A spatially explicit model to predict white-tailed deer radiocesium body burdens on the Department of Energy's Savannah River Site

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INTRODUCTION

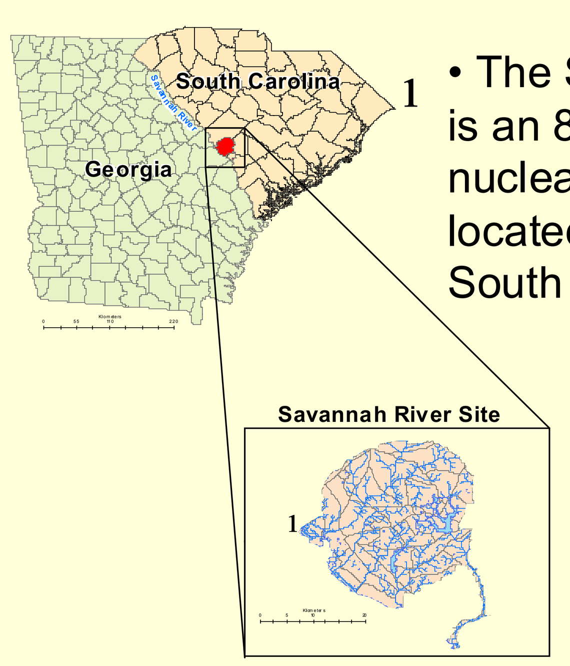
Purpose:
To develop a spatially explicit prediction model that interpolates radiocesium (^{137}Cs) body burdens of white-tailed deer (*Odocoileus virginianus*), at the Department of Energy's Savannah River Site (SRS).

Objectives:
1) Determine the proper scale to investigate deer ^{137}Cs for the SRS.
2) Within a Geographic Information System (GIS), develop a predictive surface at the aforementioned scale that will supply an interpolated estimate of ^{137}Cs for any individual deer residing on the SRS.

METHODS

Geographic Information System
- Develop base radiological data set for 22 year time period (split into 3 time periods)
  - » Overlay 100 ha (deer core area) hexagonal mesh over SRS.
  - » Determine mean body burden (bq/kg) for all deer harvested in each hex over each time period.
- Implementation of geostatistical analyses
  - » Semivariogram fitting
  - » Ordinary Kriging

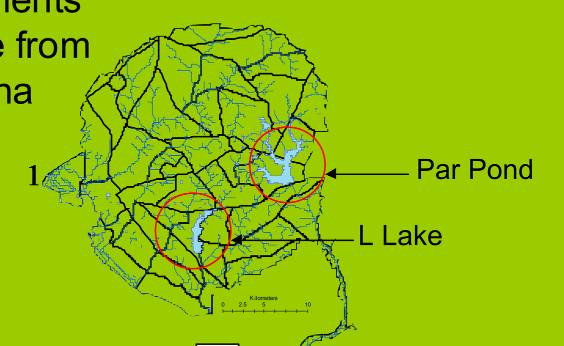
STUDY SITE



- The Savannah River Site is an 805 km^2 former nuclear production facility located in west-central South Carolina.
- This facility occupies portions of Aiken, Allendale, and Barnwell Counties.
- Radiocesium was released into the environment during the operation of a high-level waste storage system, 2 radiochemical processing facilities and daily functions of 5 production reactors.

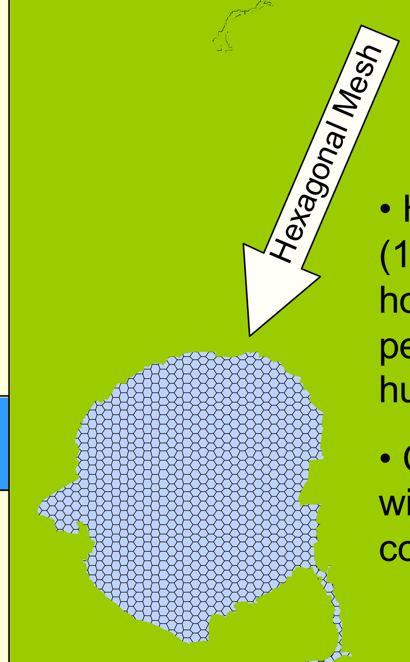
MODEL LAYERS

- The SRS is divided into 43 different hunt compartments
- Compartments sizes range from 264-3,729 ha
- Par Pond and L-Lake reactor cooling reservoirs contaminated with ^{137}Cs

