GIS Methodologies to Identify Deep Volcanic Ash Cap Soils

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IFTNC Annual Meeting

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Overview

- Introduction
  - Ash Cap Soils
    - Parent Source & Distribution
  - Problem Statement
  - Objectives
- Hypotheses
- Methods & Output
  - Kriging
  - Regression Analysis
- Application

Introduction

- Ash Cap Soils
  - Parent Source – Mt. Mazama (now Crater Lake, OR)
    - Erupted ~ 6800 yrs BP
    - Ejected ~ 120 km^3 of tephra
  - Distribution
    - Pacific Northwest, British Columbia, western Montana, and northern Nevada


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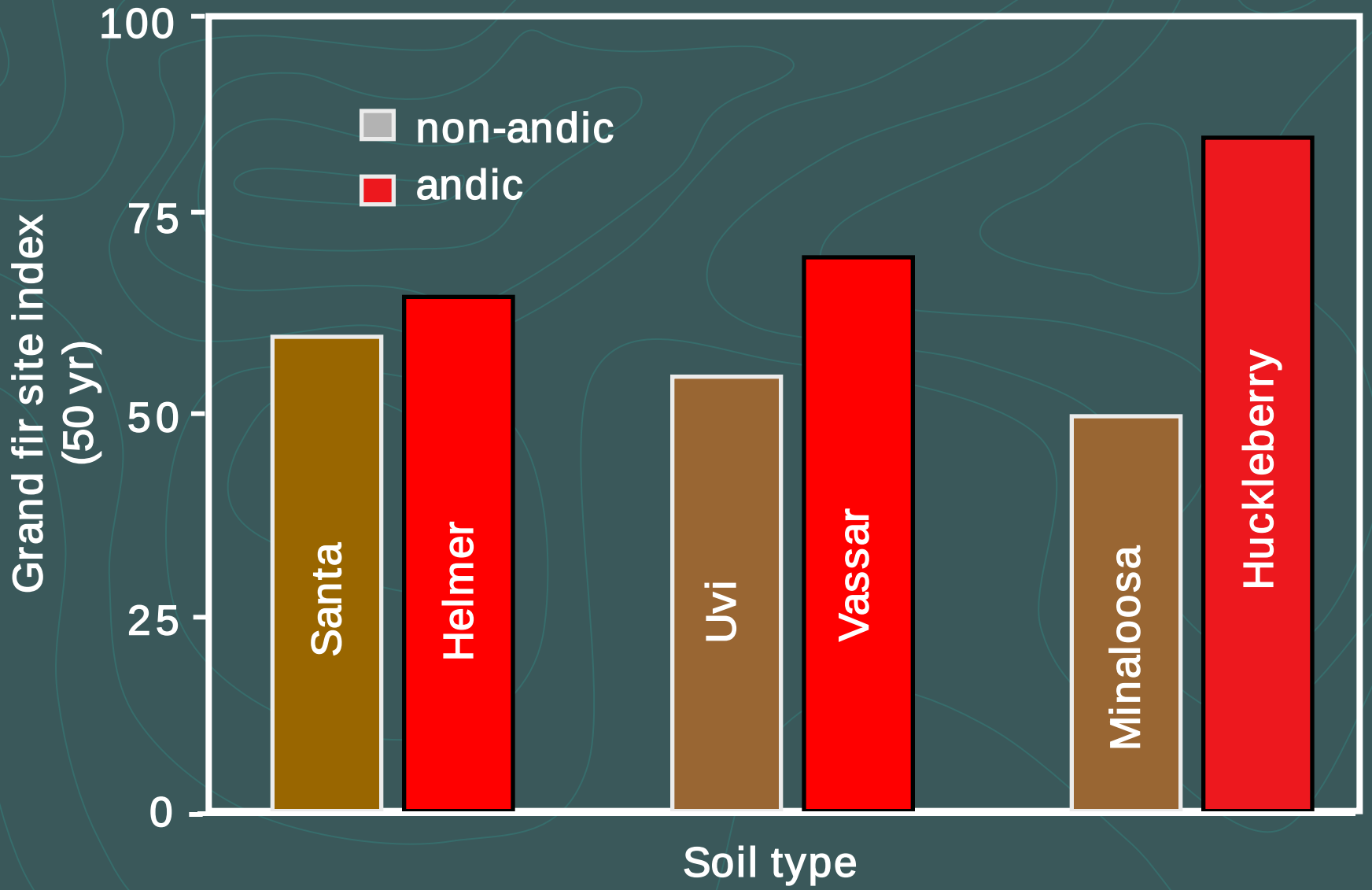
Ash & Forest Productivity

