Update on Erosion Working Group (EWG) Phase 1 Studies Erosion Modeling

10 May 2017

Quarterly Public Meeting

Overview and Near-Term (2017) Goals

Develop platform for long-term process modeling of progressive erosion at the site:

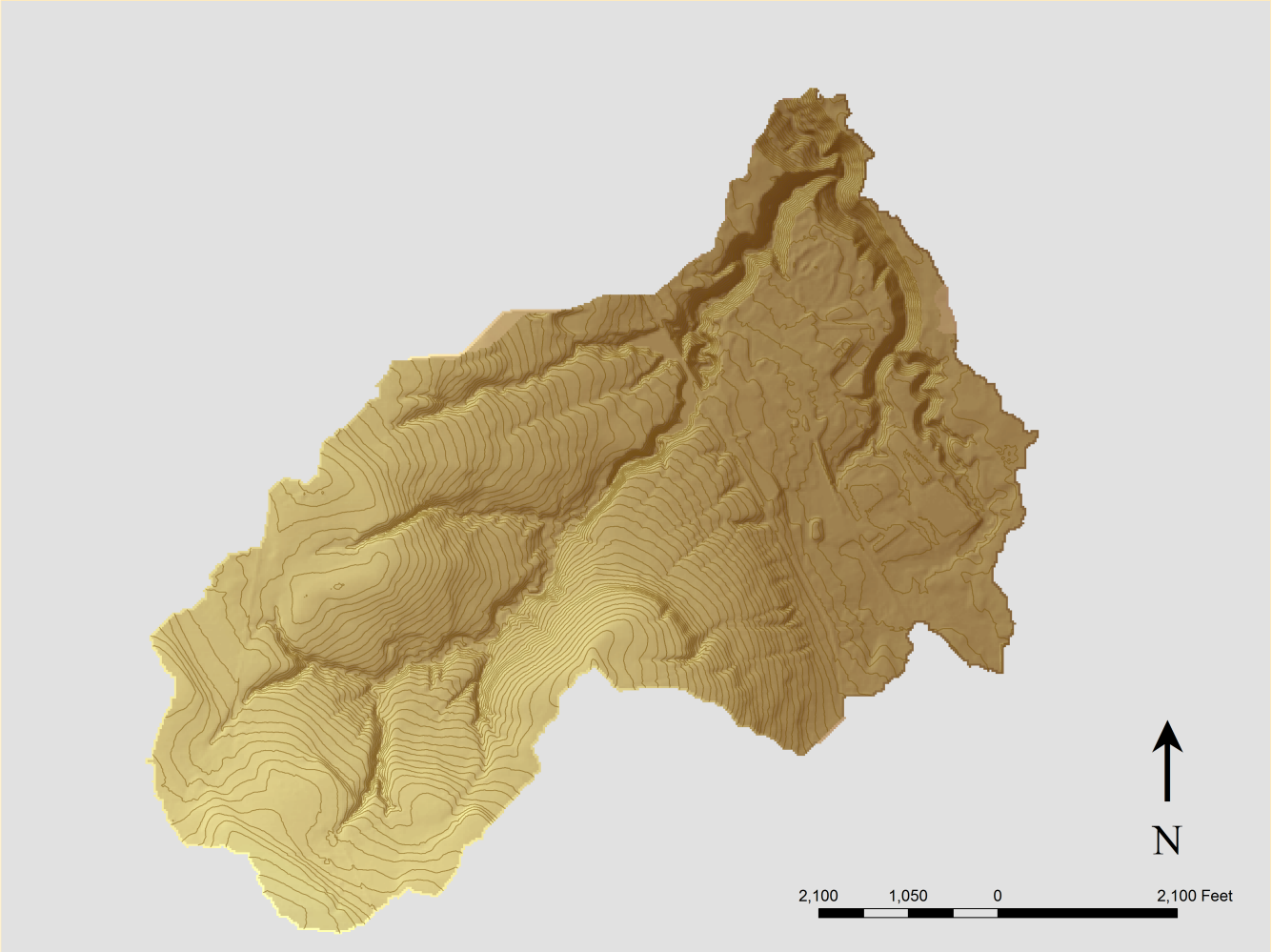
- Create Erosion Modeling Suite (EMS): collection of 35 distinct erosion models and related tools and data
- Document parameter and input-data sensitivity
- Identify appropriate parameter values
- Identify subset of models that perform best when compared with data
- Validate models
- **Quantify uncertainties** in parameters, model structure, and geologic knowledge

