Rescaling Central Valley Rivers:

Reconciling Theory with Practice

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Protecting, Connecting, and Re-imagining Floodplain Habitat: Strategies for Restoring the Benefits of Floodplains to Juvenile Salmon

35th Annual Salmonid Restoration Conference

April 01, 2017

CRAMER FISH SCIENCES

Oregon • California • Washington • Idaho • Alaska

Welcome to the Anthropocene

Geology's new age

Dams are now apart of the DNA of our Central Valley Rivers

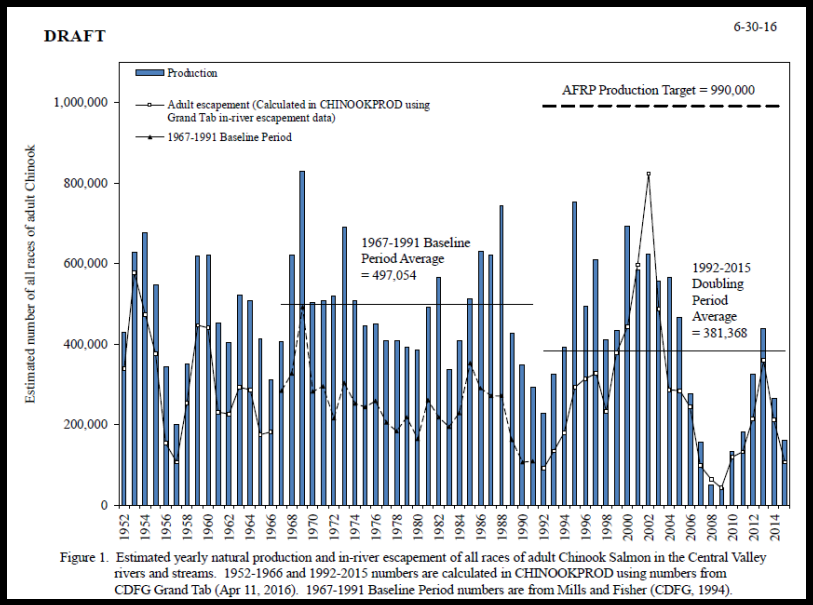
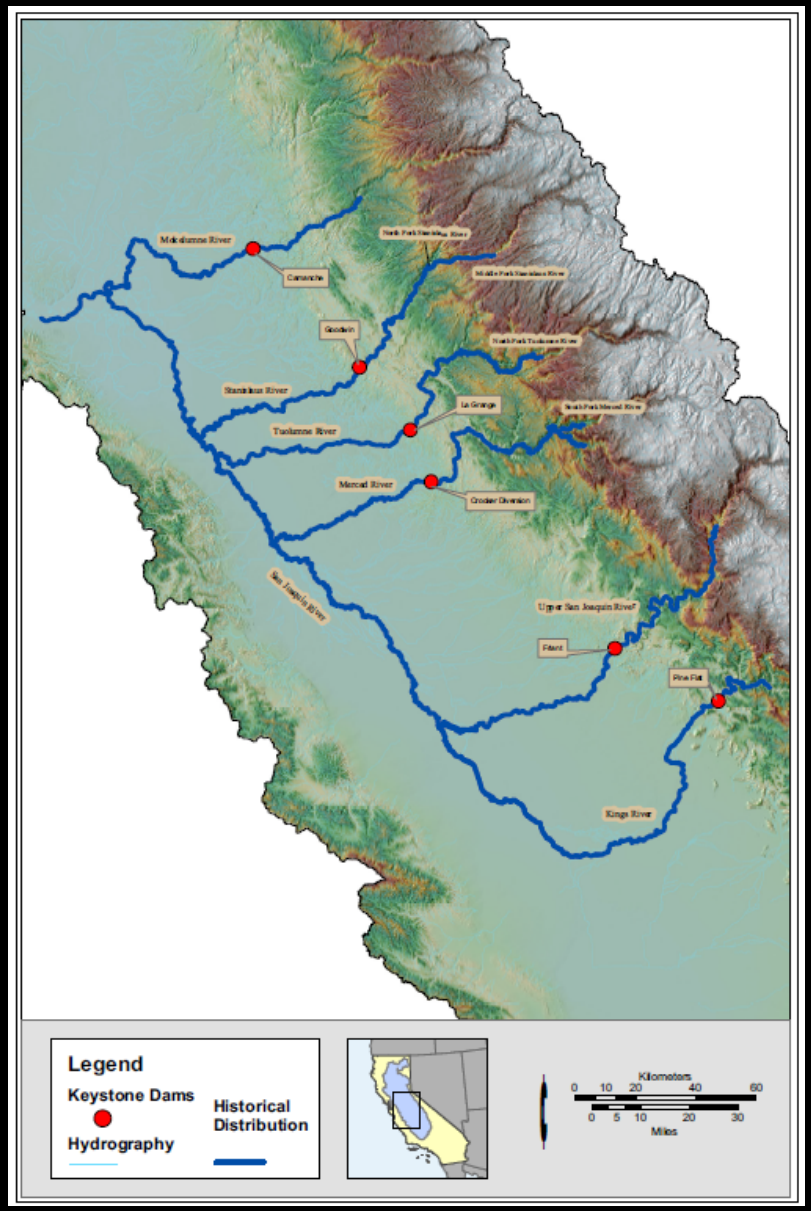
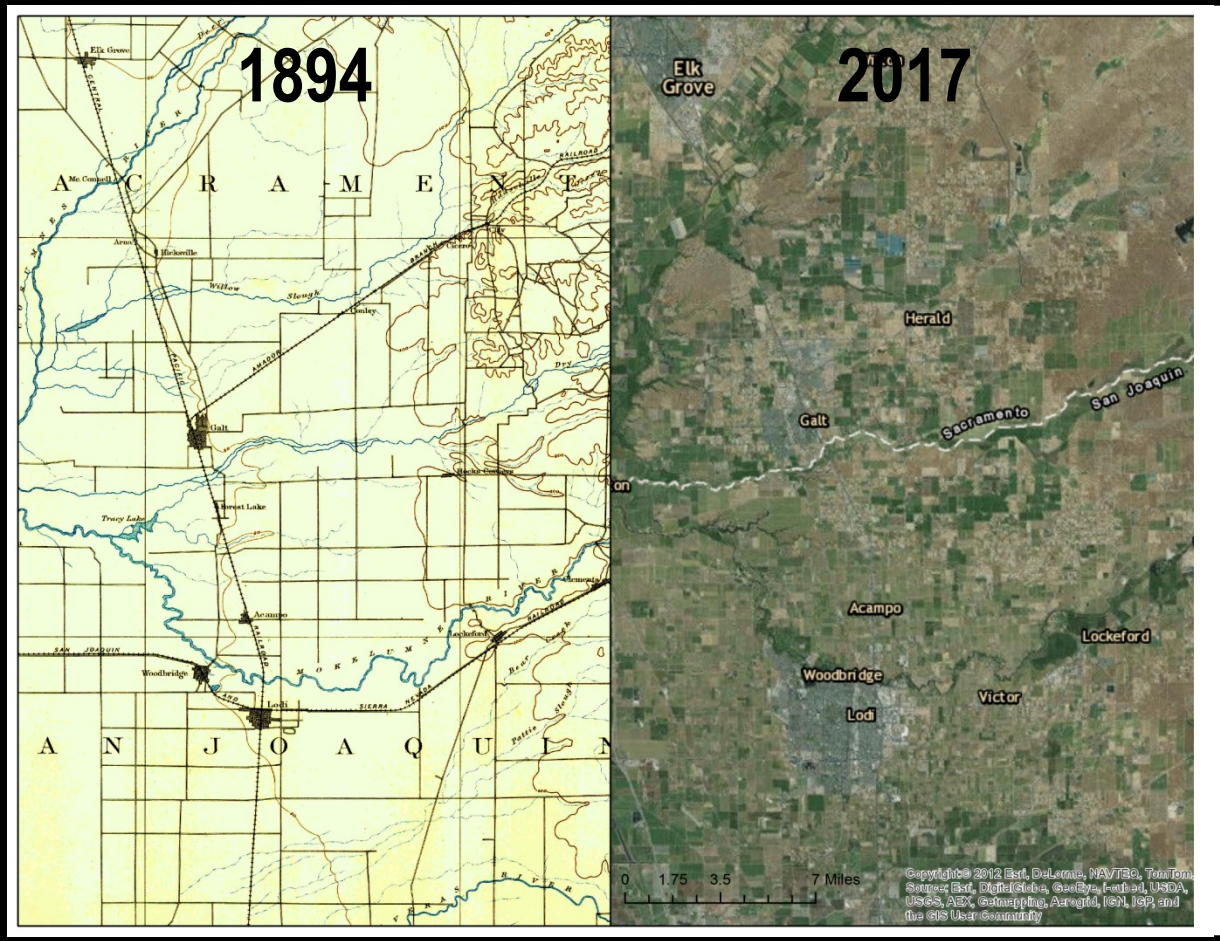