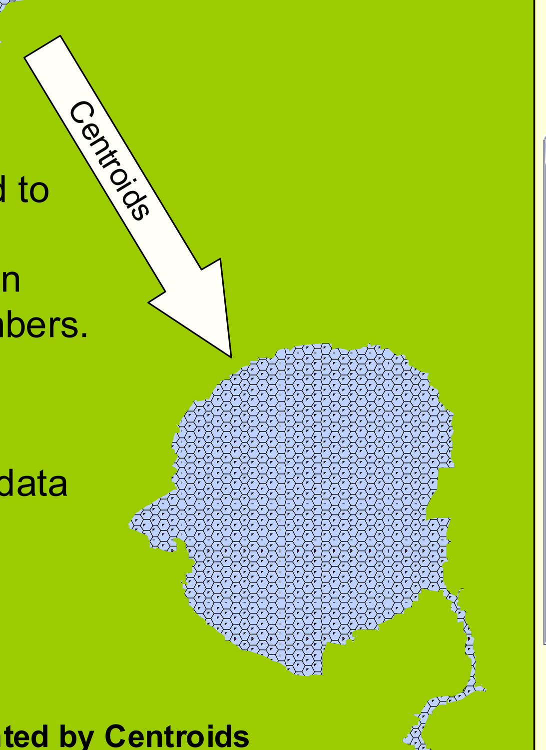


Physical and radiological data taken from harvested deer is joined with all hunt stand locations

1984-1991 (N = 5195)
1992-1995 (N = 5313)
1996-2006 (N = 8146)



- Hexagon mesh size (100 ha) determined from home range studies performed **during** SRS hunts.
- Correlates deer activity with potential onsite contamination of ^{137}Cs



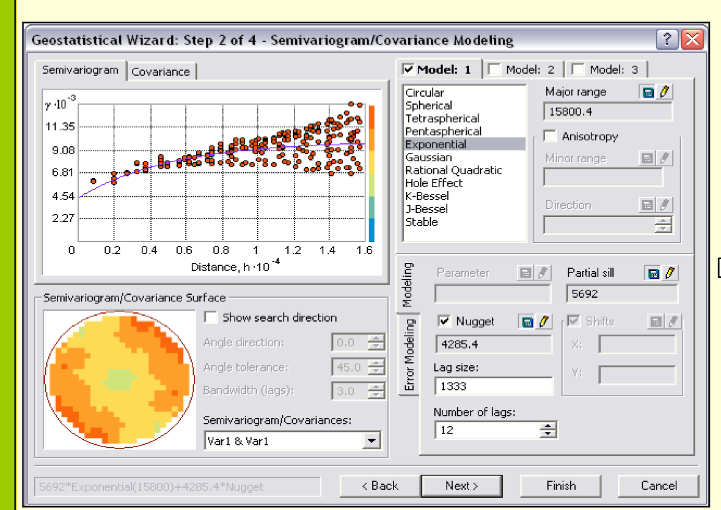
- Centroids joined to each associated hexagon based on identification numbers.
- Physical and radiological data merged into one data set.