- Ash cap soils are an important variable in forest productivity because of its:
  - High Porosity
    - Increases water holding potential
      - Reduces tree stress during droughty periods
  - Low Bulk Density
    - Facilitates root penetration and growth

Site Productivity: Ash vs. Non-Ash Soils



(from SCS Soil Survey of Latah County Area, Idaho)

Problem Statement

- NRCS soil surveys of forested lands contain probabilistic values for the presence of ash
  - E.G., Polygon ‘X’ is 60% Hugus w/~15” of ash and 40% Bouldercreek w/~7” of ash
- Forest managers are limited to binary ash mapping (i.e., present or absent)
  - No continuous ash depth coverage model exists

Hypotheses

- Volcanic ash distribution is spatially correlated
- Volcanic ash distribution is a function of terrain attributes + latitude/longitude + *land management practices* + …

Objectives

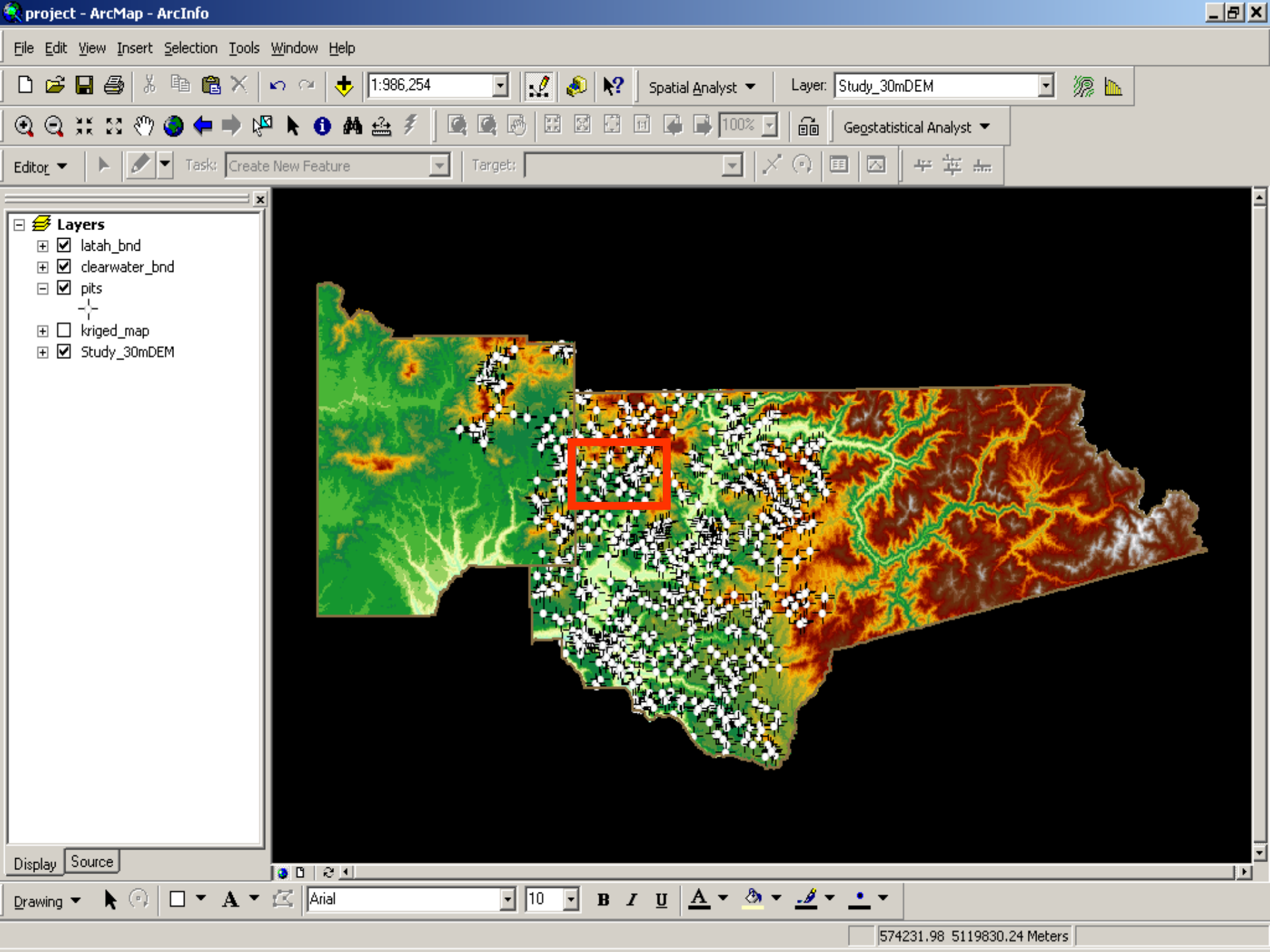
- Develop geo(statistical) models to predict the depth of ash in forested regions of north central Idaho
- Integrate ash model(s) into a GIS database for enhanced forest land management