Figure 1. Estimated yearly natural production and in-river escapement of all races of adult Chinook Salmon in the Central Valley rivers and streams. 1952-1966 and 1992-2015 numbers are calculated in CHINOOKPROD using numbers from CDFG Grand Tab (Apr 11, 2016). 1967-1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).



Historical and current mainstem habitat in southern Central valley. NOAA, 2005

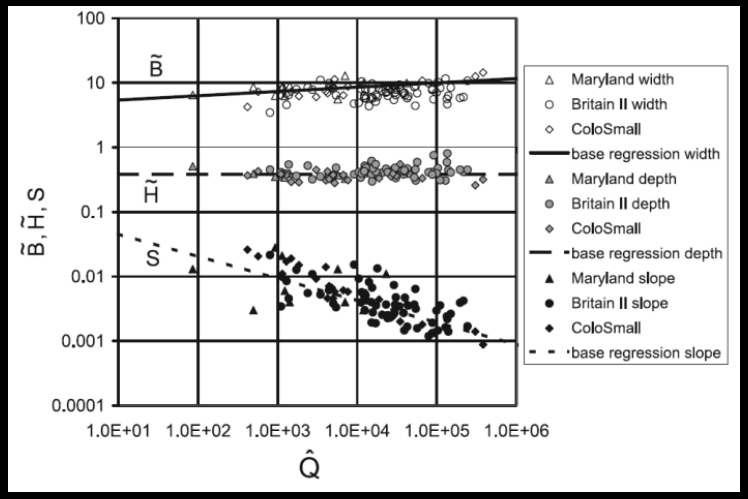
Morphogenesis of flow and form



Rescaling means reshaping channels and floodplains

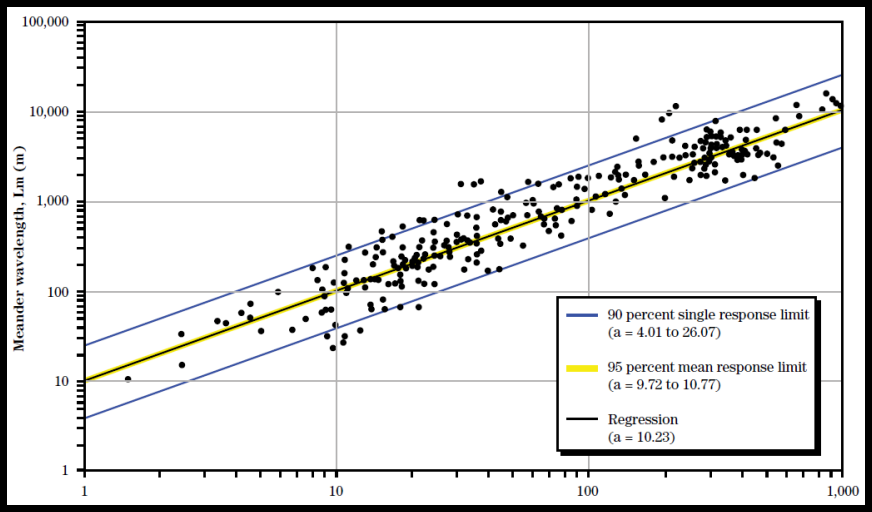
How much should we prescribe through moving dirt and rocks versus letting the river “work?

Knowing/assuming a “channel forming” flow, and some extrinsic reach properties we can calculate stuff

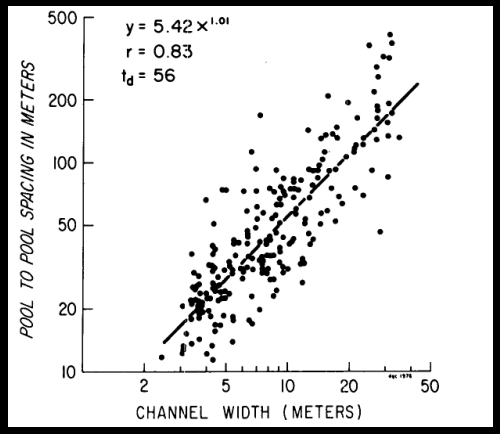


Dimensionless bankfull width ~B, dimensionless bankfull depth ~H , and down-channel bed slope S as functions of dimensionless bankfull discharge ^Q

(Parker et al., 2007. Physical basis for quasi-universal relations describing bankfull hydraulic geometry of single-thread gravel bed rivers)

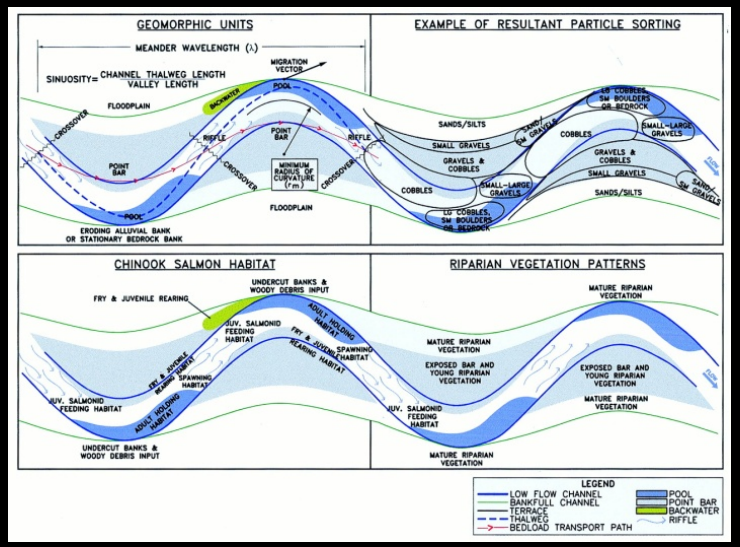


Meander wavelength as a function of channel width for 438 locations (NEH 654, Ch12)