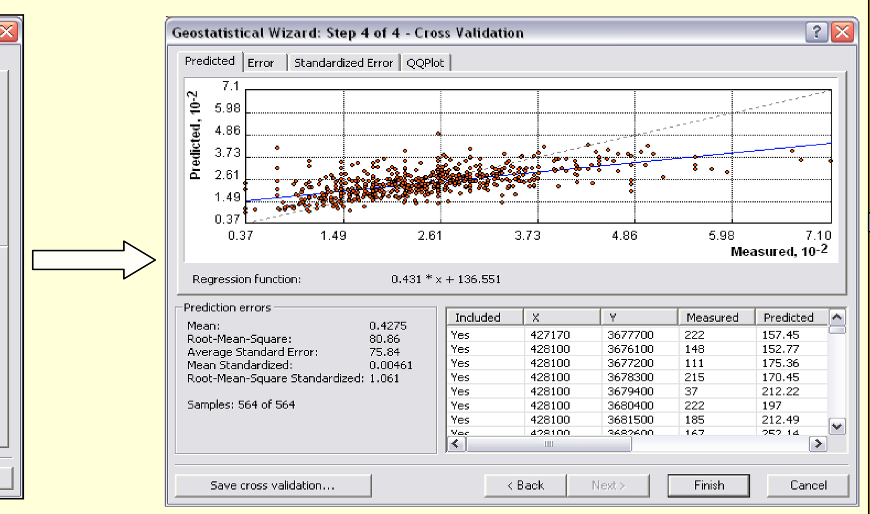
Variables Represented by Centroids
- Hexagon identification
- Centroid Identification
- Number of deer harvested per hexagon
- Radiocesium Summary Statistics (Average, Minimum, Maximum, Standard Deviation, Standard Error)

RESULTS

The 3 kriged models predict white-tailed deer body-burden concentrations and distributions. Separate models were constructed to account for the half-life of ^{137}Cs (30.2 yrs).

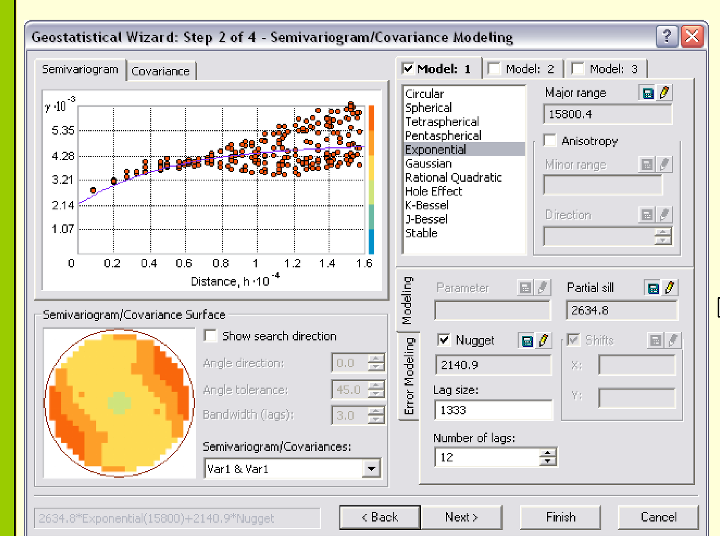
SEMIVARIOGRAMS | **CROSS VALIDATION/REGRESSION**

