SacEFT

Sacramento River Ecological Flows Tool

SacEFT is a computer program whose purpose is to improve water use decisions on the Sacramento River through the inclusion of ecological targets. It has been developed collaboratively by dozens of scientists and managers from five organizations through funding provided by the Calfed Bay-Delta Program and through a grant from the Resources Legacy Fund Foundation, as one part of the Sacramento River Ecological Flows Study. The Flows Study was led by The Nature Conservancy, utilizing the services of consulting scientists at Stillwater Sciences and ESSA Technologies, with additional scientific support from researchers at UC Davis and UC Berkeley and from stakeholders and specialists at DWR and USFWS. SacEFT incorporates *physical* models of the river (historical and simulation scenarios of discharge, temperature, sediment transport and channel migration) with *biophysical* habitat models for five focal species. Its design has been greatly aided by the Sacramento River Linkages Report (www.delta.dfg.ca.gov/erp/sacriverecoflows.asp).

SacEFT integrates the output of existing models in a purpose-built database

SacEFT's development was guided by the vision of creating software that makes it easy for non-specialists to expand the ecological considerations and science foundation used to evaluate water management alternatives, keeping the technical details "under the hood". Water use planning for the Sacramento River currently attempts to balance the social and economic needs of agricultural production, flood protection, municipal and industrial water supply and power generation. These multiple-objective decisions include few ecological considerations except for the maintenance of in-stream flow and temperature requirements at a limited number of sites thought to support species typically listed under the Endangered Species Act. Toward the Delta, salinity criteria (X2) are also paramount. SacEFT catalyzes new thinking in this domain by adding additional indicators for salmonids, Fremont cottonwood, bank swallows, green sturgeon and western pond turtles.

We believe that the use of established and accepted models is a key strength of SacEFT. The tool is able to synthesize vast amounts of information by linking ecological submodels to existing physical planning models, providing a major advance in ecological trade-off analysis capabilities. It can consider different management scenarios involving river discharge, gravel augmentation and channel configuration (rip-rap and levee set-back states). These models include generally accepted water planning tools such as Calsim[1], as well as physical process oriented models such as the meander migration model developed by scientists at UC Davis and a gravel augmentation and sediment transport model developed by Stillwater Sciences. When these models advance or change, SacEFT simply works with the best available models by plugging into *their* data. In the case of focal species, SacEFT adds functional relationships from a range of studies and data sources to generate more than 30 habitat/biological performance measures (PMs).

Physical models

In addition to historical discharge and temperature gauge data, SacEFT includes daily discharge and temperature scenarios created by Calsim, the model of the Sacramento system – river, basin and reservoirs – developed by the California Department of Water Resources. Daily flows originating from Calsim are an important driver of the sediment, meander and habitat models in most scenarios.

SacEFT also includes the results of simulation scenarios created by the TUGS sediment transport model (details available at www.delta.dfg.ca.gov/erp/sacriverecoflows.asp). TUGS works with discharge scenarios provided by Calsim and calculates both surface and subsurface grain size specific sediment transport in combination with natural sediment supply and gravel augmentation assumptions.

[1] Technically: CALSIM II – SRWQM – HEC5Q

Discharge, temperature and channel substrate results from historical gauges and modeled scenarios are loaded into the SacEFT database in such a way that the driving physical variables are never mismatched. Our database design enforces "apples-to-apples" comparisons between datasets, a critical requirement for inputs to the focal species submodels.

Finally, SacEFT incorporates a meander migration model developed at UC Davis to simulate channel movement based on the physical principles of fluid mechanics, site-specific geomorphology and excess stream power (details available at www.delta.dfg.ca.gov/erp/sacriverecoflows.asp). The channel migration predicted by this model provides estimates of newly eroded bank and the area of reworked floodplain under alternative flow and stream-bank protection states at three sections of the Sacramento River.

Focal species and indicators

Over the three-year development of SacEFT, stakeholder and expert workshops led to the evaluation and selection of six focal species. Based on the Linkages Report and available knowledge and data, five of the six species are currently incorporated into SacEFT, and for each of the species, a number of PMs are calculated. Each PM is habitat-based and independent of the other PMs for the species. (SacEFT's focal species submodels make no predictions of life-stage to life-stage population progression for any of the species).

Chinook Salmon & Steelhead Trout

SacEFT models some of the important spawning and rearing needs of Chinook salmon and steelhead trout that are influenced by discharge, temperature and channel substrate. The Chinook submodel framework is subdivided so that it independently follows four races: winter, spring, fall and late fall runs, with most spawning areas located between Keswick and Battle Creek. For each of these five groups the following six PMs are defined:

1. area of spawning habitat
2. area of rearing habitat
3. temperature-based egg-to-fry survival
4. juvenile stranding
5. redd scour
6. redd dewatering

The PMs are intentionally simplistic and do not account for interactions that naturally occur. For example, a flood leading to redd scour has the potential to affect an entire year-cohort regardless of the previous or subsequent state of the other PMs that year. This simplifying assumption helps us manage the exponential growth in uncertainty (and data requirements) inherent in a proper life-history model approach, in favor of focusing on how to improve the flow regime for multiple ecological targets, "all else being equal".

Green Sturgeon

SacEFT models a single PM for green sturgeon, using a simple model of heat hazard during the egg development period. River reaches where green sturgeon spawn are not known with certainty, and SacEFT currently assumes that spawning occurs below Red Bluff only. This assumption, like almost all used by SacEFT, is stored in a database where it can easily be modified as new knowledge becomes available. Other indicators have been identified in the Linkages Report, and are under consideration for inclusion in future versions of SacEFT.

Bank Swallow

SacEFT models the nesting requirements of bank swallows through two PMs based on peak river flow and on bank renewal simulated by the meander migration model.