Pool spacing as a function of channel width

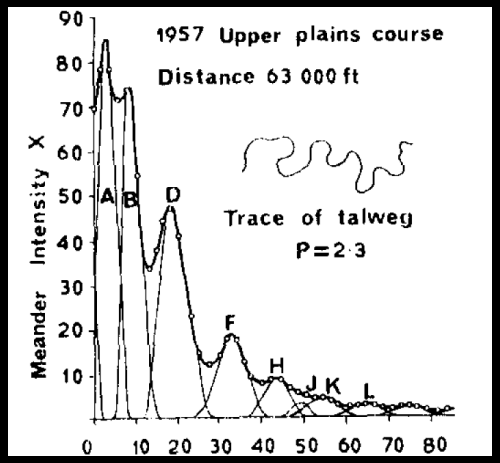
(Keller and Melhorn, 1978. Rhythmic spacing and origin of pools and riffles)



Ideal relationships between form, sediment, plants and fish

Rivers shapes are defined by variability

Meanders have multiple frequencies of oscillation, even altered systems



Meander spectrum for section of the Angabunga River
(Speight, 1965. MEANDER SPECTRA OF THE ANGABUNGA RIVER)

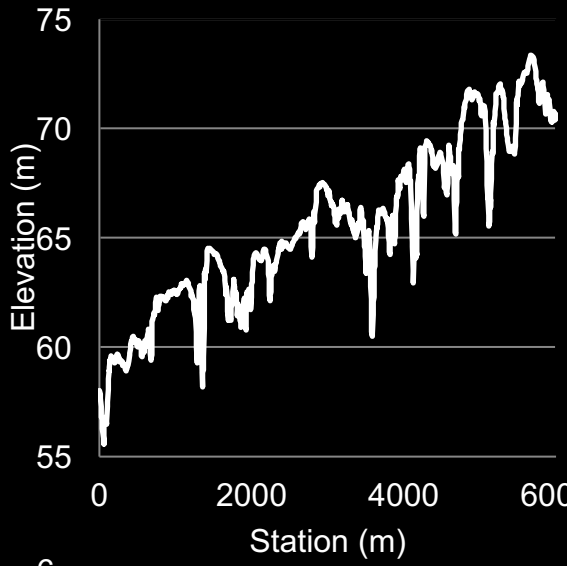
$\neq$

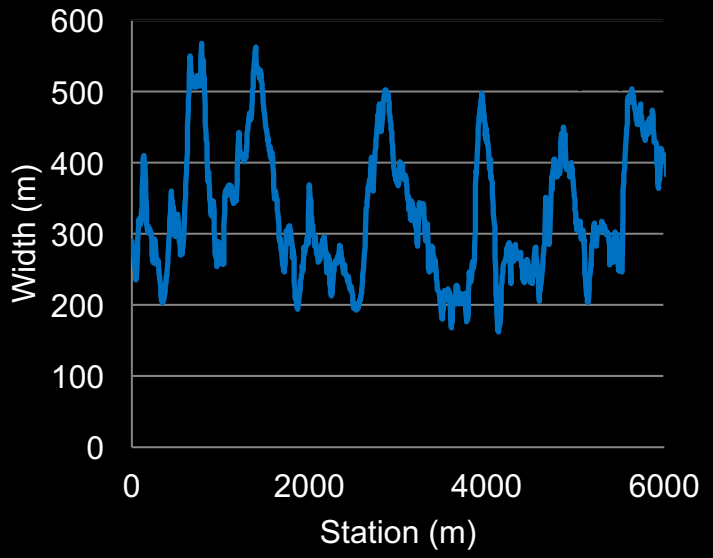
$\lambda = aW$

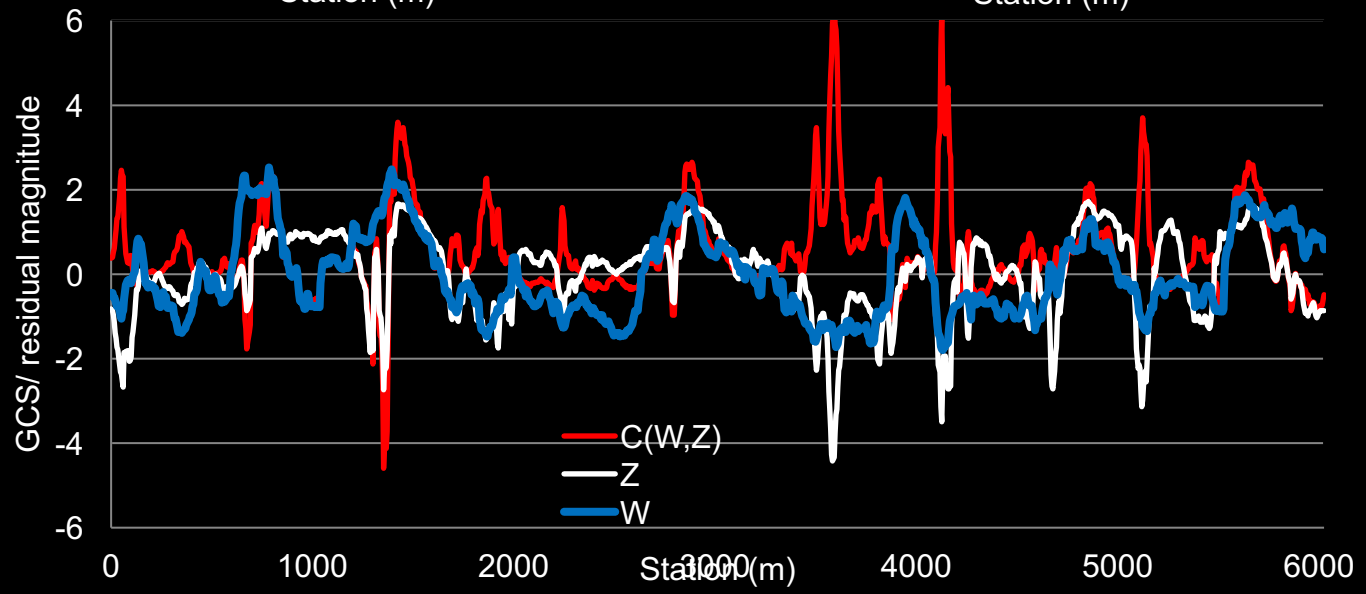
Typical meander wavelength equations are monochromatic, but real rivers are not

