EFT

Ecological Flows Tool

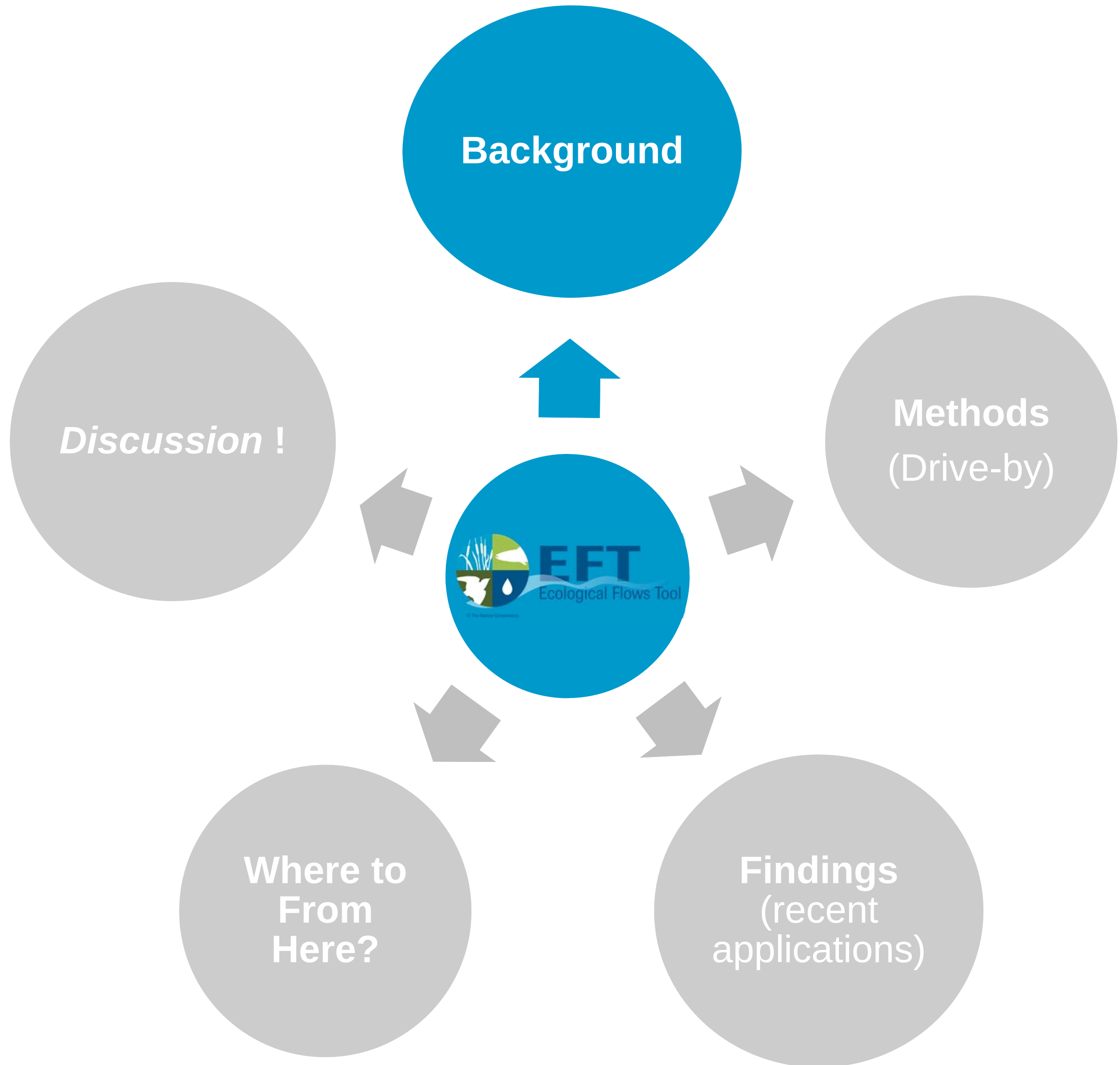
Delta Independent Science Board

August 1 2014

The Nature Conservancy
Protecting nature. Preserving life.™

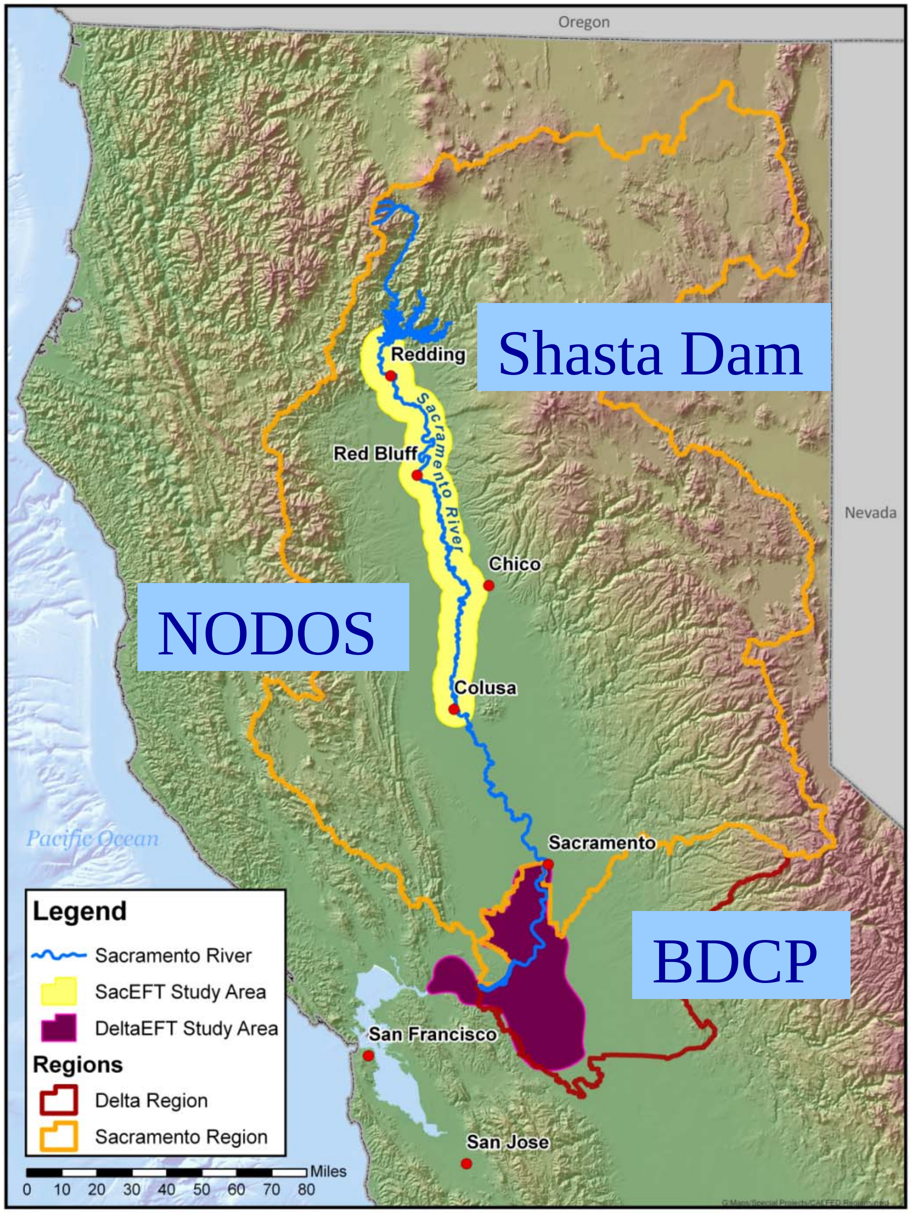
ESSA 35 YEARS

Outline


Background
Methods
(Drive-by)
Findings
(recent
applications)
Where to
From
Here?
Discussion !
EFT
Ecological Flows Tool

Why TNC developed EFT

1. Evaluate ecological trade-offs of alternative water projects and water project operations.
2. Develop a broader set of functional ecological flow guidelines.



Vision

Link hydrogeomorphic models to representative suite of functional ecosystem indicators in one decision analysis tool for evaluating multiple trade-offs

EFT
Ecological Flows Tool

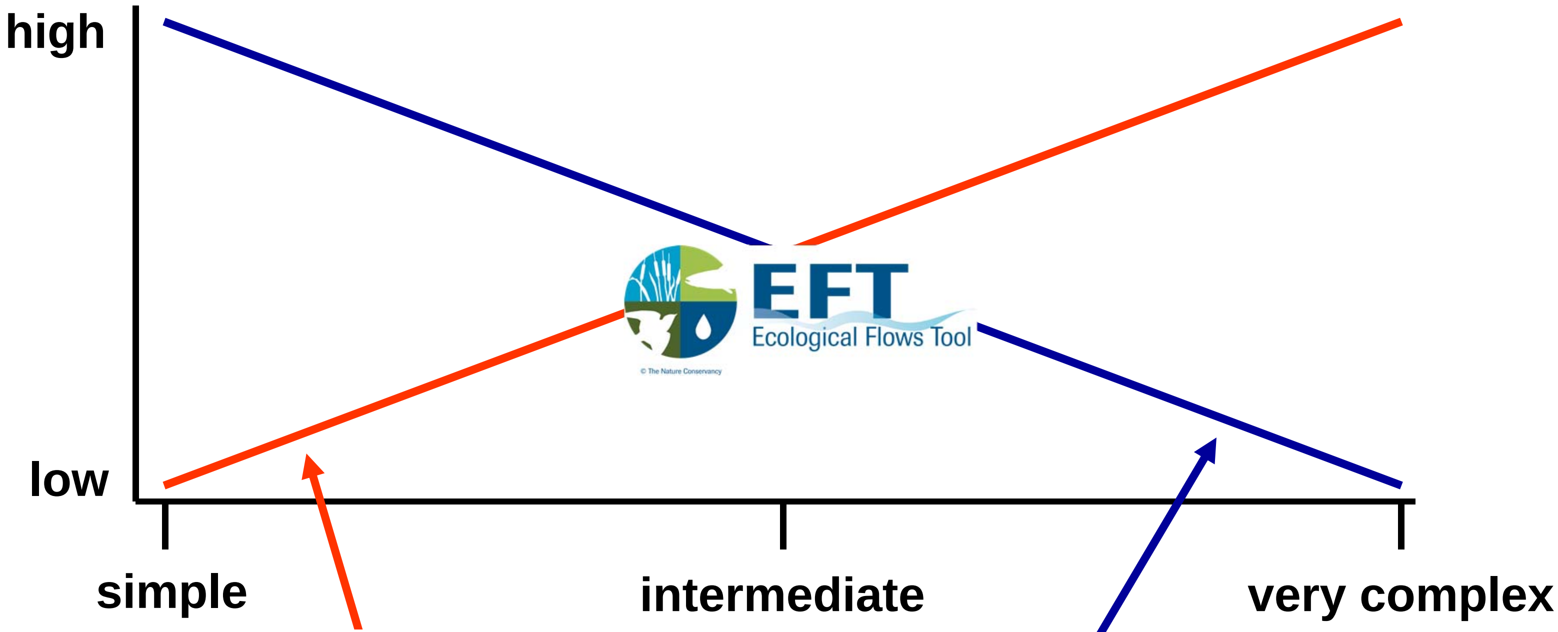
Application of the Ecological Flows Tool to Complement Water Planning Efforts in the Delta & Sacramento River

Multi-Species Effects Analysis & Ecological Flow Criteria

Ecosystem Restoration Program
Agreement E0720044

Final Report
April 30, 2014

Sufficient detail …



Model Complexity

Things that increase w complexity

- spatial / temporal resolution
- acceptability to disciplinary specialist
- perceived "realism" of process representation
- cost
- tuning & equifinality

Things that decrease w complexity

- ability to understand model behaviour
- ease of application (data, cost)
- ease of interdisciplinary linkage
- community of users (shrinks)

Your predecessors said…

"…The panel believes it is essential that a … dedicated project to build a simplified ecosystem model … [including] existing modeling capabilities … *will require a full-time multidisciplinary team devoted for at least several years…"*

