Curve Fit:

a pixel level raster regression tool

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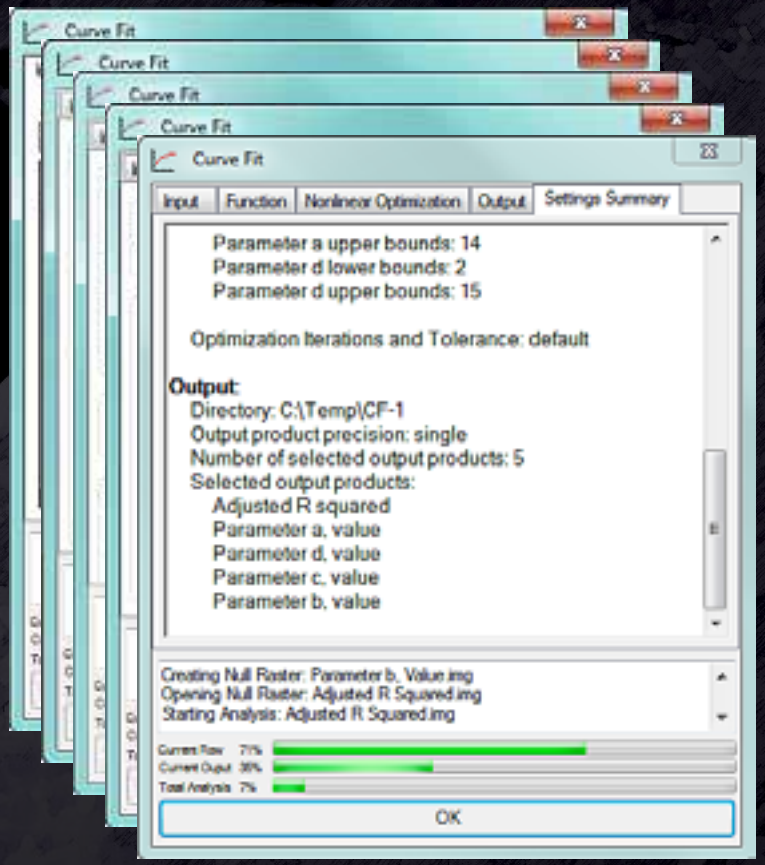
Curve Fit:
a pixel level raster regression tool

- Working with multiple raster datasets that share a common ‘theme’ is becoming more common in landscape ecology and geospatial science.
  - Multiple images taken over time
  - Multiple images that represent spatial patterns measured at different scales
  - Use of multiple maps in spatial-temporal simulation models.
- We developed an ArcMap tool that allows users to model and visualize the changes that take place across multiple images over time and/or space.
  - Replaces multiple images with a few images of regression parameter estimates that characterize change across the full-range of images.

Curve Fit:
a pixel level raster regression tool

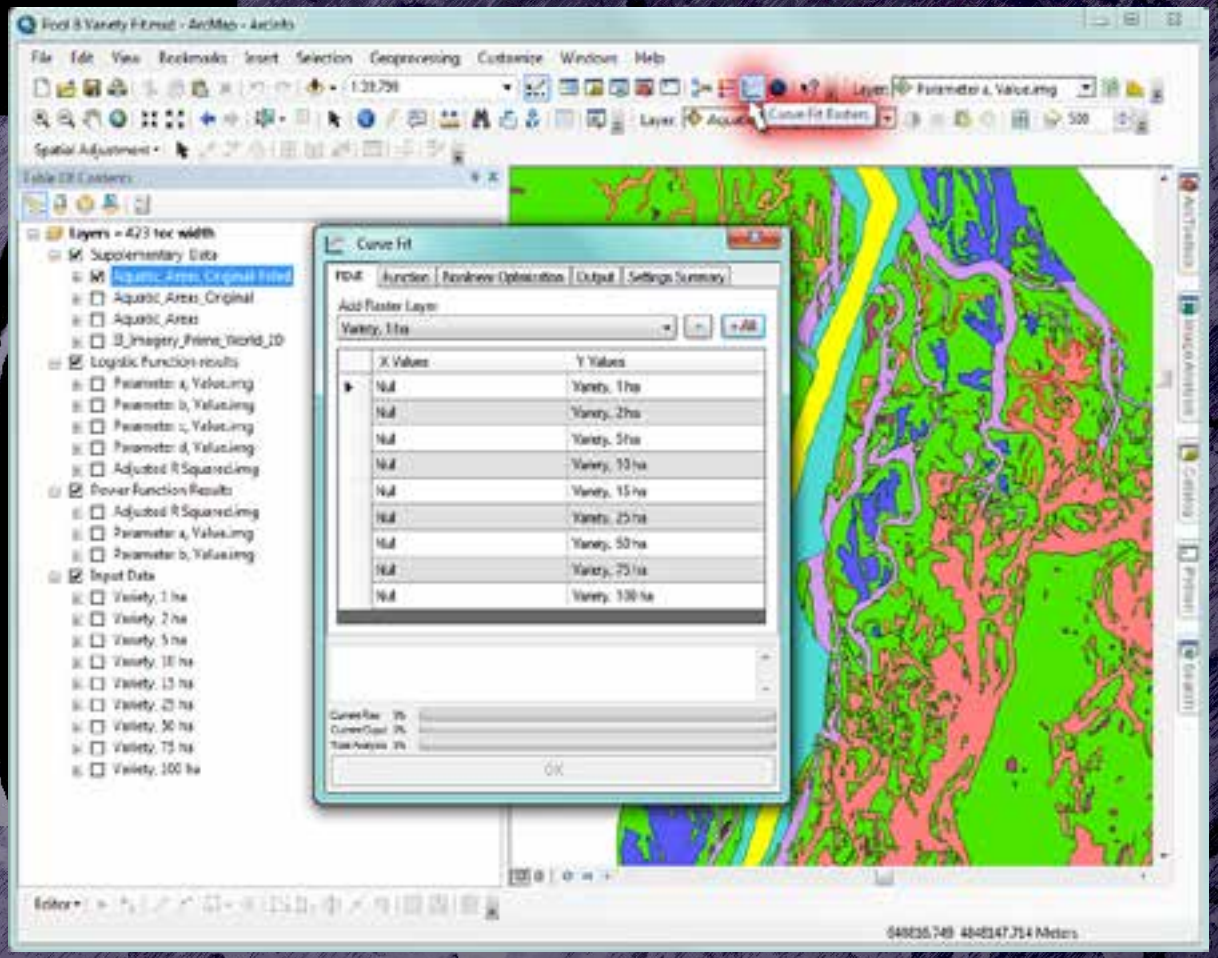
- Performs linear and non-linear regression analyses on raster datasets
- Outputs raster surfaces representing
  - Model solution
  - Model fit
  - Error estimates
  - Test statistics
  - Multi model inference criterion
- De Jager, N.R. and T. J. Fox. 2013. Curve Fit: a pixel-level raster regression tool for mapping spatial patterns. Methods in Ecology and Evolution, 4: 789–792.