Methods

- Ordinary Kriging ~ geostatistical
  - Is volcanic ash depth spatially correlated?
- Regression Analysis ~ statistical
  - Is volcanic ash depth a result of of terrain attributes + latitude/longitude + *land management practices* + …

Ordinary Kriging

- A method designed to assess the correlation between ash depth and its spatial distribution as observed by point data
- A geostatistical analysis built around the variance/covariance relationships between ash depth and distance between observed points


project - ArcMap - ArcInfo
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Spatial Analyst
Layer: Study_30mDEM
Geostatistical Analyst
Editor
Task: Create New Feature
Target:
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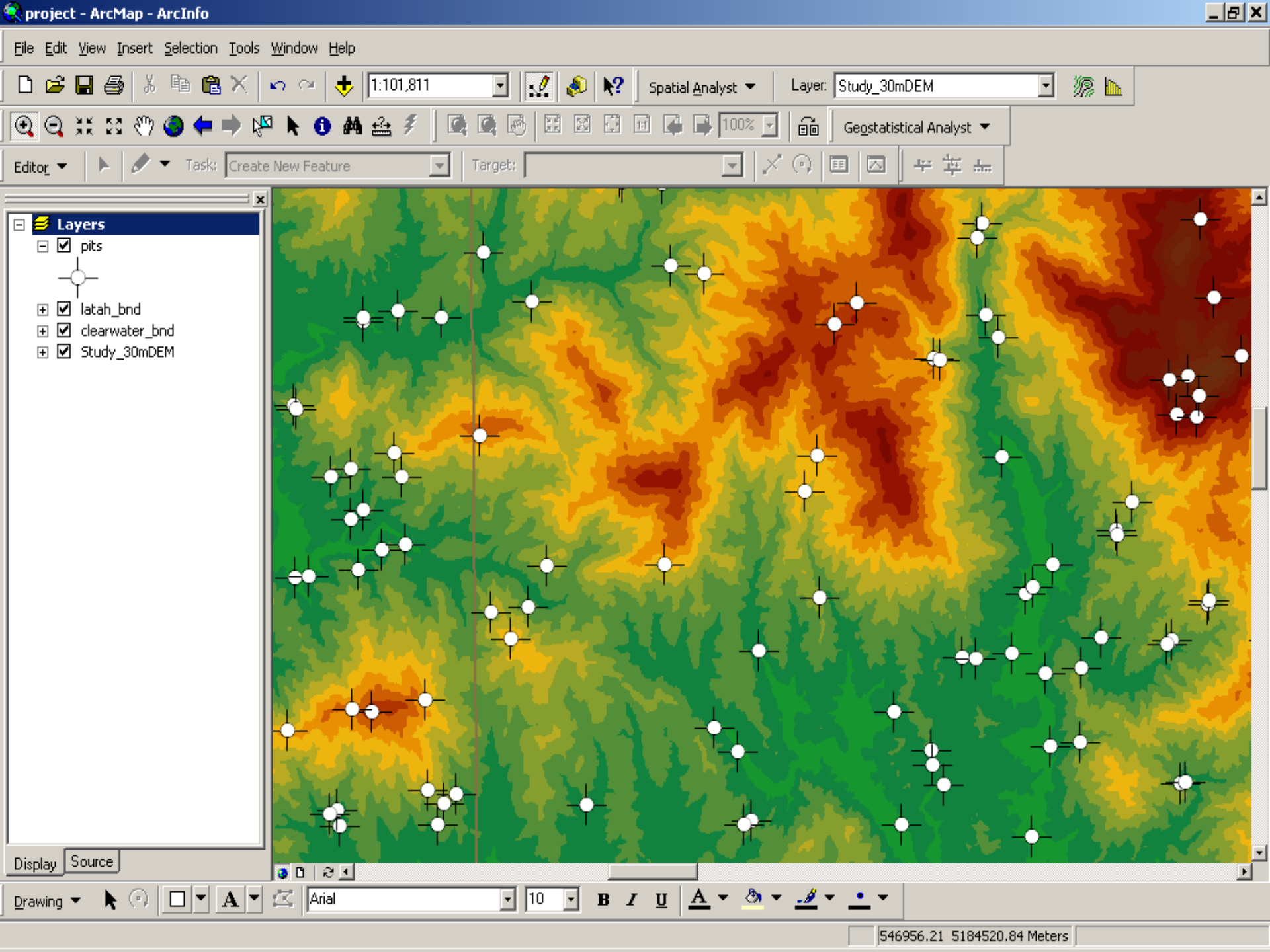