Rivers shapes are defined by variability

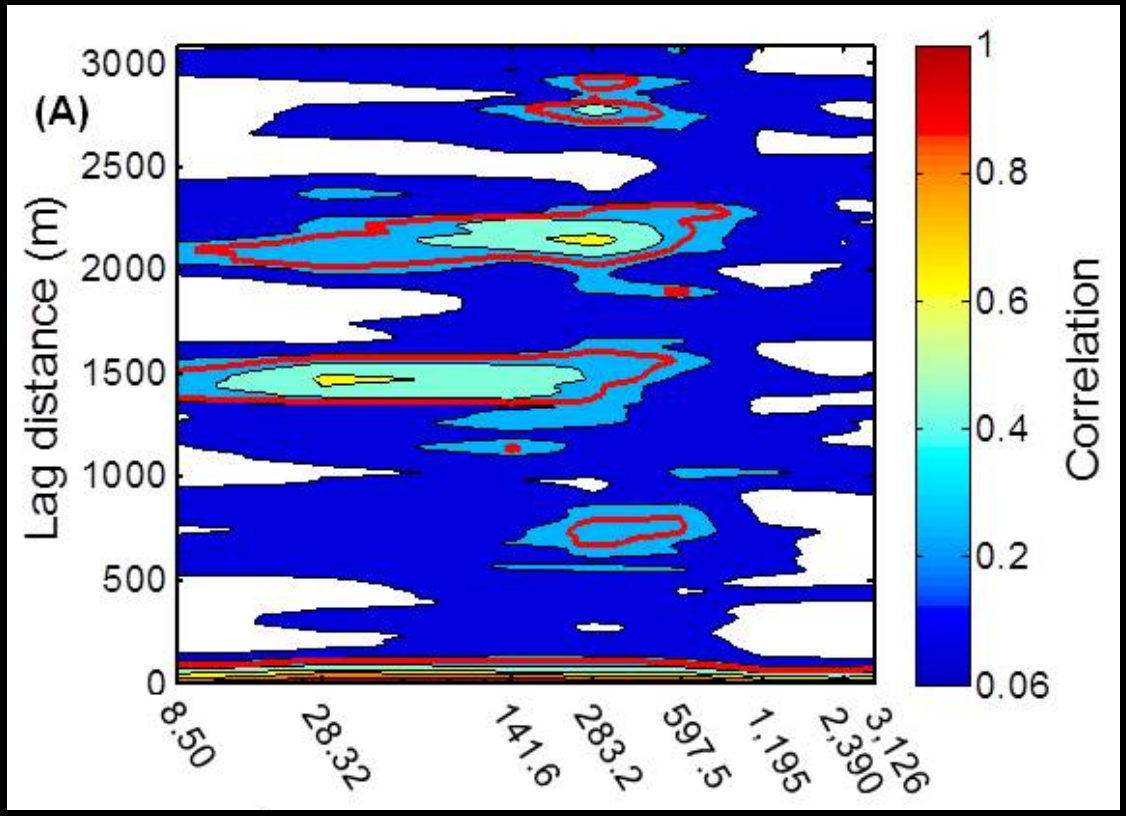
Timbuctoo Bend of LYR,
S = 0.002
Dd_{50}= 164 mm
Qbf=142







Rivers shapes are defined by variability



Autocorrelation of joint bed and width oscillations for LYR Timbuctoo Bend

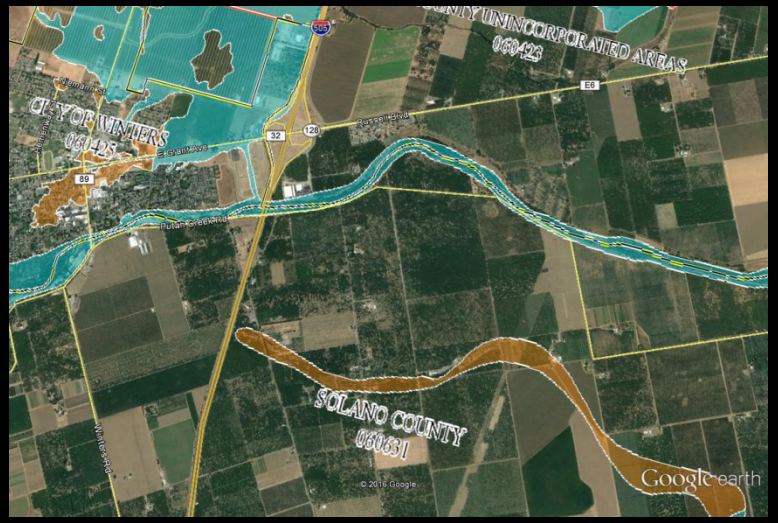
Width and depth covary and oscillate quasi-periodically, structured at several scales at channel forming flows

$\neq W=aQ^{0.5}$

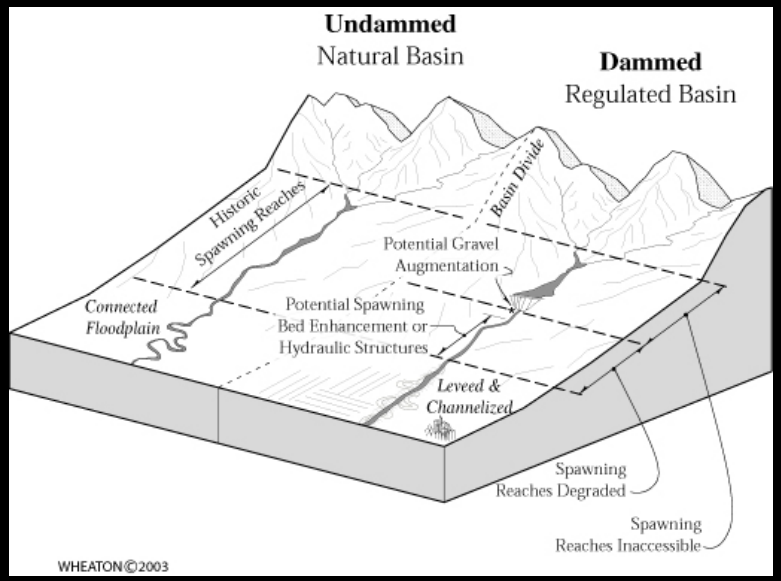
Brown, R. A. and Pasternack, G. B.: Bed and width oscillations form coherent patterns in a partially confined, regulated gravel–cobble-bedded river adjusting to anthropogenic disturbances, Earth Surf. Dynam., 5, 1-20, doi:10.5194/esurf-5-1-2017, 2017.

Channel rescaling is simple, but not for floodplains

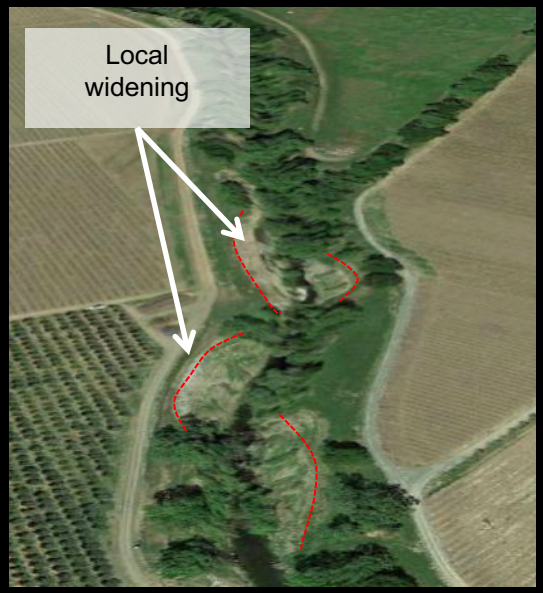
- Space for a channel is preserved through flood control, so infilling is typical to the extent that it does not raise base flood elevations
- Several factors make it difficult to restore floodplains



- Rivers have incised
- Flows are reduced
- Levees
- Former floodplains now have other uses