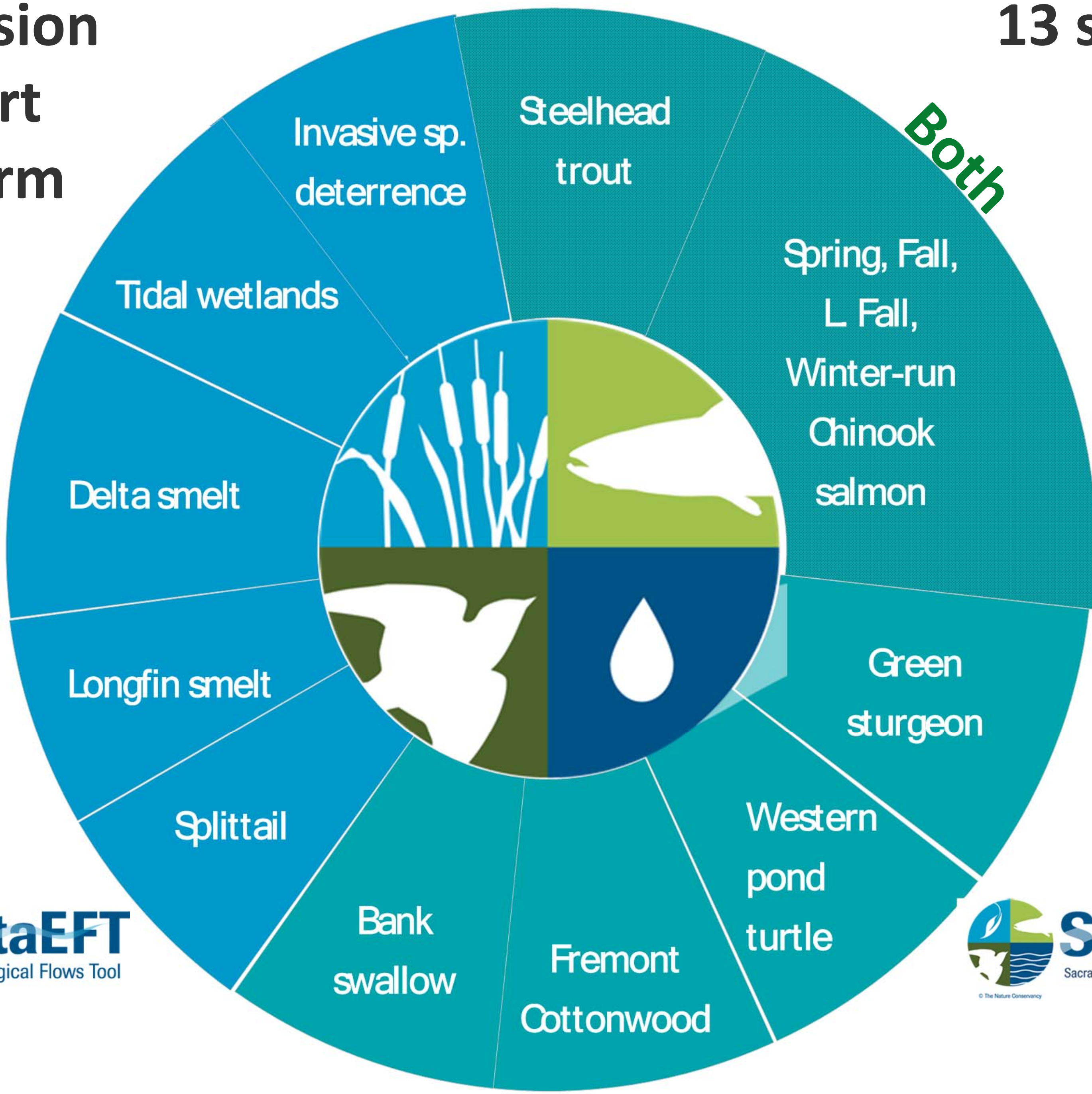
~ CALFED Science Advisory Panel, June 24, 2008

"… A variety of modeling approaches needed … including those … model the behavior of a complex system by simplifying it… *Developing a decision analysis tool for the Delta, similar to SacEFT, should be considered*."

~ CALFED Science Program, 2008, Summary Findings of Workshop 2: Linking Physical and Biological Models for Ecosystem Prediction, Planning, and Performance

1 decision support platform

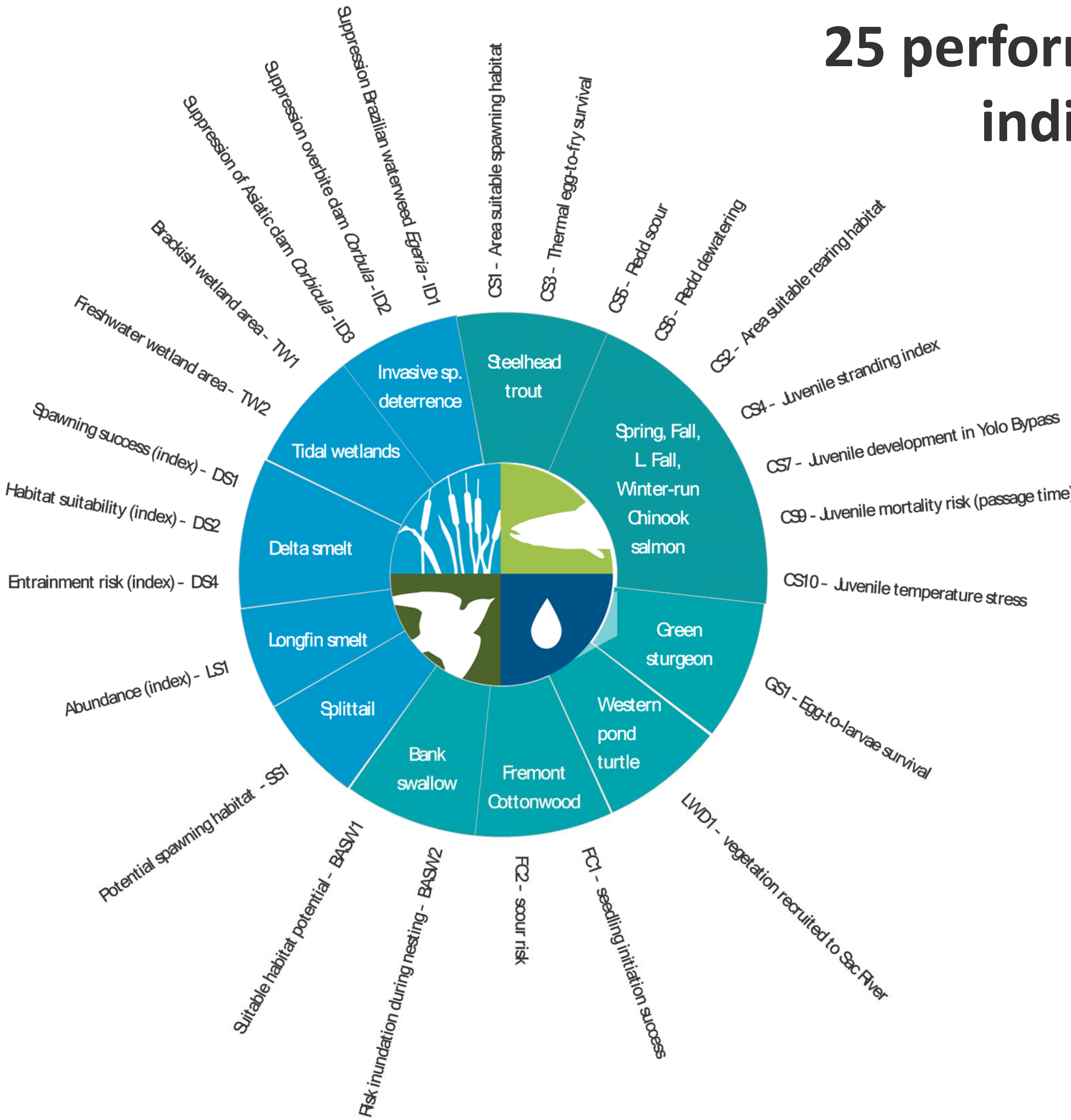
13 species



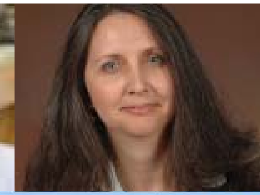
DeltaEFT
Delta Ecological Flows Tool

SacEFT
Sacramento River Ecological Flows Tool

25 performance indicators



Over 70 scientists

Core Team	SacEFT Workshop Participants		Delta EFT Workshop Participants & DeltaEFT Design contributors
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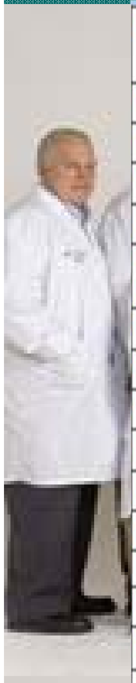
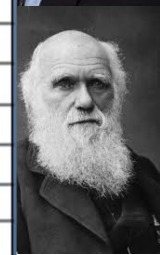
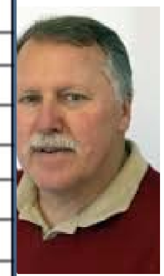
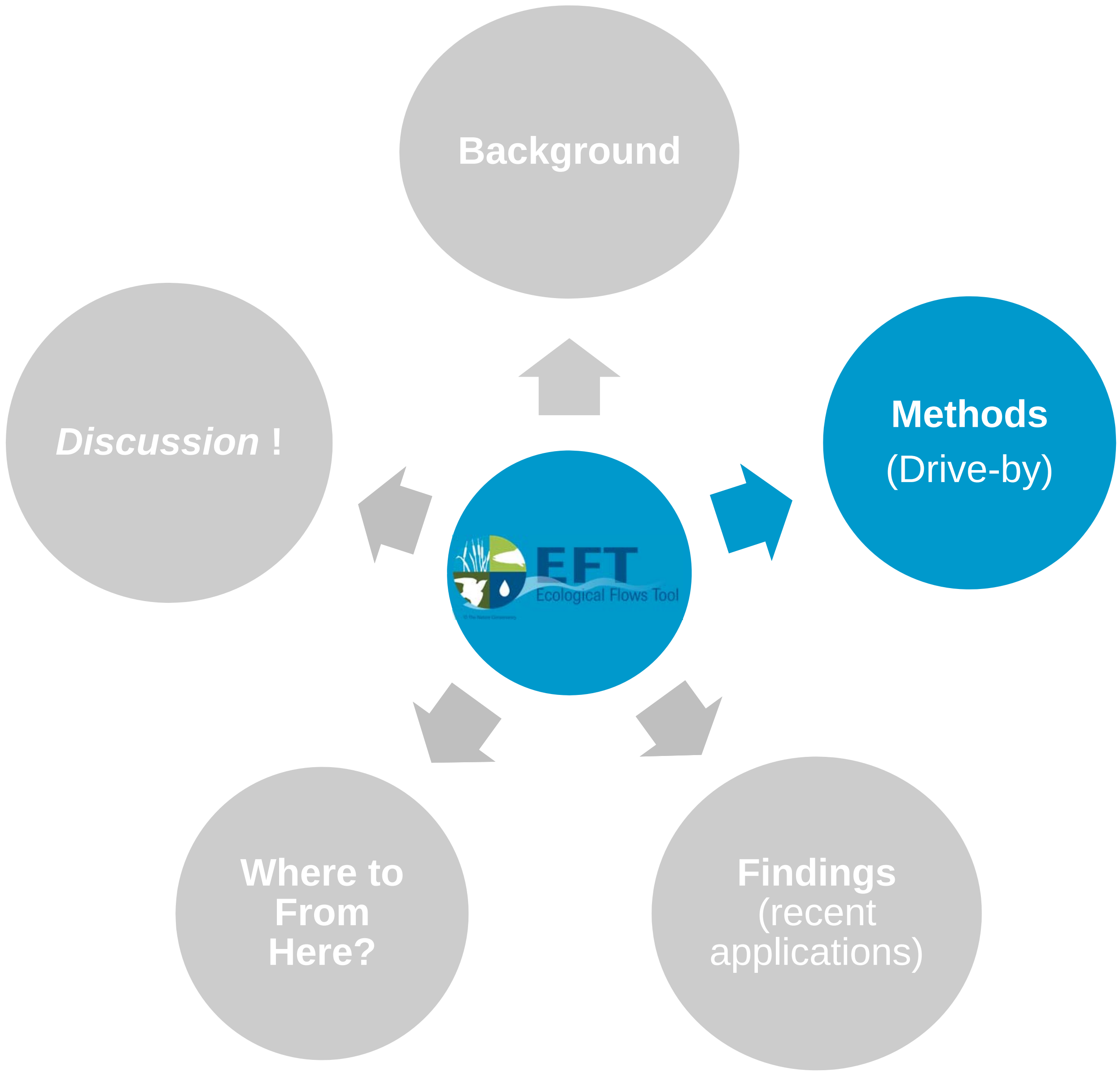
	Tom Smith, Ayres Associates	Chrissy Howell, PRBO	Wim Kimmerer, SFSU
	Dave Vogel	Joel Van Eenennaam, UC Davis	Ted Sommer, DWR






Outline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Management actions evaluated

Reservoir Operations & Conveyance

- Sacramento River dam / diversion operations
- Delta conveyance & pumping operations
- Coordinated operational criteria (e.g., biological opinions, D-1641 variations)
- External climate forcing
- Alternative human population demands

EFT Ecological Flows Tool

Bank protection & gravel augmentation

- River meander , soil erosion
- Effects on bank swallow habitat suitability, large woody debris recruitment, flows
- TUGS model, effects on salmon spawning habitat suitability

Sacramento River focal species & objectives

Sacramento River

Focal Species & Habitats	Ecological Objectives	Performance indicators		Foundation research
Fremont cottonwood	Maximize areas available for riparian initiation, and rates of initiation success at individual index sites.	**FC1** **FC2**	Cottonwood seedling initiation index Risk of scour after successful initiation	Mahoney and Rood 1998; Roberts et al. 2002; Roberts 2003; HEC-RAS supplemented stage-discharge relations; Alexander 2004 Recommendations from Riparian ecologists at the SacEFT v.1 peer review and refinements workshop (see SacEFT Design Document Section 4.3.4, pp. 96-102).
Bank swallow	Maximize availability of suitable nesting habitat	**BASW1** **BASW2**	Suitable habitat potential (bank length, m) Risk of inundation and bank sloughing during nesting	Garrison (1998, 1999); Moffatt et al. (2005); Stillwater Sciences (2007); Heneberg (2009); Natural Resources Conservation Service (2011)
Western pond turtle habitat, mainstem Sacramento River	Maximize availability of habitat for foraging, basking, and predator avoidance	**LWD1**	Index of old vegetation recruited to Sacramento River (ha)	Larsen (1995); Larsen and Greco (2002); Larsen et al. (2006) 2007 GIS layer Sacramento River GIS portal representing mature vegetation
Green sturgeon	Maximize quality of habitat for egg incubation	**GS1**	Egg-to-larvae survival (proportion)	Cech et al. (2000); ESSA Technologies Ltd. (2005)
Chinook salmon Steelhead trout	Maximize quality of habitat for adult spawning Maximize quality of habitat for egg incubation Maximize availability and quality of habitat for juvenile rearing	**CS1** **CS3** **CS5** **CS6** **CS2** **CS4**	Area suitable spawning habitat (000s ft^2) Thermal egg-to-fry survival (proportion) Redd scour (scour days) Redd dewatering (proportion) Area suitable rearing habitat (000s ft^2) Juvenile stranding (index)	Vogel and Marine (1991); USFWS / Mark Gard (2003, 2005a); USFWS (2005b); USFWS (2006)

