

ArcGIS Pro, Python, and R-Bridge Support Small Area Estimation for Forests

DAVID M. BELL ¹, CHRISTINE E. BLINN ², STEPHEN S. PEERY ²,
RANDOLPH H. WYNNE ², PHILIP J. RADTKE ², VALERIE A. THOMAS ²,
CHRISTOPHER M. OSWALT ¹, B. TY WILSON ¹

¹ USDA FOREST SERVICE

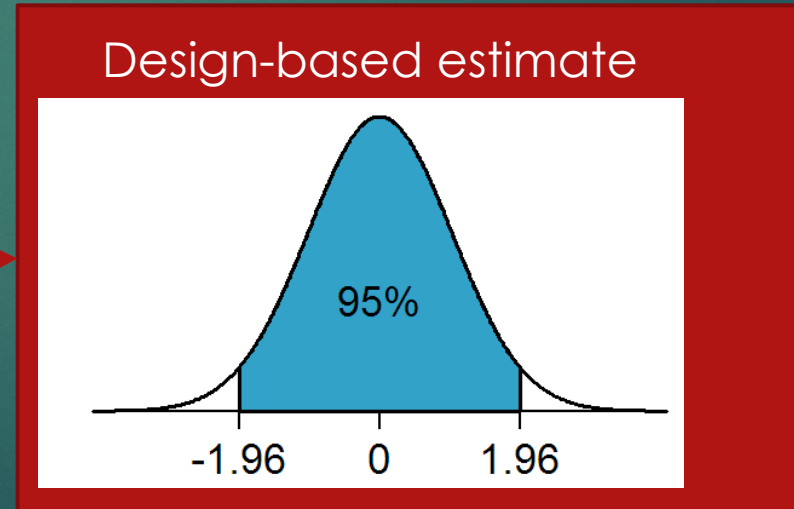
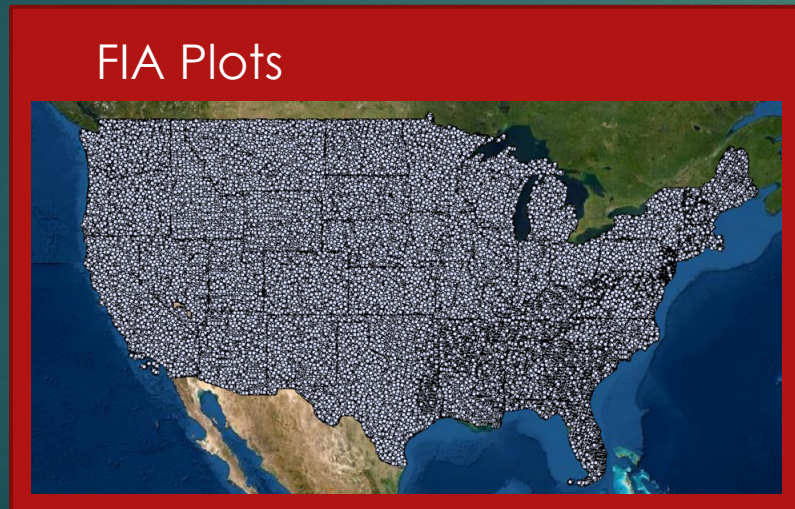
² VIRGINIA TECH

