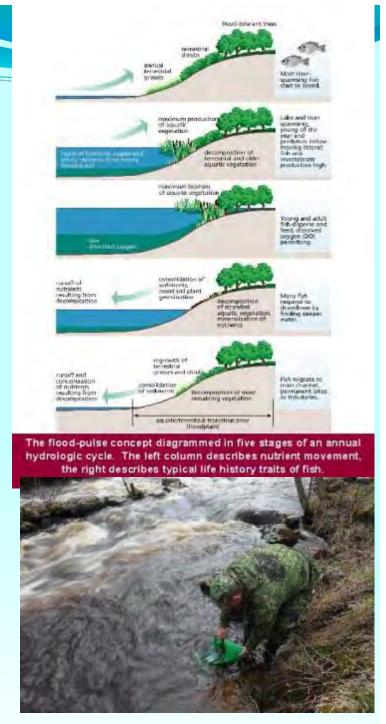
Primary literature: Harper et al 1995, Padmore 1997, Newson and Newson 2000, Thorpe et al 2010

Physical Attributes Hydrologic regime

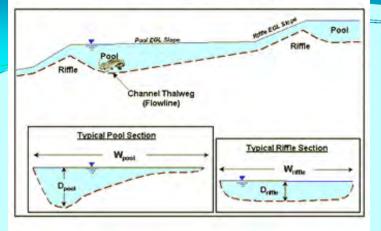
- Base flows
 - Habitability and biodiversity
- Floods and flood pulses timing
- Floodplain connectivity
 - Hydro-period, attenuation, recharge

Hydraulics

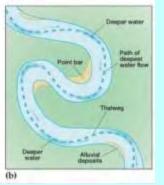
- Hydraulic diversity
 - Dead water
 - White water



Channel Geometry Characteristics



Submerged Desper water





Geomorphic

Physical Attributes

attributes

- Channel dimensions and geometry
 - Wetted area
 - Length and complexity of the shoreline
- Channel features
 - Bedforms, bars, islands, riparian margins
- Instream sediment storage
- Proportion of shoreline stable or unstable
- Substrate
 - Size and distribution, sorting, patchiness

Physical Attributes

Floodplain attributes

- Extent and Connectivity
 - Inundation surfaces
 - Duration, timing
 - Topo features on floodplain
 - Processes
 - Sediment storage
 - Carbon sequestration
 - Nutrient processing



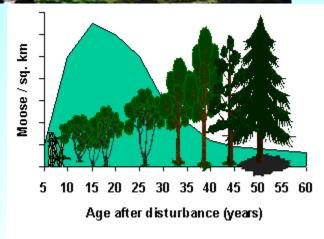




Vegetation attributes

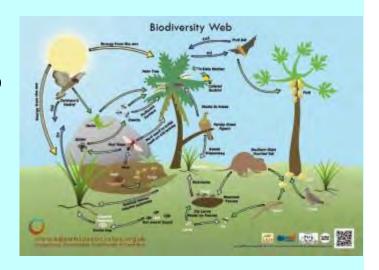
- Presence of plants
 - Aquatic, emergent, riparian, floodplain
- Leaf litter
 - Primary production support
- Tree trunk recruitment
 - Cycling nutrients and carbon
 - Hydraulic and morpho diversity
 - Channel stability
 - Sediment storage
 - Sorting and patchiness
 - Forcing hyporheic flow
- Riparian succession, dynamic landscape

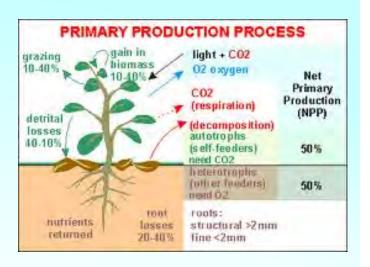




Habitat and ecosystem benefits

- Biota
 - Biodiversity (species richness and trophic diversity) varies in relation to morphologic diversity of the channel and the extent and frequency of floodplain connectivity
 - Proportion of native plants
 - 1° and 2° productivity; in proportion to the hydrologic, hydraulic, morphologic and vegetative diversity





Resilience

- Floods
 - Stage resilient edges
 - Floodplain
- Droughts
 - Water table connection
 - Availability of deep pools
- Able to withstand disturbances







Each stream Stage is associated with a gradient of hydrogeomorphic processes, attributes, and ranges and qualities of habitat and ecosystem benefits.

- Assessment per stage:
 - Interpretation of processes and resulting physical attributes,
 - Informed by published relationships between stream attributes, functional habitats, and freshwater ecology.

Attributes and Benefits, scoring scheme:

- Hydrogeomorphic attributes (26)
 - Hydraulic complexity
 - Physical channel dimensions, #
 - Hydrologic regime, floodplain
 - Channel and floodplain features
 - Substrate sorting/patchiness
 - Vegetation sediment interaction

Ordinal Score:

o = absent

1 = scarce/partly functional

2 = present and functional

3 = abundant/fully functional

- Habitat and Ecosystem Benefit attributes (11)
 - Refugia from extremes flood/drought
 - Water quality clarity/temperature/nutrient cycling
 - Biota diversity/natives/1° & 2° productivity
 - Resilience to disturbance

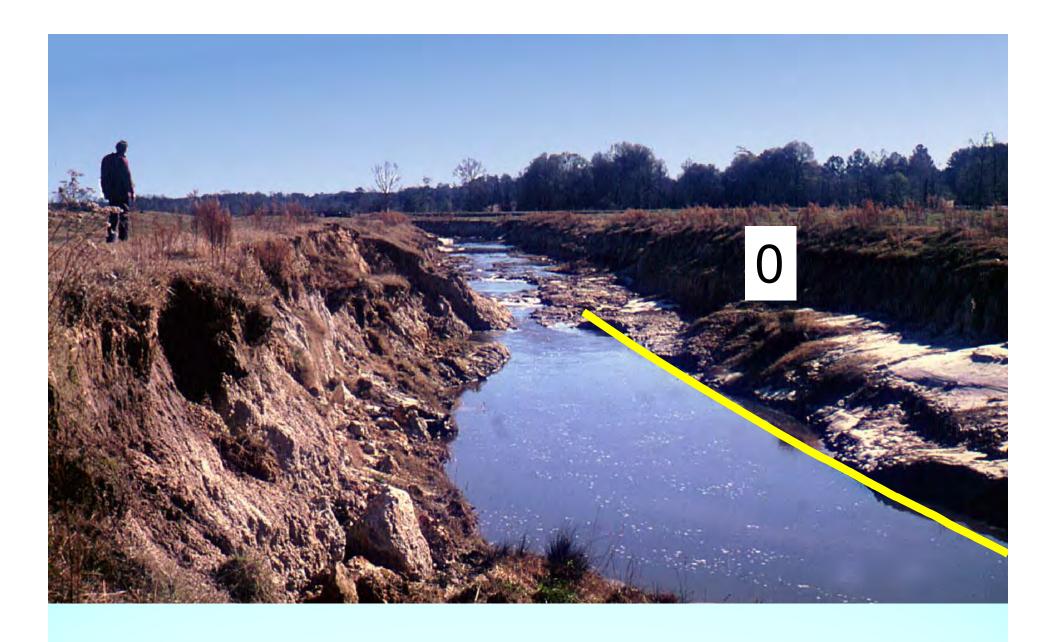
Hydrogeomorphic A	ttribu	tes Tab	le								
Stage	0	1	2	3	3s	4	4-3	5	6	7	8
Physical Channel D	imens	ions									
Wetted Area Relative to	3	2	1	1	1	0	0	1	1	2	2
Shoreline Length and Complexity	3	2	1	1	1	0	0	1	1	2	2
Channel and Flood	plain F	eature	S								
Bedforms and bars	2	3	1	0	0	1	0	2	3	3	2
Islands	3	1	0	0	0	0	0	0	0	1	3
Local Confluence/Diffluences	3	1	0	0	0	0	0	0	0	1	3
Stable banks	3	2	2	2	2	0	0	1	2	2	3
River cliffs	2	2	0	1	2	2	2	2	1	2	2
Riparian Margins	3	2	1	1	1	0	0	1	2	2	3
Floodplain Extent and Connectivity	3	3	1	0	0	0	0	1	2	2	2
Side channels	3	2	0	0	0	0	0	0	1	2	2
sediment storage	3	2	1	0	0	0	0	0	1	2	3
Connected Wetlands	3	2	- 1	0	0	0	0	0	0	1	2
Substrate											
Substrate Sorting	2	3	0	0	1	0	0	1	1	2	2
Substrate Patchiness	3	3	0	0	1	0	0	1	2	3	3
Hydraulics											
Hydraulic Diversity	3	2	0	0	1	0	0	1	1	2	3
Marginal Deadwater	3	2	0	0	0	0	0	0	1	2	3
Vegetation											
Aquatic plants	3	2	1	0	0	0	0	1	2	2	3
Emergent Plants	3	1	1	1	1	1	0	2	2	1	3
Riparian plants	3	2	0	0	1	0	0	1	1	2	3
Floodplain plants	3	3	2	0	0	0	0	0	1	2	3
Woody debris	3	1	0	1	1	2	1	2	2	1	3
Leaf litter	3	2	0	1	2	0	0	1	2	2	3
Hydrological Regim	e										
Flood pulse	1	1	2	3	3	3	3	2	2	1	1
Flood attenuation	3	2	1	0	0	0	0	0	1	2	3
Base flow	2	3	1	0	0	0	0	0	1	3	2
Hyporheic connectivity	3	3	2	0	0	0	0	1	2	3	3
				Re	sults						
possible	78	78	78	78	78	78	78	78	78	78	78
sum	72	54	19	12	18	9	6	22	35	50	67
ratio	92%	69%	24%	15%	23%	12%	8%	28%	45%	64%	86%

Table IV

Shoreline Length and Complexity



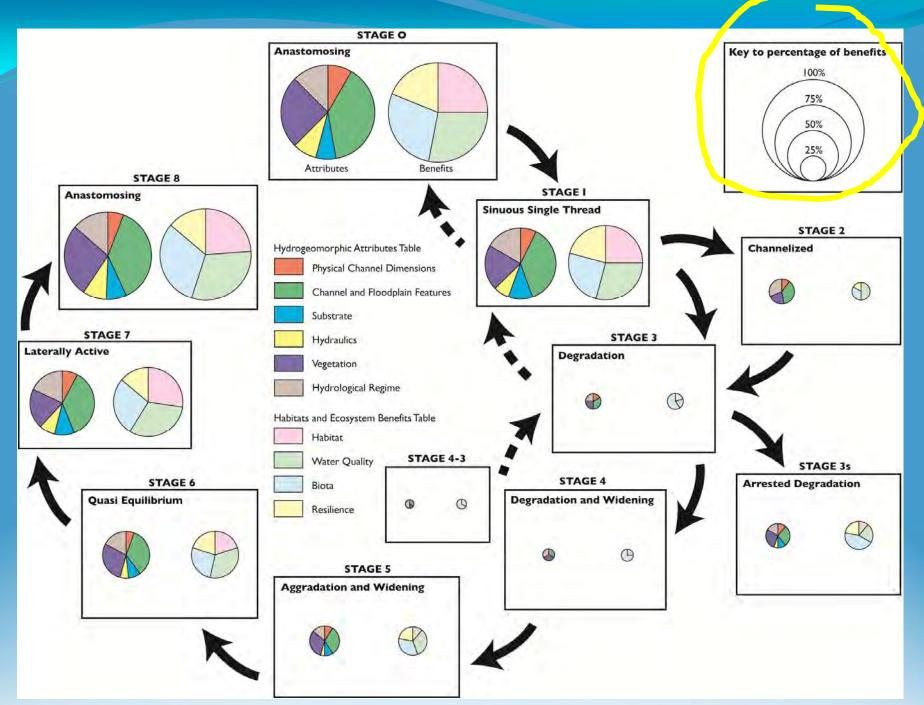


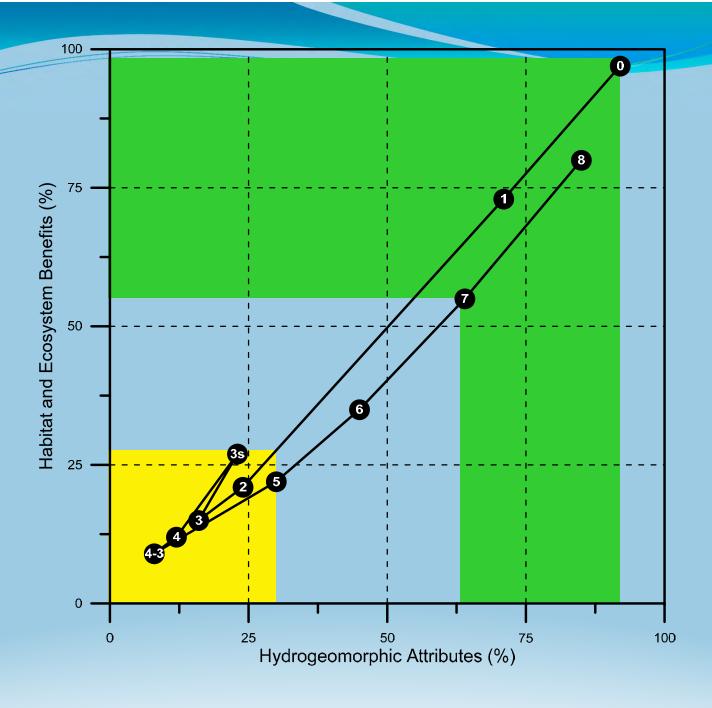


Habitat and Ecosystem Benefits Table

Stage	0	1	2	3	3s	4	4-3	5	6	7	8
Habitat											
Flood Refugia	3	2	0	0	0	0	1	1	1	2	2
Drought Refugia	2	3	0	0	0	0	0	0	1	3	2
Exposed tree roots	3	1	0	1	1	1	0	0	1	1	3
Water Quality											
Clarity	3	2	1	0	0	0	0	1	2	2	3
Temperature amelioration (shade and hyporheic flow)	3	3	1	1	2	0	0	1	2	3	3
nutrient cycling	3	2	1	0	0	0	0	1	1	2	3
Biota											
Biodiversity (species richness and trophic diversity)	3	2	0	1	1	1	1	1	1	2	3
Proportion of Native Biota	3	2	1	1	1	1	1	1	1	2	3
1st and 2nd Order Productivity	3	2	1	1	2	1	0	1	2	2	3
Resilience											
Disturbance	3	3	1	0	1	0	0	1	1	2	2
Flood and Drought	3	2	0	0	1	0	0	1	2	1	2
Results											
possible	33	33	33	33	33	33	33	33	33	33	33
sum	32	24	6	5	9	4	3	9	15	22	29
ratio	97%	73%	18%	15%	27%	12%	9%	27%	45%	67%	88%