Anthropocene floodplains in space



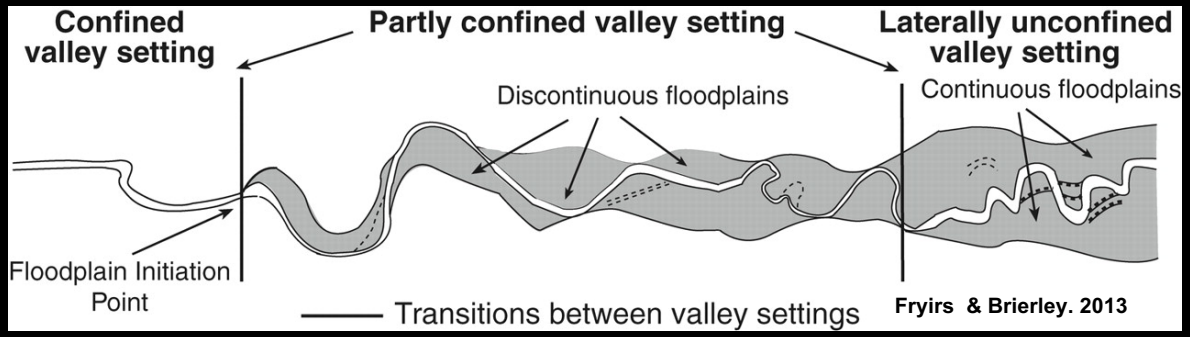
Napa River (Google)

Putah Creek

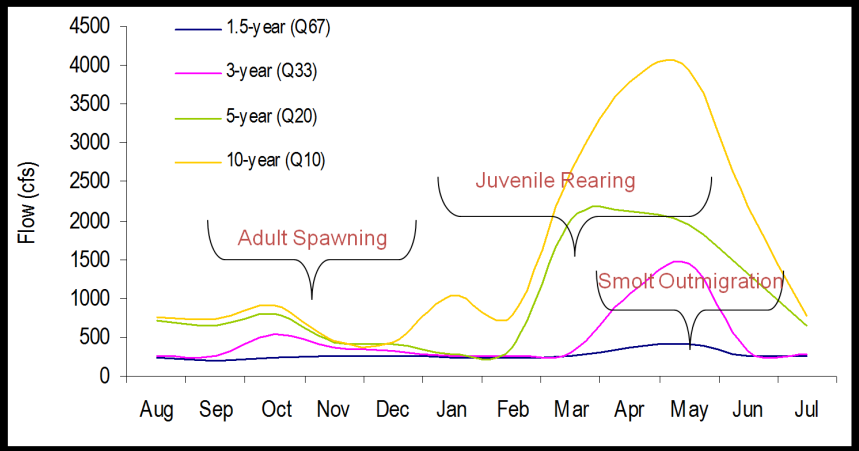
San Joaquin River (Daniel Nylen)

Merced River

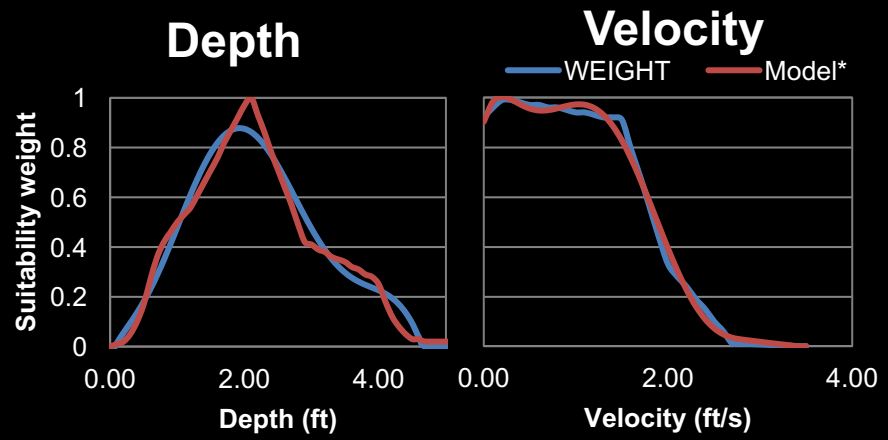
Yolo bypass (SACBEE)



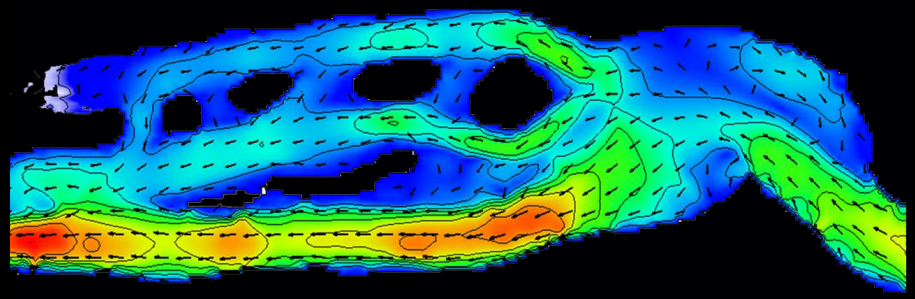
Designing and optimizing water and floodplains for fish habitat



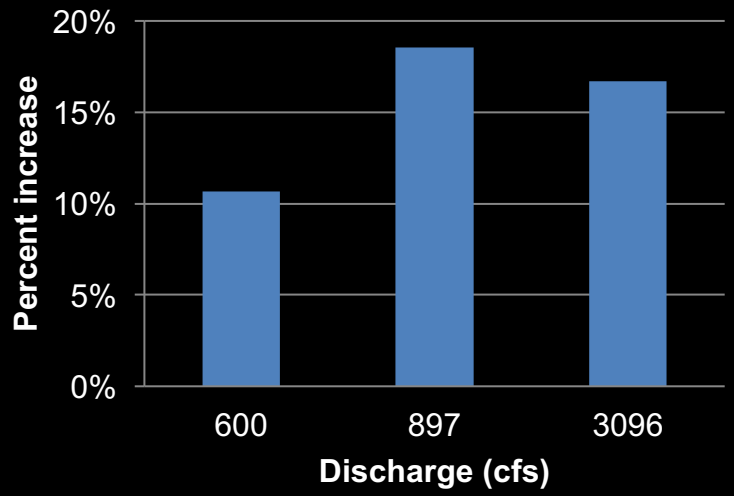
Ecohydrology of when and how long fish utilize habitat