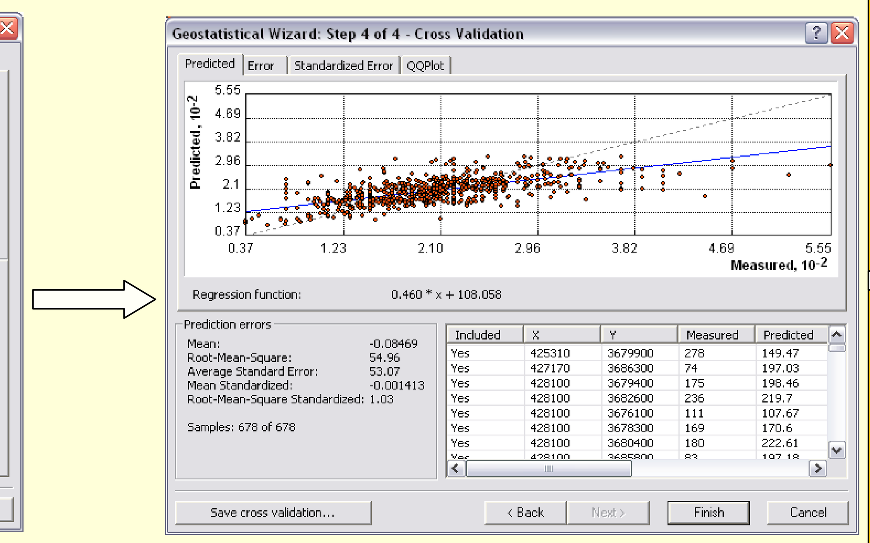




$Y = 0.431 * x + 136.551$

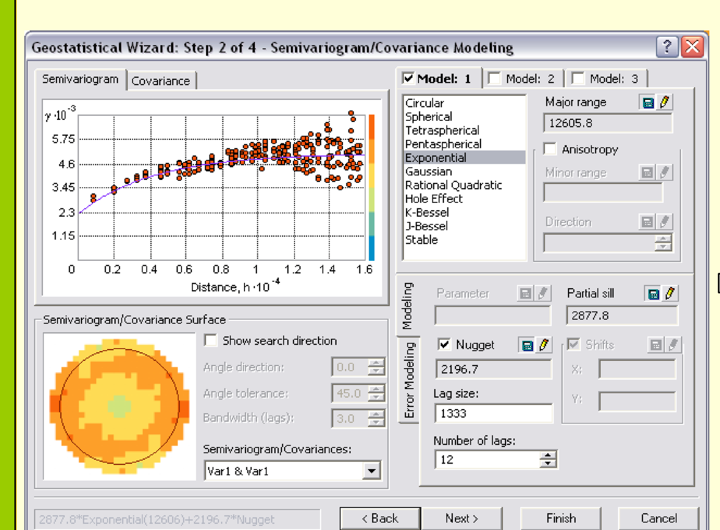
MODEL 1 PARAMETERS
- Range – 15800.4
- Nugget – 4285.4
- Lag Size – 1333
- # of Lags – 12

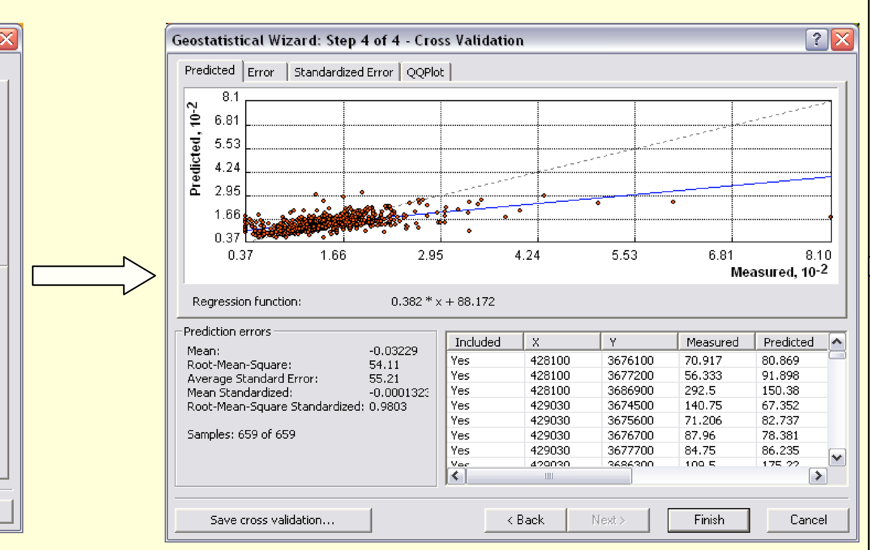




$Y = 0.460 * x + 108.058$

MODEL 2 PARAMETERS
- Range – 15800.4
- Nugget – 2140.9
- Lag Size – 1333
- # of Lags – 12