07/12/2023



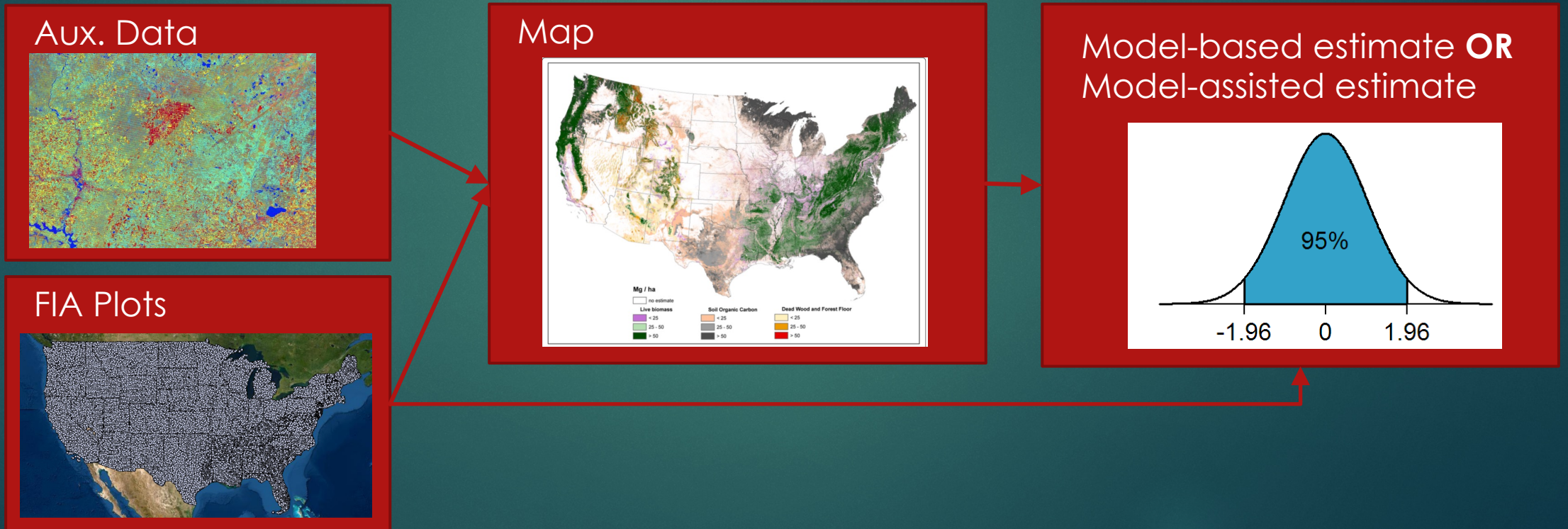
Small area estimation challenge for forest inventory

- ▶ The USDA Forest Service Forest Inventory and Analysis (FIA) Program supports design-based estimation of forest parameters
 - ▶ Means and variances (i.e., uncertainty)
- ▶ At landscape scales, there are often too few plots for reliable estimates