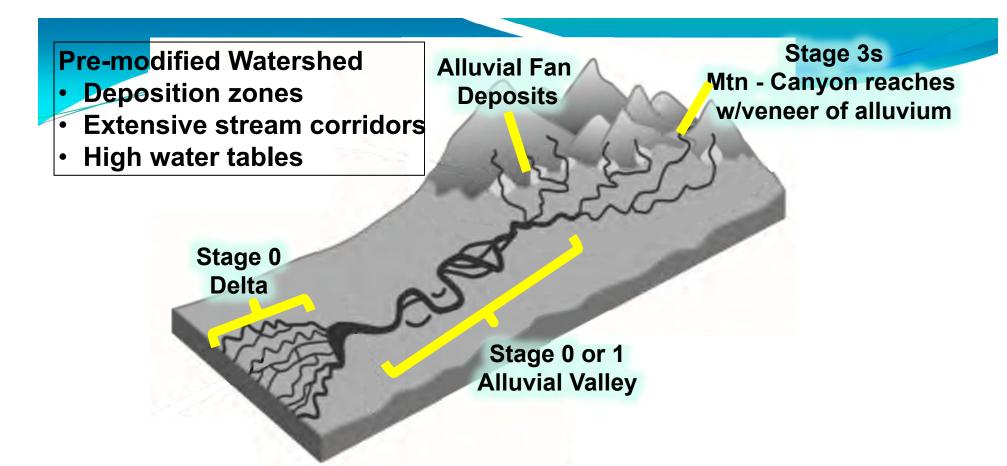
Table V

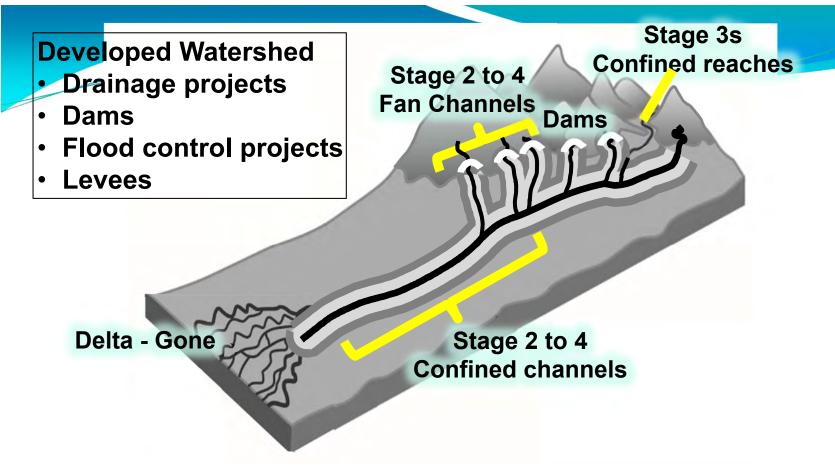


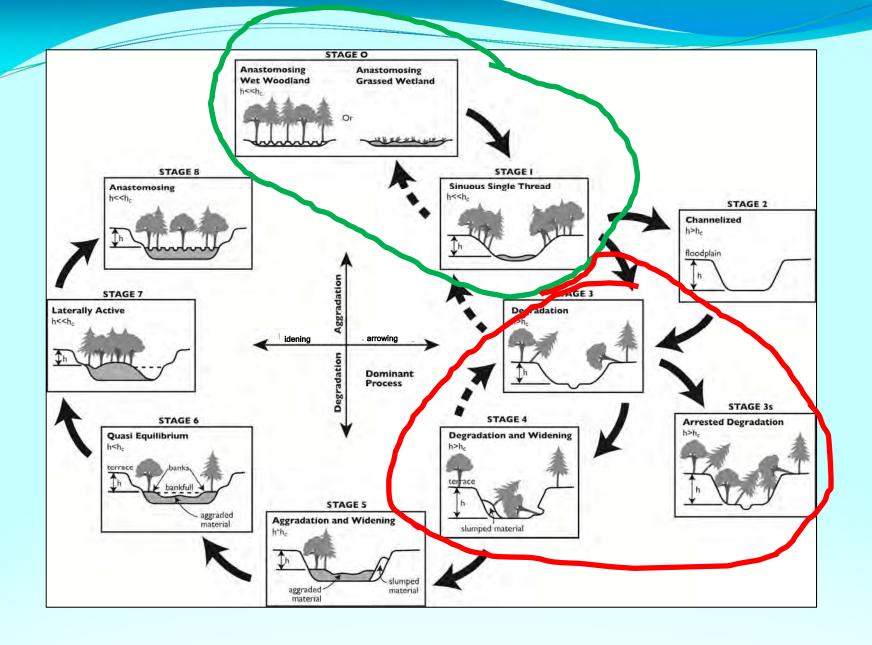


Applying the SEM

to a typical watershed.







River Management Implications

- Simply put, human modifications to alluvial valley reaches turned the once rich floodplain reaches into poor mountain-canyon reaches.
- Restoration typically enhances and stabilizes the current habitat-poor form.
- Without understanding former form and function we can't appreciate more aggressive strategies to restore historic ecosystem functions.

Restoration Practice Implications

- SEM helps us establish restoration goals that are process-based and ecosystem linked.
- Invalidates a few standard-practice design approaches:
 - Sediment balance
 - Bankfull channel and reference reach

Sediment Budget and Continuity

Papers 4 8 1



Construction of Sediment Budgets for Drainage Basins

William E. Dietrich, Thomas Dunne, Neil F. Humphrey, and Leslie M. Reid

- $\bullet [I + \Delta S = O]$
 - I, input or erosion
 - O, output or net result at any point of interest
 - ΔS, change in storage, or deposition and erosion

Sediment understanding....

- Many streams are CWA listed for sediment
- Smallest eroding banks are considered problems in fisheries
- For about 2 decades been substantial work on upland sediment source stabilization and incised stream banks
- Without critically thinking about the scale of the problem or the processes involved

Example: $I + \Delta S = O$

Russian River near Guerneville; Mean load is 4.5 million yd³/year (USGS 1974)

If a large bank collapsed into the river, 100 yd x 10 yd x 2 yd, that would be about 2000 yd³

Equals 0.03% of the annual load.

It would take 250 such banks collapsing in 1 year to be theoretically detectable at 10% of the load (measurement error).

This example is at measured transport rate, which significantly underestimates the transport capacity of the river.

$I + \Delta S \neq O$ No deposition is the problem

Example: for the same 2000 yd³ bank collapse

120 acres of floodplain accrete 1/100 ft of sediment in 1 year equals 2000 yd³

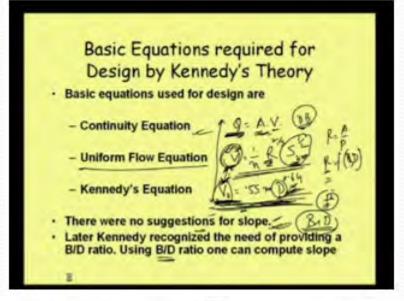
Funny understanding of sediment...

- Poor understanding of sediment supply vs. transport
- Continuity is expected in restoration
- Focusing only on the equal sign and the input side of equation (erosion)
- Failure to include deposition processes in management
- Stream channel condition is the big problem
 - Conduits -
 - No deposition zones
- In any watershed, the richest habitat is found in alluvial valleys, the deposition zones.

channel design-

Early 1900's

- Advanced in the western US in 1950's by BOR for irrigation projects



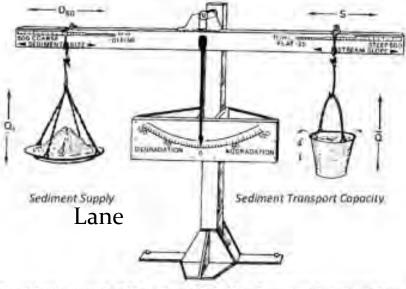
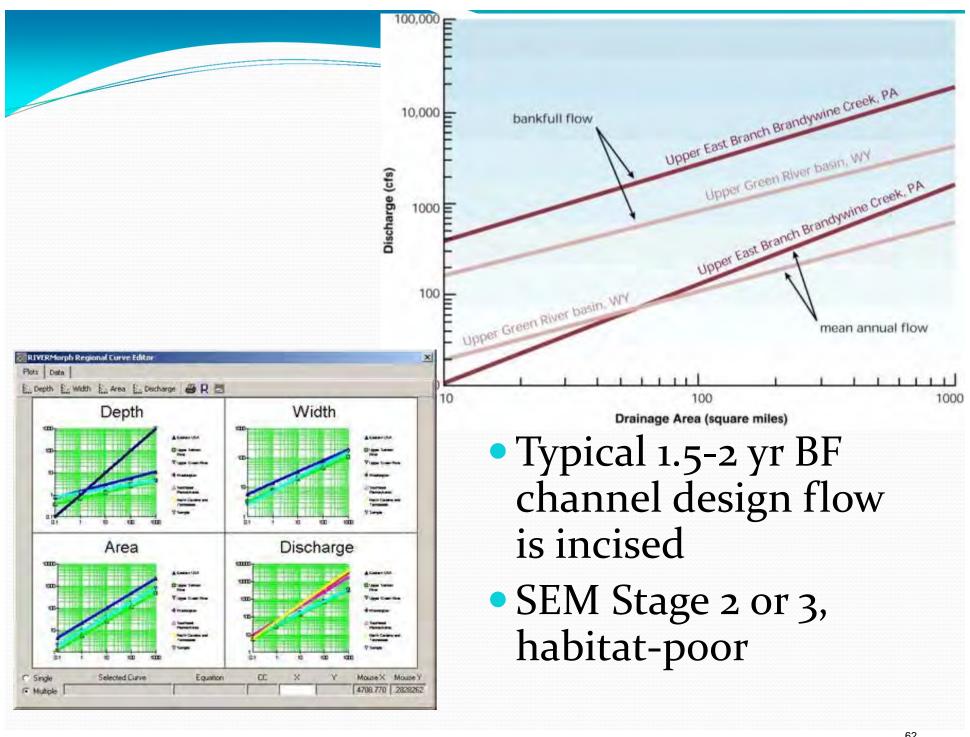


Figure 5. Lane's Balance (after E.W. Lane, from W. Borland) from Demonstration Erotion Control Design Montrol (Watson et al., 1999) with adaptations.

Hydraulic Geometry

 The empirical relationships between discharge, slope, depth, width, and stable substrate size found their way into geomorphology in the 1960's as natural channel hydraulic geometry, and is used today.

Leopold, Wolman, and Miller; 1964



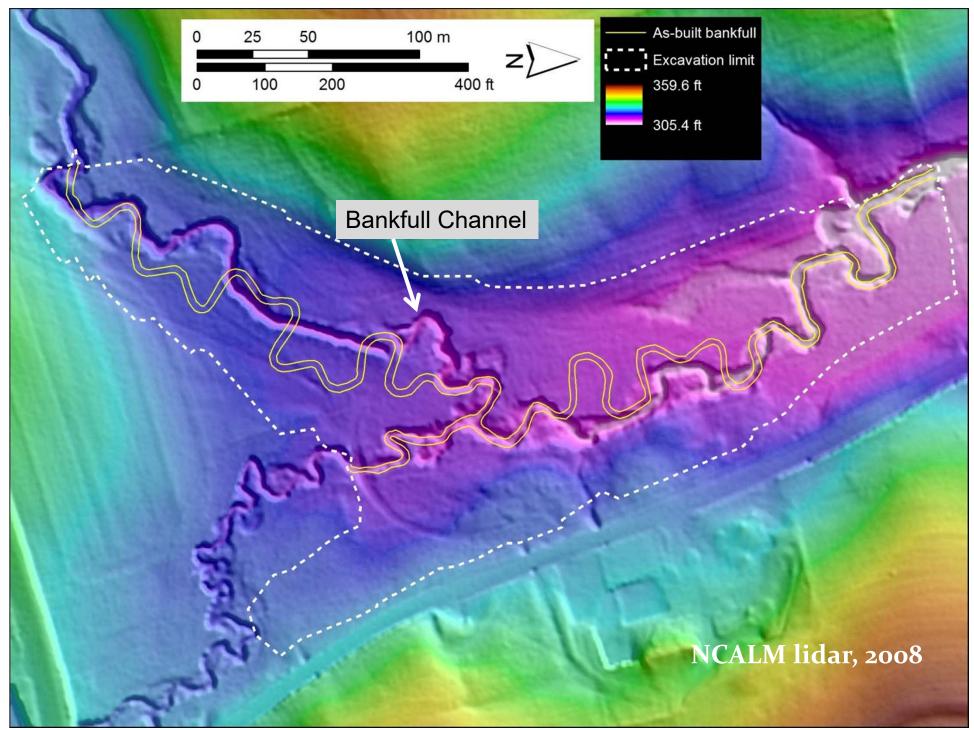
Stream Restoration in the Eastern USA: The legacy of Water-Powered Mills

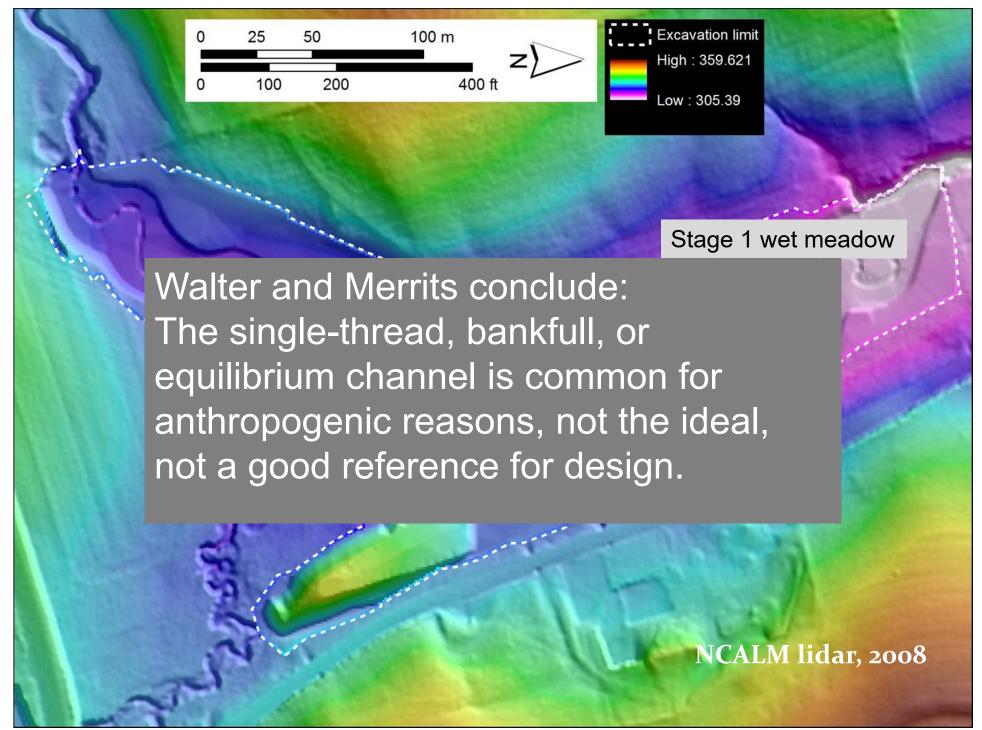
Dorothy Merritts and Robert Walter, Franklin & Marshall College, PA





Typical mid-Atlantic streams incised into millpond sediment Big Spring Run (top) and White Clay Creek (bottom), PA





Conclusions:

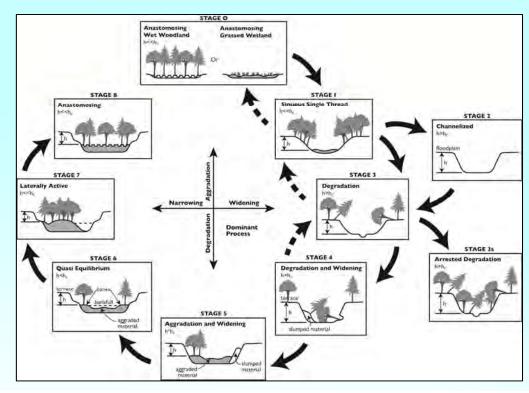
- Channel management and restoration practice are rooted in goals for stability and drainage
 - Not in Habitat and Ecosystem Benefits
- Many channel forms are stable
 - We have choices
 - Rich
 - Poor

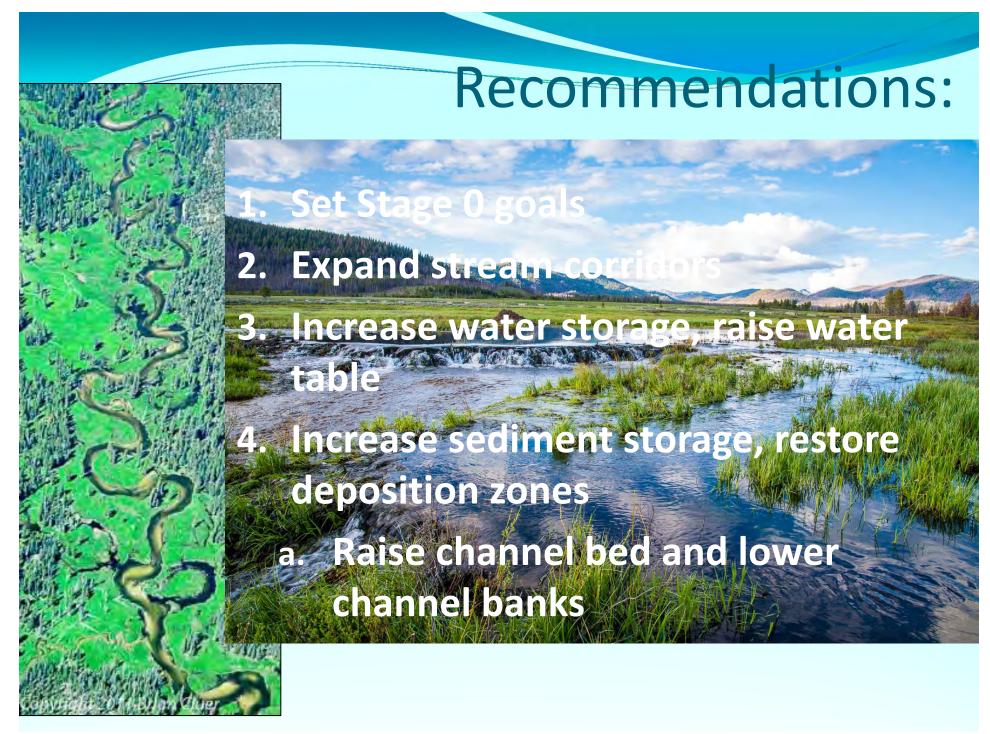




Conclusions:

- Degraded / manipulated channels can evolve to a better condition.
- Restoration can speed or stall evolution.





