Ecological Response Model- An Introduction

In 2011 City of Fort Collins Natural Areas staff initiated a collaboration with local scientists to develop the Poudre Ecological Response Model (ERM) for the urban reach of the Cache la Poudre River from Overland Trail Road to Interstate-25.

The ERM effort underlies a community-driven quest to manage for an ecologically healthy and resilient Cache la Poudre River. Thru the ERM the City has examined the past, present and likely future condition of the river. This science-based inquiry has contributed to our understanding of an urban river that has been fundamentally altered from its native condition. Moreover, the Poudre continues on a trajectory of change – and is headed for a very different future than even present-day conditions.

The ERM is an integrated model designed to address a variety of interacting questions, such as: How does a heavily plumbed watershed, a confined channel, a gravel-mined floodplain, and increasing societal demands for water intersect to create today's conditions? What is the gap between the community's vision for a healthy river and the trajectory of change that the river is on? Is the river in danger of losing its resilience and the key characteristics of a healthy river? Perhaps most importantly, what will it take to get to the future that our community desires?

While the ERM will not make societal choices for us, it provides needed scientific context and serves as a decision-support tool to contemplate the design and implementation of river-improvement efforts. While the ERM has provided sobering information about the future of the Poudre, it also has helped clarify the short and long-term improvement actions that are feasible. In addition, it will foster a more informed and productive community discussion about the future of the river.

The ERM project has two overarching goals:

1. To quantitatively inform a flow and management scenario that most closely helps us meet our community vision of a healthy river.
2. To provide a coarse-scale evaluation of future river conditions given specific streamflow scenarios. In other words, the ERM was developed to help provide a glimpse into the future across a spectrum of possible futures.

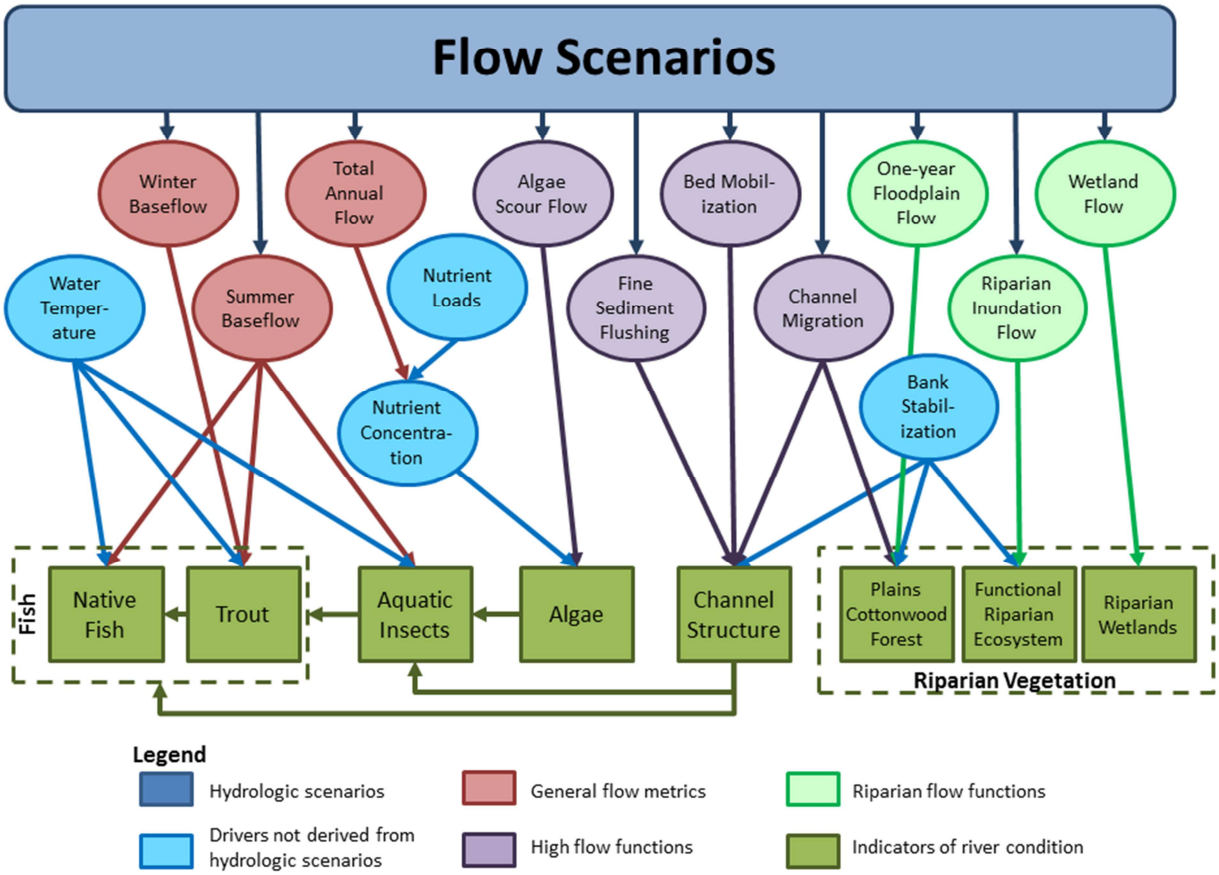
What is our vision?

The Poudre River is a treasured community resource and asset. Numerous City and community adopted planning documents reflect broad support for a healthy and resilient Poudre River. The ERM can help quantify the meaning behind these concepts including, clean water; vibrant plant and animal communities; and a river that provides for the economy and our lifestyle.