Curve Fit Interface



Curve Fit:
a pixel level raster regression tool

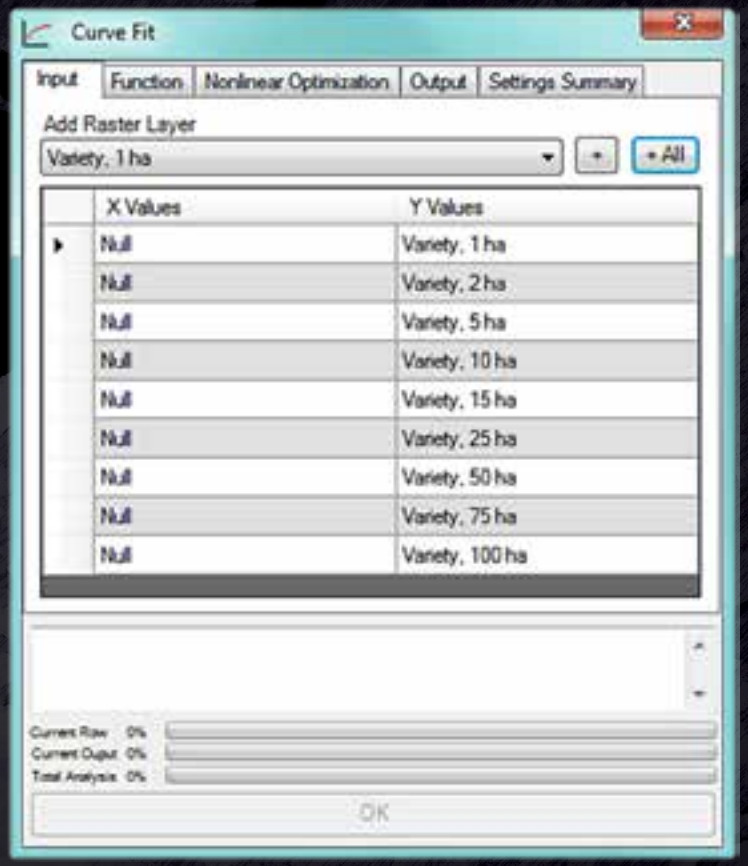
- Installs as an ArcMap 10.2 command
- Requires Spatial Analyst
- Utilizes the Extreme Math Optimization libraries



Curve Fit dialog settings: inputs

- *X* values
  - User enters an array of numeric X values
- *Y* values
  - Raster layers
  - One raster for each *X* element
  - Missing value = No Data
- Example input datasets
  - Habitat density *fn* scale
  - Water depth *fn* dam discharge

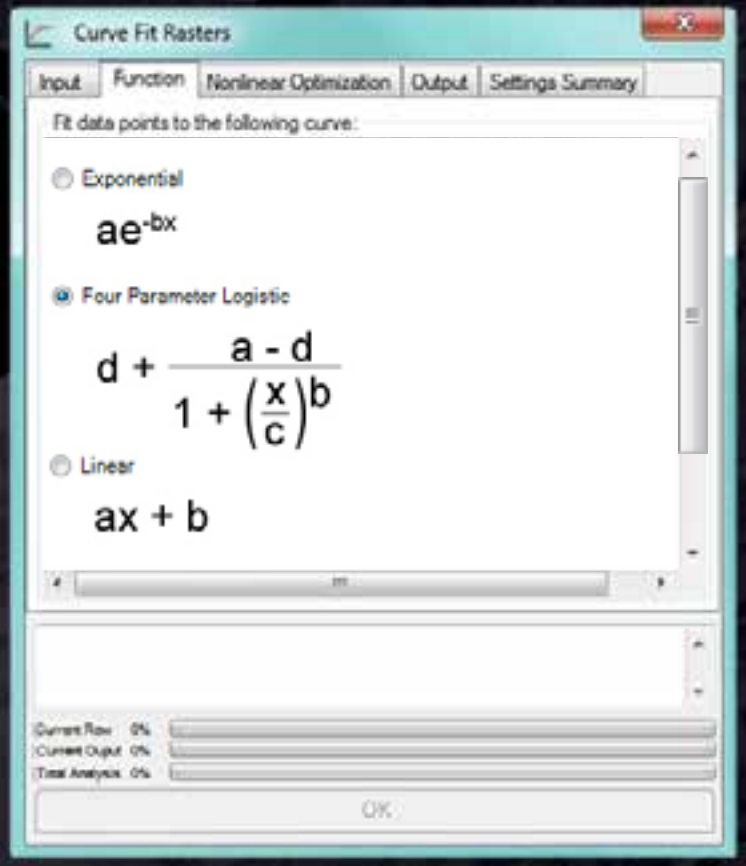
Input data



Curve Fit dialog settings: functions

- Linear regressions
  - Linear
  - Specify degree polynomial
- Nonlinear regressions
  - Exponential
  - Four parameter logistic (4PL)
  - Power
- Functions can be amended
  - Write a custom class
  - Using inheritable base classes from the Extreme Math Optimization library
  - Plans to add an asymmetric sigmoidal curve