Delta focal species & objectives

	Focal Species & Habitats	Ecological Objectives	Performance indicators		Foundation research
Sacramento River	Fremont cottonwood	Maximize areas available for riparian initiation, and rates of initiation success at individual index sites.	FC1 FC2	Cottonwood seedling initiation index Risk of scour after successful initiation	Mahoney and Rood 1998; Roberts et al. 2002; Roberts 2003; HEC-RAS supplemented stage-discharge relations; Alexander 2004 Recommendations from Riparian ecologists at the SacEFT v.1 peer review and refinements workshop (see SacEFT Design Document Section 4.3.4, pp. 96-102).
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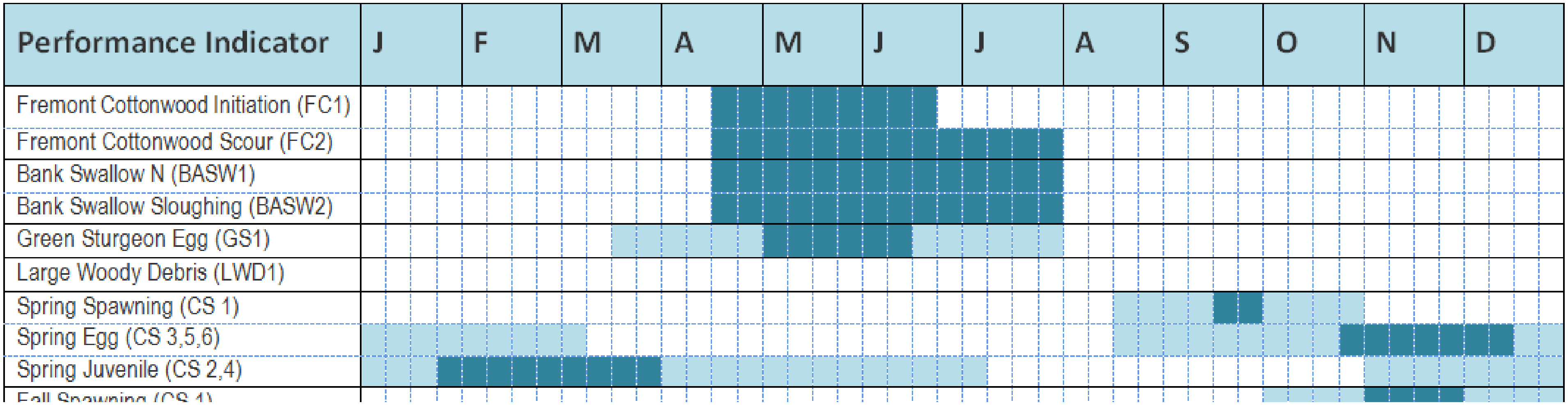
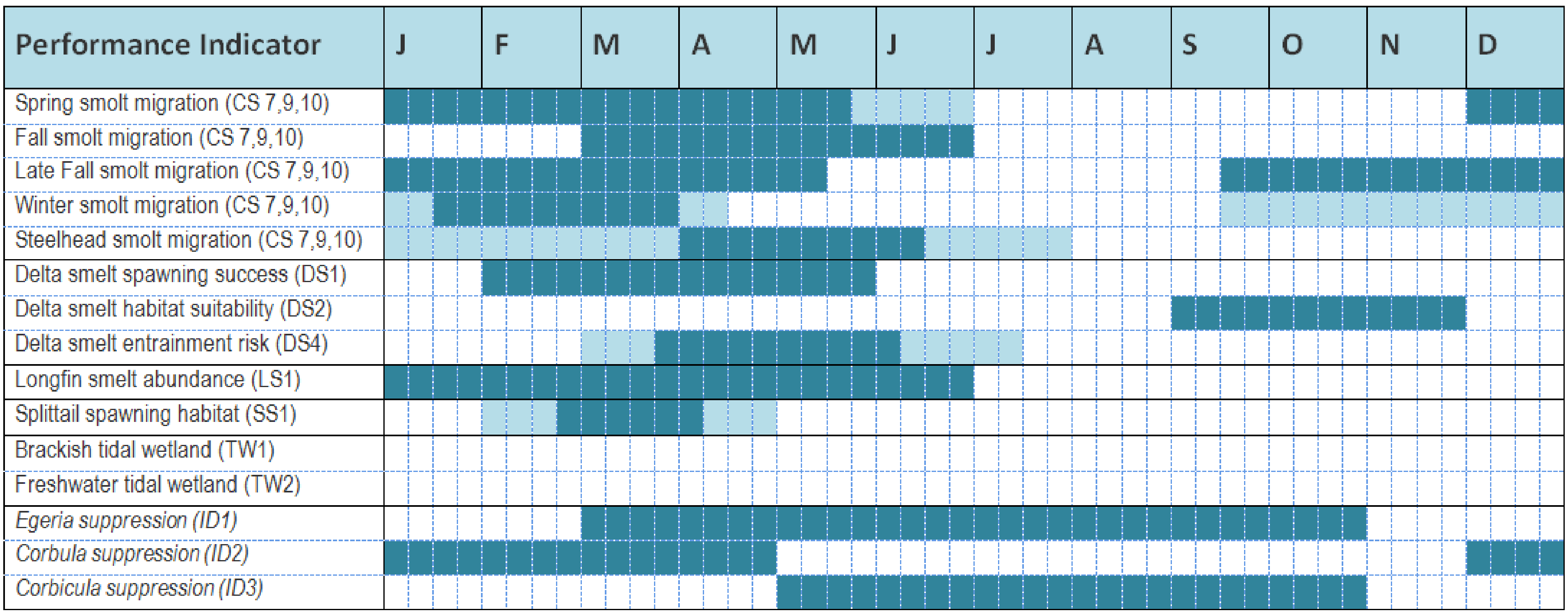
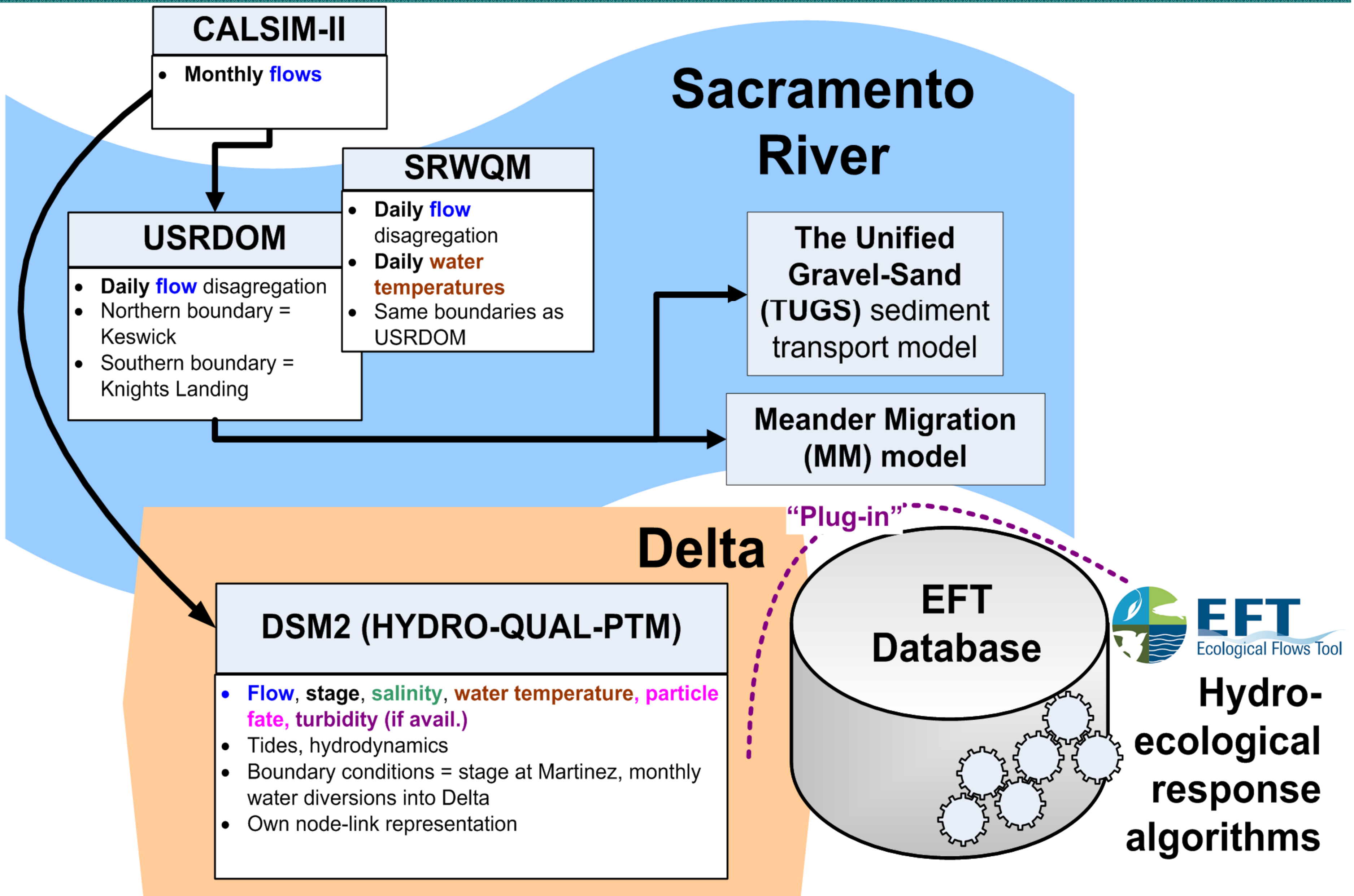
	Chinook salmon Steelhead trout	Maximize quality of habitat for adult spawning Maximize quality of habitat for egg incubation Maximize availability and quality of habitat for juvenile rearing	CS1 CS3 CS5 CS6 CS2 CS4	Area suitable spawning habitat (000s ft^2) Thermal egg-to-fry survival (proportion) Redd scour (scour days) Redd dewatering (proportion) Area suitable rearing habitat (000s ft^2) Juvenile stranding (index)	Vogel and Marine (1991); USFWS / Mark Gard (2003, 2005a); USFWS (2005b); USFWS (2006)