Questions? Comments?



Using Beaver to Restore Streams-

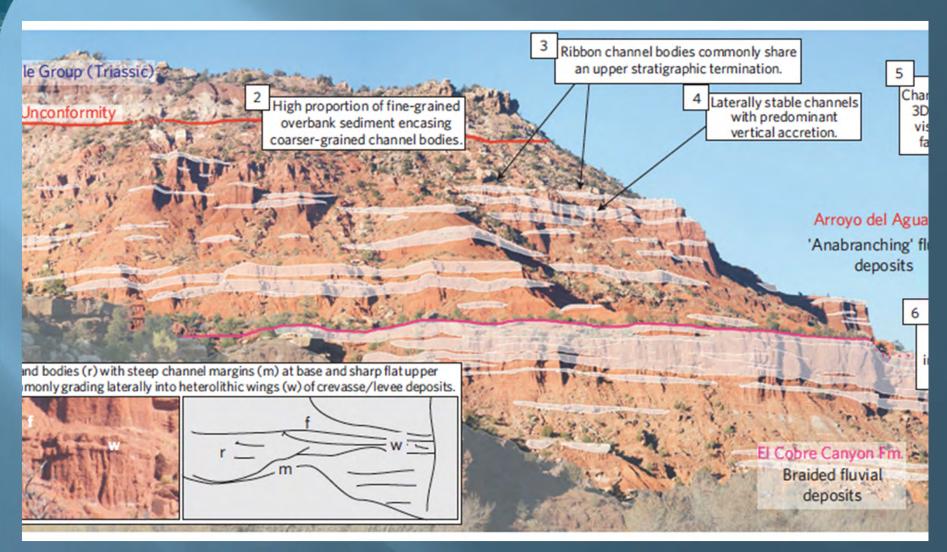


Michael M. Pollock NOAA Fisheries-Northwest Fisheries Science Center

michael.pollock@noaa.gov

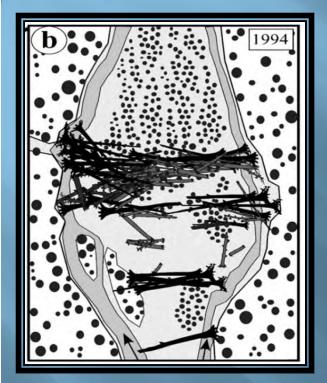


Rivers, plants and instream obstructions have been around for a long time (>500 Mya)-plants have shaped the form of channels

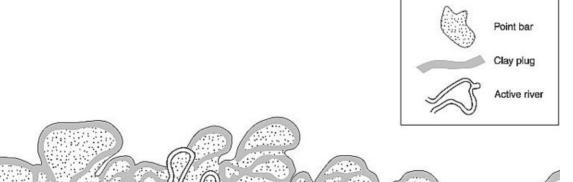


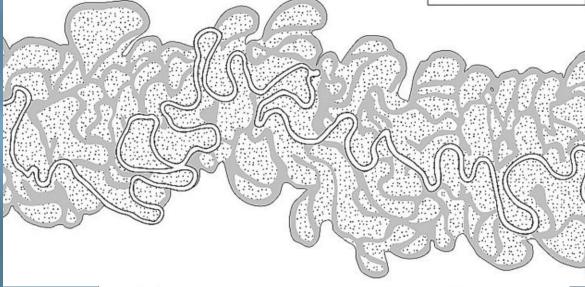


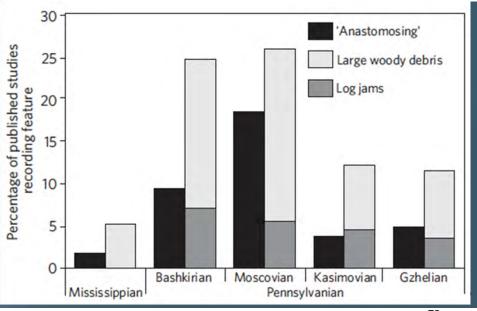
Planview of anastomosing stream



Anastomosing, large wood and log jams (obstructions) all arose together in the geologic record 320 Mya

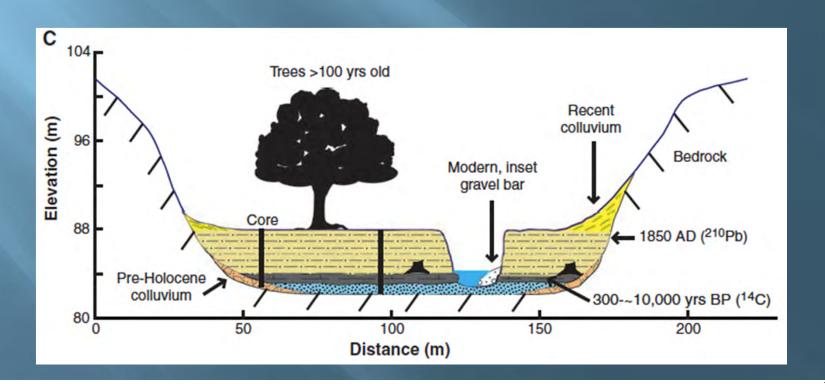




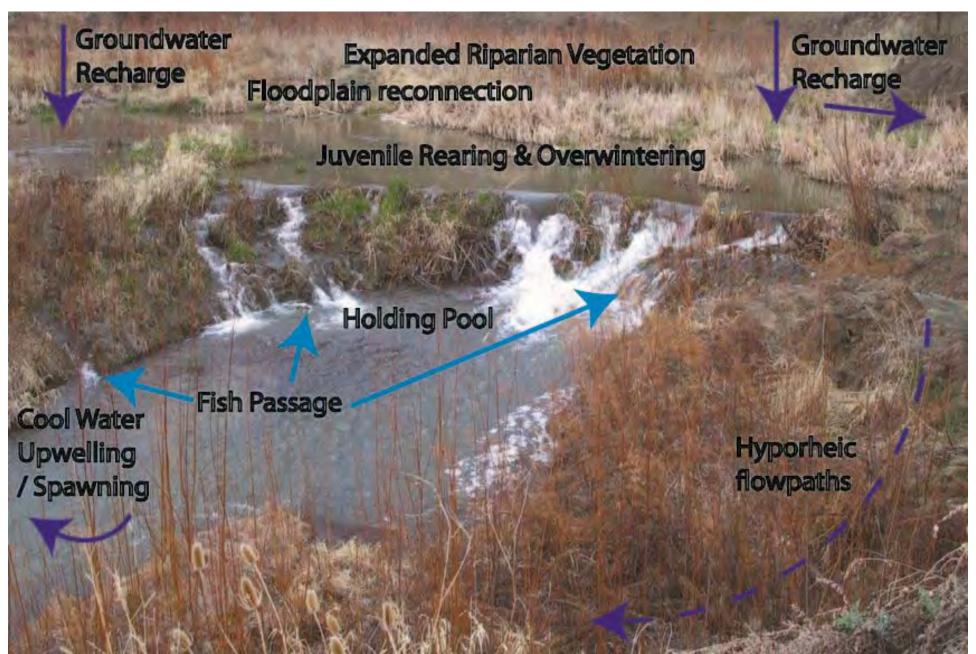




"Gravel-bedded streams are thought to have a characteristic meandering form bordered by a self-formed, fine-grained floodplain. This ideal guides a multibillion-dollar stream restoration industry. We have mapped and dated many of the deposits along mid-Atlantic streams that formed the basis for this widely accepted model. These data, as well as historical maps and records, show instead that before European settlement, the streams were small anabranching channels within extensive vegetated wetlands...."-Walter and Merritts 2008.



Beaver wood jams create anabranching habitat





Salmon River, Idaho- Example of a Stage 0 System



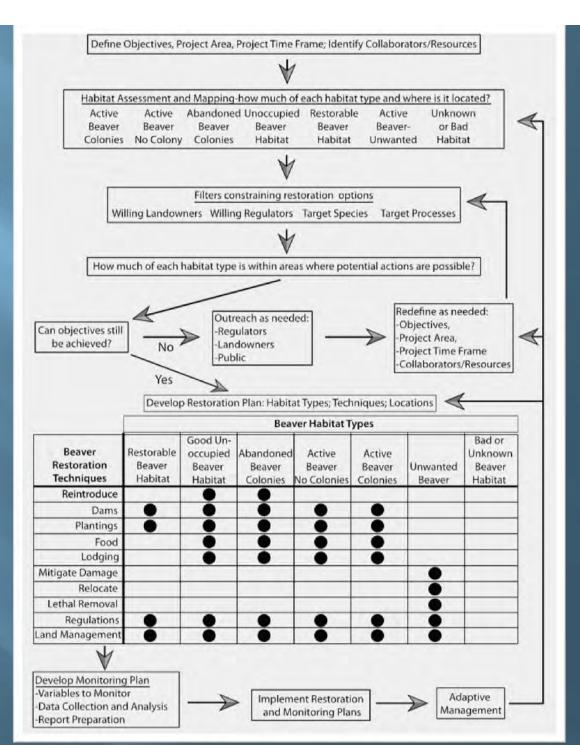


Overview of Steps in Beaver Restoration Projects

- Define project goals, time frame, spatial extent, resources, collaborators
- 2. Beaver habitat assessment-watershed level
- 3. Identify constraints on potential restoration sites
 - 4. Determine if objectives can be met based on available sites, constraints and available resources
 - 5. Redefine goals, expand resources, etc. as needed
- 6. Develop appropriate beaver restoration techniques
- 7. Develop restoration and monitoring plans
- 8. Implement restoration and monitoring plans
- 9. Adaptive management



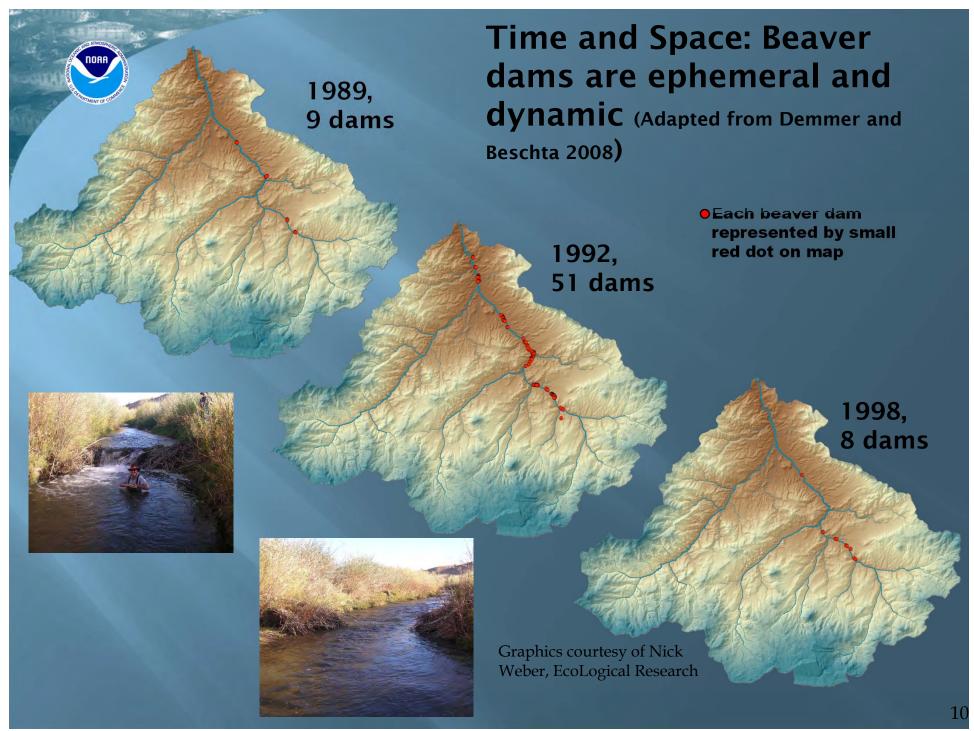
Beaver
Restoration and
Management
Techniques
Flowchart





Step 1. Define goals, time, space, and resources

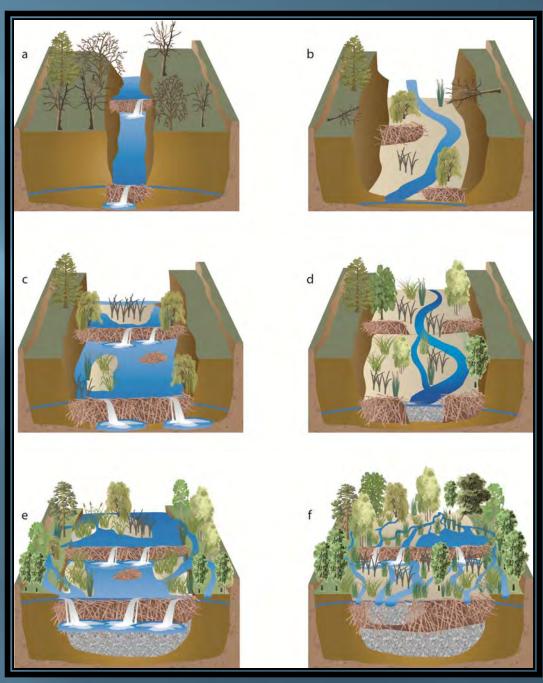
- a) Goals-what are you doing? E.g., modifying a process or building a state?
- b) How many years is your organization committed to the project?
- What is the size of your project area?
- d) What resources do you need to for your project, what resources available (e.g. GIS, permit facilitation, etc.)?
- e) Who are your collaborators and what resources can they bring to the table?
 - Landowners
 - ii. Regulatory agencies
 - iii. Non-governmental organizations
 - iv. Indian tribes
 - v. Non-regulatory agencies
 - vi. Funding agencies and organizations

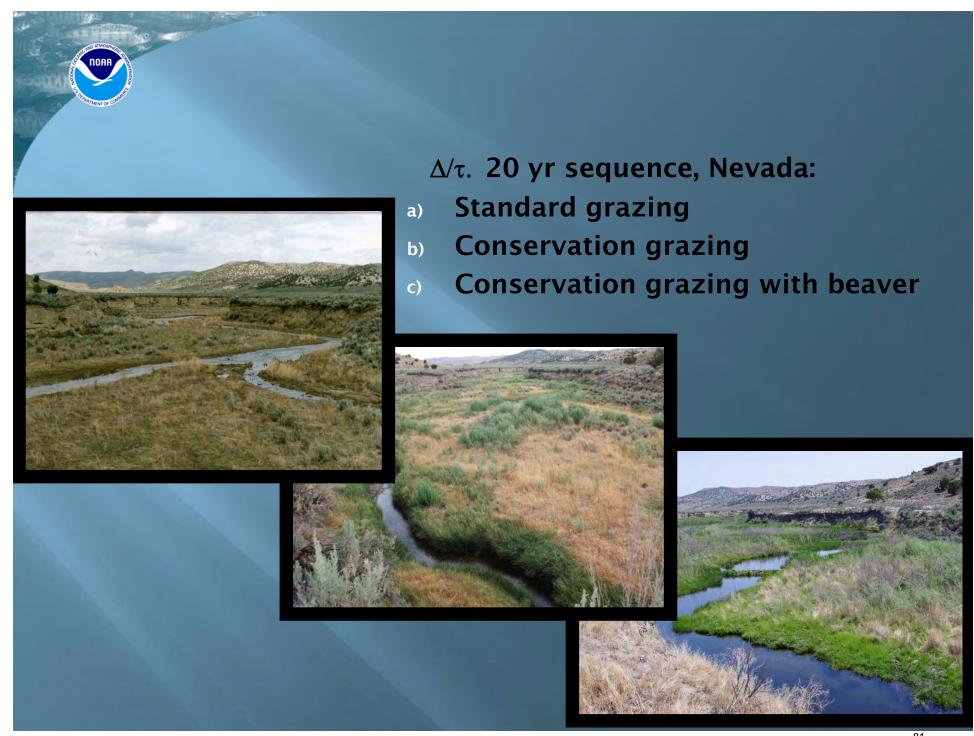




Creating a Process, Not a Static State

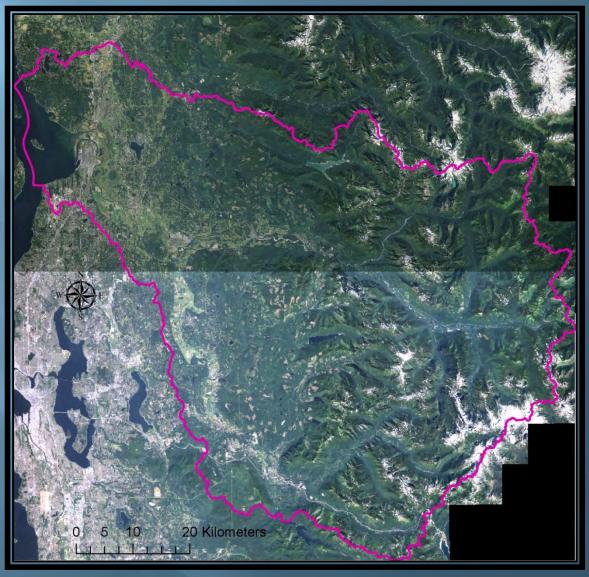
- -Value to species or even life history stages for one species Δ/τ
- -Physical benefits (e.g. groundwater recharge) Δ/τ