Erosion model: basic framework

- Each model starts with a Digital Elevation Model (DEM) derived from LiDAR
- Two scales: Franks Creek, and smaller areas of N & S plateau
- Franks Creek:
  - Smallest watershed that both contains the site and connects to Buttermilk Valley and its geologic history
  - Represented at 24'/cell (180,068 nodes; 89,979 inside watershed)
- Selected smaller watersheds:
  - Limiting the area to ~200,000 grid nodes allows resolution of 3'/cell
  - Equivalent to ~40 acres

Basic framework (continued)

- At every grid cell, each model calculates:
  - Slope gradient
  - Area upslope that contributes water
  - Rate of erosion
  - +/- other variables, depending on model
- Update topography and iterate



Quantifying uncertainty: sources

- Model structure (a.k.a. theoretical)
- Parameters (a.k.a. estimation/experimental)
- Geologic knowledge

Model structure uncertainty

- Environmental models approximate reality
- Uncertainty arises from unknown quality of the approximations
- Approach: **multi-model analysis**
  - Run multiple models
  - Compare with one another and with data
  - Identify those that perform best when compared with modern topography
  - Use spread among them to quantify uncertainty
- Goal: identify model(s) *sophisticated enough to be useful but simple enough to understand*

Parameter estimation and uncertainty

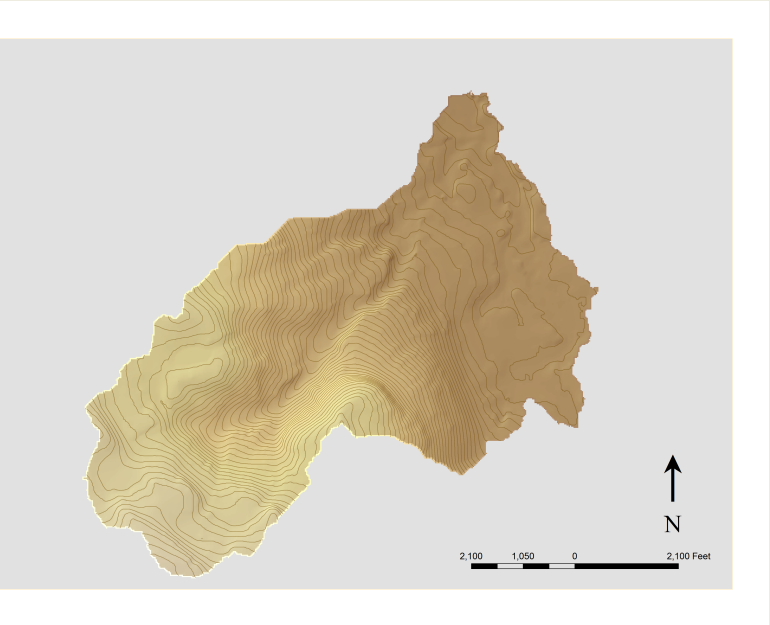
- Sources for parameter values:
  - Erosion Working Group Studies 1 and 2
  - Prior data from site and region
  - Professional literature
  - Parameter optimization