Ecologically important life history timing





Coupled modeling

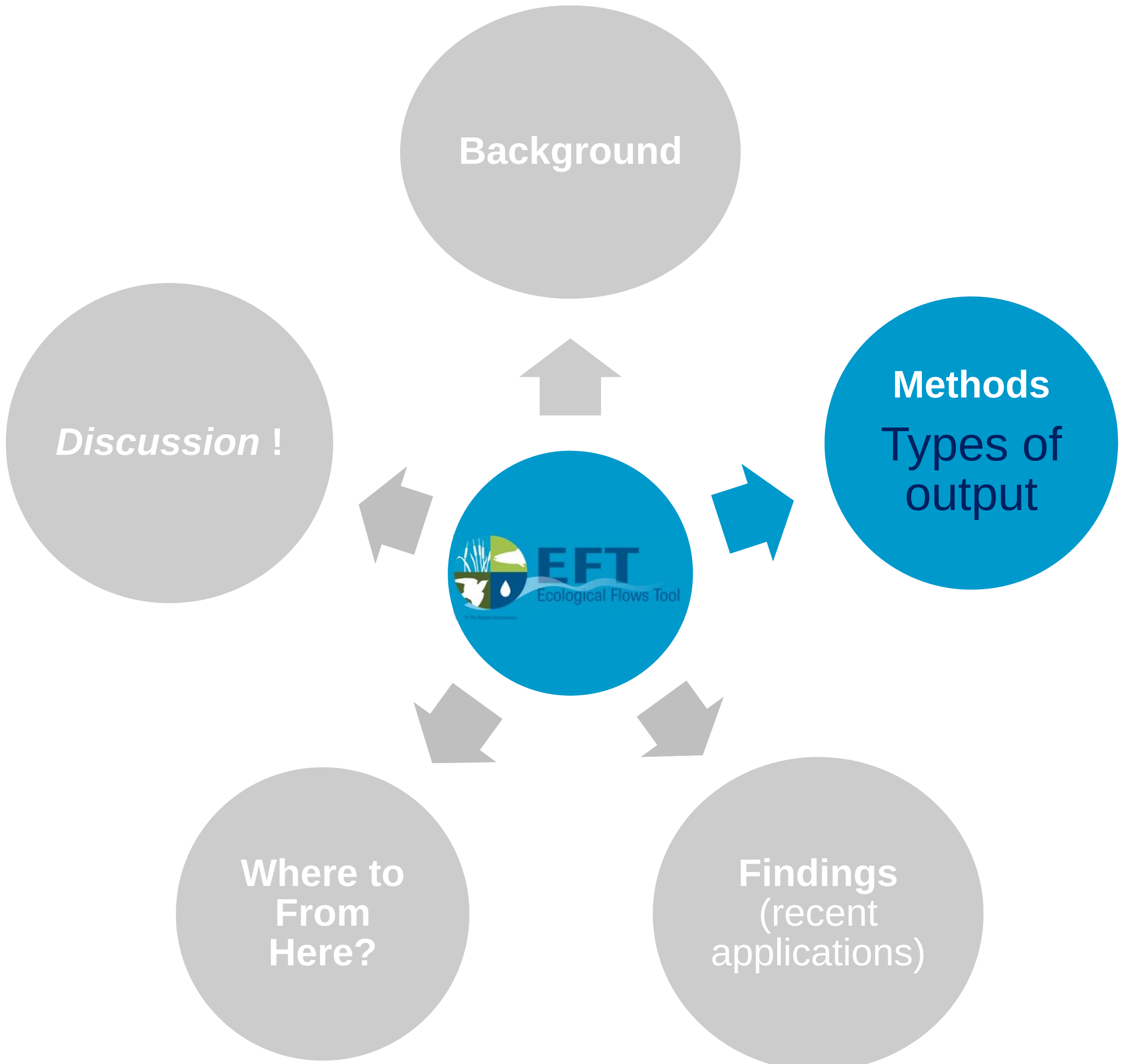


Ecologically important index locations

DeltaEFT Ecoregion Locations

EFT Short Name	Gauge or Common Name Location	River Code	RM	RKI	DSM2 Name	CDEC Name	Gauge Owner	Native Code	CS7 F	CS7 T	CS9 F	CS10 F	CS10 T	DS1 T	DS1 E	DS2 E	DS4 F	SS1 F	LF1 E	TW1 S	TW2 E	TW2 S	ID1 E	ID2 E	ID3 E
Knight	BUTTE CITY and SUTTER BYPASS	SAC	168			KNL	USGS	11389000	*	*															
Verona	SACRAMENTO R A VERONA CA	SAC				VON	USGS	11425500	*	■															
Sacramento (IST178)	SACRAMENTO R A SACRAMENTO CA	SAC	59.5	178	RSAC178	IST	USGS	11447500	*	■															
Freeport (FPT155)	SACRAMENTO R A FREEPORT CA	SAC		155	RSAC155	FPT	USGS	11447650	*	■															
Hood (SRH142)	SACRAMENTO RIVER AT HOOD	SAC		142	RSAC142	SRH	CDEC	382205121311300			*	*	■												
Above DCC (SDC128)	SACRAMENTO R AB DELTA CROSS CHANNEL CA	SAC		128	RSAC128	SDC	USGS	11447890	*	*	*	*	*												
Sac blw Georgina (GSS123)	SACRAMENTO R BL GEORGIANA SLOUGH CA	SAC		123	RSAC123	GSS	USGS	11447905	*	*	*	*	*	*	*										
Rio Vista (RVB101)	SACRAMENTO R A RIO VISTA CA	SAC		101	RSAC101	RVB,RIV	USGS	11455420	*	■	*			*	*								*	*	*
Ryer Isld	CACHE SLOUGH A RYER ISLAND	CAS			CACHE_RYER		USGS	11455350						*	*										
Emmaton (EMM92)	EMMATON (USBR)	SAC		92	RSAC092	EMM			*	*		*	*	*	*	*			*				*	*	*
Collinsville (CSE81)	COLLINSVILLE ON SACRAMENTO RIVER	SAC		81	RSAC081	CSE			*	*	*												*	*	*
Sutter Sl (SSP)	SUTTER BYPASS AT RD 1500 PUMP	SUS			SUT_US_MIN	SSP						*	■												
Steamboat Sl	Steamboat Slough	STS			STMBT_S							*	■												
Pittsburg (PTS77)	SAN FRANCISCO BAY A PITTSBURG CA	SAC		77	RSAC077	PTS	CDEC	380300121524201						*	*	*			*				*	*	*
Mallard (MAL75)	SUISUN BAY A MALLARD IS CA	SAC		75	RSAC075	MAL	USGS	11185185	*	*	*	*	*	*	*	*			*					*	
DCC	Delta Cross Channel	SAC			DCC							*	*							*	*	*			
Georgiana Sl (GGS)	GEORGIANA SLOUGH NR SACRAMENTO R	GES	50		GEORG_SL	GGS	USGS	11447903				*	*	*	*										
Fremont Weir (FRE244)	FREMONT WEIR SPILL TO YOLO BYPASS NR VERONA CA	SAC		244	RSAC244	FRE	USGS	11391021	*	■								*							
Sacramento Weir (182)	SACRAMENTO WEIR SPILL TO YOLO	SAC		182	RSAC182		USGS	11426000	*	■								*							
Walnut Grove (19)	N MOKELUMNE NR WALNUT GROVE CA	NMK		19	RMKL019		USGS	11336585				*	*	*	*										
Little Potato (STI8)	LITTLE POTATO SLOUGH NR TERMINOUS CA	SMK		8	RSMKL008	STI	USGS	11336800				*	*	*	*										
Port Chicago (PCT64)	PORT CHICAGO	SAC		64	RSAC064	PCT								*	*	*			*	*	*	*		*	
Jersey Point (JER18)	SAN JOAQUIN R A JERSEY POINT CA	SAN		18	RSAN018	JER	USGS	11337190						*	*					*	*	*			
Antioch (ANH7)	SAN JOAQUIN R A ANTIOCH CA	SAN		7	RSAN007	ANH	USGS	11337200						*	*								*	*	*
Tracy (MTB27)	MIDDLE RIVER AT TRACY BLVD	MID		27	RMID027	MTB								*	*										
Rough & Ready (RRI53)	ROUGH AND READY ISLAND	SAN		53	RSAN053	RRI								*	*										
Martinez (MRZ54)	CARQUINEZ STRAIT A MARTINEZ CA	SAC		54	RSAC054	MRZ	USGS	11182450						*	*	*			*					*	
Venice Isld (VNI43)	SAN JOAQUIN R A VENICE ISLAND - TIDE GAUGE CA	SAN		43	RSAN043	VNI	CDEC	380301121294500						*	*										
San Andreas (SAL32)	SAN ANDREAS LANDING	SAN		32	RSAN032	SAL						*	*	*	*								*	*	*
Bacon Isld (BAC24)	OLD R A BACON ISLAND CA	OLD		24	ROLD024	OBI,BAC	USGS	11313405						*	*		*								
Borden (VIC23)	MIDDLE R AT BORDEN HWY NR TRACY CA	MID		23	RMID023	VIC	USGS	11312674																	
Stockton (SJG)	SAN JOAQUIN R BL GARWOOD BR A STOCKTON	SAN				SJG	USGS	11304810						*	*										
Middle R (MDM15)	MIDDLE R AT MIDDLE RIVER CA	MID		15	RMID015	MDM	USGS	11312676						*	*		*			*	*	*			
Holland Cut (HLL14)	HOLLAND CUT NR BETHEL ISLAND CA	OLD		14	ROLD014	HLL	USGS	11313431						*	■										
Beldon (BDL11)	BELDON LANDING	MZS		11	SLMZU011	BDL								*	*					*	*	*		*	
Steamboat-Sutter (SSS11)	DWR-CD 1479, 11km up Steamboat Slough, below Sutter Slough	SUS		11	SLSBT011	SSS						*	*	*	*										
Farrar (FRP9)	FARRAR PARK	DUS		9	SLDUT009	FRP								■	*								*	*	*
Barker (BKS2)	BARKER SLOUGH PUMPING PLANT (KG000000)	BAS		2	SLBAR002	BKS														*	*	*			
Bethel Isld (BET3)	BETHEL ISLAND	PRS		3	SLPPR003	BET																	■	■	■
Goodyear (GYS3)	GOODYEAR SLOUGH	GYS		3	SLGYR003	GYS																		■	
Sunrise (SNC2)	SUNRISE CLUB	CBS		2	SLCBN002	SNC																		*	
National Steel (NSL25)	NATIONAL STEEL	MZS		25	SLMZU025	NSL																		*	
Volanti (VOL12)	VOLANTI	SNS		12	SLSUS012	VOL																		*	
Yolo	YOLO BYPASS NR WOODLAND CA	YOL			BYOLO040	YBY	USGS	11453000											■					■	
Chipps	SUISUN BAY AT CHIPPS ISLAND CA	SAC		0			CDEC	380245121551001																	
Webb	USBR station, False River at Webb Tract	FAL		8	RFAL008																				
Oakley?	CONTRA COSTA CN NR OAKLEY CA			6	CHCC006	CNT	USGS	11337000																	
Holt	TURNER CUT NR HOLT CA				CFTRN000		USGS	11311300																	
Turner	USGS SJR-TC, San Joaquin River between Turner Cut and Columbia Cut	SAN		46	RSAN046																				
EFT Short Name	**Region or Route Location**	**River Code**	**RM**	**RKI**	**DSM2 Name**	**CDEC Name**	**Gauge Owner**	**Native Code**																	
Interior Rgn	Oakley To Interior Delta																						■	■	■
Oakley Rgn	Chipps Island to Oakley																							■	■
Suisun Rgn	680 Bridge to Chipps Island																							■	
Big Break Wtld	Big Break Wetland																				■				
Montezuma Wtld	Montezuma Slough Wetland																		■	■					
Ryer Wtld	Ryer Island Wetland																		■	■					
Skinkee Wtld	Skinkee Tract Wetland																				■				
Grizzly Wtld	Grizzly Bay Wetland																		■						
Hood-RioVista Rte	Sacramento R - Hood to Rio Vista										■														
Knight-RioVista Rte	Sacramento R - Knights Ldg - Rio Vista								■	■															
Knight-Frmt Weir Rte	Sacramento R - Knights Ldg - Yolo via Fremont - Rio Vista								■	■															
Knight-Sac Weir Rte	Sacramento R - Knights Ldg - Yolo via Sacramento Weir - Rio Vista								■	■															
Western B1 Rte	Eastern Delta - through Sutter Slough to Suisun (B1)											■	■												
Western B2 Rte	Eastern Delta - through Steamboat Slough to Suisun (B2											■	■												
Eastern C Rte	Eastern Delta - through Georgiana Slough to Suisun (C)											■	■												
Eastern D Rte	Eastern Delta - through Georgiana Slough to Suisun (D)											■	■												
Eastern E1 Rte	Eastern Delta - through DCC, east branch to Georgiana to Suisun (E1)											■	■												
Eastern E2 Rte	Eastern Delta - through DCC, west branch to Georgiana to Suisun (E2)											■	■												

Outline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Methods
Types of output
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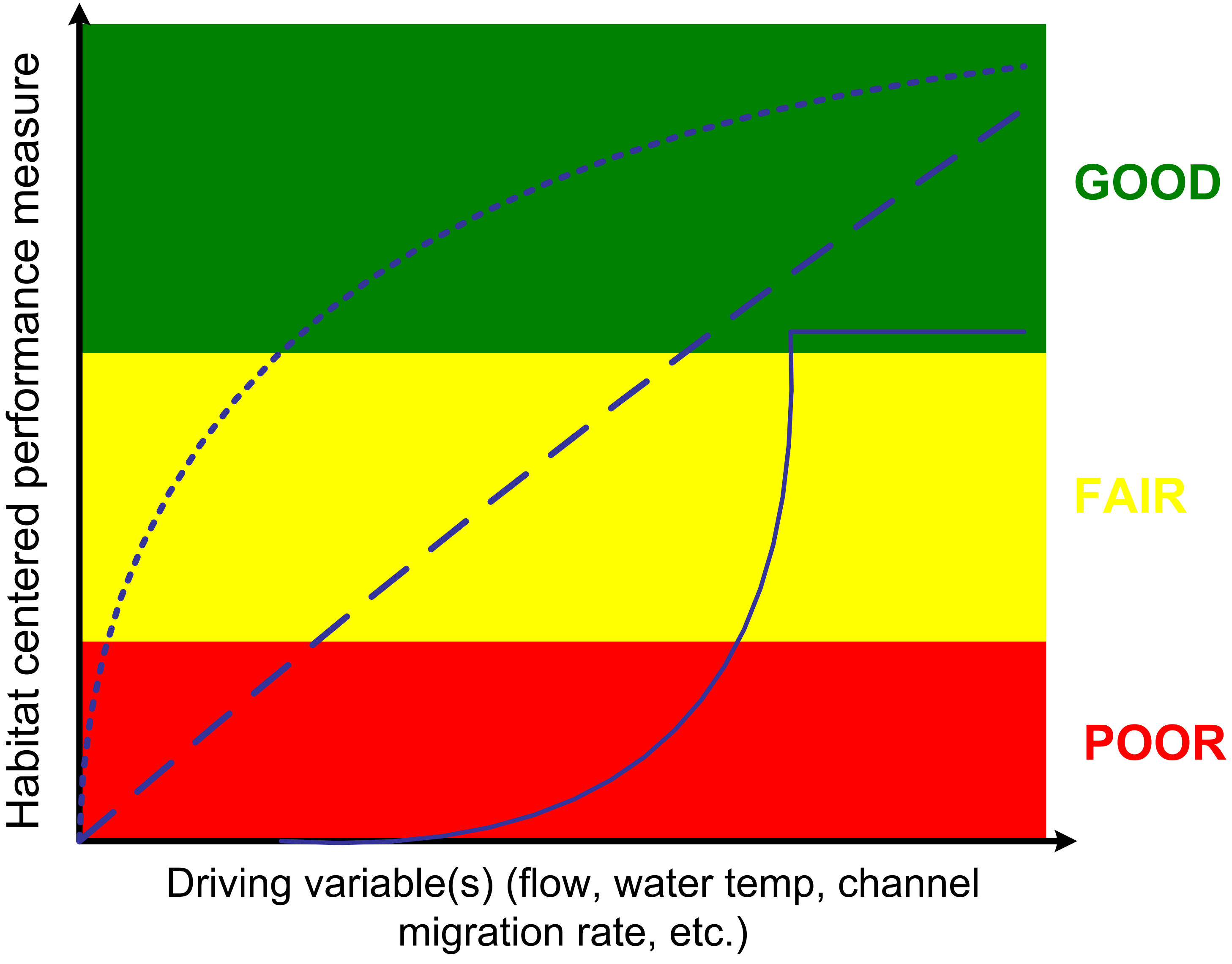
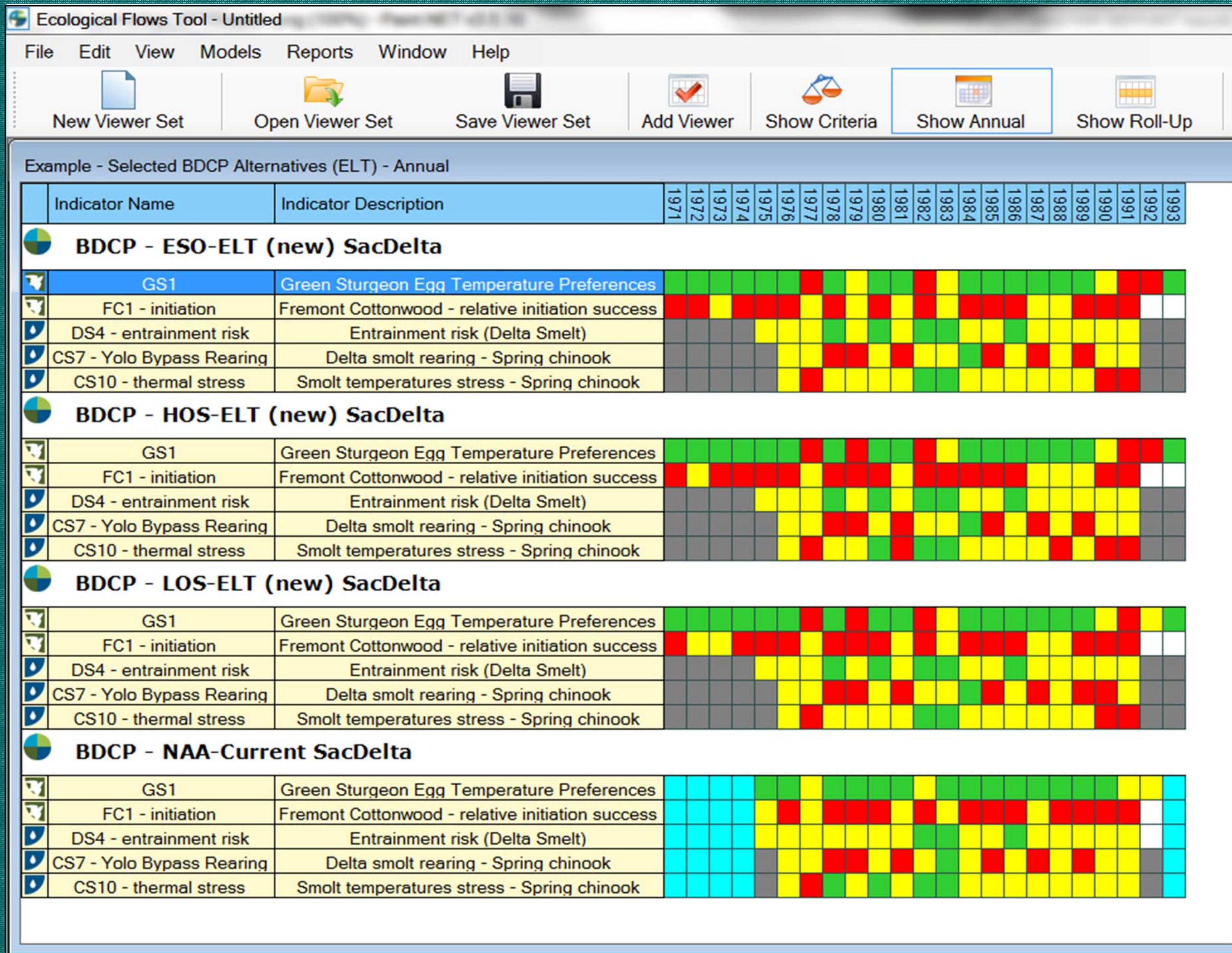
Findings
(recent applications)
Where to From Here?
Discussion !