Ecohydraulics for what fish need when they are there



Numerical model of predicted hydraulics for design conditions

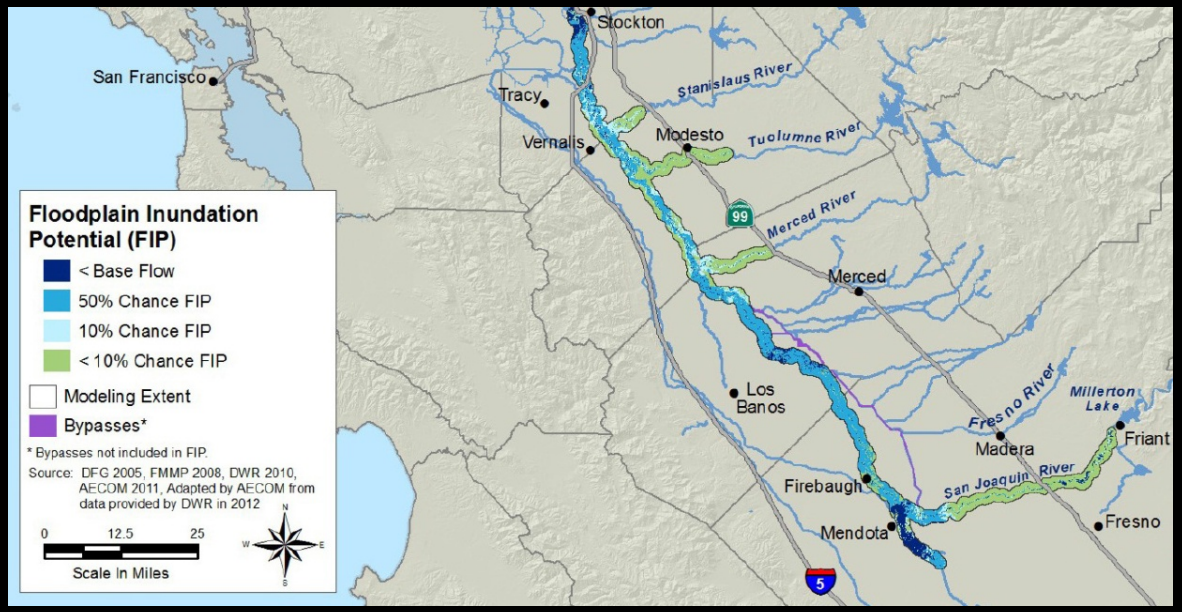


Does "work" yield an increase in habitat?

Beyond habitat suitability to populations

- See talk by Travis M. Hinkelman, Ph.D.

  Emigrating Salmonid Habitat Estimation (ESHE): A Modeling Framework for Estimating Habitat Needs for Outmigrating Juvenile Salmonids

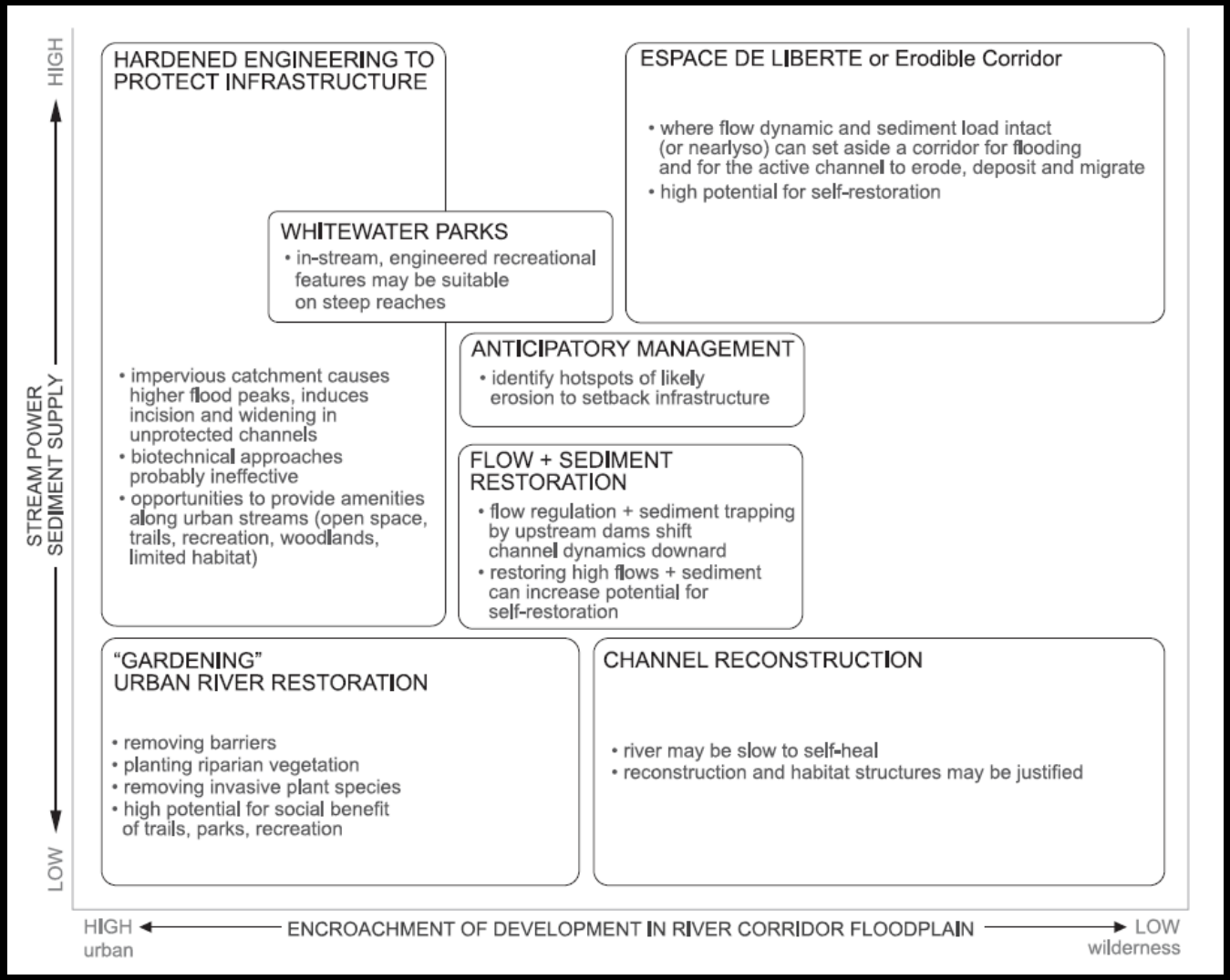


Habitat capacity
= Available suitable habitat

territory size

CVFPP Conservation, DWR 2016

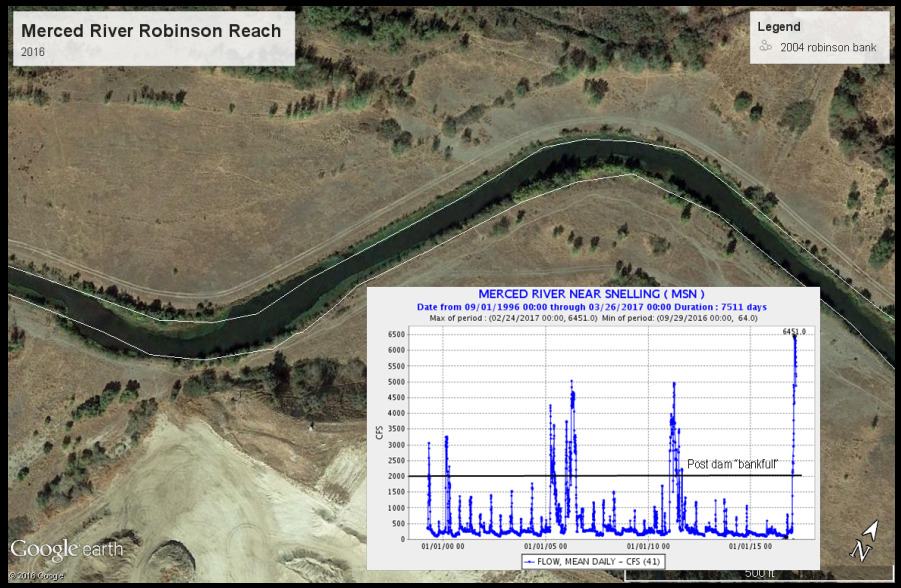
When can a river heal itself?