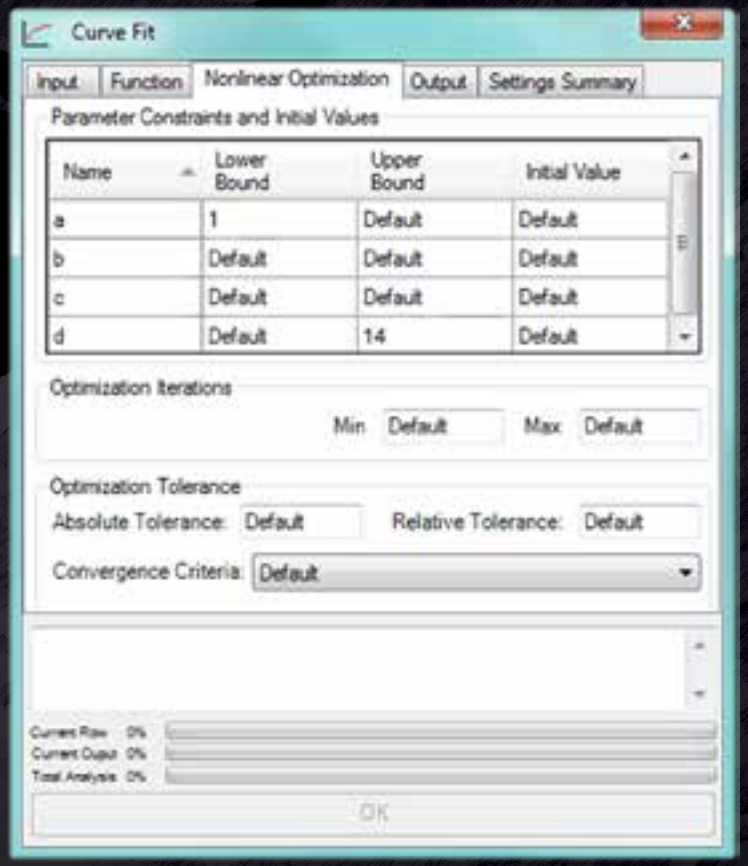
Functions



Curve Fit dialog settings: nonlinear optimizations

- Parameters
  - Constraints
  - Initial values
- Iterations
  - Minimum
  - Maximum
- Tolerances
  - Absolute
  - Relative
  - Require convergence
  - Convergence criteria
    - Within absolute tolerance
    - Within relative tolerance
    - Within either

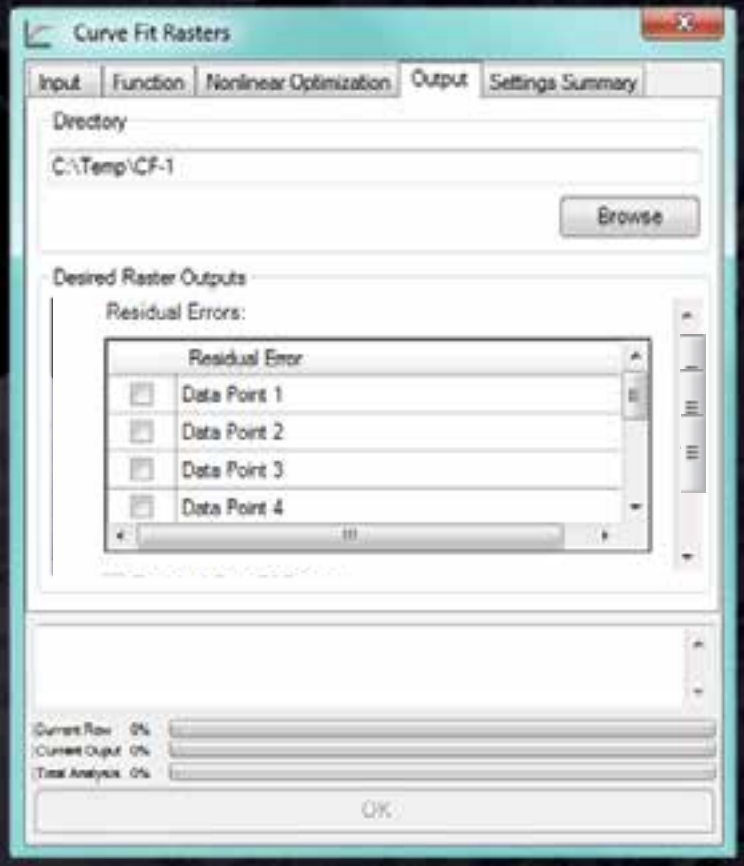
Nonlinear Optimization



Curve Fit dialog settings: outputs

- Output location
- No data value
- Outputs are stored as:
  - Single or double precision floating point IMG files
  - Double precision creates very large output files
- Frugal selecting outputs