These concepts are challenging to achieve; in fact, some might argue that they are mutually incompatible, but the authors of this report present evidence that while the river is different than it was,

together we can support an ecosystem that embodies the essence of river well into the future. But this can only occur if we make well-informed choices and strategic investments today.

The Model



The ERM is built upon the best available hydrologic and ecosystem data available today. The network of hydrologic and non-hydrologic drivers expressed in the above graphic are related to ecosystem functions and ultimately to indicators of river condition. All links (i.e. arrows) are expressed with a probability of influence. These probabilities come from available data and fundamental understanding of the ecosystem by our team of experts. These probabilities cascade down through the model resulting in conditional probabilities for each indicator.

Ecological Response Model (ERM): Q & A

What are the challenges of modeling the urban Poudre River ecosystem?

The goal for the ERM was to fill a niche in our understanding of this system by developing a perspective of the whole system. To do so required the team to integrate multiple factors which represent the interdependent and complex nature of the Poudre River. Creating this comprehensive model has five specific challenges:

1. Choosing the best modeling approach in a fairly new science of comprehensive ecosystem modeling (most analyses evaluate a narrower set of inputs and outputs and ignore uncertainties);
2. Selecting the vital ecological endpoints to include and determining the causal links for each within the model;
3. Incorporating data from many disciplines of river science, including overcoming hurdles of data gaps and a spectrum of data quality and data types;
4. Identifying and quantifying the distinct characteristics of each river reach such as changes in flow, confinement, and river geometry; and
5. Conveying the strengths and limitations of the ERM results in the context of the above challenges.

How does the ERM address these challenges?

The process of developing the ERM took longer than initially anticipated due to the complexities of modeling a multifaceted river system that is heavily influenced by both anthropogenic and natural events. In the end a robust modeling process was developed which:

- Incorporates the best available data as well as expert opinion into a probabilistic Bayesian model which allows for a multi-factor analysis and consistent evaluation of uncertainty;
- Focused initial analysis to three of the nine reaches through Fort Collins which represent the spectrum of floodplain confinement and bank armoring found through Fort Collins;
- Developed a series of intermediate numerical models to represent ecosystem functions (e.g. peak flow functions and riparian inundation); and
- Solicited feedback and evaluation by members of the Fort Collins scientific community.

What indicators are used to describe the state of the ecosystem in the ERM? Why were these indicators chosen?

The ERM includes the following eight indicators because they are either key components of ecosystem function and thus indicators of ecosystem condition, may have regulatory implications, or have social value. Collectively they provide an indication of overall river health. Each of the indicators represents the summation and interaction of a number of physical and biological system functions that are known to be sensitive to river flows.

1. **Channel Structure** – the combined influence of substrate conditions and channel geometry as the physical template for physical and ecological processes.
2. **Algae** – the base of the aquatic food web but often viewed as unaesthetic by the public, excessive amounts are related to nutrient loading in rivers.
3. **Aquatic Macroinvertebrates** – abundance and species distribution of aquatic insects as an indicator of water quality and crucial link in the aquatic food web.
4. **Native Fish** – reflect the relative health and condition of the system.
5. **Trout** – valued recreational component of the ecosystem and representation of the thermal and hydrologic regime.
6. **Riparian Wetlands** – the area where inundation from the river is sufficient to support plant communities dominated by wetland species.

7. **Rejuvenating Mosaic Forest** – multi-stage forest dominated by those native riparian species adapted to disturbance-prone environments.
8. **Functioning Riparian Forest** - an endpoint that represents a forest that develops under wetter lowland conditions and includes the functions associated with overbank flooding and shallow groundwater, but is not dependent on erosional processes.

What have we learned so far?

This first phase of the ERM has provided some important insights into the ecological function of the Poudre River.

- The current ecological function of the Poudre River through the City is greatly altered from its pre-settlement function due to water and land-management activities, as well as introduction of exotic fish and plants.
- Change in certain ecological resources in the Poudre River will continue over the coming decades under current management practices. For example:
    - Populations of sensitive aquatic insects such as mayflies and stoneflies will likely be diminished, where species that are more tolerant of heavy siltation and poor water quality (e.g. worms, midges) may predominate in the future,
    - Both trout and native fish populations can be expected to decline further and could become more vulnerable to elimination from some sections of the river, and
    - Riparian species reliant on disturbance, such as plains cottonwood, can be expected to decline over time and the riparian forest is expected to narrow.

  There is a relative scarceness of available ecological data. Although the Poudre River runs right through the middle of Fort Collins, the depth and breadth of analysis was limited by the amount of data available on historic and present ecological conditions.
- No one action alone is likely to impact the degree or pace of potential change in the biological indicators. For example, adequate flow in winter is crucial for a healthy trout fishery, but increased winter flow only does so much if the quality of the habitat in the river is poor (e.g., clogged with algae or silt) due to lack of scouring by high flows. As a result, actions to move toward a healthy and resilient river will need to be multi-faceted and integrated.
- It is combinations of management actions that can slow or prevent further change in some or all of the biological indicators.

What can the ERM tell us about the impacts of various future water development projects?

The model cannot be used to project outcomes that are highly detailed. Rather, the ERM is intended to provide insight into probable trajectories of how the river might change in the future under given scenarios. For each scenario the quality of the output parallels the quality of the input. At this time the flow data available to represent the water development projects is a dataset that combines all three proposed water storage projects (Halligan, Seaman, and Glade). The dataset is being improved as part of the Army Corp of Engineers' "Common Technical Platform" for these projects. Thus, the current version of the ERM provides a gauge as to impacts and specific concerns associated with key biological indicators and modified flows, but will not predict precise outcomes.