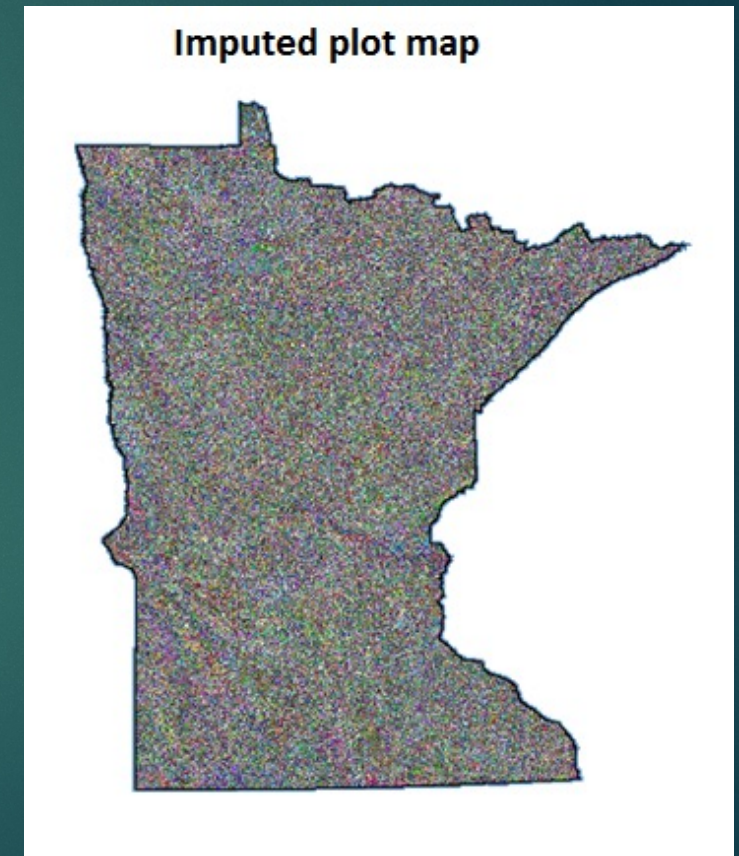
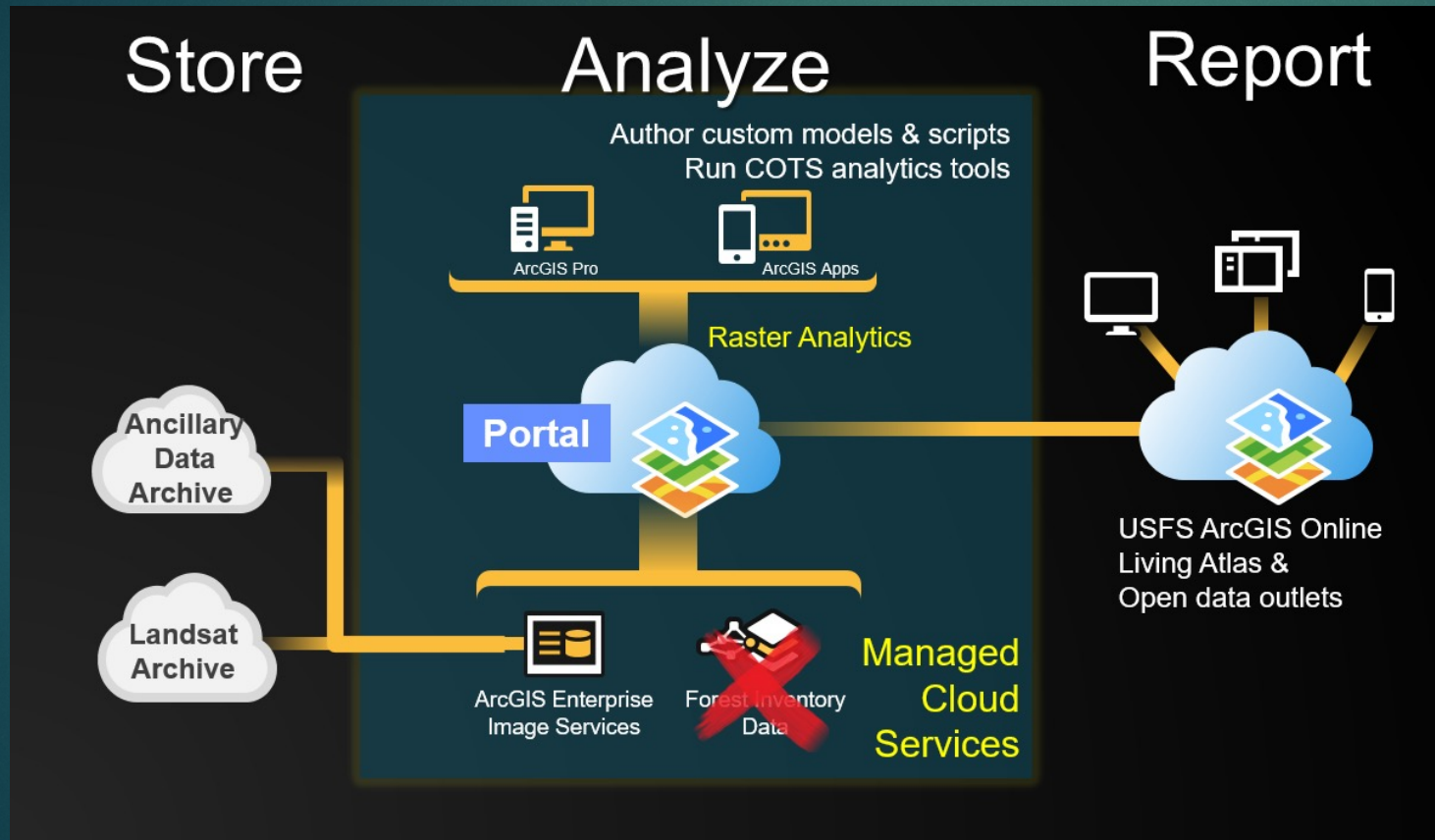