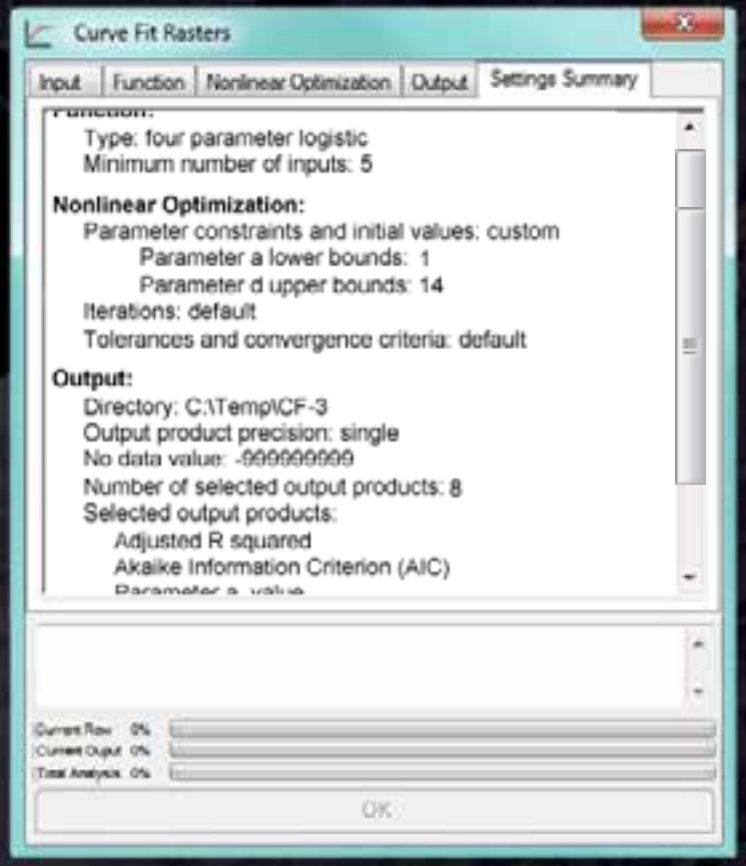
Output Products



Curve Fit dialog settings: summarization

- Settings checking
  - Minimum number of raster inputs determined by degrees of freedom
  - No missing *X* values
  - Output location
- Setting summaries, red means something is missing
- When all requirements are met the OK button is enabled

Summary



Curve Fit: model encapsulation

Giving Diverse Models a Common Interface

- Physical process
- Authors
- Platforms
- Diverse proprietary software packages
- As long as there is a XY relationship Curve Fit provides a common solution

Curve Fit: applicability

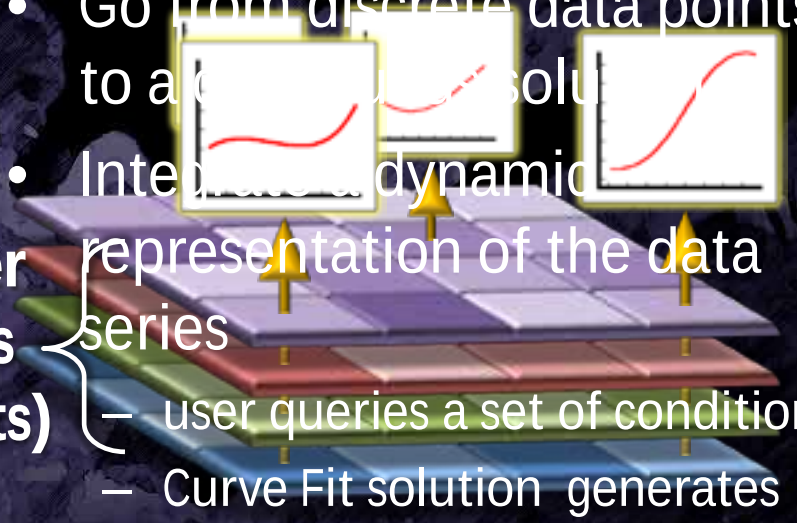
Curve Fit Derived Model

- Analytical applications (e.g. habitat variety *fn* scale)
- Encapsulate a bivariate process
- Go from discrete data points to a [illegible] solu[illegible]
- Inte[illegible] dynamic representation of the data series
  - user queries a set of conditions
  - Curve Fit solution generates the response surface

Data Series

e.g. bathymetry, current velocity, shear stress

Parameter Estimates (coefficients)