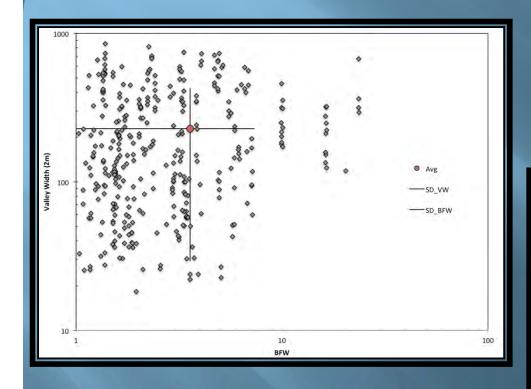


Step 2. Beaver Habitat Assessment



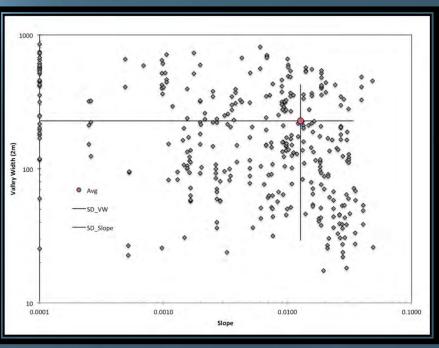


Beaver Reach Characteristics-Snohomish Basin, WA

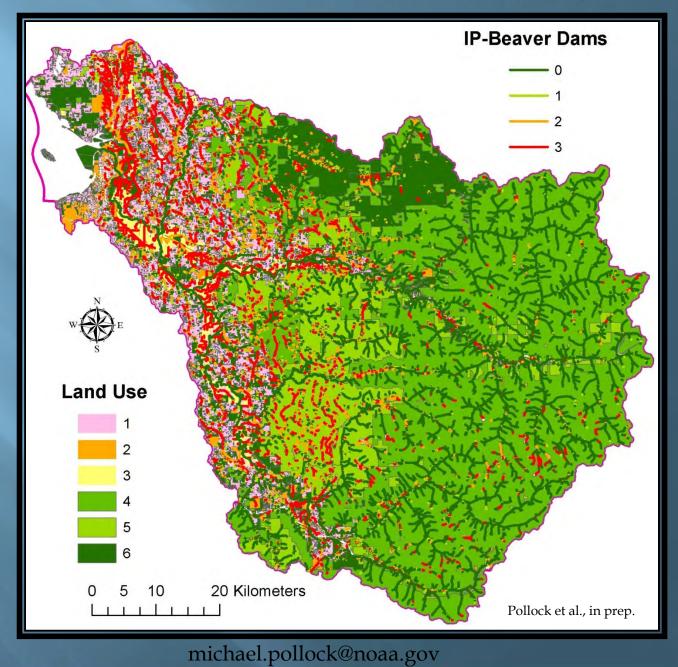


Pollock et al., in prep.

- < 8 m BFW
- > 30 m VW
- < 4% Slope



Beaver Intrinsic Potential Map



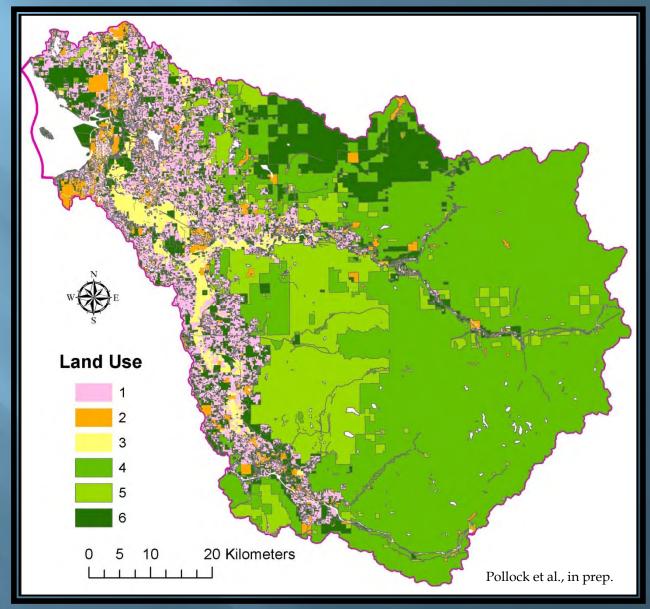


Step 3. Identify Constraints on Potential Restoration Sites

- a) Landowner constraints
- b) Regulatory constraints (to be discussed later)
 - a) State
 - b) Federal
 - c) Tribal
 - d) Regulations vary by landowner type (private, federal, tribal) and activity (e.g. instream work, riparian work, beaver relocation)
- Target species distribution
 - a) Salmonids
 - b) Cascade frog
 - c) Willow flycatcher
- d) Target habitat type (e.g. Incised streams)
- e) Funding constraints



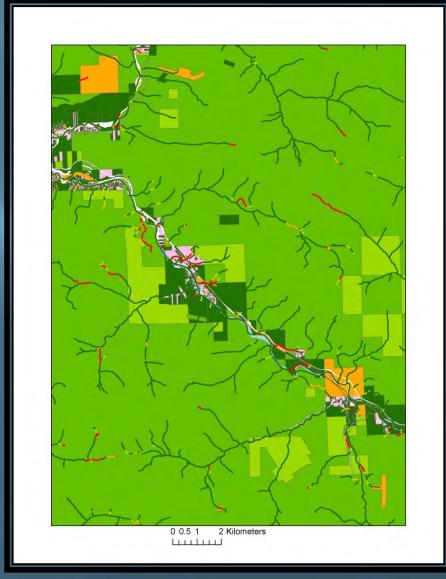
Land Use/Ownership = Biggest External Constraint





BIP in Fragmented v. Unfragmented Landscapes







On-the-ground data are essential

- Beaver (past and present)
- Infrastructure
- Property Boundaries
- -Vegetation
- -Competitors
- Ground truthing

Methow Beaver Project Beaver Habitat Score Card (compliments of Kent Woodruff)

Release Site Score Card Site ID		Location	on Description	Observe owatershed	Date	
GPS Coordinates_UTM (NAD 83)at Long Stream Gradient of the o	defined habita	Location	on Description	owatershed		
Lat LongStream Gradient of the o	defined habita	Location	on Description			
Stream Gradient of the		at unit				
			-00			
			29%			
Stream Flow			Min (fall)			
		garden hose	fire hose	30"culvert	un- wadeable	
Max	garden hose	1				
(spring)	fire hose	3	4			
***************************************	30"culvert	4	5	5		
	un- wadeable	1	2	1	0	
b. 3. Within 10 met c. 3. Large amount Woody food sc. Herbaceous Food 3.Grass/Forbs P	(thousands of	axbxc	2. Some (hu	Within 100 me		(dozens)
Floodplain Width			5.4			
5. Wide stream b	oottom		0.1	Narrow V Cha	innel	
Dominant Stream Subst 5. Silt/Clay/Mud		1. Gravel	0. Cobble	-1. Boulders	-3. Bedrock	
Historic Beaver use 10. Old structure	s present	0. No i	ndication of pre	evious occupar	ncy	
Lodge and dam building 5. variety of 1-6		ody vegetation	on avail10	. no building m	aterial present	
Browsing / Grazing impa 5. No Impact or		nce of brows	ers / grazers	(-10). He	eavy browsing / g	grazing impa
Bonus: (5 points each) 1	Easy Access 2 Re	cent fire. 3. No con	nflict with human value	es 4. Existing aquatic	escape cover. 5. Landow	ner / user enthusi
Total Score						



Beaver Habitat Types

	Beaver Habitat Types							
Beave Restoration Techniques	Restorable Beaver Habitat	Good Un- occupied Beaver Habitat	Abandoned Beaver Colonies	Active Beaver No Colonies	Active Beaver Colonies	Unwanted Beaver	Bad or Unknown Beaver Habitat	
Reintrod								
Dams								
Plantings								
Food								
Lodging								
Mitigate Damage				_				
Relocate								
Lethal Removal								
Regulations								
Land Management								



Summary-Where can beaver thrive?

- BIP or similar models help guide where to look (and where not to look) for beaver habitat. They are an indicator, but not necessarily a good predictor at the reach level
- Land ownership is a key filter
- Need a favorable regulatory environment
- On-the-ground surveys are ultimately needed to evaluate:
 - Current and historic beaver usage
 - Substrate (bank and bed) conditions
 - Competition
 - Verification of remotely sensed parameters
 - Stream slope
 - Stream width
 - Valley width
 - Vegetation



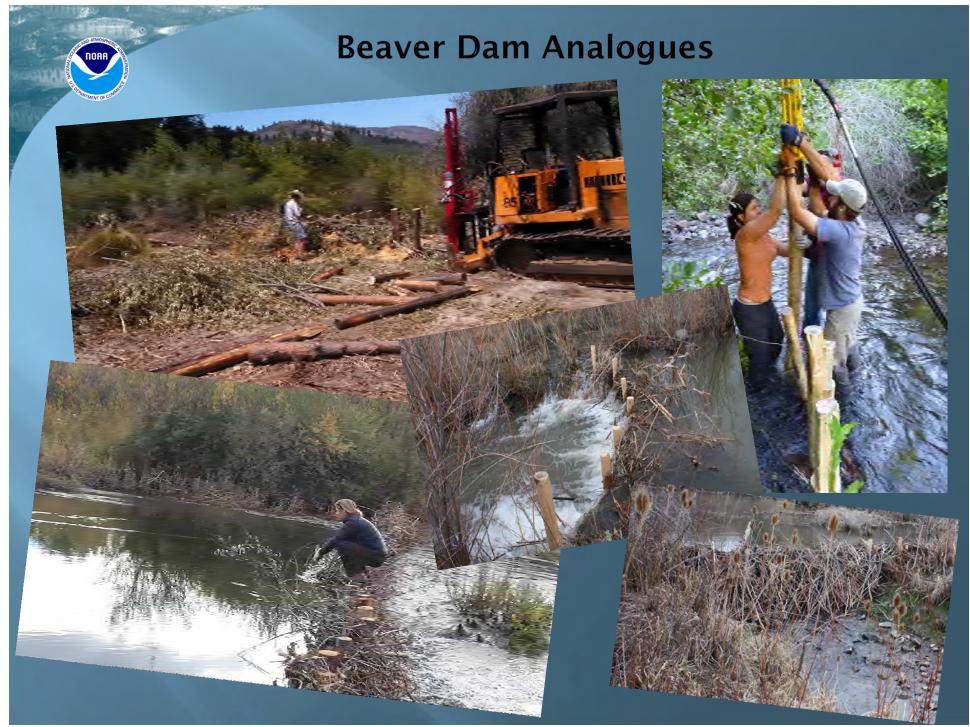
Overview of Steps in Beaver Restoration Projects

- Define project goals, time frame, spatial extent, resources, collaborators
- 2. Beaver habitat restoration assessment-watershed level
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- 6. Develop appropriate beaver restoration techniques
 - 7. Develop restoration and monitoring plans
 - 8. Implement restoration and monitoring plans
 - 9. Adaptive management



6. Developing Appropriate Beaver Restoration Techniques (By Habitat Type)

	Beaver Habitat Types						
		Good Un-					Bad or
Beaver	Restorable	occupied	Abandoned	Active	Active		Unknown
Restoration	Beaver	Beaver	Beaver	Beaver	Beaver	Unwanted	Beaver
Techniques	Habitat	Habitat	Colonies	No Colonies	Colonies	Beaver	Habitat
Reintroduce							
Dams							
Plantings							
Food							
Lodging							
Mitigate Damage							
Relocate							
Lethal Removal							
Regulations							
Land Management							





Beaver Dam Analogues

- What are BDAs and what do they do?
 - Working Definition: "Structures completely or partially built by humans that mimic many of the functions of natural beaver dams"
 - Characteristics
 - Reduce velocities
 - Raise water tables
 - Reduce bedload and washload transport
 - Disperse flow
 - Create ponds, pools and wetlands
 - Create riparian habitat
 - Passable to fish
 - 100% Organic
 - Dynamic and stochastic
 - Porous
 - Often used by beaver
 - Require multiple treatments



BDAs-Materials and Equipment

- Materials-similar to beaver dams
 - Willow branches
 - Herbaceous vegetation
 - Rocks
 - Mud
 - Wood posts*
- Equipment needed
 - Chainsaw-to cut and sharpen posts
 - Hand saws to cut willow
 - Post pounder/power source (hydraulic or pneumatic)
- Material cost and labor = \$500-\$5000/structure
 - Size of structure (length)
 - Size of stream (depth of posts)
 - Source distance of building materials
 - Labor costs
 - Efficiency



BDA VariantsPost Line

- Post Line with Willow Weave
- Starter Dam(=sealed PLWW)
 - Upstream berm
 - Downstream berm
 - No berm
- Reinforced Existing or Abandoned Dams

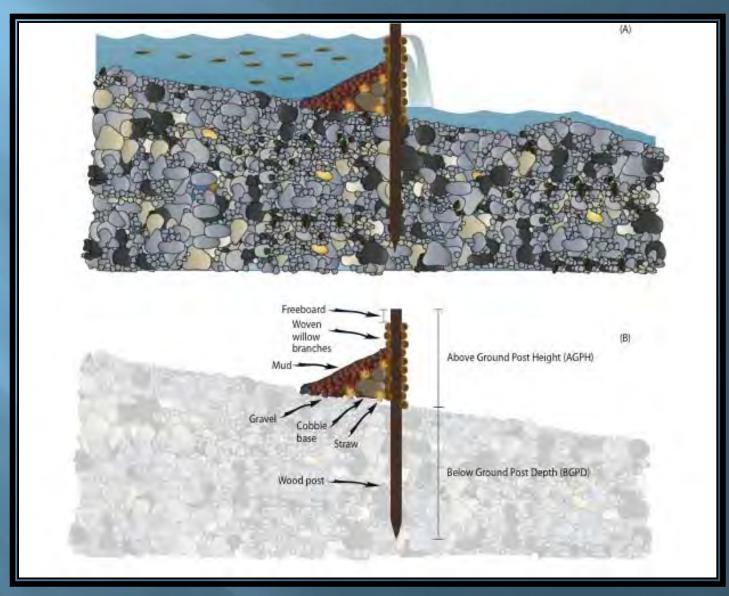








Beaver Dam Analogue-Side View



Beaver Dam Analogue-Plan View

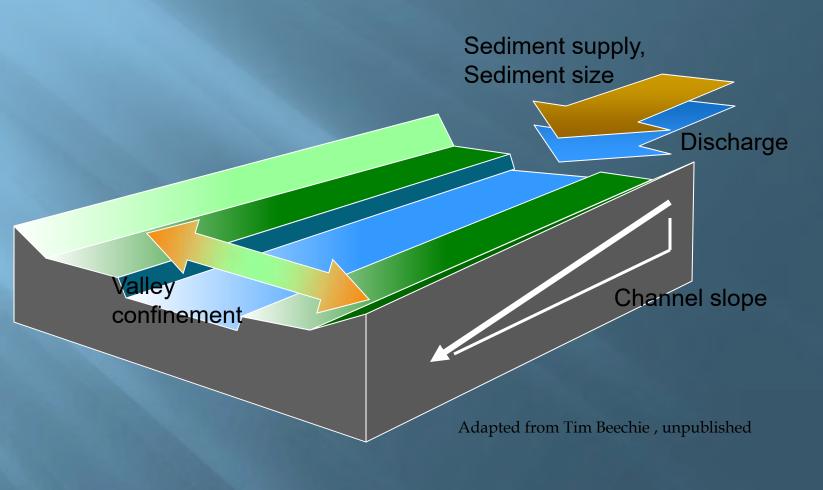


Beaver Dam Analogues-Placement

- Where are BDAs placed?
 - In reaches that can or could support beaver
 - Site-specific considerations include:
 - Habitat unit (e.g. glide, pool, riffle)-Riffle crests preferred
 - Degree of incision
 - Floodplain width
 - Terrace width
 - Stream planform
 - Stream slope
 - Bank material
 - Bed material
 - Beaver presence/absence
 - Proximity to infrastructure
 - Competitors and predators
 - Vegetation
- Placement is most technically challenging aspect of BDAs