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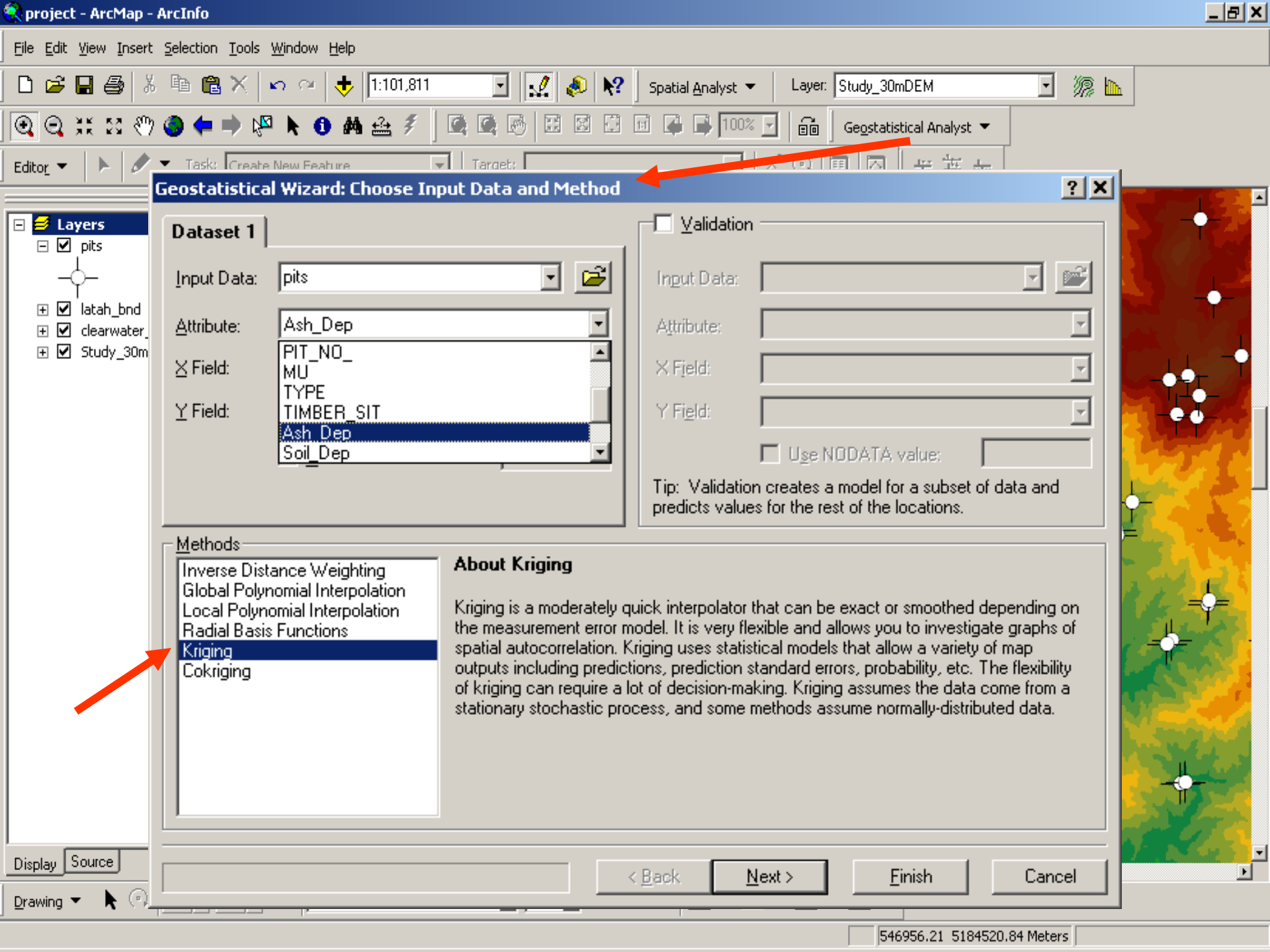
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Layer: Study_30mDEM
Geostatistical Analyst
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Task: Create New Feature
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Study_30m
Geostatistical Wizard: Choose Input Data and Method
Dataset 1
Input Data: pits
Attribute: Ash_Dep
X Field:
Y Field:
PIT_NO_
MU
TYPE
TIMBER_SIT
Ash_Dep
Soil_Dep
Validation
Input Data:
Attribute:
X Field:
Y Field:
Use NODATA value:
Tip: Validation creates a model for a subset of data and predicts values for the rest of the locations.
Methods
Inverse Distance Weighting
Global Polynomial Interpolation