a_3
a_2
a_1
a_0

3rd Degree Polynomial

$$a_3X^3 + a_2X^2 + a_1X + a_0$$

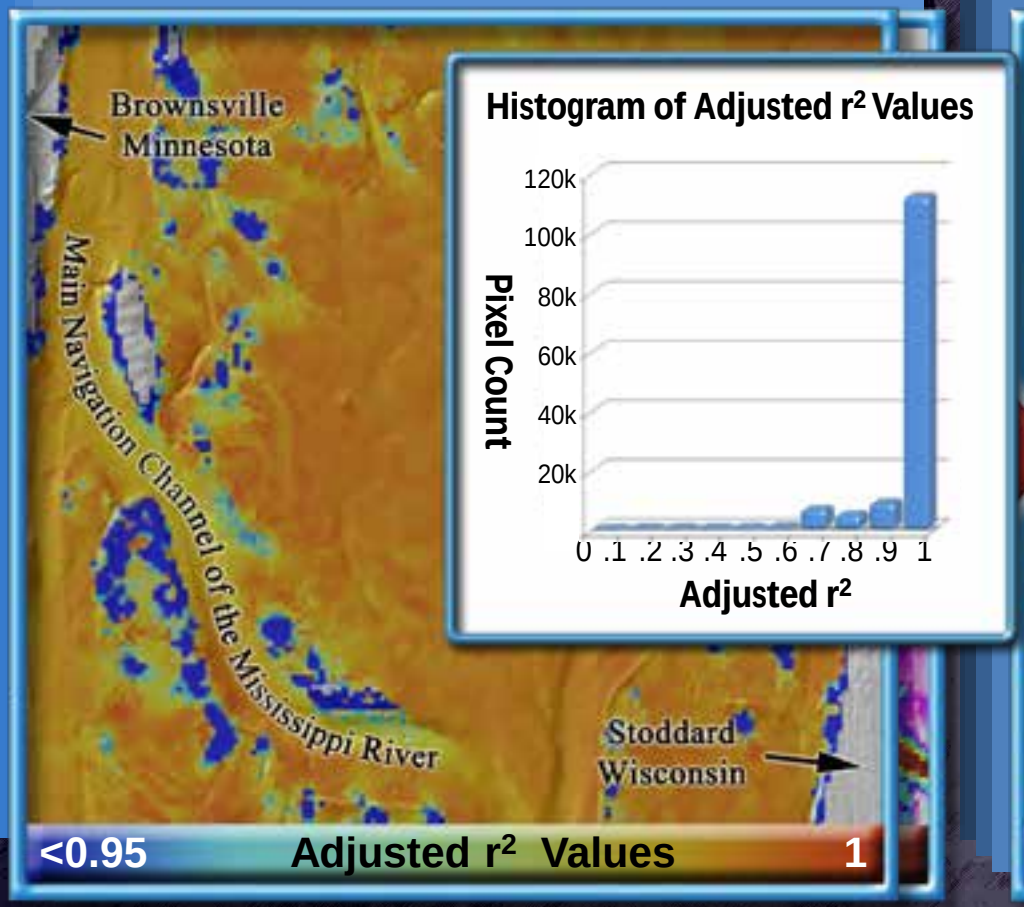
Curve Fit: applications

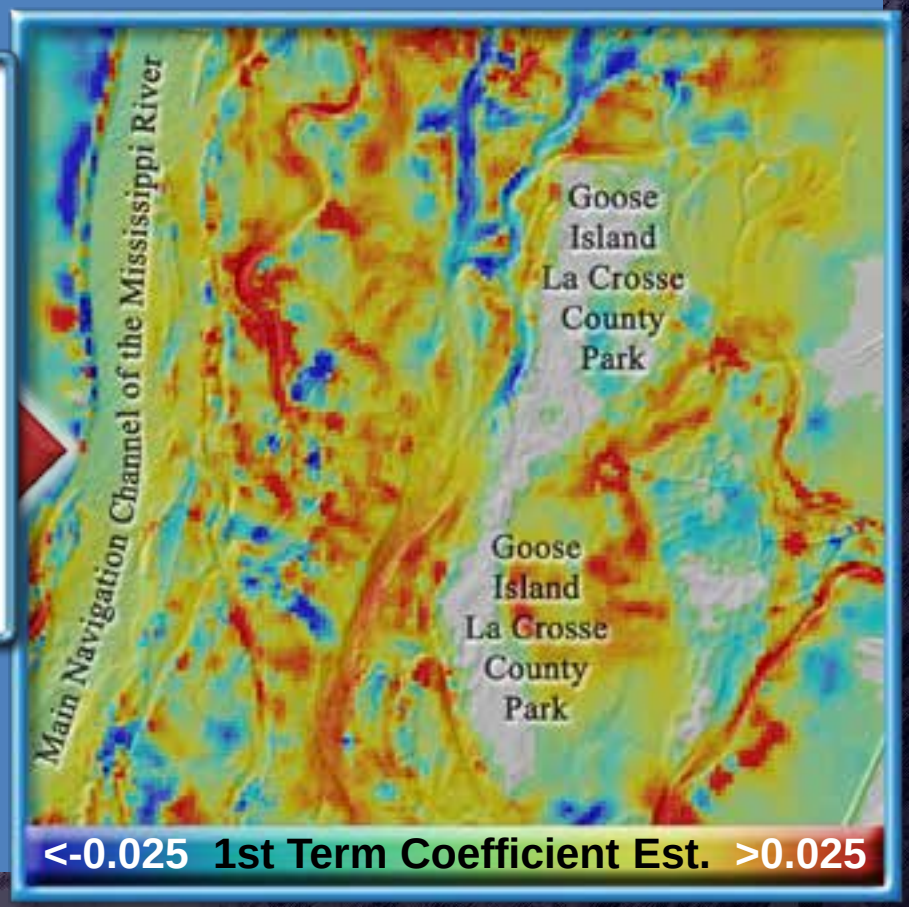
- Characterizing spatial/temporal change:
  - Quantifying and mapping spatial patterns in habitat diversity across multiple scales (De Jager and Fox 2013).
  - Examining temporal changes in snow cover with respect to climate change (Lindsay et al. In prep).
- Use in spatial simulation models
  - Examining spatial patterns of river-floodplain connectivity (De Jager, Fox and Rohweder In prep).

Curve Fit: example output

Adjusted r^2 for 10,000 Intervals (Polynomial Models)

1st Term Coefficient Estimate, 3rd Degree Polynomial (1 of 4 coefficients)