The role of mapping in SAE

- ▶ Integrating FIA plots and auxiliary data to make maps can form the basis for small area estimates

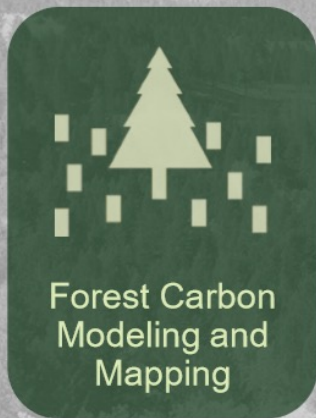


Big Data, Mapping, and Analytics (BIGMAP) as a platform for mapping and estimation



Expanded Analysis of Our Nation's Forests

Integrating scientific methods with technology



Better science for forest carbon management and policy



Smarter processing for forest disturbance detection



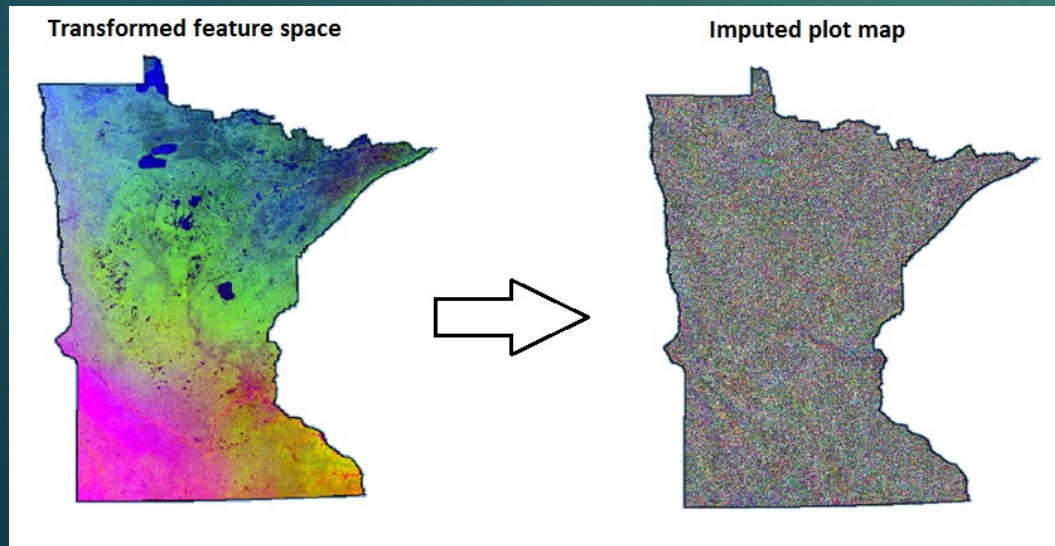
High resolution mapping of forest cover and change



Better access to science for decision making

Small Area Estimation for k Nearest Neighbors (kNN) Imputation

- ▶ Users need more than maps; they need ways to generate estimates
- ▶ Methods for areal mean and variance estimators based on kNN already exist (e.g., McRoberts et al., 2007)
- ▶ How do we integrate existing methods into BIGMAP to facilitate connections between analysis and reporting?