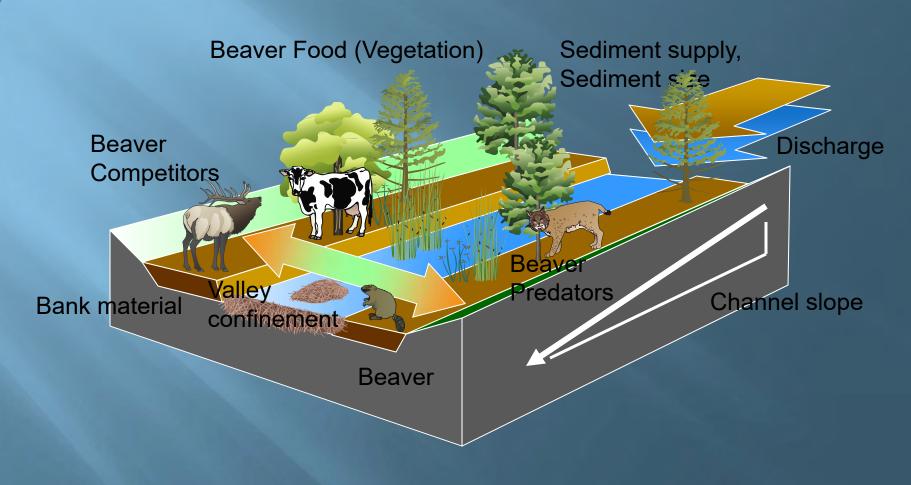


Local Controls on BDA Placement/Response



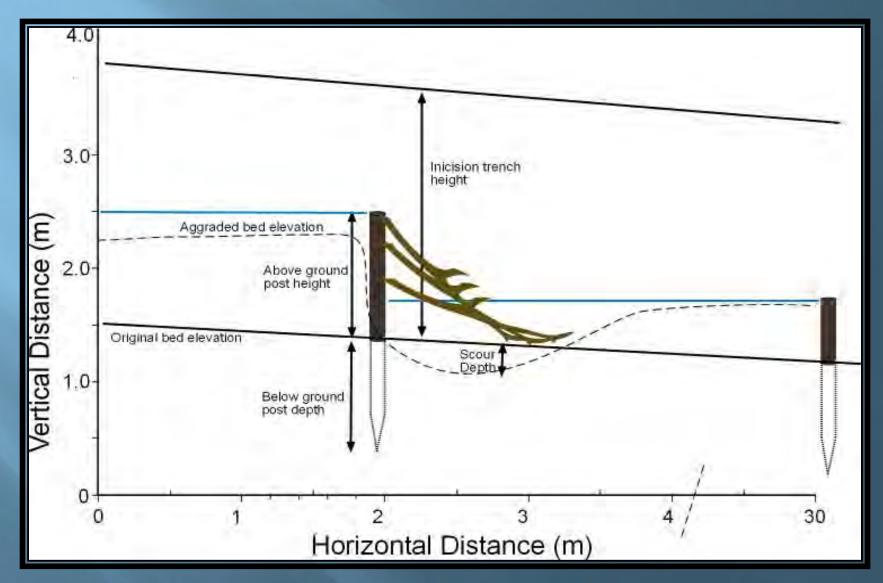


Local controls on BDA Placement/Response



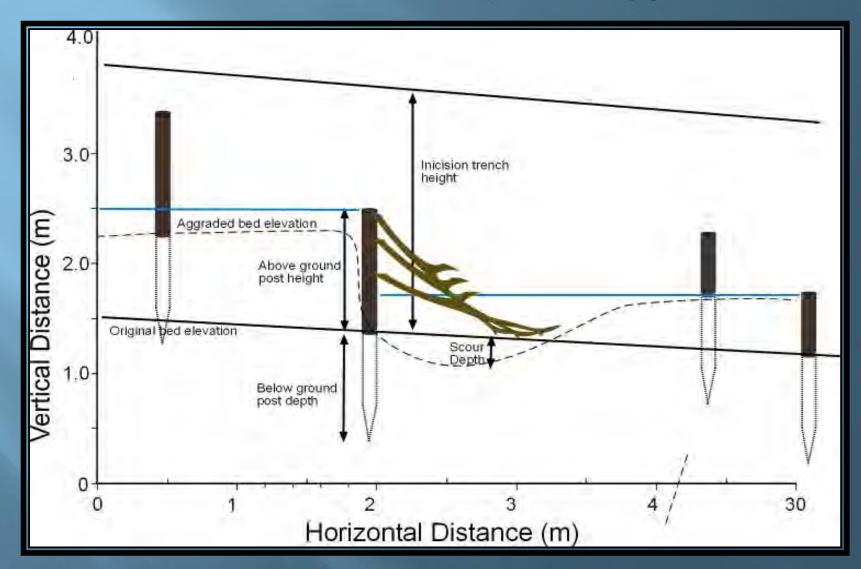


BDA Placement in Incision Trench



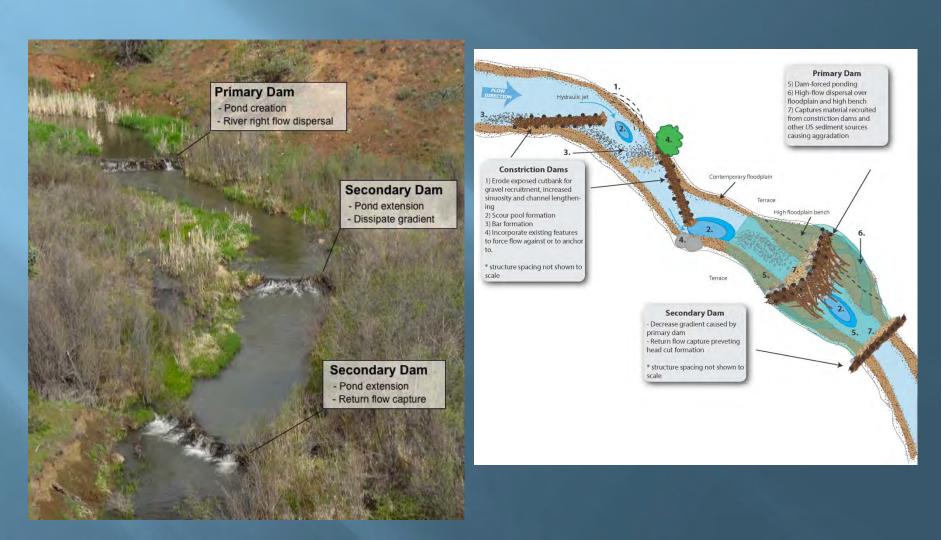


BDA Placement-Round 2, after Aggradation





BDAs work well together



michael.pollock@noaa.gov



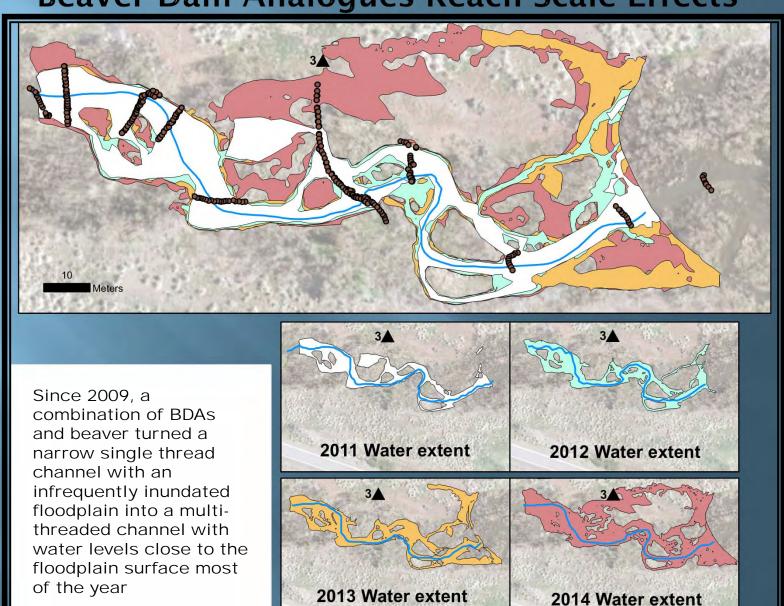
Beaver Dam Analogues-Reach Scale Treatment



Figure courtesy of Carol Volk, South Fork Research



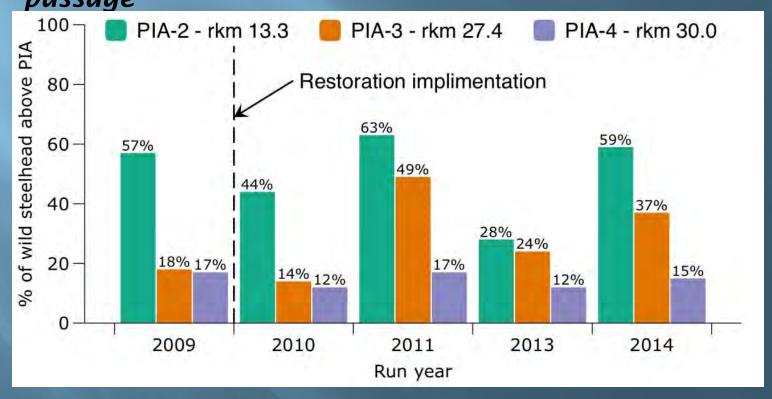
Beaver Dam Analogues-Reach Scale Effects





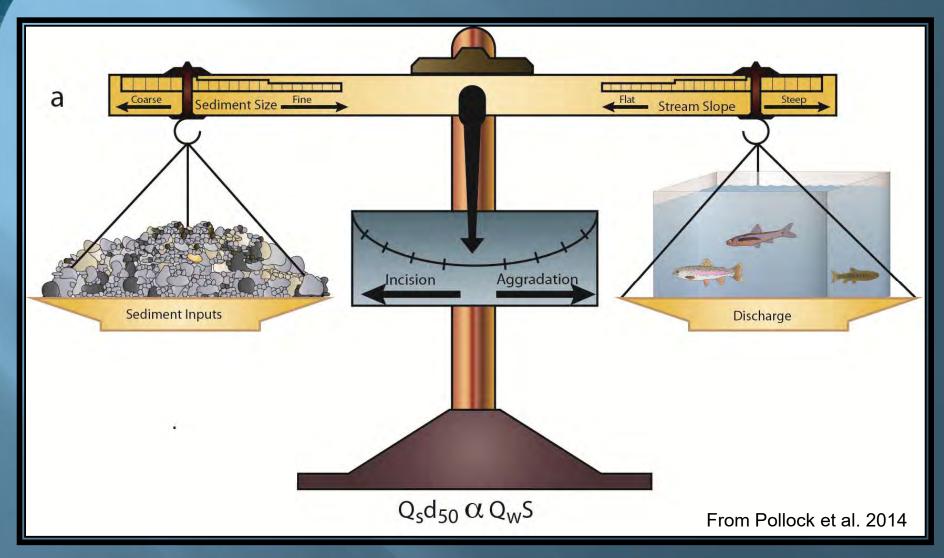
Effects of Multiple Dams on Fish Passage

By 2014 over 200 BDAs and natural dams over 30 km on Bridge Creek-no adverse effect on fish passage



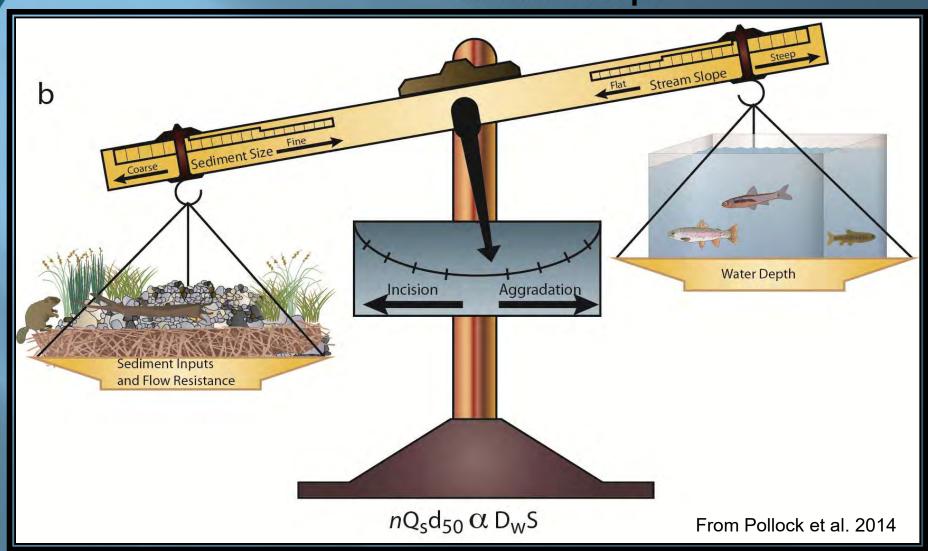


Physical Models Focus on the Relationship Between Hydrology and Sediment





Biology (e.g. beaver dams and vegetation), Significantly affects sediment-discharge relationships

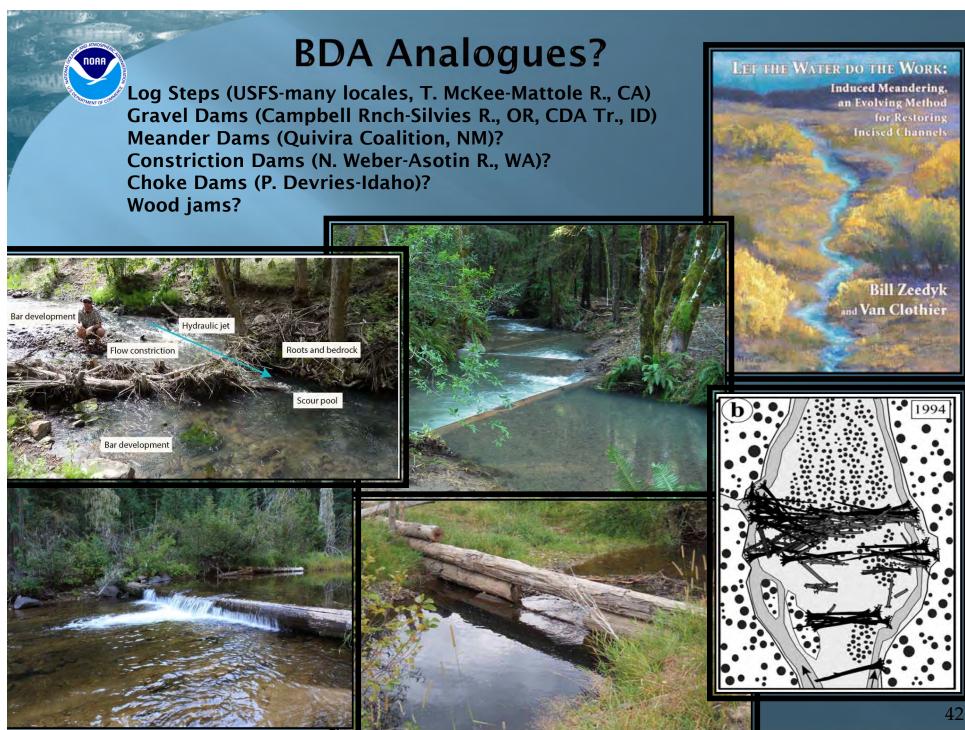




Some things to think about

- WWBD?
- Stream
 management (sim
 to forest
 management)
- Dynamic and stochastic, therefore hard to cookbook
- Helps to understand habitat-forming processes

- Involves longer temporal and spatial scales than typical projects
- Coevolutionstreams, beaver and salmon have been around a long, long time
- Many species not adapted to engineered streams





BDA "failure"

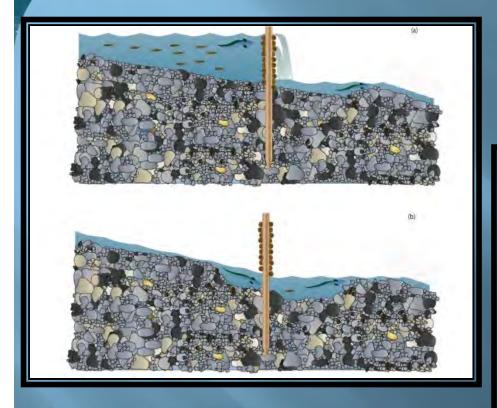
- 1. "Fail" Definitions not applicable-
 - -To not succeed
- -To stop functioning normally
- -To be unsuccessful in achieving ones goal
- -To prove deficient or lacking
- -To perform ineffectively or inadequately
- 2. Spatial and temporal scales of fail
- 3. Comparative costs of incr. fail v. decr. fail
- 4. You will fail
- 5. If you don't fail, that is in itself, failure