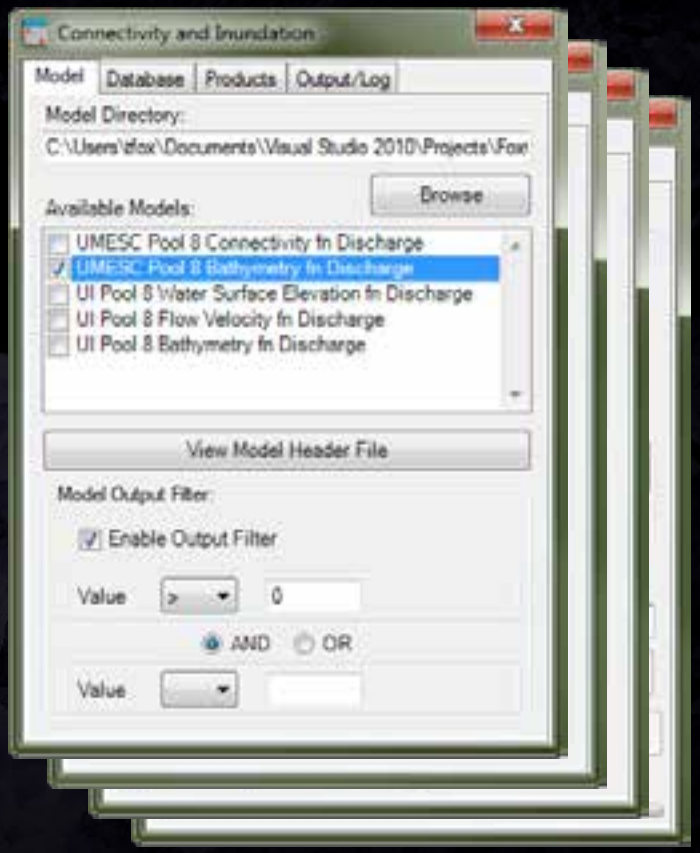




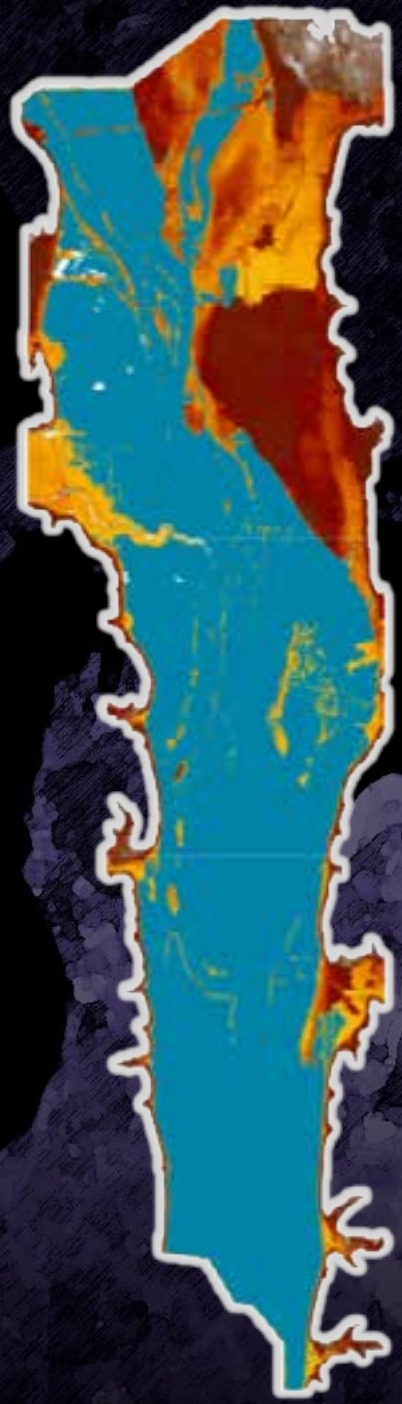
Curve Fit: Connectivity and Inundation Tool

- Provides an expandable framework through the use of Curve Fit regression models
  - Curve Fit parameter estimates
  - XML header file
- Preloaded Curve Fit regression models
  - Bathymetry
  - Main channel connectivity
  - Flow velocity
  - Shear stress

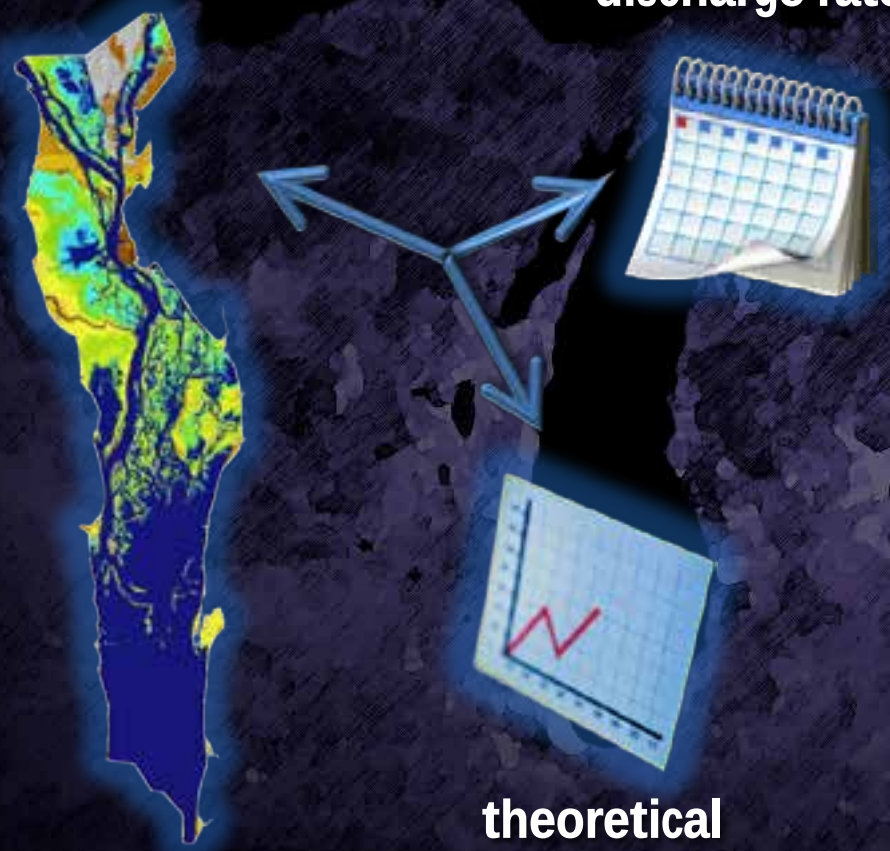
Connectivity & Inundation Interface



Moving from static maps to dynamic simulations



Curve Fit: Connectivity and Inundation Tool

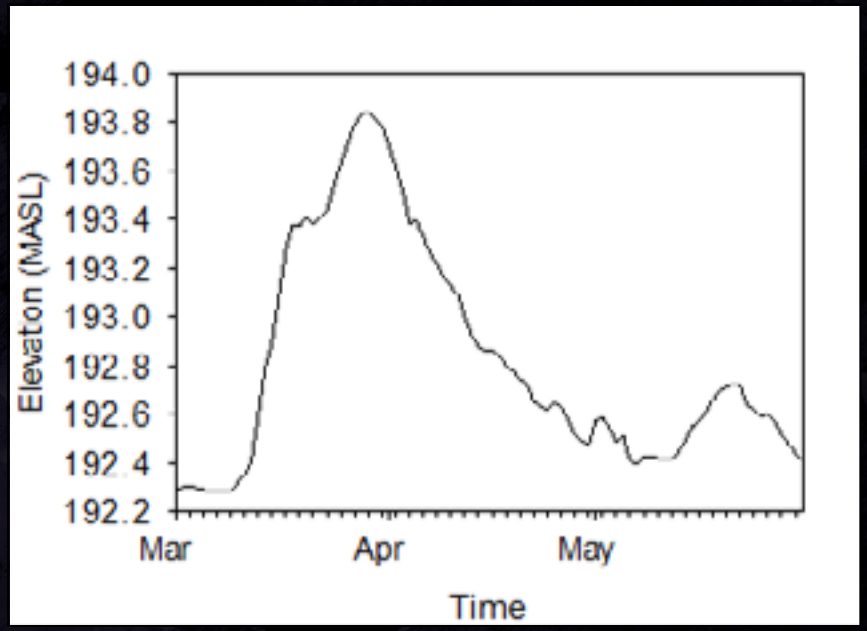


- Connectivity and inundation Tool
  - Database of discharge rates
  - User defined query
    - date range
    - model value range
- Applications
  - Vegetative succession
  - Fish distribution
  - Nutrient cycling and export