Local Polynomial Interpolation
Radial Basis Functions
Kriging
Cokriging
About Kriging
Kriging is a moderately quick interpolator that can be exact or smoothed depending on the measurement error model. It is very flexible and allows you to investigate graphs of spatial autocorrelation. Kriging uses statistical models that allow a variety of map outputs including predictions, prediction standard errors, probability, etc. The flexibility of kriging can require a lot of decision-making. Kriging assumes the data come from a stationary stochastic process, and some methods assume normally-distributed data.
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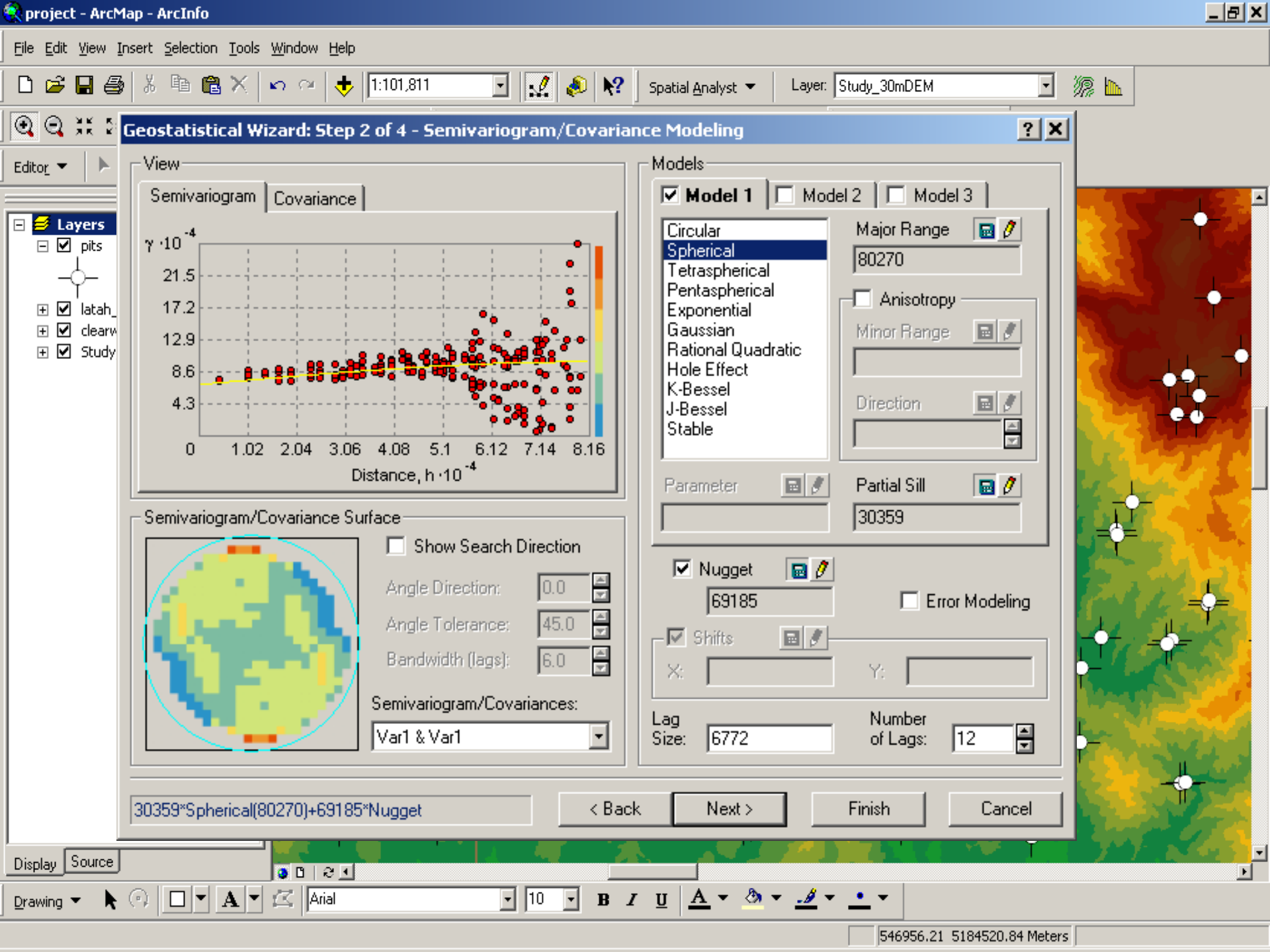
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Distance, h ·10 -4