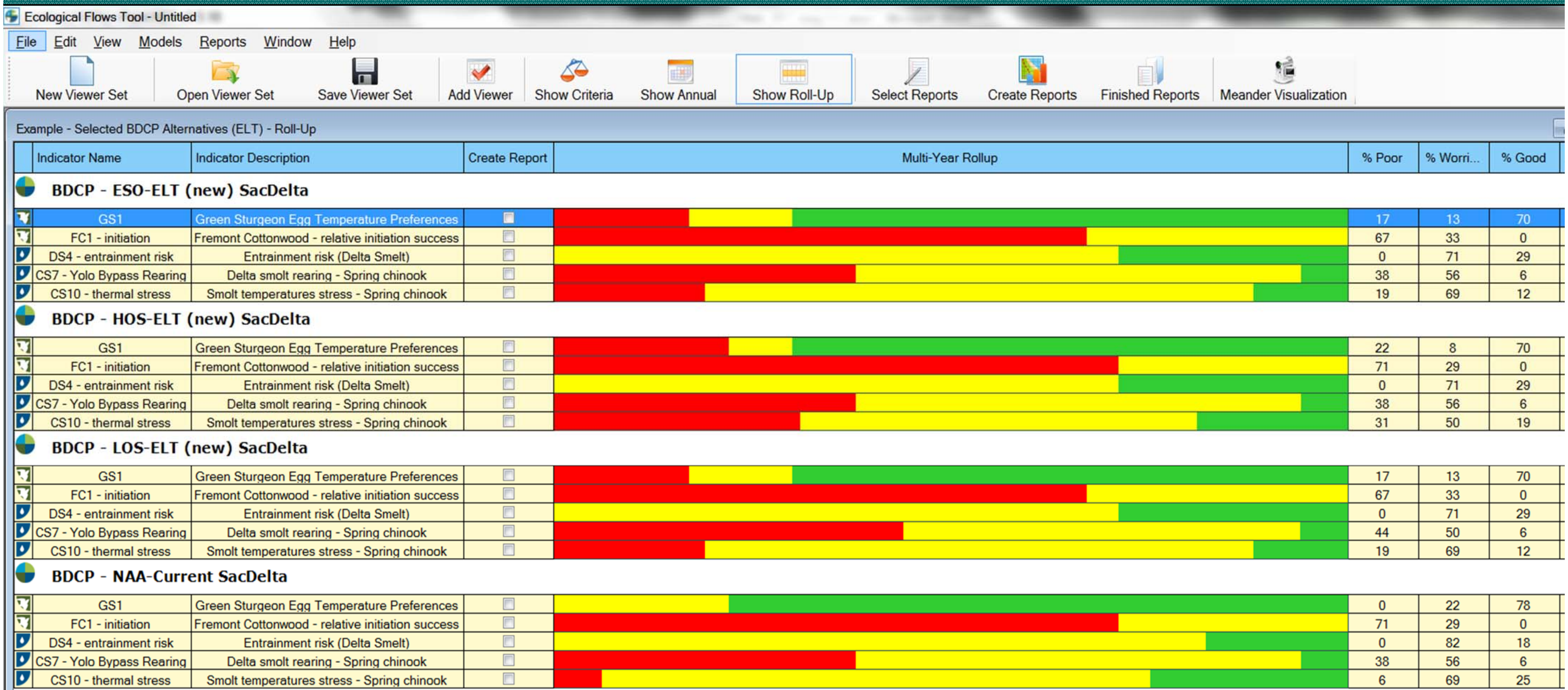
Relative suitability rating



Output: Annual “roll-up”



Output: Multi-year "roll-up"



Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worri...	% Good
BDCP - ESO-ELT (new) SacDelta						
GS1	Green Sturgeon Egg Temperature Preferences			17	13	70
FC1 - initiation	Fremont Cottonwood - relative initiation success			67	33	0
DS4 - entrainment risk	Entrainment risk (Delta Smelt)			0	71	29
CS7 - Yolo Bypass Rearing	Delta smolt rearing - Spring chinook			38	56	6
CS10 - thermal stress	Smolt temperatures stress - Spring chinook			19	69	12
BDCP - HOS-ELT (new) SacDelta						
GS1	Green Sturgeon Egg Temperature Preferences			22	8	70
FC1 - initiation	Fremont Cottonwood - relative initiation success			71	29	0
DS4 - entrainment risk	Entrainment risk (Delta Smelt)			0	71	29
CS7 - Yolo Bypass Rearing	Delta smolt rearing - Spring chinook			38	56	6
CS10 - thermal stress	Smolt temperatures stress - Spring chinook			31	50	19
BDCP - LOS-ELT (new) SacDelta						
GS1	Green Sturgeon Egg Temperature Preferences			17	13	70
FC1 - initiation	Fremont Cottonwood - relative initiation success			67	33	0
DS4 - entrainment risk	Entrainment risk (Delta Smelt)			0	71	29
CS7 - Yolo Bypass Rearing	Delta smolt rearing - Spring chinook			44	50	6
CS10 - thermal stress	Smolt temperatures stress - Spring chinook			19	69	12
BDCP - NAA-Current SacDelta						
GS1	Green Sturgeon Egg Temperature Preferences			0	22	78
FC1 - initiation	Fremont Cottonwood - relative initiation success			71	29	0
DS4 - entrainment risk	Entrainment risk (Delta Smelt)			0	82	18
CS7 - Yolo Bypass Rearing	Delta smolt rearing - Spring chinook			38	56	6
CS10 - thermal stress	Smolt temperatures stress - Spring chinook			6	69	25

Output: Relative suitability

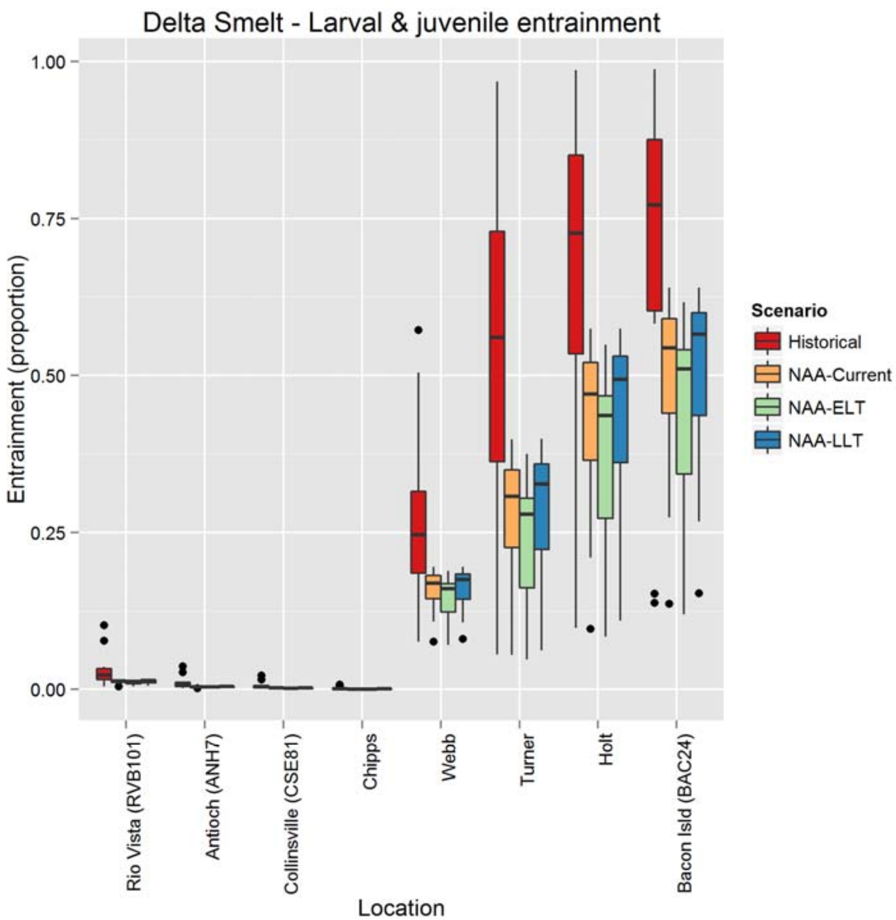
Table 2.11: EFT effects analysis – high-level roll-up using the relative suitability (RS) method. The method reports the percentage change in the years with good/favorable conditions compared to a reference case. This standardizes the comparison units in terms of a relative suitability rating and is internally consistent and able to accurately identify alternatives that are better or worse. The RS method does not provide an assessment of ***absolute*** suitability.

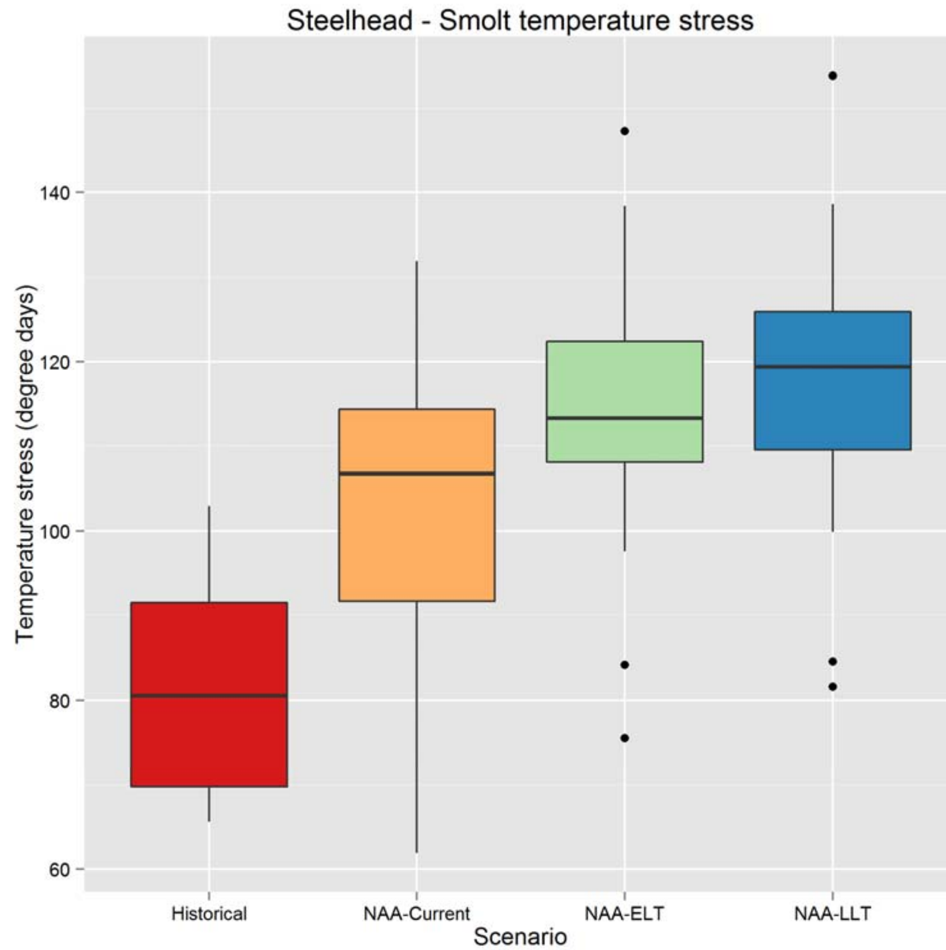
Focal species	Performance indicator (incomplete listing)	Effect Alternative vs. Reference case			
		Alt. 1	Alt. 2	Alt. 3	
Upper and Middle Sacramento River Indicators					
Fall Chinook	Suitable spawning habitat (CS1)	15	16	15	
Late Fall Chinook	Suitable spawning habitat (CS1)	-3	-5	-2	
Winter Chinook	Juvenile stranding (CS4)	-14	-18	-17	
	Suitable rearing habitat (CS2)	10	26	4	