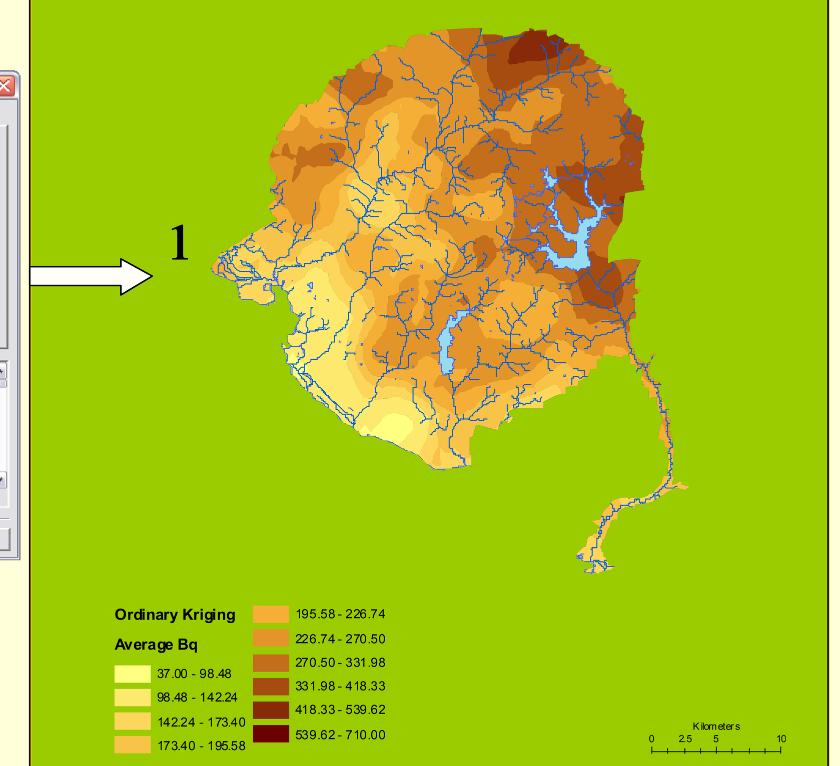


$Y = 0.382 * x + 88.172$

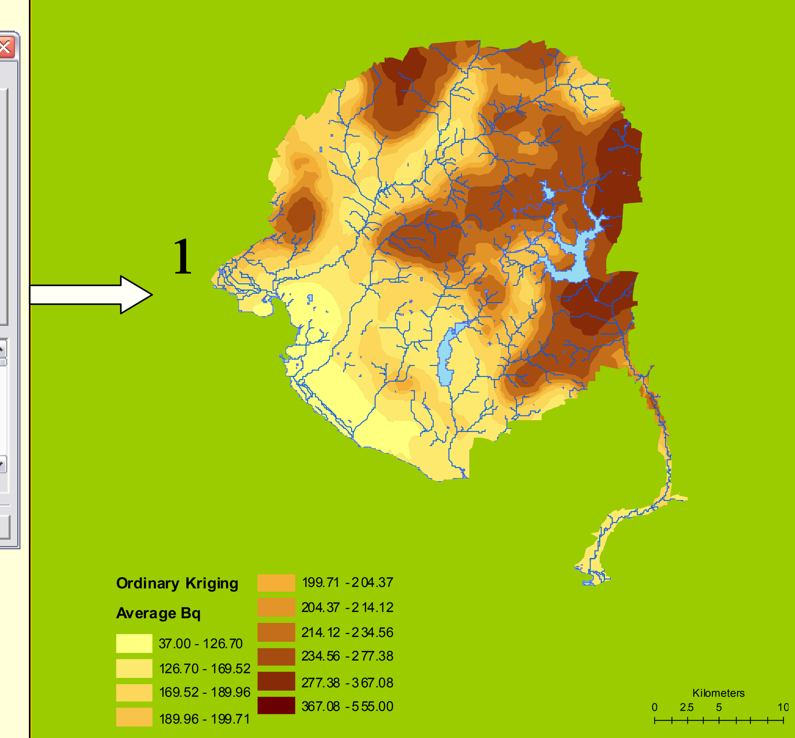
MODEL 3 PARAMETERS
- Range – 12605.8
- Nugget – 2196.7
- Lag Size – 1333
- # of Lags – 12