Semivariogram/Covariance Surface
Show Search Direction
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Angle Tolerance:
45.0
Bandwidth (lags):
6.0
Semivariogram/Covariances:
Var1 & Var1
Models
Model 1
Model 2
Model 3
Circular
Spherical
Tetraspherical
Pentaspherical
Exponential
Gaussian
Rational Quadratic
Hole Effect
K-Bessel
J-Bessel
Stable
Major Range
80270
Anisotropy
Minor Range
Direction
Parameter
Partial Sill
30359
Nugget
69185
Error Modeling
Shifts
X:
Y:
Lag Size:
6772
Number of Lags:
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30359*Spherical(80270)+69185*Nugget
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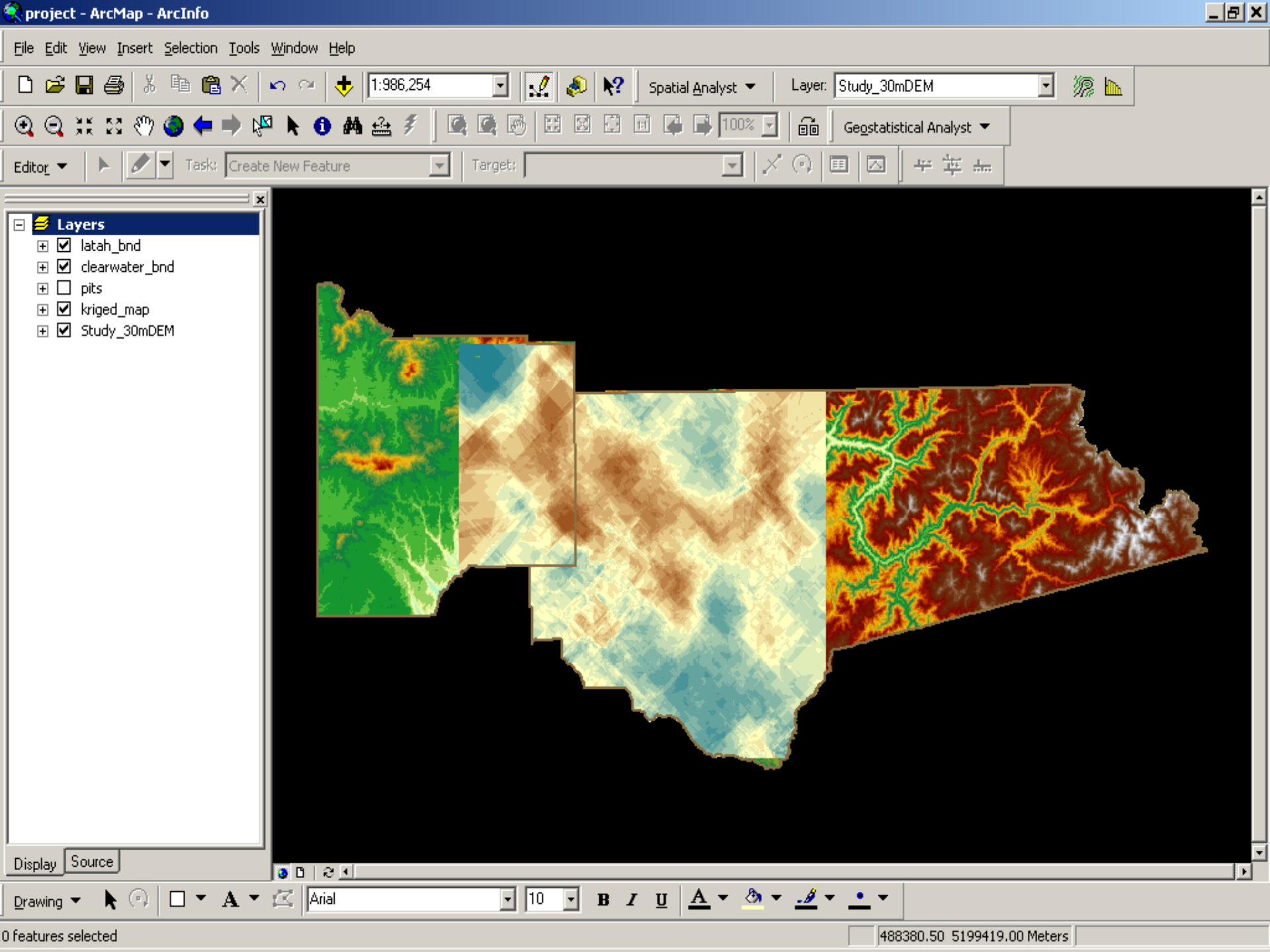
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Regression Analysis