Output: effect size (ES)

Focal species	Performance indicator (incomplete listing)	Reference case	Alt. 1	Alt. 2	Alt. *n*
Upper and Middle Sacramento River Indicators					
Fall Chinook	Suitable spawning habitat (CS1; 000s ft²)	3,738	4,081 (9.2%)	4,069 (8.9%)	3,998 (6.9%)
Late Fall Chinook	Suitable spawning habitat (CS1; 000s ft²)	1,272	1,195 (-6.0%)	1,187 (-6.7%)	1,232 (-3.1%)
Winter Chinook	Juvenile stranding index (CS4)	0.085	0.106 (-2.1%)	0.094 (-0.9%)	0.101 (-1.6%)
	Suitable rearing habitat (CS2; 000s ft²)	37,153	37,602 (1.2%)	37,804 (1.8%)	37,101 (-0.1%)

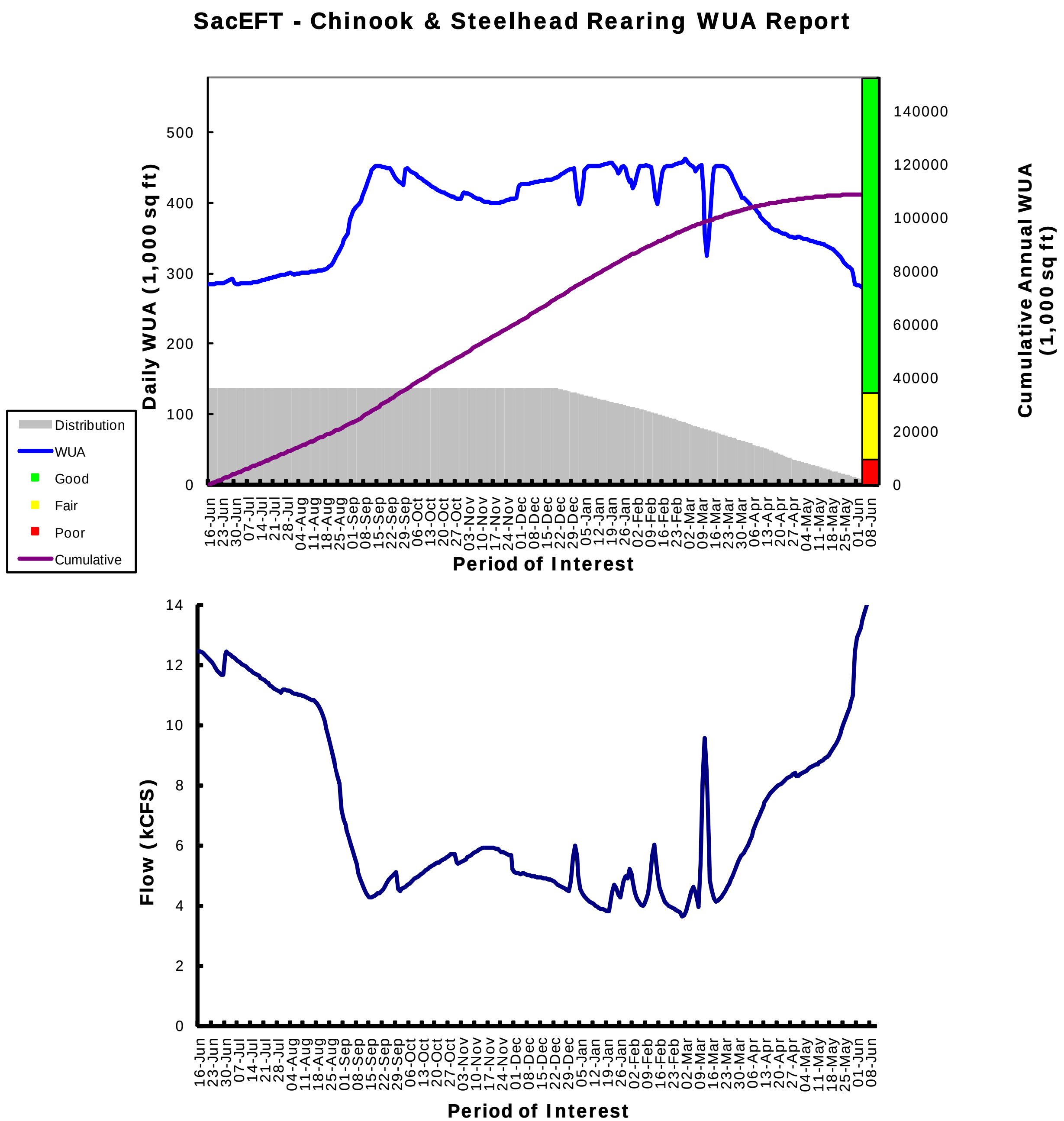
Output: effect size (ES) box plots



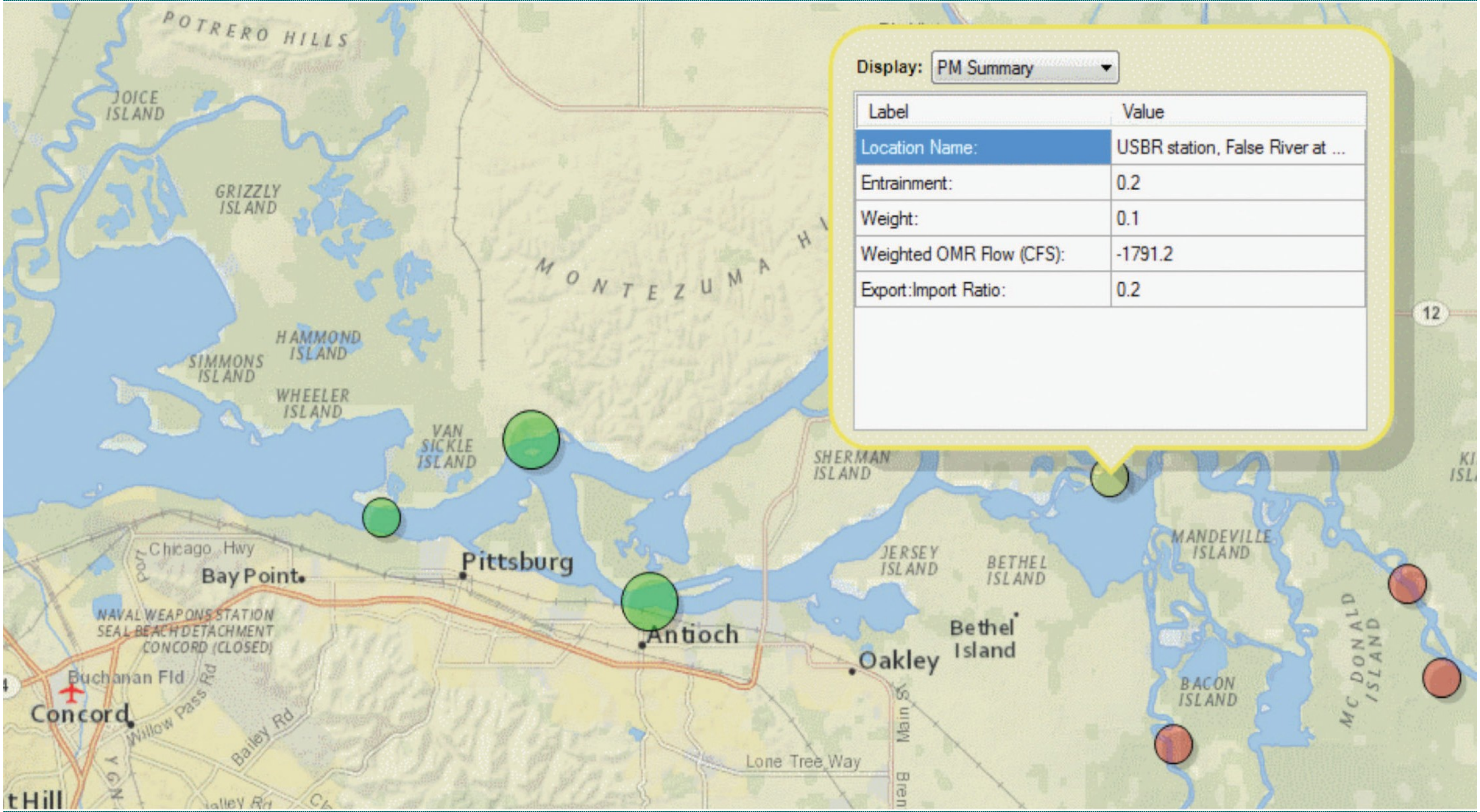


Output: within year daily results @ specific locations

Water year: 1986
Location of interest: CS Reach 5
River Miles 280.2 - 298.5
Species Steelhead
Units Sq Feet



Output: Spatial visualizations / animations



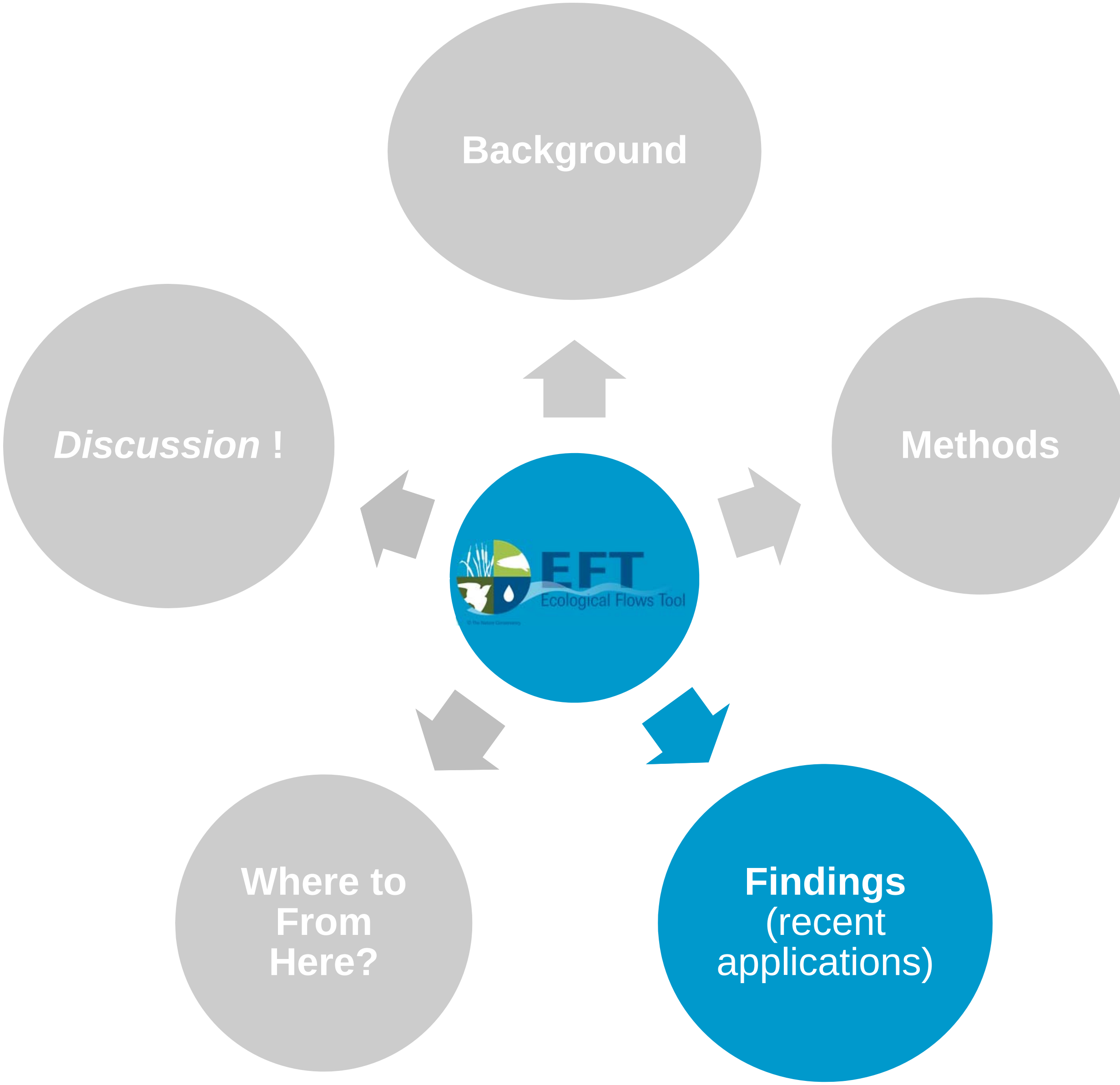
http://youtu.be/WcwRdM3f6Ao

Overall weight of evidence

Table 3.36: Overall summary of "winners and losers" for the selected BDCP alternatives.

