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SMRF: A MODELING APPROACH FOR SIMULATING METACOMMUNITIES OF RIVERINE FISHES

Problem

Fish in rivers provide valuable benefits to people, including food, recreation, and cultural value. Fish are also visible indicators of river health.

Riverine fish can be affected by changes in habitat and water quality resulting from land development and human activities in the watershed. Stressors from these activities – altered flow, temperature, sediment, nutrients, and other pollutions – can affect water quality and habitat conditions for fish. Understanding how stressors affect fish is complicated by interactions among fish species, as well as patterns of movement across river networks.

Environmental managers are working to best protect and restore water quality and habitat in watersheds that provide valued fish populations. To best target their activities, managers require tools to help understand how fish populations will respond to management actions.

EPA's Approach

Modeling can be used to assess the consequences of multiple stressors to multiple populations of one or more fish species across a river network. Modeling represents important processes in order to assess scenarios.

The US Environmental Protection Agency (EPA) developed a model that simulates multiple populations of one or more fish species – a metacommunity –in response to multiple stressors across a river network. The model is called SMRF (Simulating Metacommunities of Riverine Fishes) It is spatially-explicit and age-structured, with three components: habitat suitability; population dynamics, including species interactions; and movement across a spatial network.

SMRF is designed to assist the Agency's ability to ensure that the nation's waters are fishable and to assess whether water quality standards are protective of aquatic life. SMRF can also support economic assessment of the benefits of regulations. The model was designed for use by communities, land managers, policy makers, scientists and engineers.

SMRF can be downloaded from https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=346971

Model Structure

The SMRF model is typically set up to run across a network of connected river reaches. Fish populations are simulated within and among river reaches that can vary in suitability.
Fish species in the model can be input using PiSCES, an EPA tool that estimates fish at unsampled sites. Data collected through EPA's National Aquatic Resource Surveys can be used to calibrate the model. SMRF simulates survival and reproduction of multiple age classes, where survival is affected by habitat, water quality, competition, and predation.

River reaches support fish communities in the SMRF model

SMRF model input includes measures of water quality and habitat, which may change through time. SMRF's outputs include relative numbers of different species of fish within watersheds, with the expectation that abundances will capture order-of-magnitude differences among species and general patterns of distribution (presence/absence).

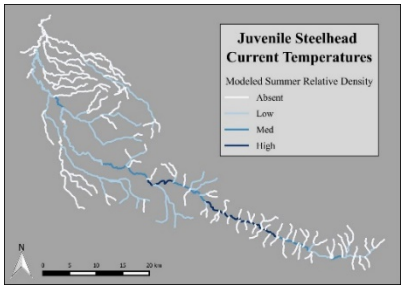
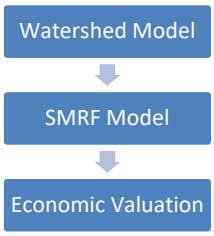


Figure of an example stream network (Calapooia River, Oregon) illustrating the distribution and relative density of juvenile steelhead trout (*Oncorhynchus mykiss*) as predicted by a SMRF model. Darker colors indicate stream sections with higher trout densities.

Integrated Modeling

SMRF can be incorporated into an integrated modeling system for watershed management and prediction. Watershed models can provide flow, temperature, nutrients, and other habitat varables to SMRF, which can provide fish species abundance, distribution, and diversity to economic models.



Example Applications

SMRF provides useful insights into the net effects on fish communities of stream network habitat conditions (water temperature, channel slope, stream size), spatial configuration (proximity of seasonal habitats), and fish species characteristics (fecundity, survival, competition). Some example applications are to:

- Compare the effects of watershed and water quality management scenarios on fish communities.
- Communicate to landowners how activities on their property are connected to fish in the larger context.
- Support assessment of potential outcomes for biotic integrity based on watershed and water quality improvements, habitat losses, or other changes.
- Identify critical knowledge gaps or refine assumptions where data are currently lacking.
- Evaluate the expected benefits to fish of spatially-explicit habitat actions, such as target areas for restoration, which may be particularly useful for foundations, granting agencies, and tribes.
- Provide input for valuation.

Learn More

EPA's research on Ecosystem Services

PiSCES - https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=297970

National Aquatic Resource Surveyshttps://www.epa.gov/national-aquatic-resource-surveys

Integrated Environmental Modeling - https://www.epa.gov/measurements-modeling/integrated-environmental-modeling-general-information-and-guidance

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