Using coupled meander migration and vegetation models to estimate LWD inputs to a large river

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Riparian forests on meandering rivers

- Hotspots of biodiversity and productivity
- High conservation value for agencies, NGO's, many stakeholders
- Floods and channel migration drive:
 - New stand establishment
 - LWD recruitment
- Dams and bank revetment decrease these processes
 - Less forest area
 - Lower LWD inputs to river

Co-evolution of floodplains and riparian forest succession



Stella et al. (2004). Riparian vegetation dynamics on the Merced River. Pages 302-314 in California Riparian Systems Proceedings, Sacramento.

Large woody debris on the middle Sacramento River





Ecological Flow Tool: (SacEFT) – v1





- Multi-species, multi-function decision support framework
- Uses and integrates existing datasets
- Physical submodels drive biological & functional response
- LWD ~ f(Q, bank erosion)

Sacramento River



Steelhead trout

Bank swallow



Chinook salmon



Green sturgeon







Western pond turtle

Fremont cottonwood

Focal Species Performance Measures	Physical datasets and submodels				
	Flow	Stage - Discharge	Temperature	Sediment Transport	Meander Migration
Fremont cottonwood (FC)	•	•			
Bank swallow (BASW)	•				•
Green sturgeon (GS)			•		
Chinook, steelhead (CS)	•		•	● ¹	
Large Woody Debris (LWD) recruitment	•				•

¹ Certain indicators only. The linkage between channel bed conditions and Chinook and steelhead is restricted to weighted useable area for spawning. According to source data from Mark Gard (USFWS), rearing habitat is unaffected by substrate conditions. We relate substrate suitability curves taken from *River-2D* with substrate conditions predicted by the TUGS sediment transport model.



Sacremento River Ecological Flows Tool

View Models

11

Save

File Edit

• Annual 'traffic-light' summaries and multi-year roll-ups for flow and management scenarios

Create Reports

Configure Reports Finished Reports

Reports Window Help

Annua

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EFT Criteria

Sacramento River







Steelhead trout

Chinook salmon

Green sturgeon



Bank swallow

Western pond turtle

Alex Tuesday, February 16, 2010

Fremont cottonwood

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CH-CS11	Smolt Salinity Prets (Chinook)	SACET - Annual					
CH - CS8	Smolt Entrainment (Chinook)	Performance Measure	Description	9651 9651 9651 9651 9651 9651 9651 9651	State Very Roles	3 Poor 3 Fair 1 Good	
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Ready

Modeling Channel Migration

- Floodplain formation processes
 - Bank erosion and channel migration
 - Channel cutoff and abandonment
- Mechanistic meander migration model (Larsen et al., 2006. JAWRA)
 - Calculate stream power from daily mean discharge data: $\Omega = \gamma QS$
 - Annual cumulative effective streampower $\Omega_{ce} = \gamma S * \sum Q_{e,}$ where Q_e is effective discharge over erosion threshold
 - Calibrate Ω_{ce} to observed channel migration rates



Dynamic LWD modeling

Predicting LWD inputs by linking

meander migration + riparian forest succession



Improved approach to LWD modeling in SacEFT v2





Stratifying land cover using existing maps

Vegetation map

Nelson et al., 2008. CSU Chico and Viers et al., 2010. Proceedings from the ESRI International User Conference.

Floodplain age map

Greco et al., 2007. Landscape and Urban Planning 81: 354-373.





Sacramento River riparian forest inventory (2010–2012)

- 19 large point bars from Red Bluff to Colusa
- 430 plots (500 m²) in patches stratified by
 - vegetation type (TNC 2007)
 - floodplain age (Greco et al.)
- Tree composition, size, health, snags
- Fine sediment accumulation over the former gravel bar

River Mile 163 Vegetation Plo 40° 14° 14° 14° 14° 14° 14°

Stella et al., 2012. Riparian forest dynamics on a large, regulated river (California, USA): impacts and implications for management. Proceedings of the IS Rivers Conference, Lyon, France

Riparian succession patterns from vegetation chronosequences



Stella et al., 2012. Riparian forest dynamics on a large, regulated river (California, USA): impacts and implications for management. Proceedings of the IS Rivers Conference, Lyon, France

Modeling tree size (DBH) distributions using empirical inventory data



- Predict LWD, defined as trees >40 cm DBH
- Stratified by structural/composition groups



Revetment removal scenario: Phelan Island, 2004 – 2086

Revetment intact

Revetment removed





Revetment removal scenario: Phelan Island, 2004 – 2086

Revetment intact

Revetment removed





Cumulative trees recruited as LWD

Scenario - With Revetment Removal - Without Revetment Removal



Predicted shifts in veg group proportions

Revetment intact

Revetment removed



Predicted functional LWD proportion



Comparing the two largest sites

	Kopta Slough	Phelan Island
Bank Length (m)	1,775	1,410
Additional eroded area (% increase)	37.7 ha (327%)	37.8 ha (129%)
Additional trees recruited (% increase)	33,904 (514%)	19,041 (125%)
Additional trees >40 cm (% total)	6,238 (18.4%)	2,875 (15.1%)
Additional LWD per meter revetment removed	3.5 trees/m	2.0 trees/m
	40000 Trees Recruited (Kopta Slough, 82 yrs) Revetment removed (514% more LWD) Baseline 1920 1940 1960 1960 1980 2000	Trees Recruited (Phelan Island, 82 yrs) Revetment removed (125% more LWD) Baseline

Conclusions & Implications

- Predictions at 4 sites increased LWD 24% over baseline
 - 55,000 additional trees total
 - 15% of stems were >40 cm dbh
- Comparing predictions at most promising restoration sites:
 - Additional trees recruited range 125% to >500%
 - 2 to 3.5 more trees recruited per meter of revetment removed
 - Large trees (>40 cm) recruited ranged 15--18% of all trees.
- Simulations help us understand local differences that can assist in selecting effective restoration sites.
- Evaluate effects of flow regimes and management actions (storage reservoirs, revegetation projects)



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Sacramento River Ecological Flow Tools (SacEFT)

- Ryan Luster, The Nature Conservancy
- ESSA Technologies Ltd. 2011. Sacramento River Ecological Flows Tool (SacEFT): Record of Design (v.2.00). Prepared by ESSA Technologies Ltd., Vancouver, BC for The Nature Conservancy, Chico, CA. 111 p. + appendices.

Meander migration model

Larsen EW, Fremier AK, Girvetz EH. 2006. J. Amer. Water Res. Assoc. 42:1063–1075.

Vegetation map

- Nelson C., M. Carlson and R. Funes. 2008. Sacramento River Monitoring and Assessment Program. Geographical Information Center, CSU Chico.
- Viers, J.H., A.K. Fremier, and R.A. Hutchinson. 2010. Proceedings from the 2010 ESRI International User Conference, San Diego, California. 21 pp.

Floodplain age map

Greco, S.E., A.K. Fremier, E.W. Larsen, and R.E. Plant. 2007. Landscape and Urban Planning 81(4):354-373.

Phelan site – revetment intact













Phelan site – revetment removed