			Sacramento River species	San Joaquin-Delta species		
Focal species	***All Alternatives***	**ESO-ELT (237)**	**LOS-ELT (238)**	**HOS-ELT (242)**	**Primary benefit / [Challenge]**	**Caveats**
Fall Chinook	↑				CS1	
Late Fall Chinook	↑	*<benefit from ELT baseline conditions, not the alternatives>*			CS2, CS7 [CS10]	Delta thermal stress (CS10)
Spring Chinook		↓	↑	↓	CS1, CS6, CS2	
Winter Chinook	No clear discriminatory results/preferences amongst alternatives (though *some* evidence conditions better under HOS)					Delta thermal stress (CS10)
Steelhead	No clear discriminatory results/preferences amongst alternatives					Delta thermal stress (CS10)
Bank Swallows	No clear discriminatory results/preferences amongst alternatives					
Green sturgeon	↓				[GS1]	
Fremont cottonwood	No clear discriminatory results/preferences amongst alternatives					
Large woody debris	No clear discriminatory results/preferences amongst alternatives					
Splittail	↑				Fremont weir notch included in all project alternatives	
Delta Smelt			↓		[DS2]	
Longfin Smelt				↑	LS1	
Invasive Deterrence	↓				[ID2]	
Tidal Wetlands	↓				We do not consider physical habitat restoration effects in this EFT analysis (did not have post restoration DEM)	

Outline


Background
Methods
Findings (recent applications)
Where to From Here?
Discussion !
EFT
Ecological Flows Tool

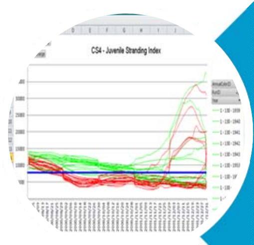
Recent EFT applications

Effects Analysis Application of SacEFT to North-of-the-Delta Offstream Storage Investigation

- SacEFT
- 5 alternatives including reference case
- Analysis based on RS method (only)

Effects Analysis Application to BDCP

- SacEFT & DeltaEFT
- 8 alternatives including reference case and future climate change variants
- Full analysis



Pilot investigation – Incorporating EFT Derived Ecological Flow Criteria to CALSIM

- Rule-sets converted to WRESL
- Winter-run chinook and Delta smelt

EFT effects analyses

Step 1

- EFT baseline simulation (relative suitability thresholds)
- Study simulations:
  - Reference case
  - Alternatives
- Establish structure of comparisons

Step 2

- Assess degree of change physical variables (flow, water temp, salinity, etc.)

Step 3

- Examine changes in EFT perf. indicators using different methods (RS, ES, boxplots, etc.)
- Identify major trade-offs

Step 4

- Perform weight of evidence net effect scoring (NES)
- Provide interpretative narrative
- Document caveats/ limitations

BDCP effects analysis: Key Findings

1. LOS preferable for species in Sacramento River HOS preferable for Delta species.
   - LOS ecosystem benefits only slightly better for Sacramento River, *results from HOS generally very similar*.
   - Various trade-offs noted, ***HOS alternative is likely most preferable.***

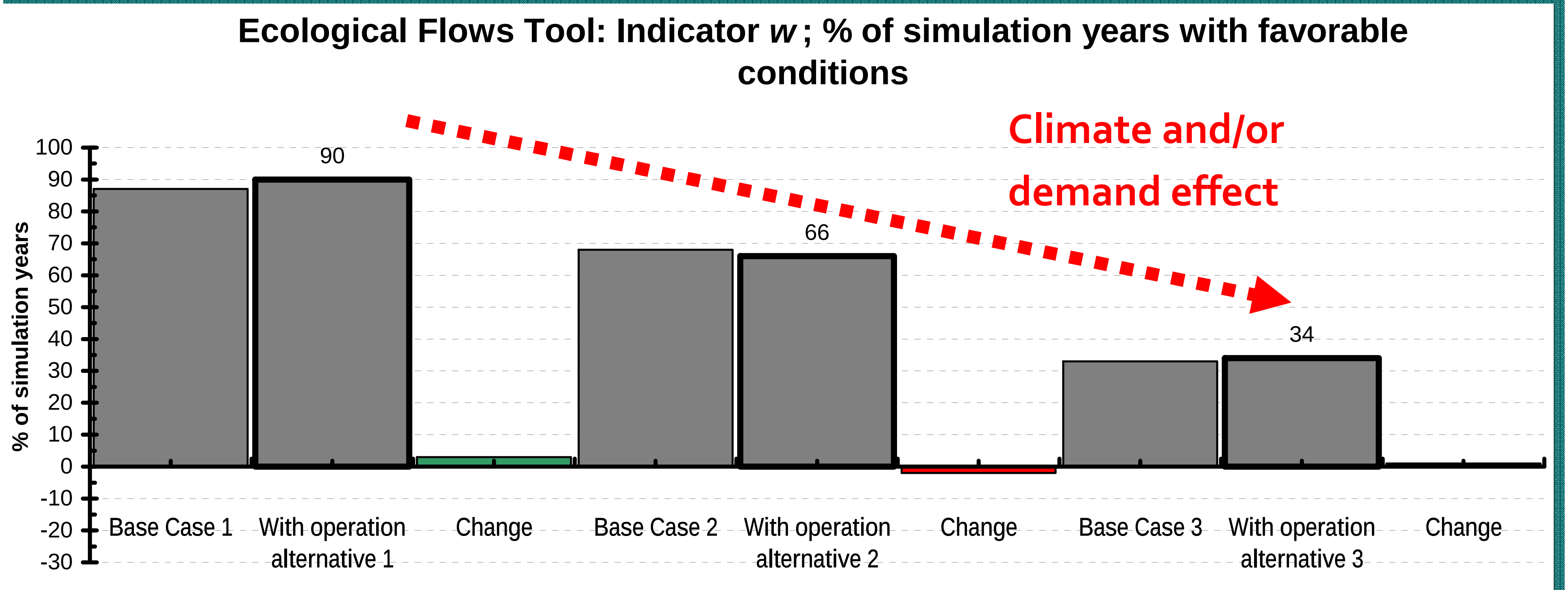
BDCP effects analysis: Key Findings

Winners	Losers
❑Fall-run Chinook, ❑Late fall-run Chinook & ❑Splittail	❑ Green sturgeon, ❑ deterrence of invasives, ❑ brackish wetland habitats

BDCP effects analysis: Key Findings

2. Climate change dwarfed effects of operational alternatives,
    - From ecosystem point of view, inadequate to compare future operations *relative to a progressively deteriorating baseline.*

Deteriorating baseline comparisons mask "what matters" ecologically



Current ELT LLT

BDCP effects analysis: Key Findings

3. BDCP alternatives include some offsetting benefits.
   - e.g., Delta rearing conditions improved by notching Fremont Weir, higher X2 outflows, USFWS (2008), NMFS (2009) actions.
   - Relative benefit of flow mediated improvements will depend on detrimental effects of *warming water temperatures*.

BDCP effects analysis: Key Findings

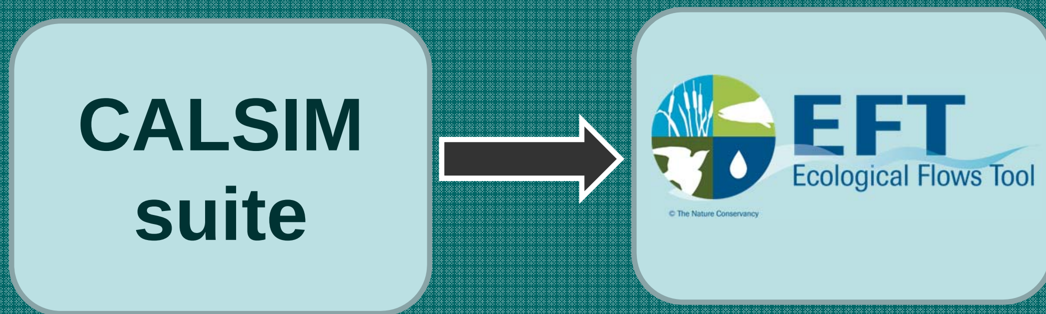
4. Reservoir operational criteria cemented in BDCP effects modeling highly constrained, limiting ability of BDCP to *fully* explore and realize opportunities.

BDCP effects analysis: limitations

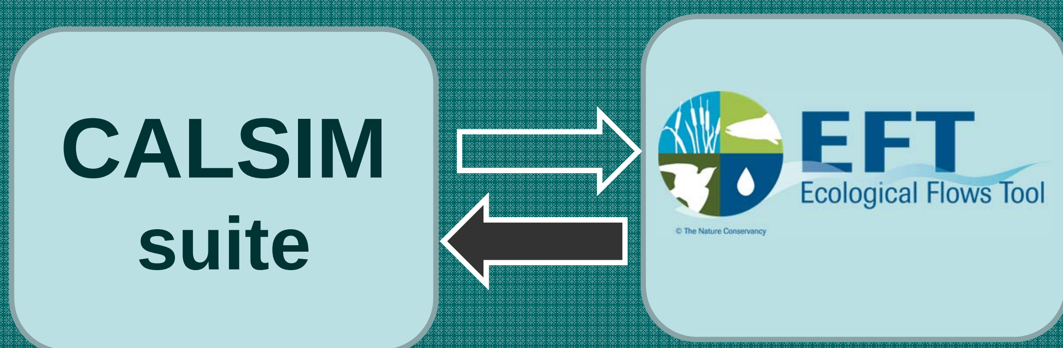
Caveats / Limitations

1. **EFT focuses on flow** operations & includes Yolo Bypass enhancement, does not evaluate all 22 conservation measures.
2. EFT addresses 13 species, **not every species, nor food web interactions, nor attempt to model all behavioral movement & life-cycle survival progression**
   - Framework ready for new species & performance indicators
3. **EFT uses outputs from external hydrologic models (CALSIM, DSM2, etc.).**
   - Easy to swap in results from any physical model in EFT

Pilot test: integrating EFT with systems operations models



Incorporating EFT derived ecological flow criteria to CALSIM



Step 1: Define ecological flow criteria

Bay Delta	
Delta Smelt	
Indicator	DS4 — Entrainment index
Objective & Rationale	The indicator simulates entrainment risk from the CVP and SWP export operations. Low flow years historically have higher incidences of entrainment than high flow years because fish are distributed closer to the points of diversion in low flow years, when a higher proportion of juveniles rear in the Delta (Moyle 1992; Sommer *et al.* 1997). The greatest entrainment risk from export operations is thought to occur during winter, but juveniles are also vulnerable; with peak of risk in May-June (Nobriga *et al.* 2001). The indicator is based on the results of a Particle Tracking Model (PTM) experiment (Kimmerer and Nobriga 2008), which simulates the fate of particles released in the Delta under a range of inflows and exports. In order to satisfy the PTM assumptions, the indicator applies only to the larval and juvenile life stages. (Design Document Section 2.2.2, pp. 89-100)
Timing	O N D J F M A M J J A S Recommended Used in Pilot
Locations	Combined Old + Middle River (OLD R A BACON ISLAND CA, ROLD024, 11313405) + (MIDDLE R AT MIDDLE RIVER CA, RMID015, 11312676)
Variable & Condition	≤ Normal WYT: Q_{avg} > –2,000cfs > Normal WYT: Q_{avg} > 0cfs — Recommended
	≤ Normal WYT: Q_{avg} > 2,000cfs > Normal WYT: Q_{avg} > 0cfs — Used in Pilot
Other Triggers	Juvenile smelt detected through trawls
Recurrence	Annually
Potential conflicts & trade-offs	May conflict with export objectives
References	Kimmerer and Nobriga (2008)

Step 5: Results

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Fall Chinook	Spawning WUA (CS1)	-14
	Thermal egg mortality (CS3)	4
	Redd Dewatering (CS6)	-1
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	0
	Rearing WUA (CS2)	-5
Late Fall Chinook	Spawning WUA (CS1)	-2
	Thermal egg mortality (CS3)	0
	Redd Dewatering (CS6)	1
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	0
	Rearing WUA (CS2)	3
Spring Chinook	Spawning WUA (CS1)	-15
	Thermal egg mortality (CS3)	11
	Redd Dewatering (CS6)	36
	Redd Scour (CS5)	2
	Juvenile Stranding (CS4)	5
	Rearing WUA (CS2)	-12
Winter Chinook	Spawning WUA (CS1)	35
	Thermal egg mortality (CS3)	2
	Redd Dewatering (CS6)	21
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	34
	Rearing WUA (CS2)	-10
Steelhead	Spawning WUA (CS1)	-1
	Thermal egg mortality (CS3)	0
	Redd Dewatering (CS6)	-2