PREDICTION SURFACE

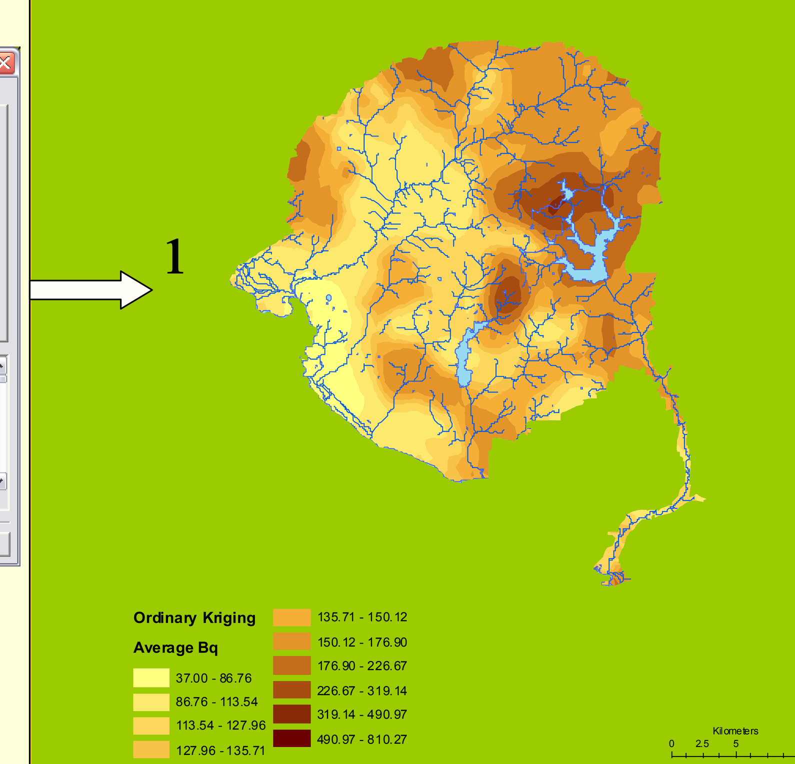
1984-1991



1992-1995



1996-2005



CONCLUSION

- The hexagonal approach where each hex represents the deer core area is the most biologically relevant scale to estimate the body-burdens of deer on the SRS.
- This scale allows for the determination of "Hot Spots" due to increased bioavailability of ^{137}Cs to deer.
- All cross validation regression lines indicate there is an over-prediction of **low** level radiocesium concentrations and an under-prediction of **high** level concentrations.
  - Overestimation likely due to hot spots.
  - The majority of deer are acquiring their body burden from radiological fallout from atomic testing.
- The cross-validation gives a powerful insight to the source of ^{137}Cs in white-tailed deer inhabiting the SRS.
  - Managers can use the cross-validation model, coupled with the interpolated surface for risk assessment purposes to limit access to high risk areas (all deer are monitored prior to removal).

FUTURE ANALYSES

SOIL
- ^{137}Cs has a decreased rate of mobility in presence of fine fraction clays.
  - Develop a cokriging model using the soil composition and clay content.

HABITAT
- Cover type has the potential to intercept ^{137}Cs from atmospheric fallout
  - Use vegetation and soil composition to develop a better model that would predict the bioavailability of ^{137}Cs to white-tailed deer on the SRS.

ACKNOWLEDGMENTS

- Eastern Illinois University, Department of Biological Sciences
- United States Department of Energy
- Savannah River Site