Curve Fit: Connectivity and Inundation Tool

- Example output:
  - Curve Fit model: water depth *fn* dam discharge
  - Spring 2010 (March 1st – May 31st)
  - Duration days where water depth > 0
- Strong flood that Spring
- Levee effects

Hydrograph, Spring of 2010



Curve Fit: Connectivity and Inundation Tool

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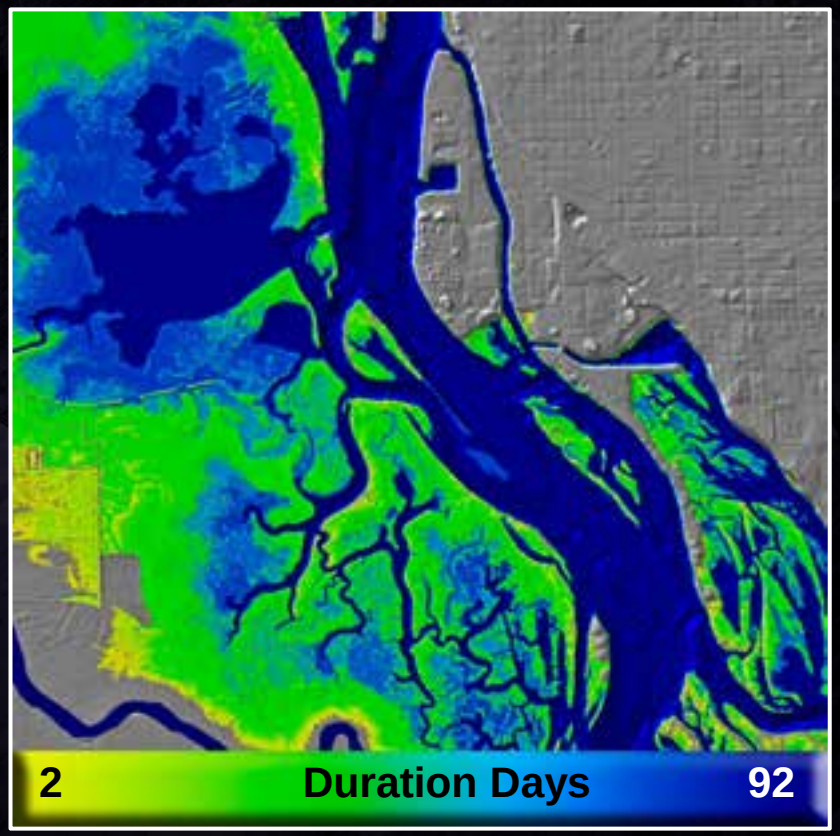
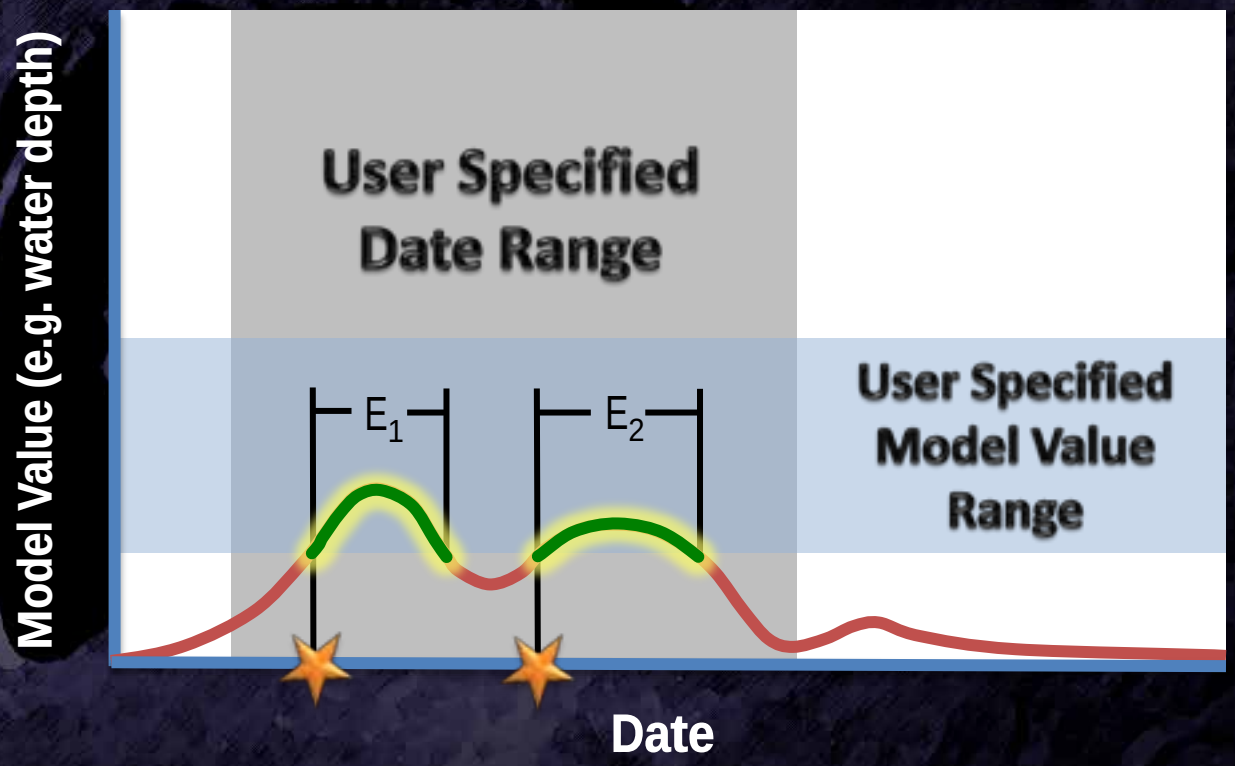
Main Channel Connectivity, Spring of 2010