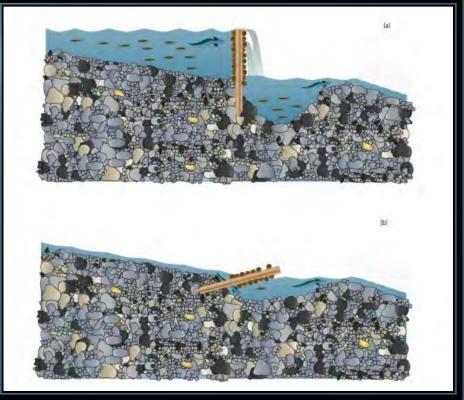






BDA Failure mechanisms, continued





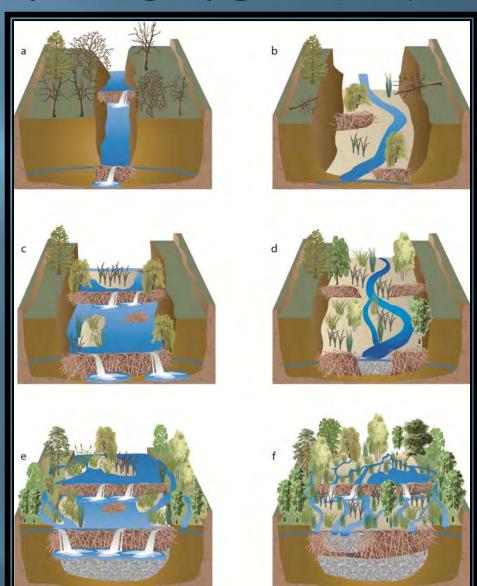
michael.pollock@noaa.gov



THINK BIG THINK LONG-TERM

"Success" or "failure" is a function of

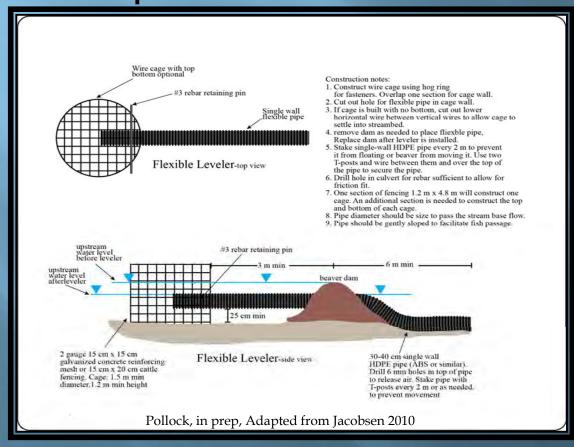
- -time
- -space
- -goals





Mitigating Beaver Damage

- Pond levelers
- Culvert guards
- Tree protection





Pond leveler photographs from Boyle

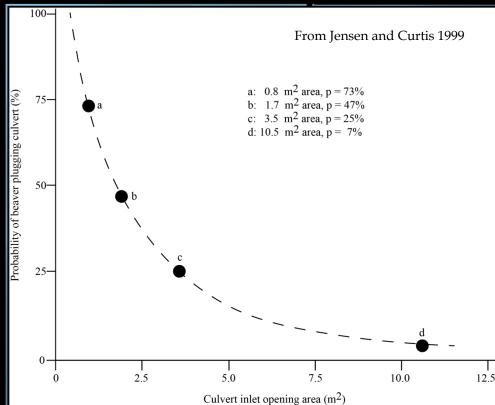


Mitigation Techniques







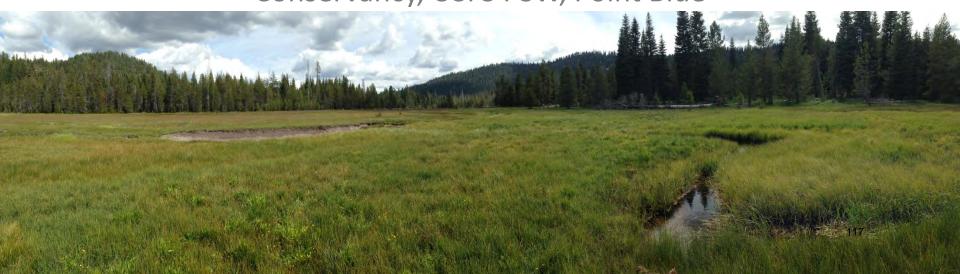


Culvert guard photographs from Boyle 2006



A Demonstration of the Carbon Sequestration and Biodiversity Benefits of Beaver and Beaver Dam Analogue Restoration Techniques

Childs Meadow, Tehama County CA
UC Davis Center for Watershed Sciences, The Nature
Conservancy, USFS PSW, Point Blue



Childs Meadow Partners



UC Davis - Sarah Yarnell, Teddy Eyster (hydrology, geomorphology, restoration)



The Nature Conservancy – Kristen Podolak, Rodd Kelsey, Andrea Craig, Brian Cohen and Chris McColl (restoration and grazing mgt, geomorphology, uav)



UC Davis – Evan Wolf (carbon, restoration)



Point Blue –Ryan Burnett (birds, restoration)



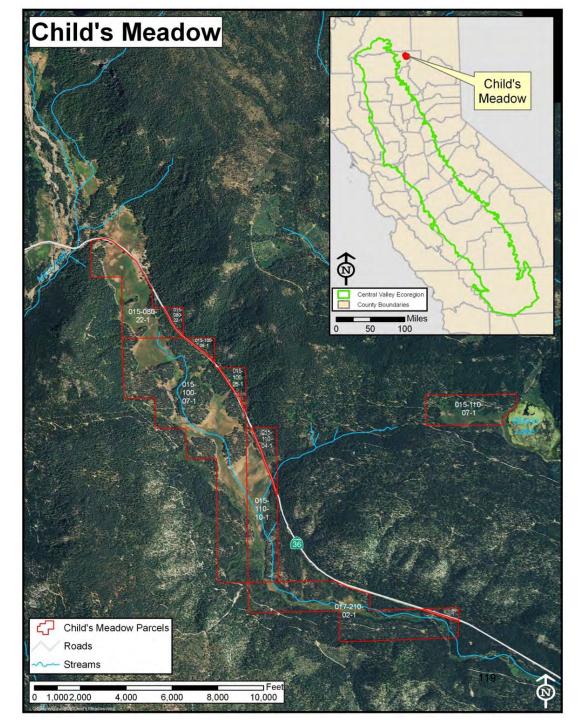
USFS PSW – Karen Pope (amphibians, restoration)



Peter Thamer ₁₁₈ (BDA construction)

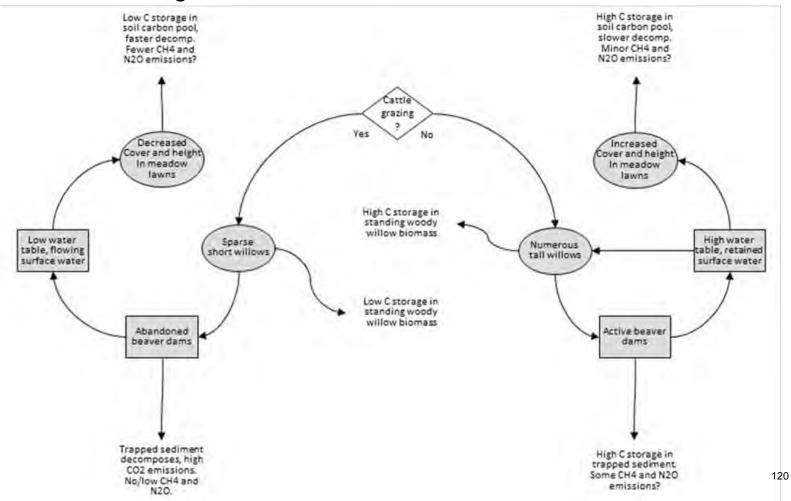
Opportunity

- Private landowner
- Independently held grazing rights
- Sensitive species adjacent
- Beaver colonization possibility
- Collaborative partners
- Interest in an experimental study



Land-use History

- Current owner: Collins Pine Timber Company with a conservation easement by The Nature Conservancy (2015)
- Cattle grazing hypothesized to be a source of meadow degradation limiting beaver and carbon storage

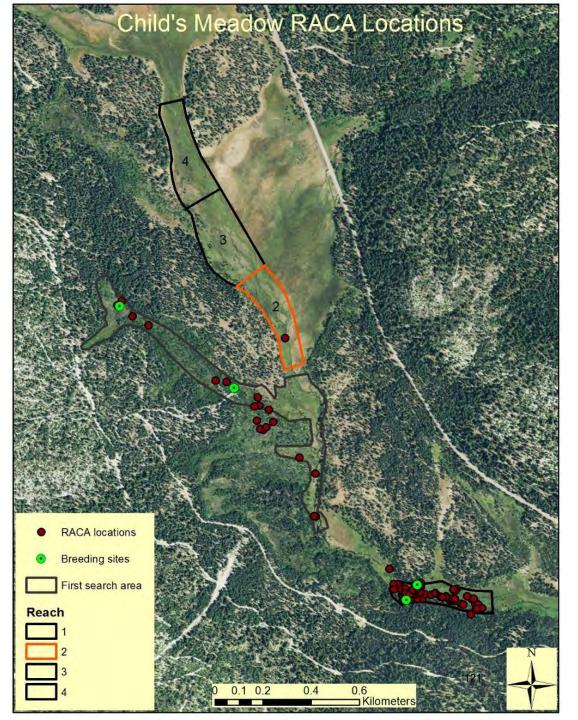


Sensitive Species

- Willow flycatcher
- Cascades frog









Pre-restoration meadow conditions



Funded by CDFW

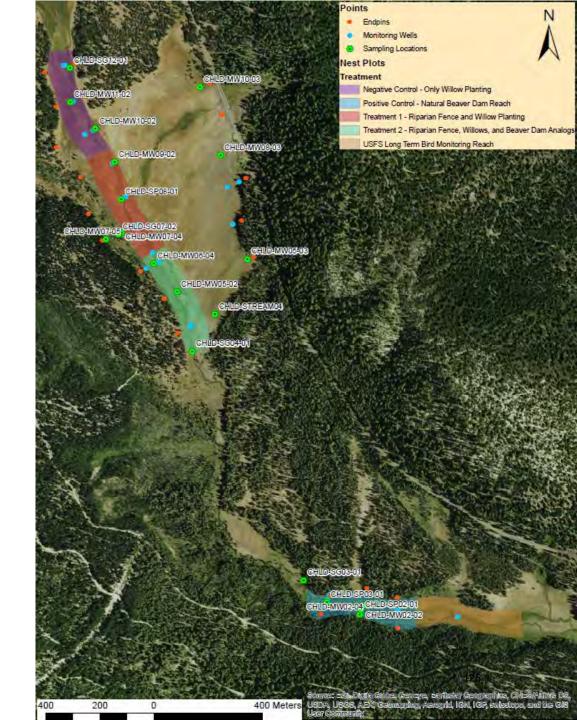
- Wetland Restoration for Greenhouse Gas Reduction Grant Program (Grant # P149600
- July 1, 2015 Nov 30, 2019
- Pre-restoration data collection: 2015-2016
- Post-restoration data collection: 2017-2019
- Study Goal: To assess the effects of riparian fencing, willow planting and installation of BDAs on meadow hydrology, geomorphology and ecology using a classic experimental study design



Study Design

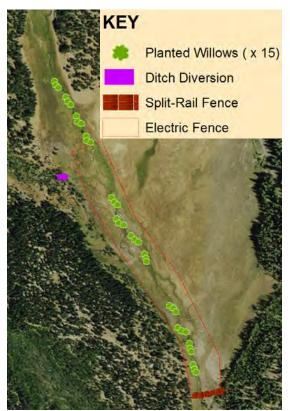
- BACI
 - 2 treatments
 - 2 controls
- Above and below-ground carbon
- Hydrogeomorphic conditions
- Response of targeted wildlife spp.
 - Willow flycatcher
 - Cascades frog





Restoration Plans

- Fall 2015
 - Grazing exclosure fence
 - Block ditch
 - Plant 540 willows (3*15*12)
- Fall 2016
 - Install six beaver dam analogues











Expected Benefits

- 1. Restore 80 acres of Childs Meadow using costeffective Beaver Dam Analogues and riparian fencing
- 2. Increase carbon sequestration, as measured by soil organic carbon, by 10% over 3 years postrestoration
- 3. Increase groundwater levels and surface water extent by 10% over 3 years post-restoration
- 4. Increase sensitive species habitat by 60% based on stream miles

Permitting for BDAs

- CEQA lead agency is CDFW, categorical exclusion
- 1. 404 (27) permit— may use USFWS partnership program, will submit application to ACOE
- 2. 1600 Lake and Streambed Alteration
 Agreement will submit to CDFW
- 3. 401 Water Quality Certification will submit to the Central Valley Regional Water Quality Control Board



A Practitioners Guide to Working with Beaver to Restore Streams, Wetlands and Floodplains

Available at USFWS website:

http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp

Greg Lewallen -- Oregon Department of Environmental Quality

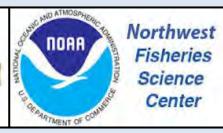
Michael Pollock, Chris Jordan — NOAA Northwest Fisheries Sciences Center

Kent Woodruff – US Forest Service

Janine Castro — US Fish and Wildlife Service & NOAA Fisheries















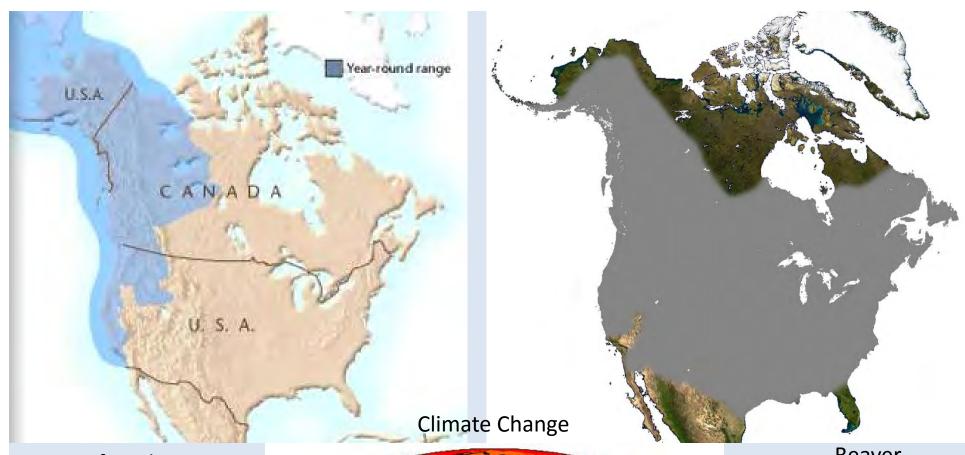
Promote development, coordination & dissemination of <u>science</u>

to <u>inform</u> landscape-level conservation & sustainable <u>resource management</u>

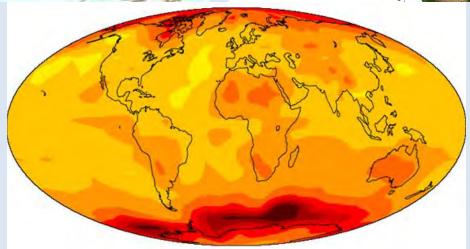
in the face of a <u>changing climate</u> and related stressors.