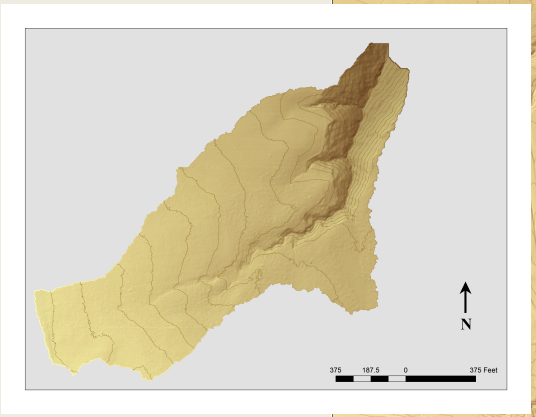
Parameter optimization

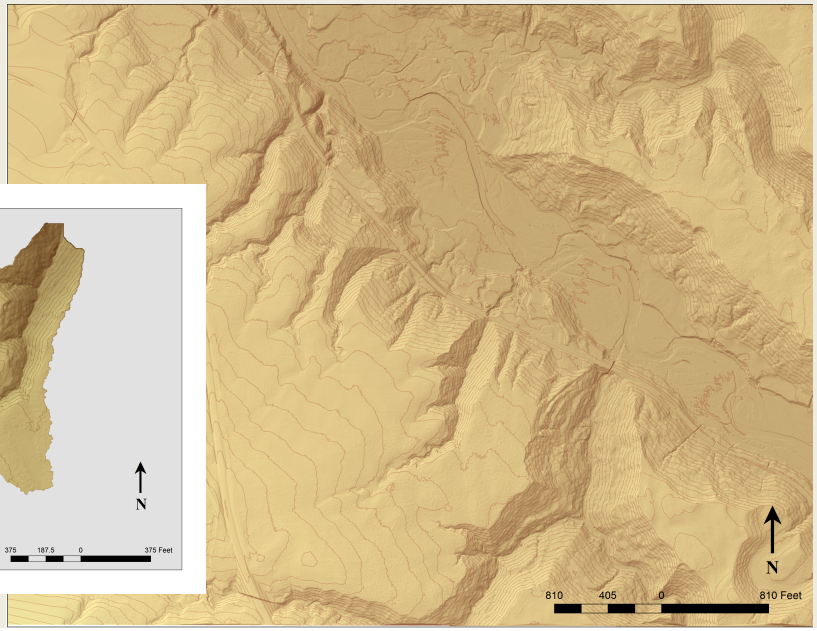
- Tune parameters to find best possible match ("calibration")
- Provides:
  - Estimate of parameter values
  - Uncertainty quantification
  - Measure of model performance

Parameter optimization: past-to-present approach

- Reconstruct post-glacial topography
- Reconstruct downcutting history of Buttermilk valley
- Compare observed and modeled terrain