Available online at www.sciencedirect.com



Remote Sensing of Environment 111 (2007) 466–480

Remote Sensing
of
Environment

www.elsevier.com/locate/rse

Estimating areal means and variances of forest attributes using the k -Nearest Neighbors technique and satellite imagery

Ronald E. McRoberts^{a,*}, Erkki O. Tomppo^b, Andrew O. Finley^c, Juha Heikkinen^b

^a Northern Research Station, USDA Forest Service, St. Paul, MN, USA

^b The Finnish Forest Research Institute, Helsinki, Finland

^c Department of Forest Resources, University of Minnesota, St. Paul, MN, USA

Received 2 October 2006; received in revised form 5 April 2007; accepted 7 April 2007

Objectives

7

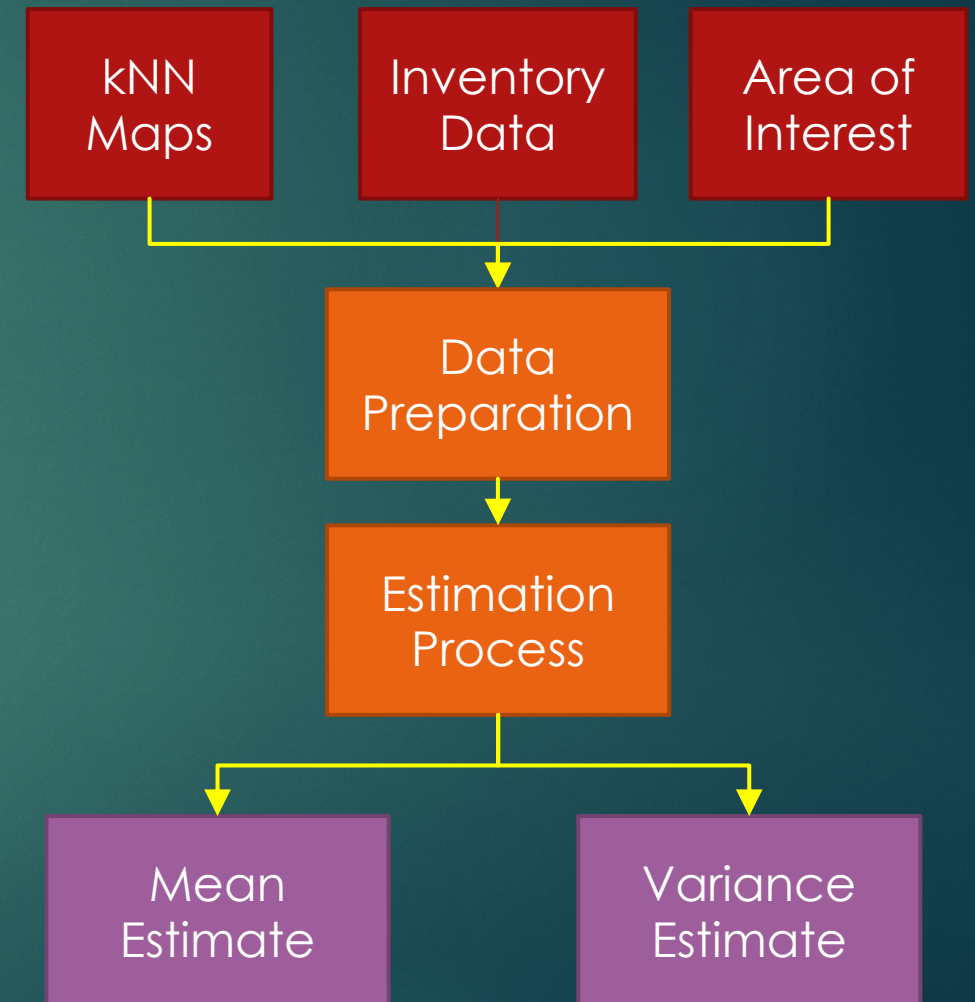
- ▶ Examine different implementations for small area estimation in the BIGMAP project
 - ▶ Implementation in ArcGIS Pro, using Python (and R for internal usage)
 - ▶ Web-based implementation to expand accessibility to a broader audience