Bank swallows are known to have more complex requirements than those included in this submodel. For example, they have preferences for bank height, slope and age and are sensitive to the vegetation on adjacent land areas. Once these attributes data become more readily available, they can be built into a future version of SacEFT.

Fremont Cottonwood

SacEFT models the initiation of Fremont cottonwood seedlings based on river stage-recession relationships during the seed dispersal period. The initiation model also accounts for taproot growth and capillary fringe height, ultimately predicting the relative survival of seedlings at select index locations.

SacEFT results

In keeping with the design principle of making it easy for non-specialists to understand the model's results, SacEFT creates output that can span the range from high-overview (Figure 1) to high-resolution (Figure 2). The output interface makes extensive use of a "traffic light" paradigm that juxtaposes PMs and scenarios to provide an intuitive overview of whether a given year's PMs are healthy (**green**), of some concern/fair (**yellow**), or of serious concern/poor (**red**).[2]

Figure 1. Example of annual roll-up traffic light indicator ratings.

As shown in Figure 1, results from any scenario can be viewed side-by-side with results from other scenarios. Combinations of multiple PMs and years can be further explored by clicking on the colored grid (see the circled check-mark in Figure 1). For each annual PM result requested, SacEFT then creates custom detailed reports and automatically sends them to Excel (Figure 2) for display.

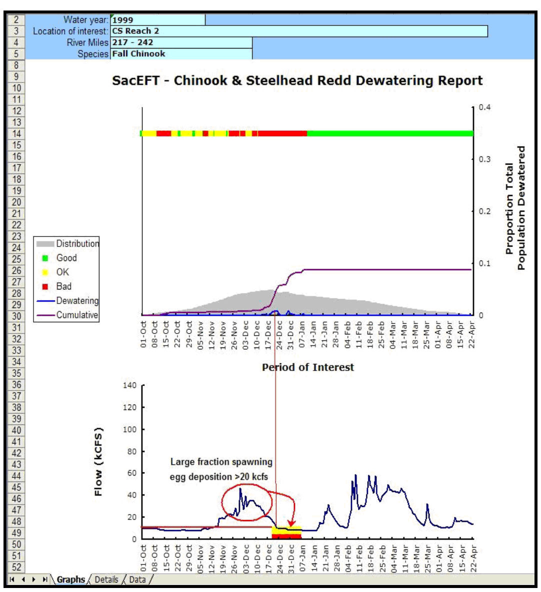

Figure 2. Detailed reports in Excel.

Figure 3. Example results in multi-year roll-up view

[2] Color blind users: traffic light colors are under user control.

The detailed reports also employ a traffic-light approach, allowing SacEFT users to see within-year periods that have the most significant influence on each PM.

SacEFT also provides a means to "roll-up" multiple years of output into even more condensed reports (Figure 3).

Because detailed reports like Figure 2 are exported along with all the data used to create the report, it is straightforward to make additional use of the underlying data to create customized reports or syntheses that incorporate multiple scenarios and PMs. An example of this kind of output is shown in Figure 4.

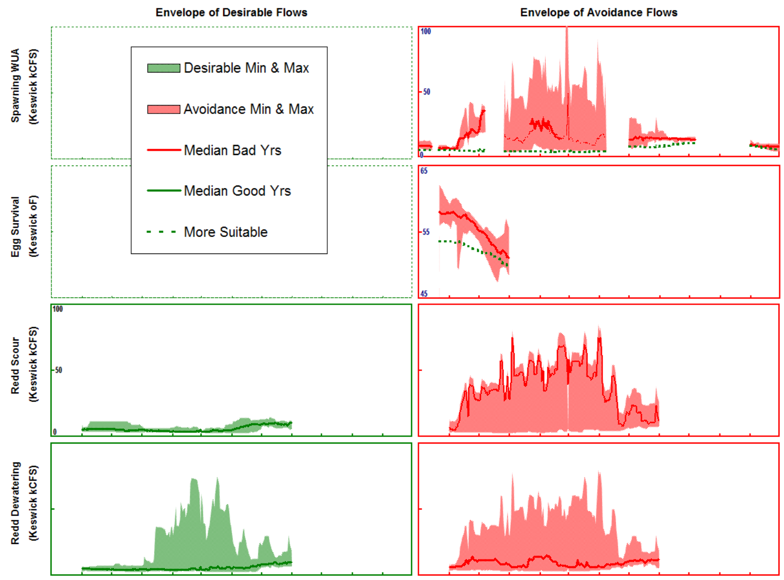

Figure 4. SacEFT target and avoidance flow envelopes.

Under the hood

SacEFT is designed around an extensive database of over 90 tables containing five classes of information:

1. **Model Scenario logic:** locating appropriate datasets for compatible scenarios, linkages to data sources, references and reviews, user selections and preferences for simulation runs;
2. **Output logic:** user preferences for assigning red, yellow or green hazard measures and run results for scenarios;
3. **Mapping logic:** consistent definitions for points, segments, cross sections as they relate to the physical input data and focal species;
4. **Physical input data:** discharge at gauges and network segments (historical and simulated); temperature at gauges and network segments (historical and simulated); channel sediment characteristics (simulated); and
5. **Biophysical data:** knowledge about the preferences and physical needs of five focal species; numerous unique PMs for each.

All model information—user preferences, physical and biological data and simulation outputs – are stored in a Microsoft SQL Express Server database residing on the user's workstation, linked through a Visual Basic.NET user interface. SacEFT automates an Excel reporting engine to deliver detailed output reports.

Additional information

www.delta.dfg.ca.gov/erp/sacriverecoflows.asp

- SacEFT Backgrounder
- SacEFT Design Guidelines
- Final Report & Appendix F

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The Nature Conservancy
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