- Jagger's Law*: inverse correlations exist

You can't always get what you want

Integrating EFT with systems operations models: Key Findings

1. We successfully demonstrate EFT rule-sets can be "inserted" and generate beneficial effects in CALSIM

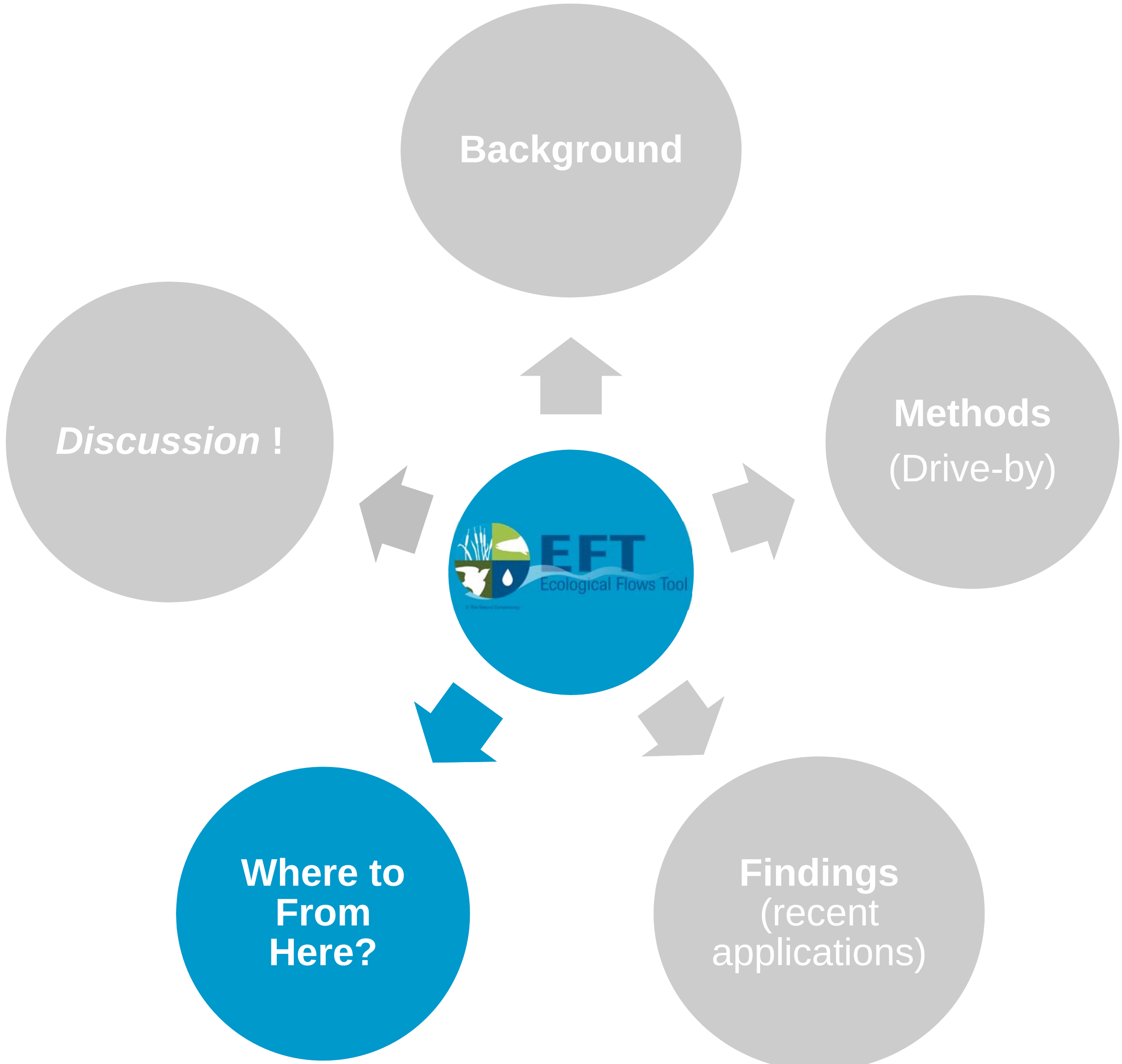
   ...without significantly impacting storage or exports

2. Irreconcilable, ceaseless trade-offs will always exist between-species and ecoregions

   - ❑ These trade-offs do not owe to failure to create clever enough models.

   - ❑ *A single, unchanging optimal solution does not exist.*

Outline


Background
Methods
(Drive-by)
Findings
(recent
applications)
Where to
From
Here?
Discussion !
EFT
Ecological Flows Tool

Where to from Here?

A new paradigm: flexible ecosystem priorities

- Recognize multiple, equally acceptable solutions exist
- Smart, state-dependent priorities
- Build multi-objective, state-dependent optimization engine

Sustained refinement & application of EFT

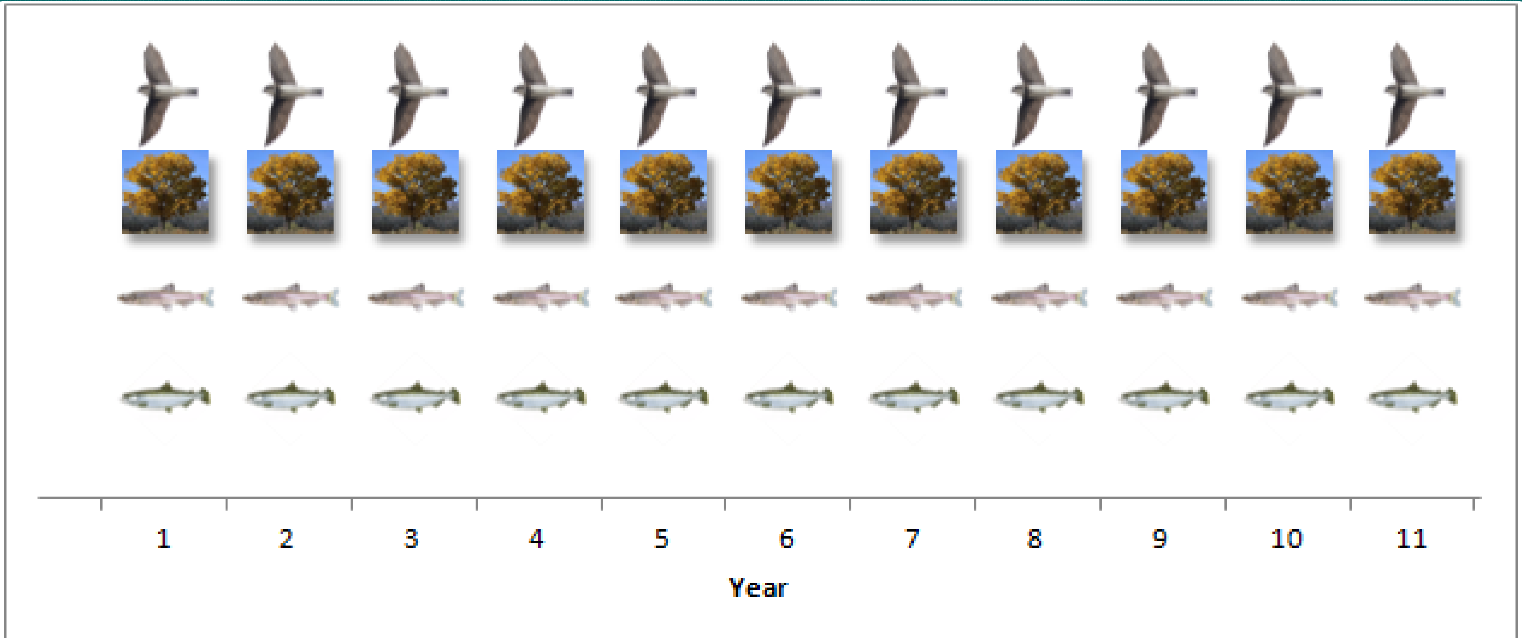
- EFT one element of community modeling hub
- “Gathering place” for generally accepted functional relationships / algorithms
- Every CALSIM run should be coupled with an EFT run

Design adaptive management experiments, <u>real-time</u> decision support tools

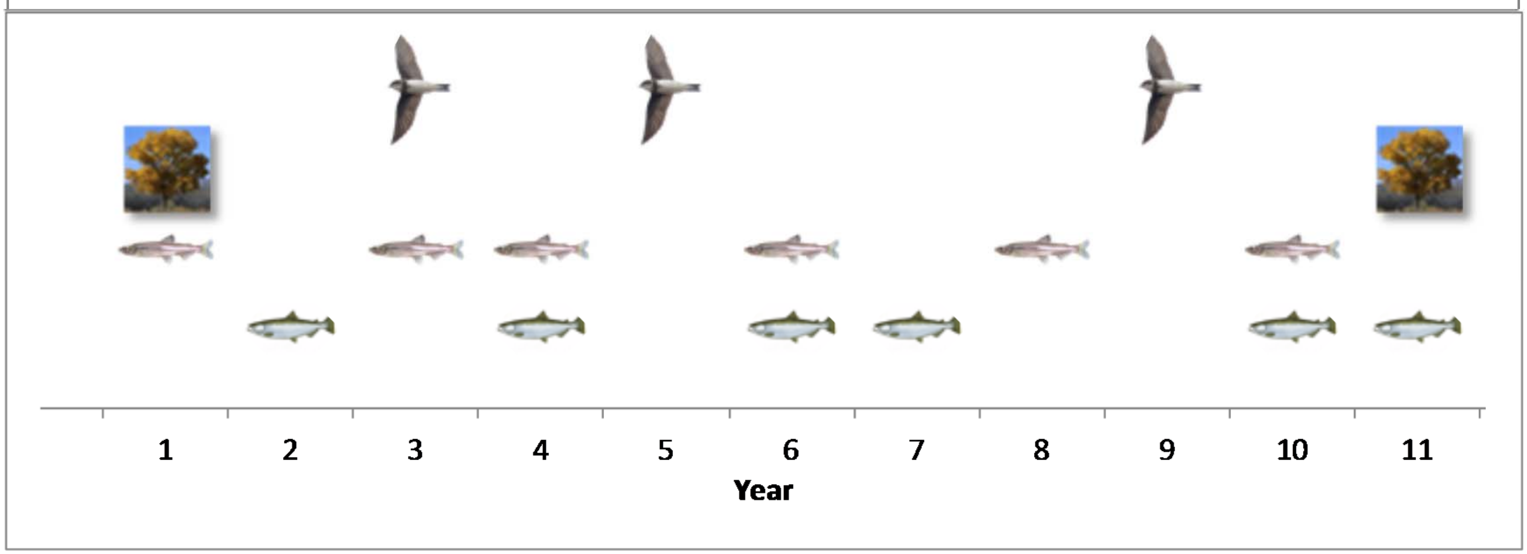
- Disproportionate amount of effort devoted to water planning models in California

A New Paradigm:
flexible ecosystem priorities

Existing



New Paradigm



Where to from Here?

Sustained Refinement & Application of EFT

- EFT one element of community modeling hub
- "Gathering place" for generally accepted functional relationships / algorithms
- Viewer distribution & training program

- EFT provides a very successful & rare example of synthesis & integration.
- Intuitive, durable user interfaces, data visualizations, data mining/exploration
- Leveraging investment more cost-effective than duplication / re-invention.

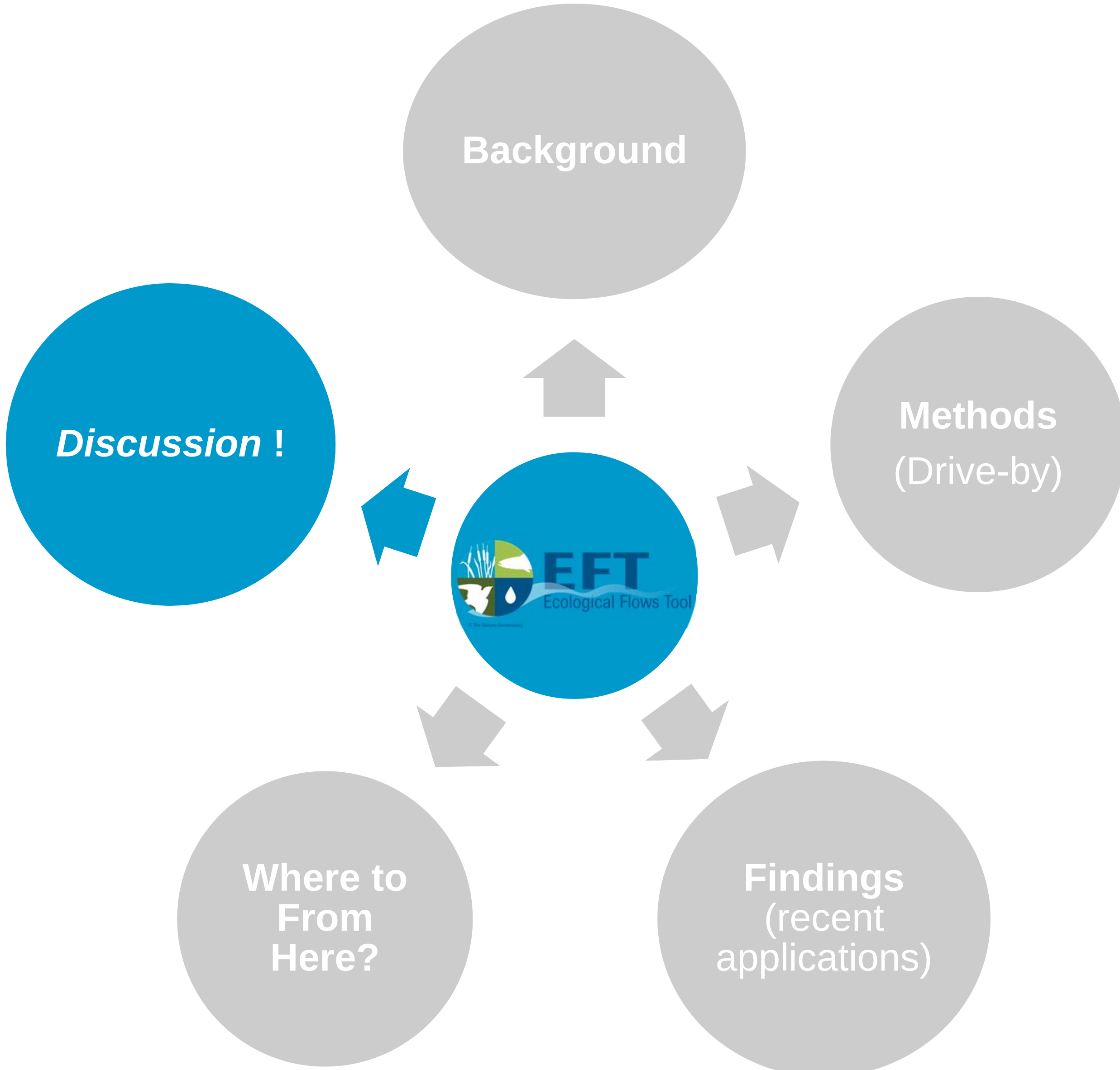
Where to from Here?

Design adaptive management experiments, real-time decision support tools

- **Disproportionate amount of effort devoted to water planning models in California**

- EFT can help winnow ecological flow mgmt alternatives & direct more efficient adaptive management experiments.
- In-season modeling tools that build-in ecological guidelines needed that impact on-the-ground decisions.

Outline


Background
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Ecological Flows Tool

Information

EFT software:

essa.com/tools/ecological-flows-tool/

eft-userguide.essa.com/

Final Report:

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