Kondolf et al. SETTING GOALS IN RIVER RESTORATION

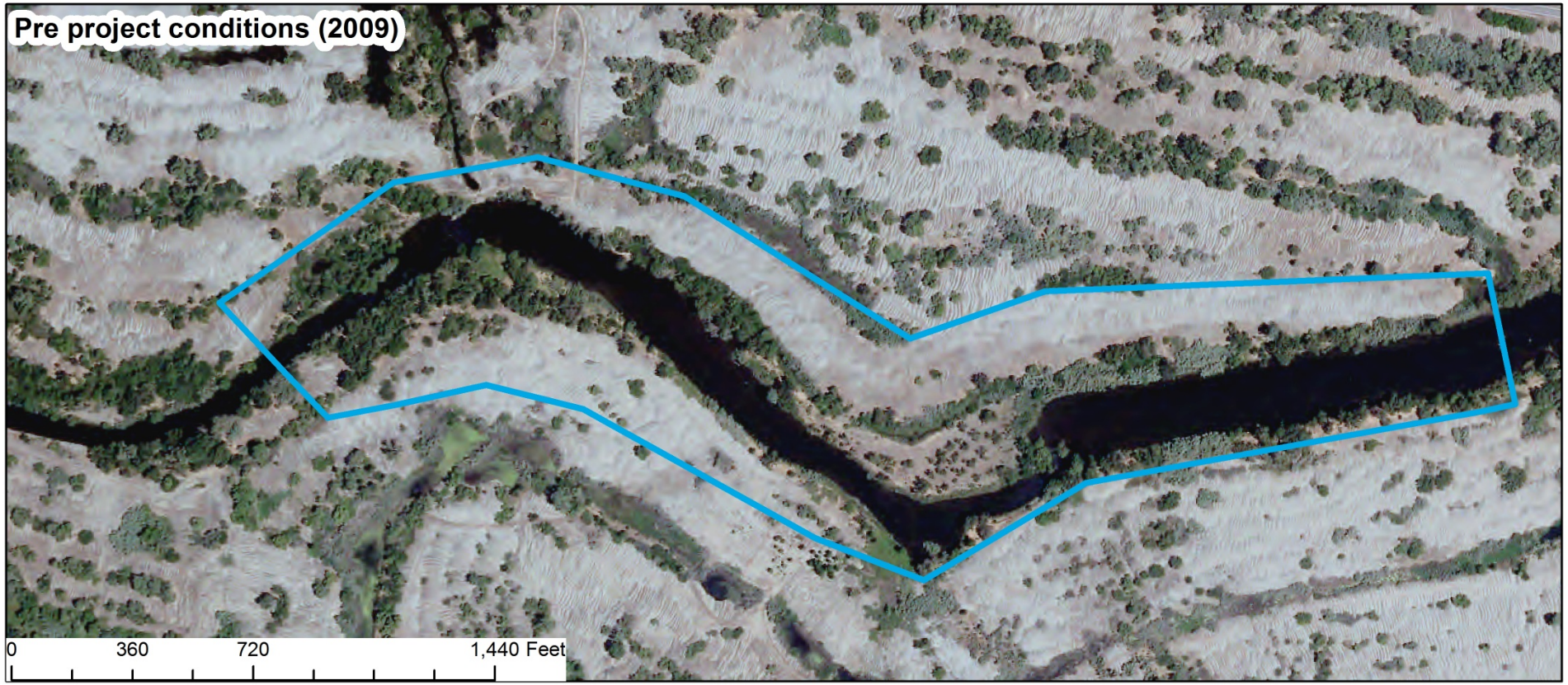
Hitting reset

Robinson Reach of the Merced River



Point bar and chute formation occurring, but very slowly

Merced River Ranch



Merced River Ranch

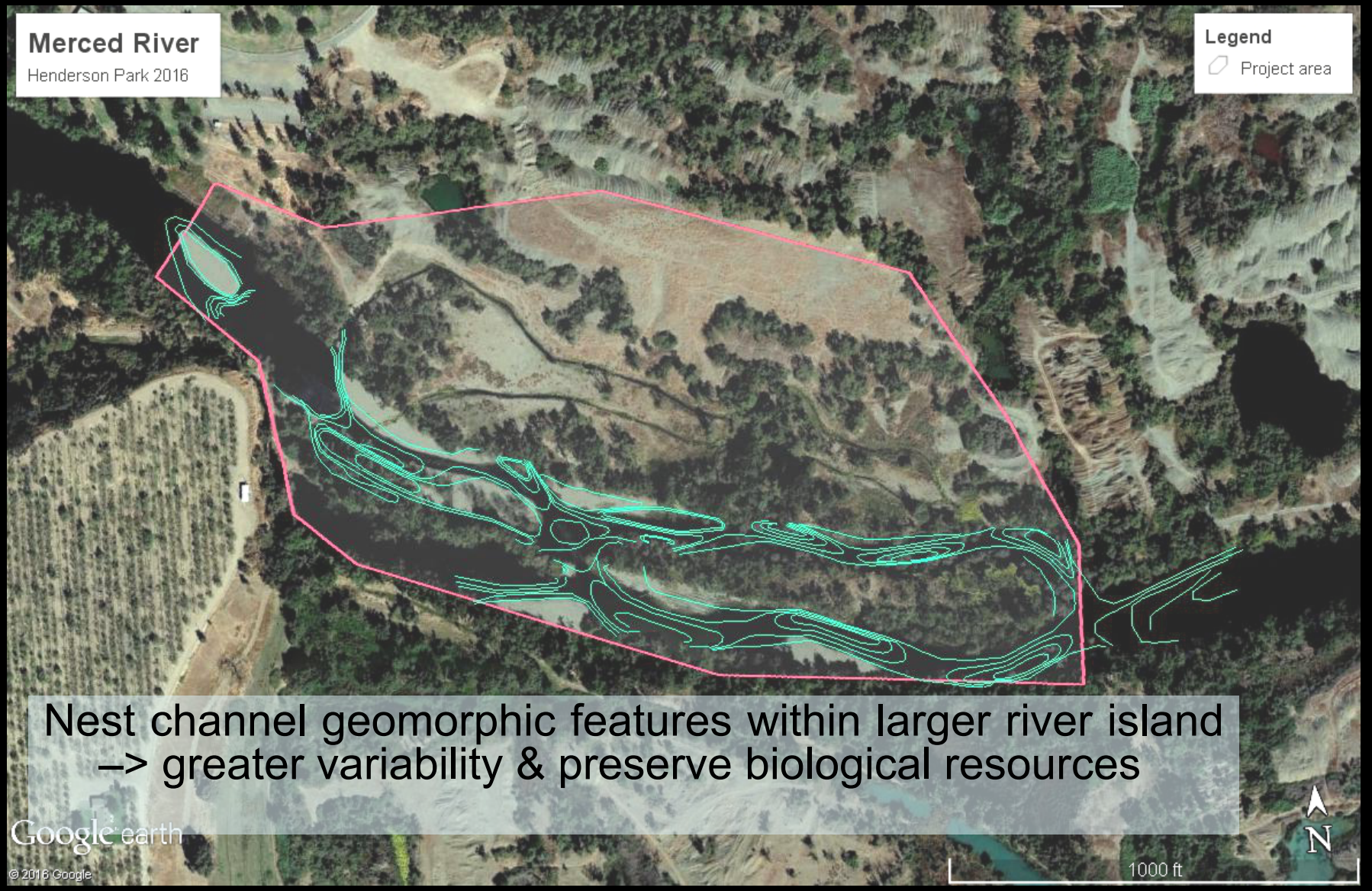
How much to prescribe through design versus letting river “do it’s thing”?