NorthPacificLcc.org

- Learn more about the NPLCC and our science projects
- Join our mailing list
- Find out how to contact us



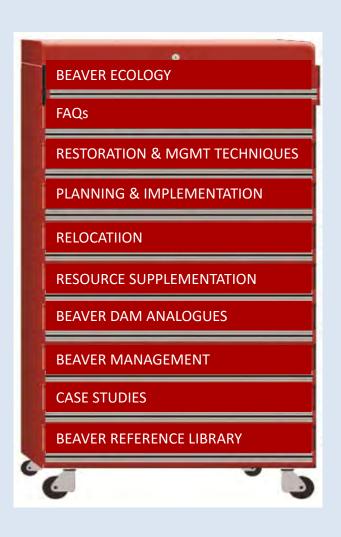
Pacific Salmon From: canadiangeographic.ca



From: nature-education.org

Beaver

From: commons.wikimedia.org



Broad Intended Audience

Regulators → Interested Public

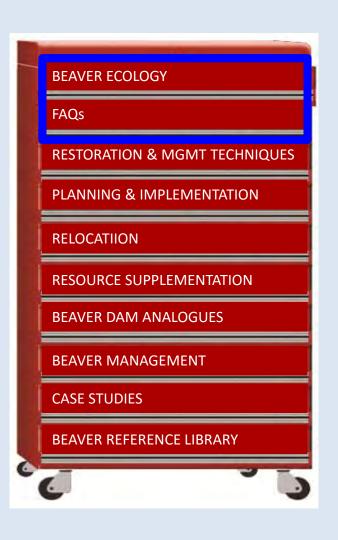
State of the Science

Beaver bib. > 1,400 References

Access

USFW Website:

http://www.fws.gov/oregonfwo/Tool sForLandowners/RiverScience/Beave r.asp

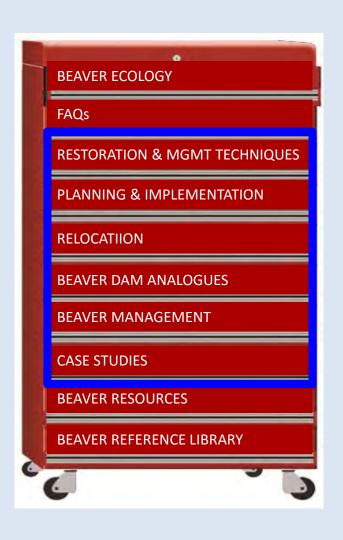


Section 1 – Beaver Ecology

Ch.1- Effects of beaver dams

Ch.2- FAQs

Ch.3- Beaver myth busters



Section 2 – Restoration & MGMT

Ch. 4- Watershed planning

Ch. 5- Relocation

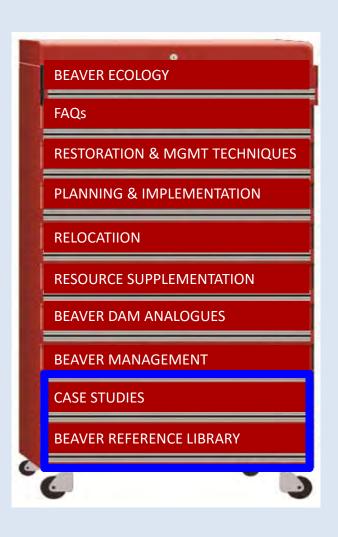
Ch. 6,7- BDAs

Ch. 8- Managing habitat for beaver

Ch. 9- Non-lethal MGMT

Ch. 10- Beaver dam viability matrix

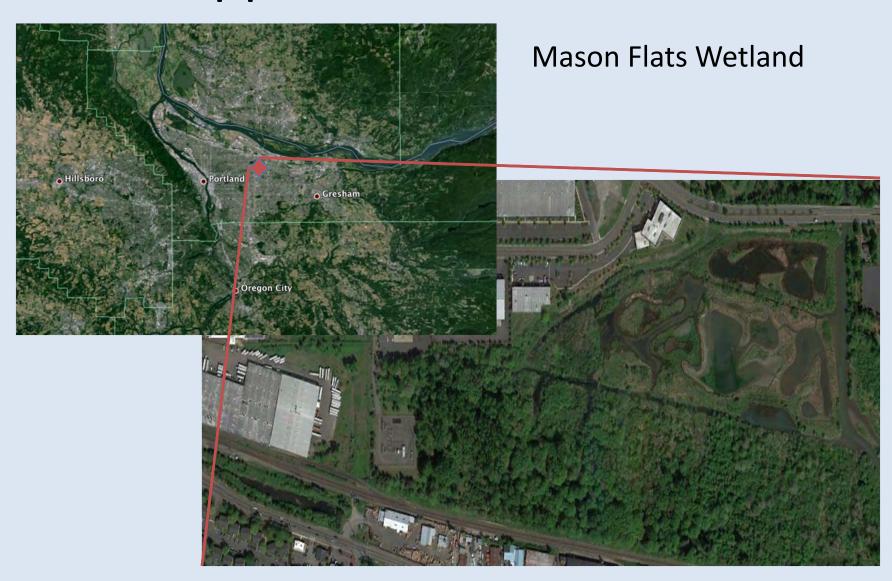
Ch. 11- Case studies



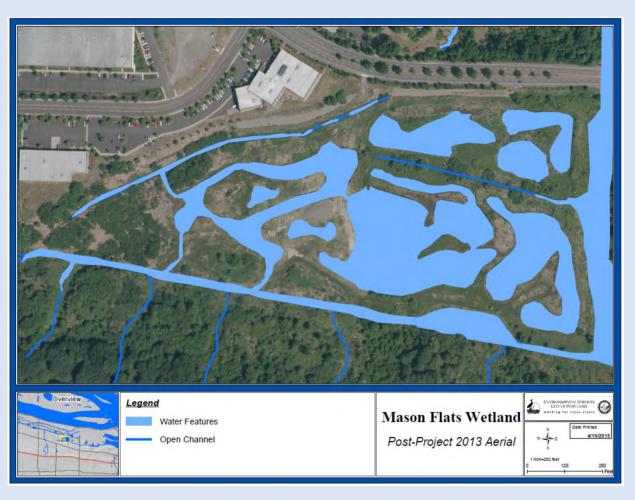
<u>Section 3 – Supplemental Info</u>

Beaver Resources
Acronyms & Abbreviations
Literature Cited
Plant Species
Subspecies

Application of the BRG



Application of the BRG



Project Goals

Improve Columbia
Slough water quality

Improve habitat for native species

Increase floodplain function and FW storage

Increase riparian veg.

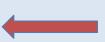
Protect and enhance wetland habitat

Major Questions

Is beaver-based restoration applicable?



Will beaver modifications support the restoration project goals?



How will beavers impact this site?



What Techniques can be utilized to reach goals?

BEAVER ECOLOGY SECTION

Chapters: 1-3

Increased water retention and baseflows

Decreased peak flows

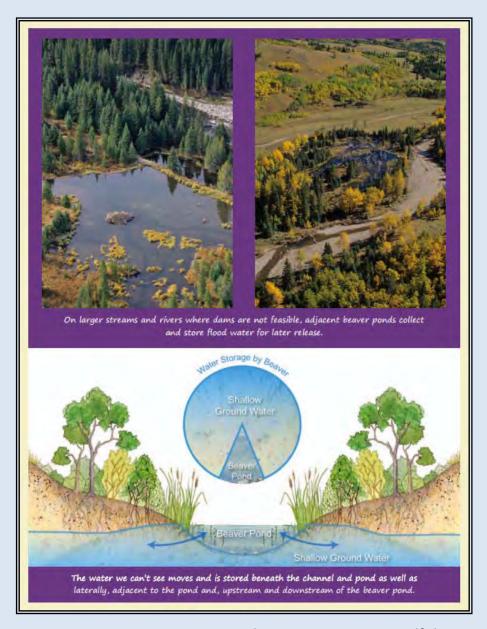
Create habitat for red-legged frogs, painted turtles, willow fly-catchers

Increase riparian vegetation

Increased wetland habitat



Photo: Fitch, L. 2016

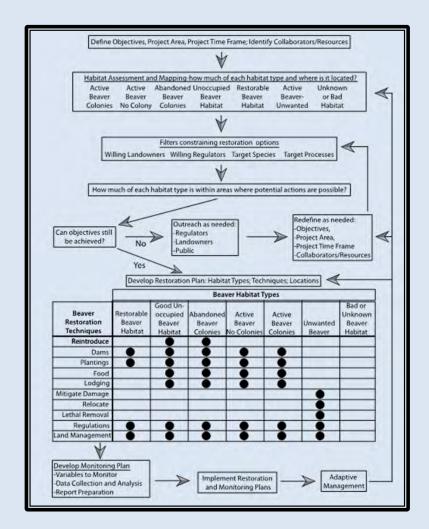


Fitch, L. 2016; www.cowsandfish.org

What Techniques Can be Utilized?

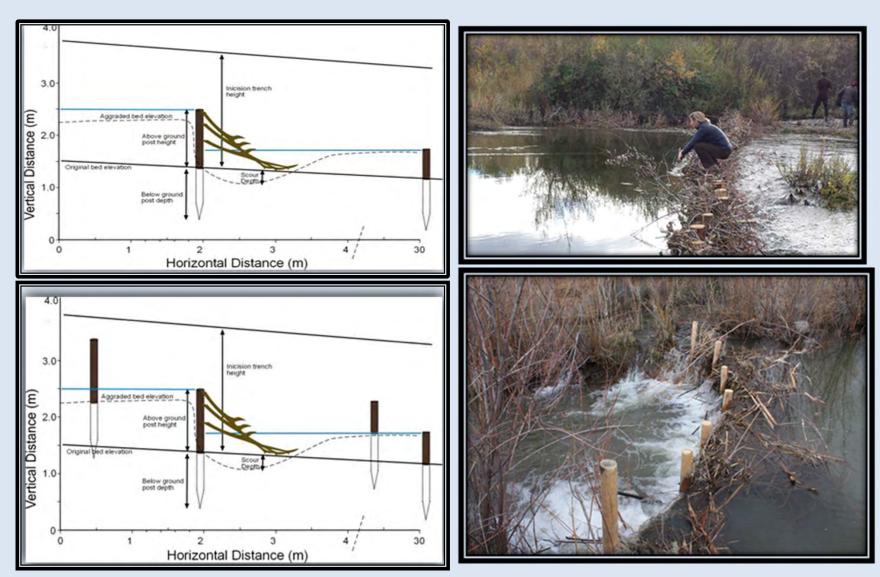
Watershed Planning Chapter 4

- Project Area, Time Frames, Habitat Assessment
- External Constraints
 - Adjacent land use
 - CommunityAssessment



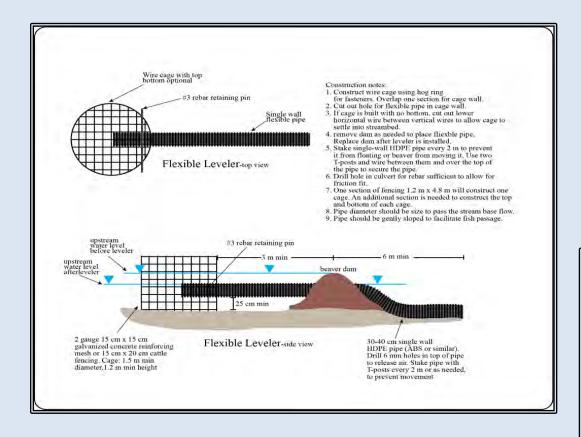
Beaver Dam Analogues

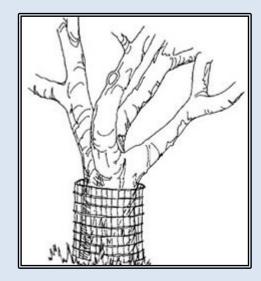
Chapters 6 & 7



Non-Lethal MGMT of Beaver

Chapter 9

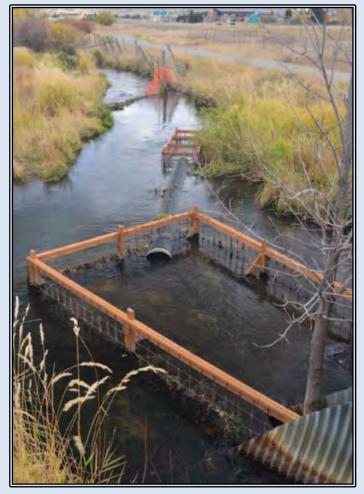






Non-Lethal MGMT of Beaver

Chapter 9



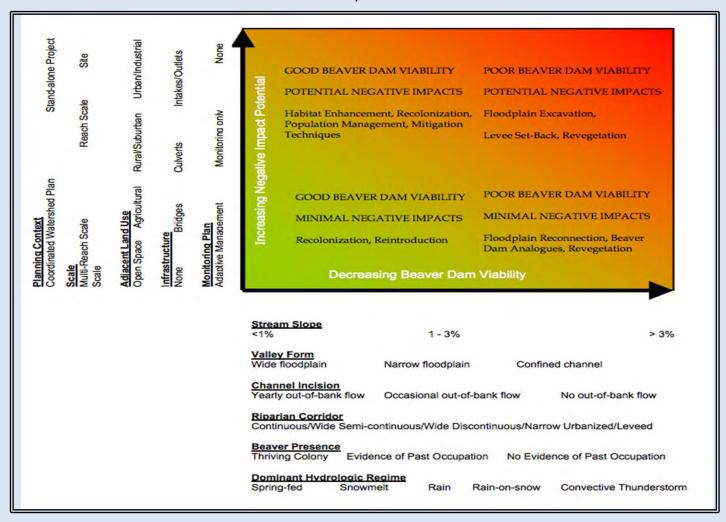
Fitch, L. 2016; www.cowsandfish.org



Methow Beaver Project: Photo

Risk Assessment

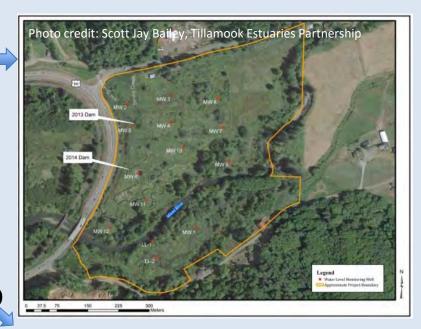
Chapter 10



Case Studies

Chapter 11

- 1. Miami Wetlands, Oregon
- 2. Camp Creek, Oregon
- 3. Mason Flats, Oregon
- 4. Tualatin Basin, Oregon
- 5. Wet Meadows, Idaho
- 6. Cucumber Gulch, Colorado
- 7. Myers Creek, Washington
- 8. Hansen Creek, Washington
- 9. Private Ranch, New Mexico





Case Studies

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- 1. Miami Wetlands, Oregon
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- 7. Myers Creek, Washington
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- 9. Private Ranch, New Mexico





Photo credit: Okanogan Highlands Alliance

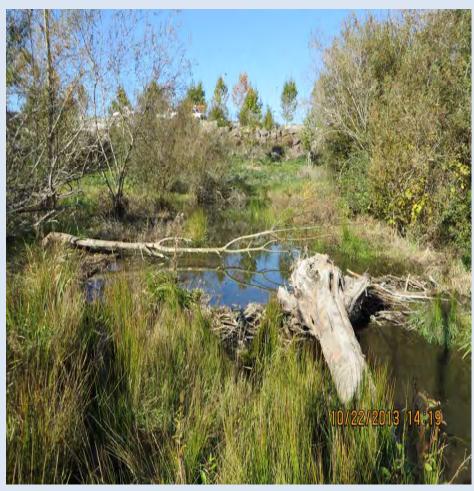
Is Beaver Restoration Applicable?



Dam 14 Oct. 10 2012

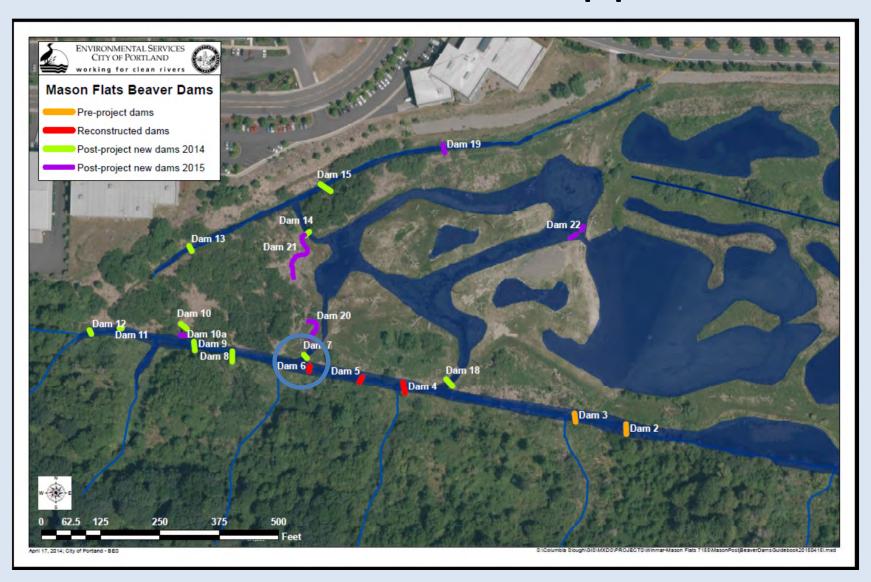
Dam 14 Oct. 10 2013





Photos: City of Portland

Is Beaver Restoration Applicable?