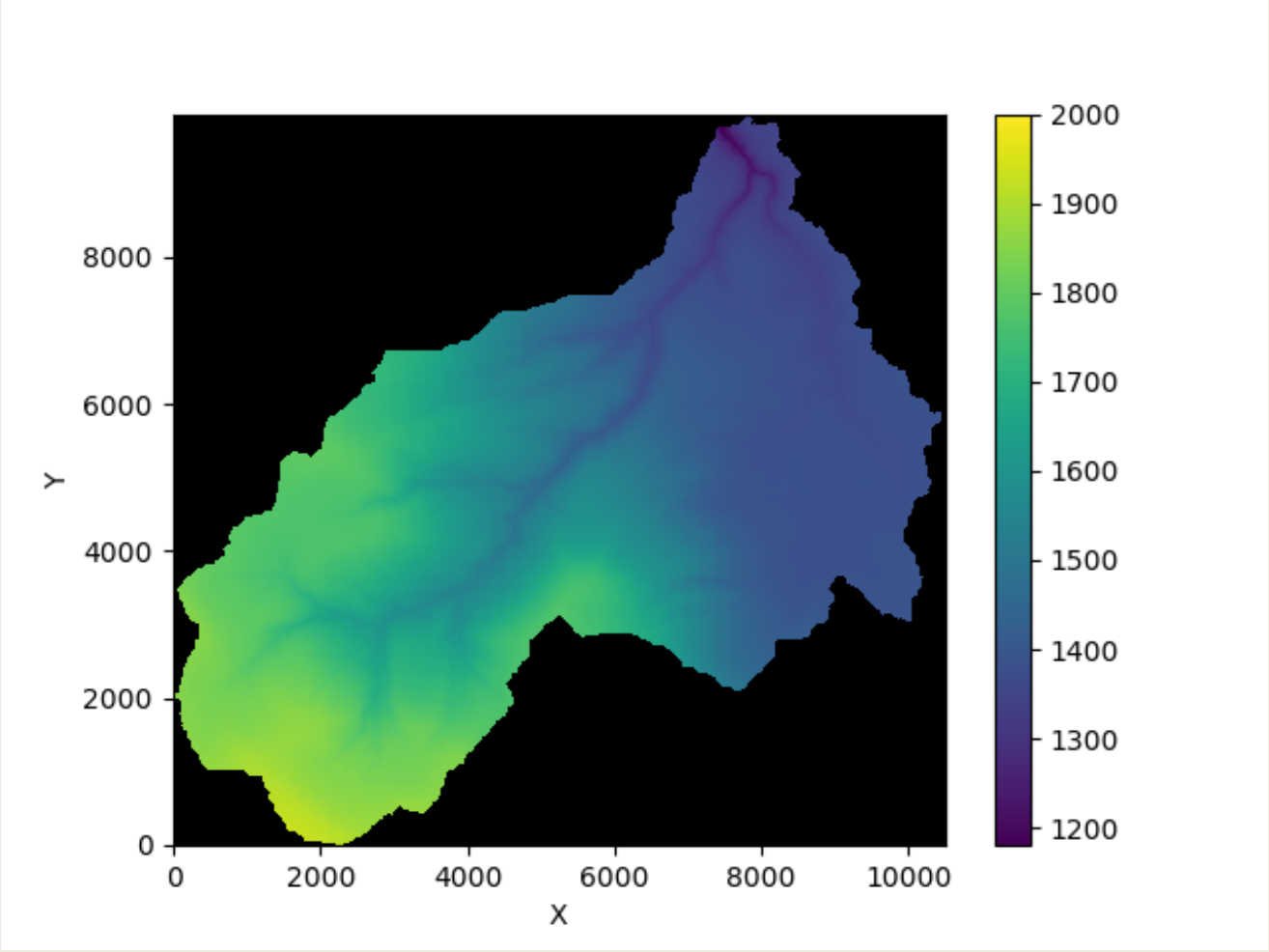




Model performance metrics

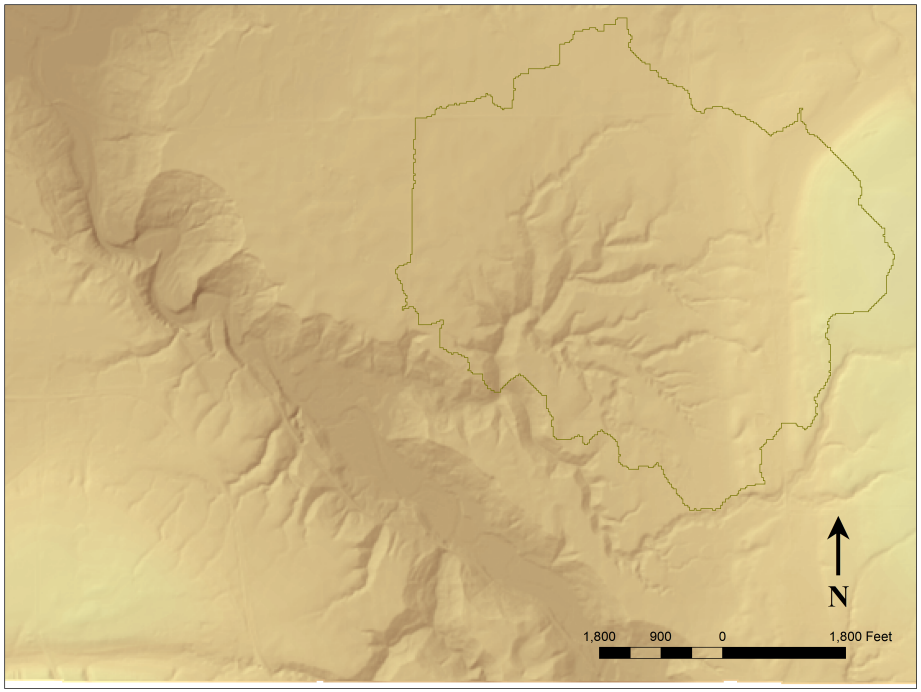
- Models are compared to LiDAR data using the following metrics:
  - Total volume loss - Hypsometric integral
  - Mean elevation - Variance in elevation
  - Mean gradient - Variance in gradient
  - Elevation quantiles - Drainage area quantiles
  - Spatial distribution of Chi index values
- The misfit between data and model is quantified with an *objective function:* weighted sum of $(\text{observed} - \text{modeled})^2$

Example of a best-fit model



Model validation

- Test model(s) in a different watershed without further calibration
- Provides additional measure of uncertainty



Geologic uncertainty

Sources:

- Post-glacial topography
- Downcutting history
- Underlying geology

Tests:

- Up to 6 different initial surfaces
- 3 downcutting histories
- Models with and without rock, till, and soil layers

Summary and expected outcomes for model development and analysis

- Erosion Modeling Suite (EMS)
- Input grids for site (topography and geology; modern and post-glacial)
- Selection of models based on performance
- Parameter estimates
- Validation tests
- Quantification of uncertainty associated with:
  - Model structure
  - Parameters
  - Geologic knowledge

Results provide envelopes of cumulative erosion through time that could be used in PPA