- A multiple linear regression approach will utilize terrain attributes derived from Digital Elevation Models, coordinate locations, and other variables to predict the depth of ash

Formula:

$$Ash\_Depth = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + e$$

where;

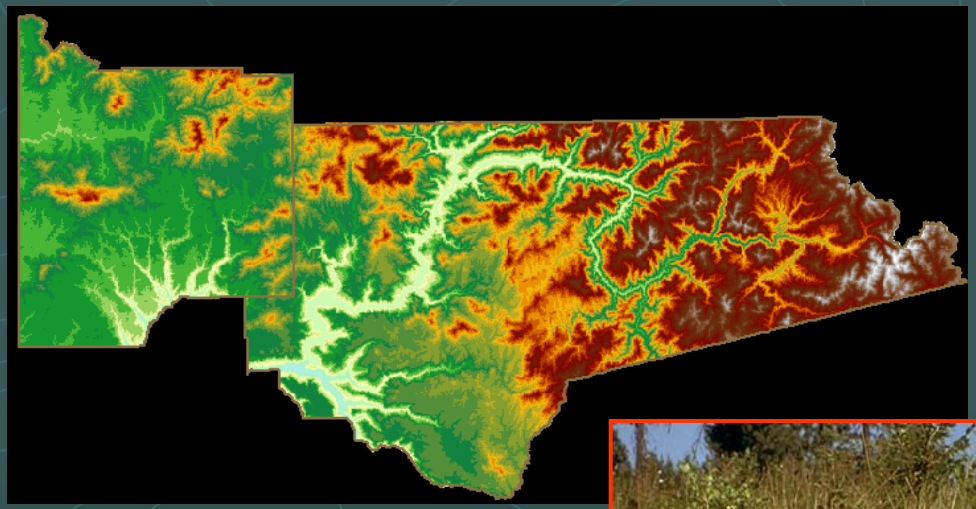
$\beta_0, \beta_1, \beta_2, \ldots, \beta_n$ ***are influence estimators, and***
$x_1, x_2, \ldots, x_n$ ***are terrain/location variables***

Regression Analysis

- Result:
  - A multiple regression equation that can be applied to a digital elevation model, creating a predicted ash depth coverage model
  - A screening tool for selecting variables highly correlated with volcanic ash
    - These highly correlated variables would then be used in a co-kriging analysis

Application

- Integrate the presence *and* quantity of volcanic ash into land management databases
- Improve land use management decisions that could negatively impact volcanic ash deposits
- Further define the relationship between forest productivity and volcanic ash



Thank You

Any Questions?