Curve Fit: Connectivity and Inundation Tool

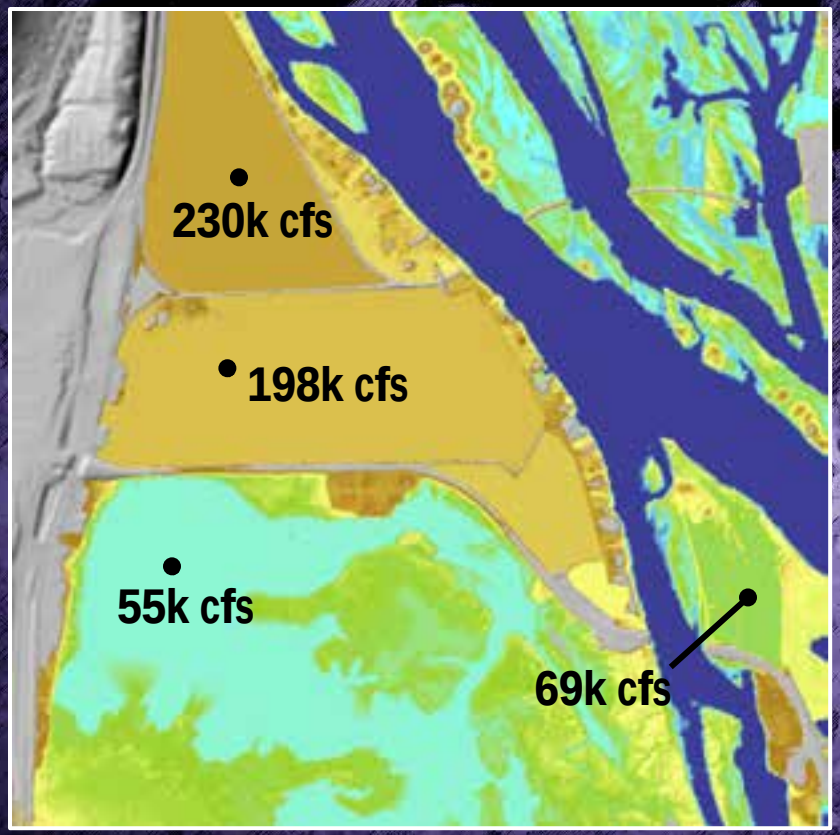
- User specified:
  - Model
  - Date range
  - Model value range
- Output products:
  - Event count
  - Duration days
  - Event start date
  - Summary statistics examples
    - Max flow velocity
    - Mean water depth

Model value over time with user specified ranges and resulting events

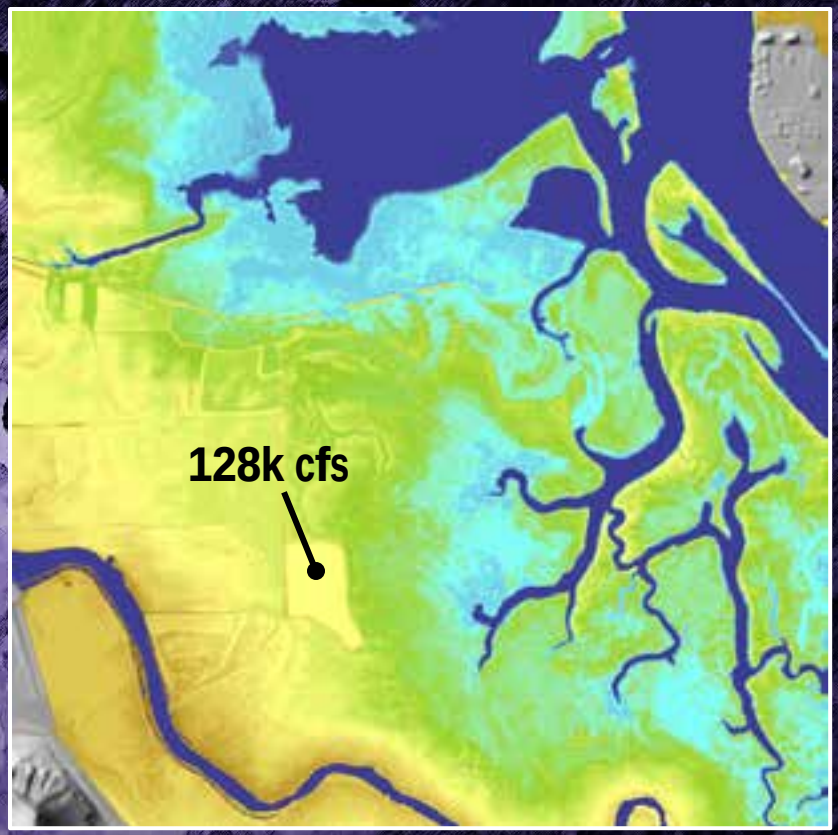


Curve Fit:
Connectivity and Inundation Tool

Blue Lake & Areas North



Target Lake & Areas South



Curve Fit: Summary

- Robust analytical tool
- Performs both linear and nonlinear regression analyses on bivariate data
- Convenient method of capturing a continuous mathematical model from a discrete series of data
- Curve Fit polynomial regression models are used at UMESC to create flexible DSS tools