Dam 7 March 2014

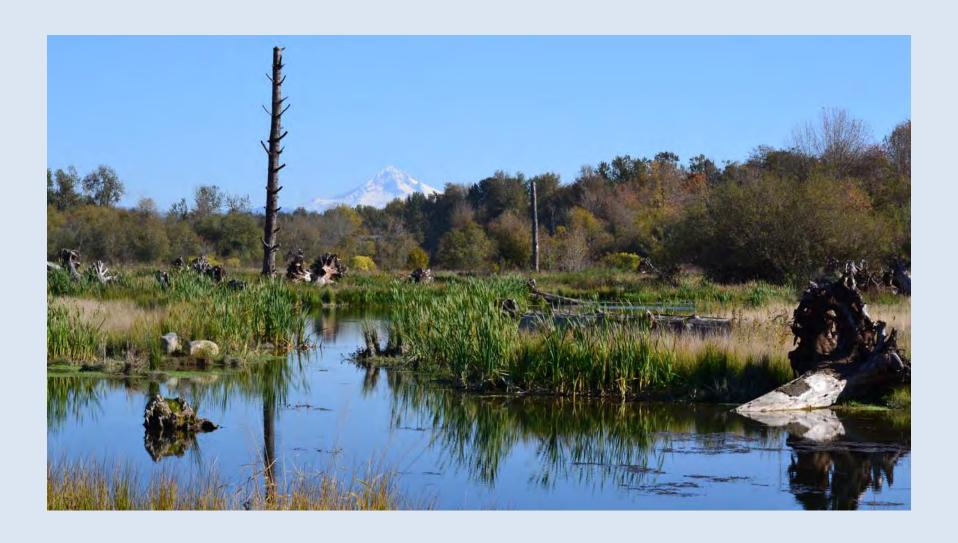
Dam 6 & 7 Sept. 2015





Photos: City of Portland

Mason Flats



Thank You

Greg Lewallen, Natural Resource Specialist, DEQ

glew2@pdx.edu

503-349-4865

Beaver Restoration Guidebook:

http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp















BRG Release Statistics

- Total Opens: 12,283
- Domains who forwarded to their networks
 - Mississippi State College of Forest Resources
 - Pacific States Marine Fisheries Commission
 - Great Northern LCC
 - USFS
 - Yurok Tribe
 - Confederated Tribes of Warm Springs
 - CDFG
 - ODFW
 - New York State Department of Enviro. Conservation
 - Natural System Design
 - State of Main

BRG Release Statistics

Twitter

First tweet: 717 impressions, 9 engagements

Second Tweet: 339 Impressions, 5 engagements

Northwest Climate Science Center Tweet: 4,910 impressions, 48 engagements

Independent tweets from others (+follower counts):

@AlbertaTomorrow (838) @NW_CSC (603)

<u>@beckyhammer</u> (501) - retweeted by official USFS, 87k fol-

@cakeXchange (1,241) lowers, Ecological society of America,

@CleanWaterNews (4,715) 17.6k followers

@clgrivervalleys (208) @PLWAInfo (33)

@CowsandFish (369) @QuiviraAgRanch (1,214)

@DrTComendant (37) @RestoreCAL (164)

@FSologists_AK (1,048) @restoreCAL (164)

@root branch des (87)

@SageGrouseInit (1,479)

@SARSAS (125)

@SEAlbertawaters (1,682)

@tswcd (379)

@USFWSPacific (51.8k)

BEAVER ECOLOGY SECTION

Chapters: 1-3

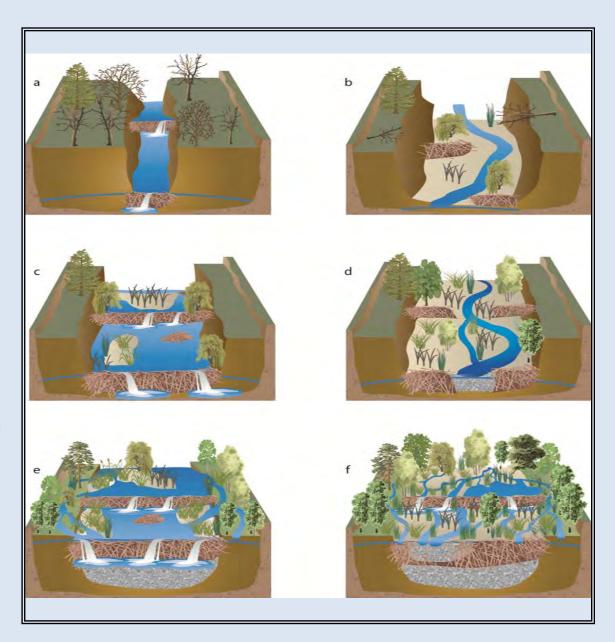
Increased water retention and baseflows

Decreased peak flows

Create habitat for redlegged frogs, painted turtles, willow fly-catchers

Increase riparian vegetation

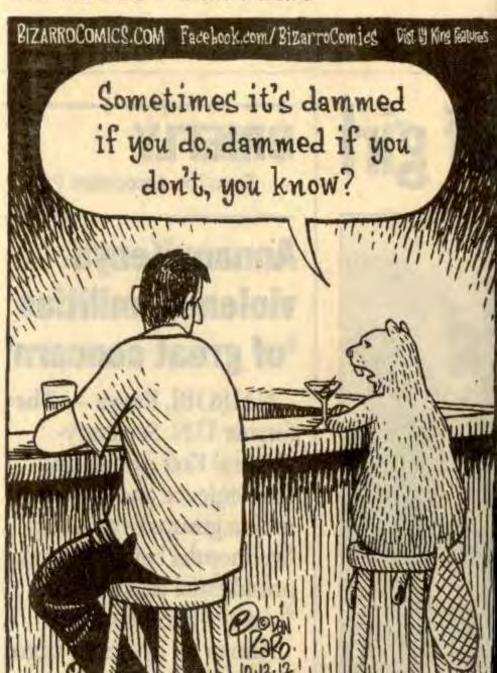
Increased wetland habitat





TIME Inc. 1955

BIZARRO / Dan Piraro



Beaver Dam Analogs: Regulatory and Permitting Considerations

SRF Workshop, Fortuna, CA. April 6, 2016

Gordon Leppig,
California Department
of Fish and Wildlife



Paradigm Shift Happens



A hydrologic Paradigm Shift

- Simplicity vs. Complexity
- Discharge vs. Sinuosity and Roughness
- Conveyance vs. Slow it, Sink it, Store it





Low Impact Development (LID)





The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains
Version 1.0, June 30, 2015



Photo credit: Worth A Dam Foundation (martinezbeavers.org)

Prepared

US First and Wildlife Service
National Oceanic and Atmospheric Administration
Portland State University
US Forest Service

Funded by

North Pacific Landscape Conservation Cooperative

Janine Castro Michael Pollock and Chris Jordan Gregory Lewallen Kent Woodruff



2009 California Climate Adaptation Strategy



Water storage mitigates the loss of snow pack

2009 CALIFORNIA CLIMATE ADAPTATION STRATEGY A Report to the Governor of the State of California

A Report to the Governor of the State of California in Response to Executive Order S-13-2008







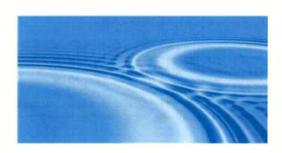
California Water Action Plan

One Goal:

Restore 10,000 acres of mountain meadow habitat.



California Water Action Plan









2015 State Wildlife Action Plan



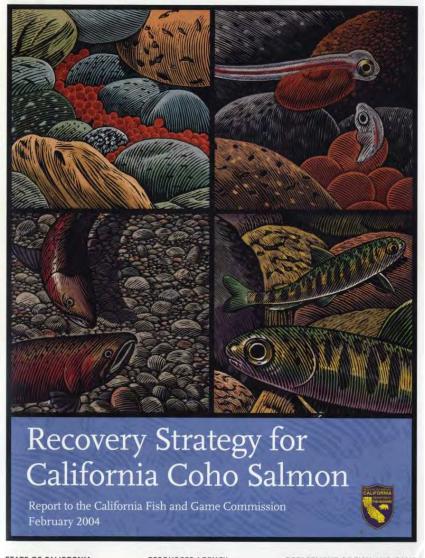








2004 Coho Salmon Recovery Strategy



California Superlatives

California has:

- The highest and lowest points in the continental US
- The 3rd longest coastline (~1000 miles) after AK and FL
- The most National Parks (9)
- The most Federally-designated wilderness areas (149)
- The most federally listed species, after HI (~313 taxa)
- The most diverse flora (>7000 taxa)
- Highest percentage of endemic plants ~1/3
- The world's tallest trees, largest trees, and oldest trees

California also:

- Has the largest state population (>38 million) (expected to be >50 million by mid-century)
- Is home to 1 in 8 Americans
- Has unsurpassed agricultural output (>\$43 Billion in 2011)
- Produces about 1/2 all US-grown fruits, nuts and vegetables
- Is the world's seven or eighth largest economy larger than the economies of Canada, India, or Russia.

California has also lost:

- ~90% of its wetlands (a greater percentage of wetland loss than any other state)
- ~80-90% of its riparian habitat
- >90% of its native grasslands
- >90% of its vernal pool habitat
- >one third of its oak woodlands
- And, almost every major river in the state is dammed, diked, and diverted for agricultural and domestic water use or flood control.

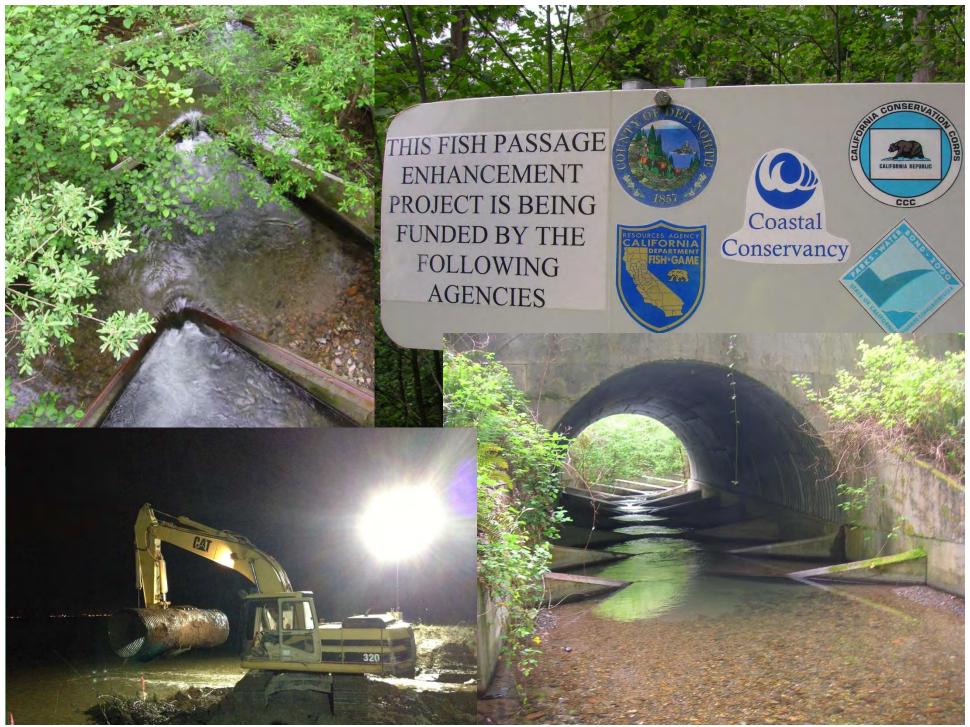
Lake and Streambed Alteration Agreement (LSAA)

- Substantial alteration of bed, bank, or channel
- Substantially divert/obstruct the natural flow





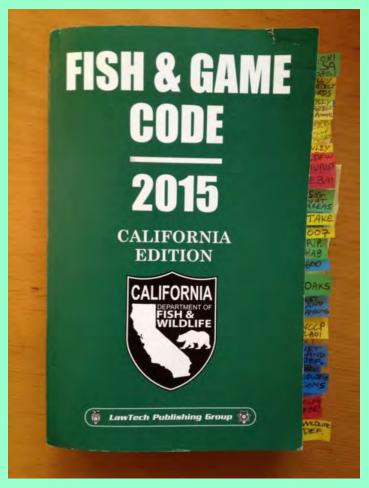




FGC Sec. 5901. Prevent or Impede Fish passage

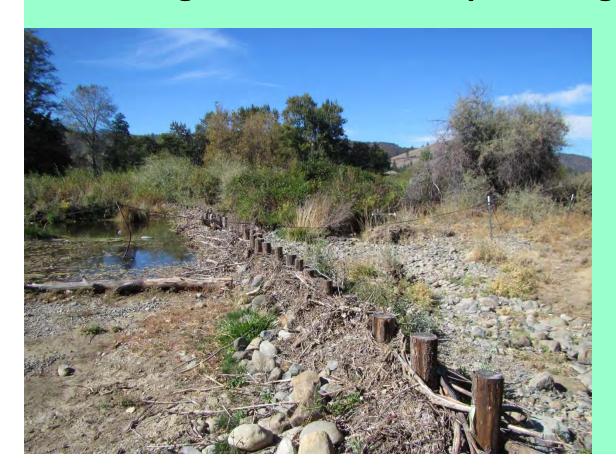
...Unlawful to construct or maintain a contrivance that prevents, impedes, or tends to prevent or impede the passage of fish up and down stream.





FGC Sec. 5937. Sufficient water for Fish existing below dams

...dam shall allow sufficient water to pass, over, around, or through the dam, to keep fish in good condition...

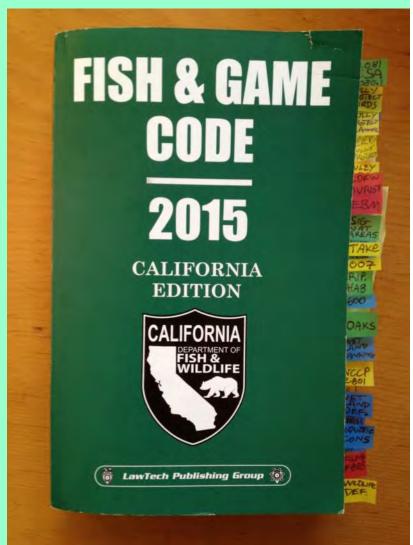




FGC Sec. 5948. Log Jam, Debris, or Artificial Obstruction of Steams; Unlawful

Unlawful to cause or to permit to exist any log jam or debris accumulation, or any other artificial barrier...

...which will prevent the passing of fish up or down stream, or which is deleterious to fish....

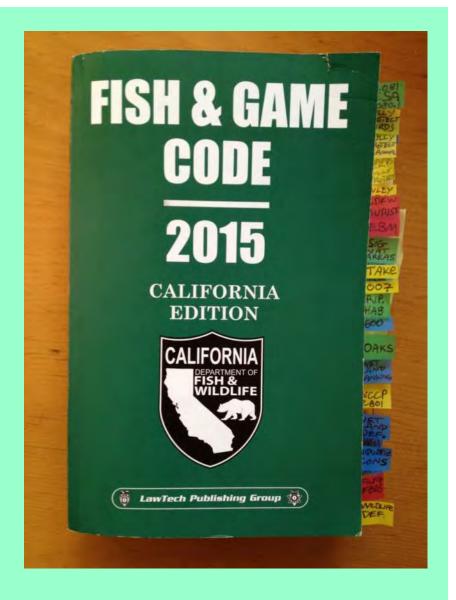




Incidental Take Permit CA. Endangered Species Act (ESA)

Take: hunt, pursue, catch, capture, or kill, or attempt to do so.





Potential Significant Effects?

Determines the appropriate environmental document:

- Categorical exemption
- Negative Declaration
- Environmental impact Report (EIR)



GORDO

2014

California Environmental Quality Act

CEQA Guidelines





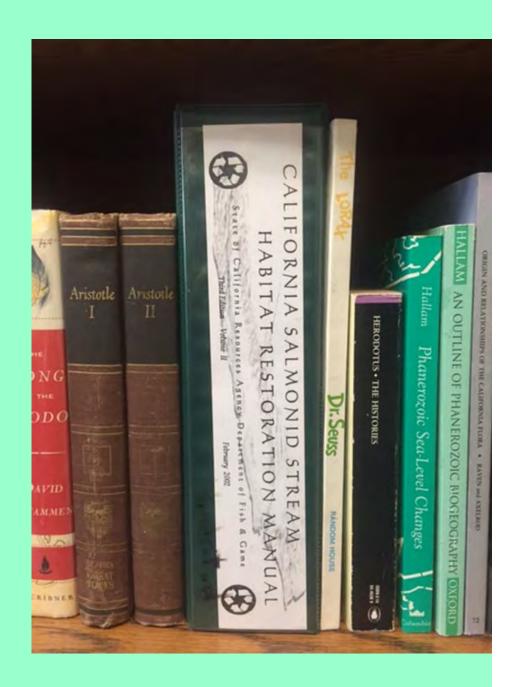


- The Policy of the State, CDFW, and the F&G Commission to use ecosystem-based management informed by credible science in all resource management decisions—to the extent feasible.
- And to incorporate <u>Adaptive Management</u>, where feasible.

CA. Salmonid Stream Habitat Restoration Manual

Revised Edition due out in 2017

Consult CDFW BDA Engineering Design Checklist



Restoration Project Permit Streamlining

- Coho Help Act,
 FGC Sec. 6950
- Habitat
 Restoration and
 Enhancement
 Act, FGC Sec.
 1650



Conservation Biology is the Confluence of Science and Public Policy



Permitting Suggestions:

- Early consultation and agency buy-in is good.
- More information in a permit (LSAA) application is better than less.
- Address head-on all pertinent FGC Sections.
- Consult CDFW BDA Engineering Design Checklist.

Wait for Revised Salmonid Stream Habitat

Restoration Manual....