- Simple shapes evolve into fluvial forms with flow
- Increased stabilization of bars from vegetation growth during drought

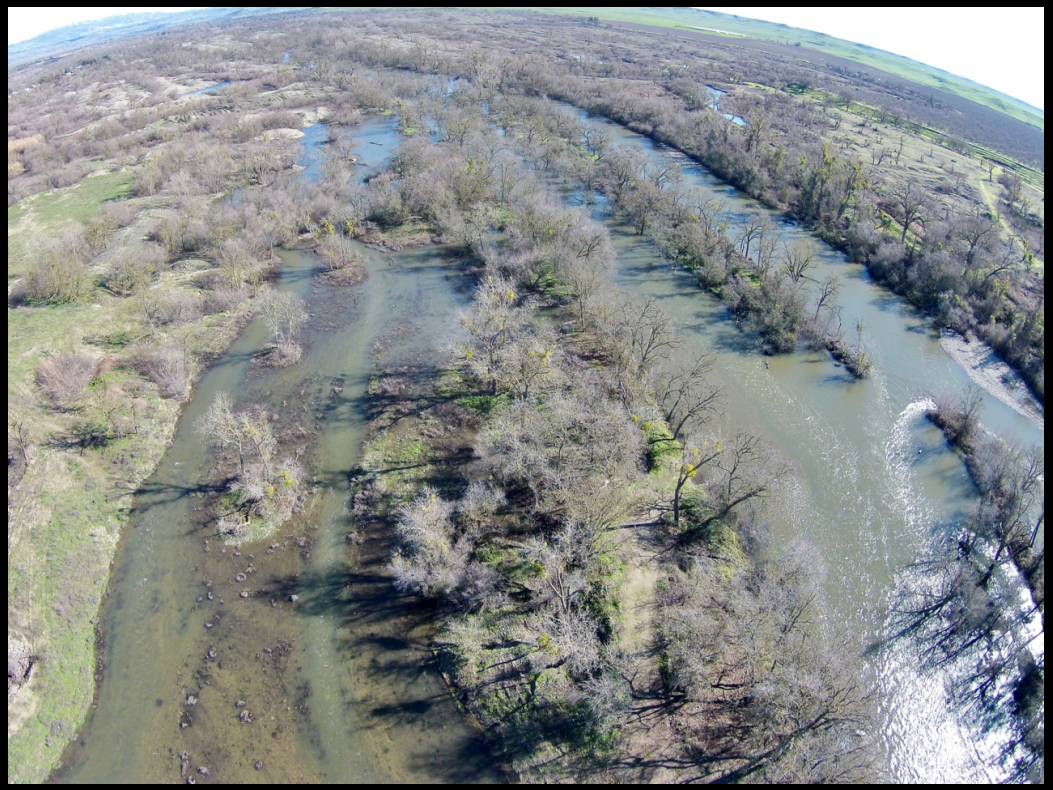
River islands as rearing habitat

Merced River Henderson Park

Merced River Henderson Park



Merced River Henderson Park



Initially flat floodplain with proto channels now evolving with flow, sediment and biogeomorphic feedbacks

Monitoring is ongoing

Natural morphogenesis on Putah Creek

Island and point bar evolution on Putah Creek
break up oversized bathtub sections

Deposition during floods in winter,
colonization during summer

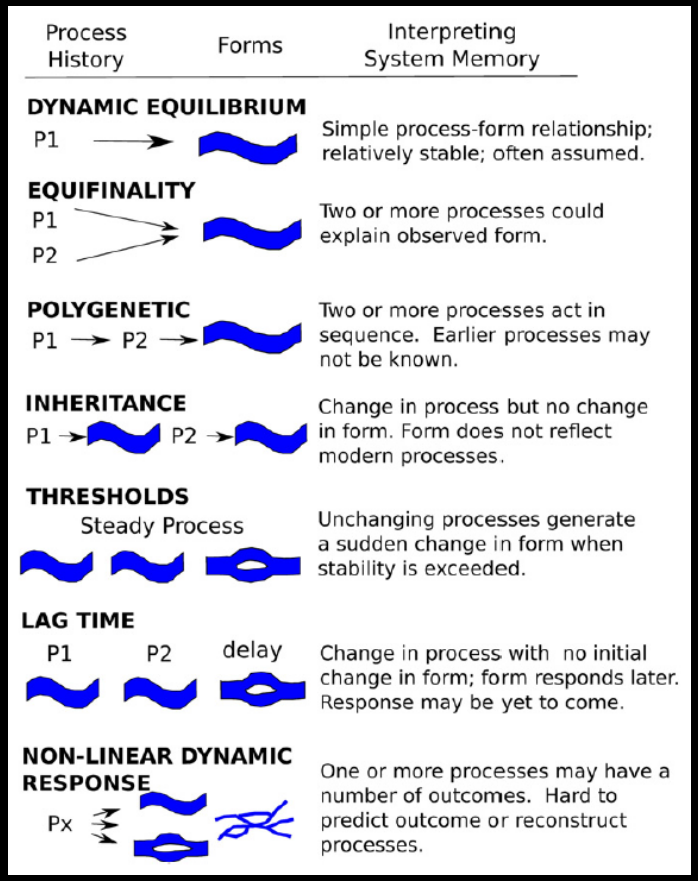
Initial island appears to be setting up
meandering

Natural morphogenesis on the Stanislaus River

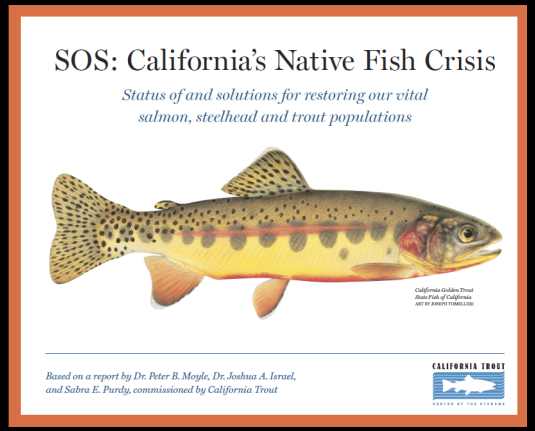
Island formation on Stanislaus River

Flow splits help sort sediment

Looking forward…with eyes wide open



Process-form dynamics that introduce potential complexities in the temporal evolution of landforms. Geomorphic systems retain a memory of past processes, but interpreting process history from form is non-trivial. James. 2015



Those who
cannot remember the past are
condemned to repeat it
- George Santayana

Acknowledgements

- The opportunity and content associated with this talk is due to A LOT of people