SAE within ArcGIS Pro

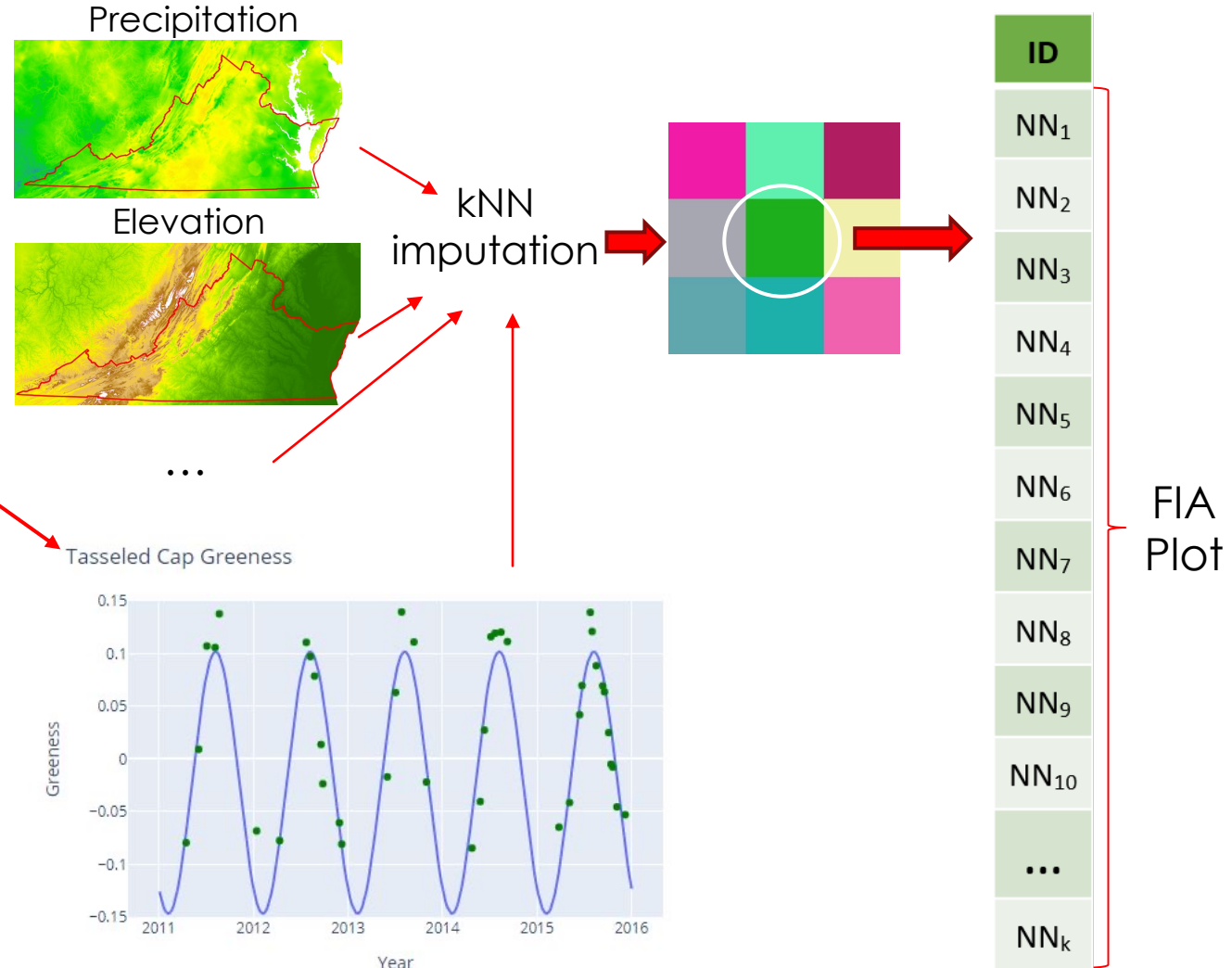
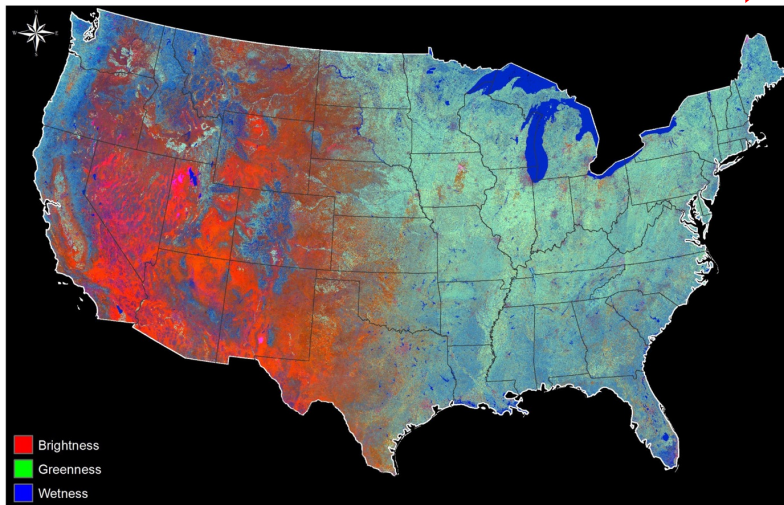
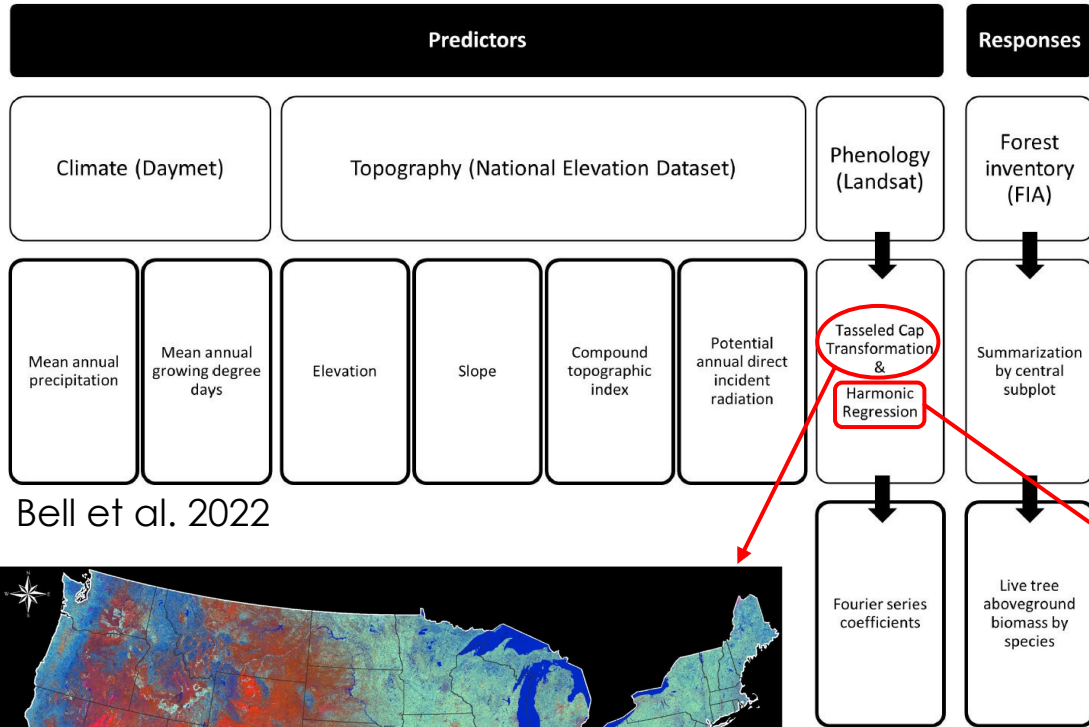
8

- ▶ Original R script handled all data preparation, estimation, and reporting procedures
- ▶ Developed an implementation in ArcGIS Pro to increase accessibility
 - ▶ ArcGIS Pro for GIS and easy interface
 - ▶ R for statistical estimation (with some C++) (*now superseded*)
 - ▶ Python (*originally only for sampling data*)



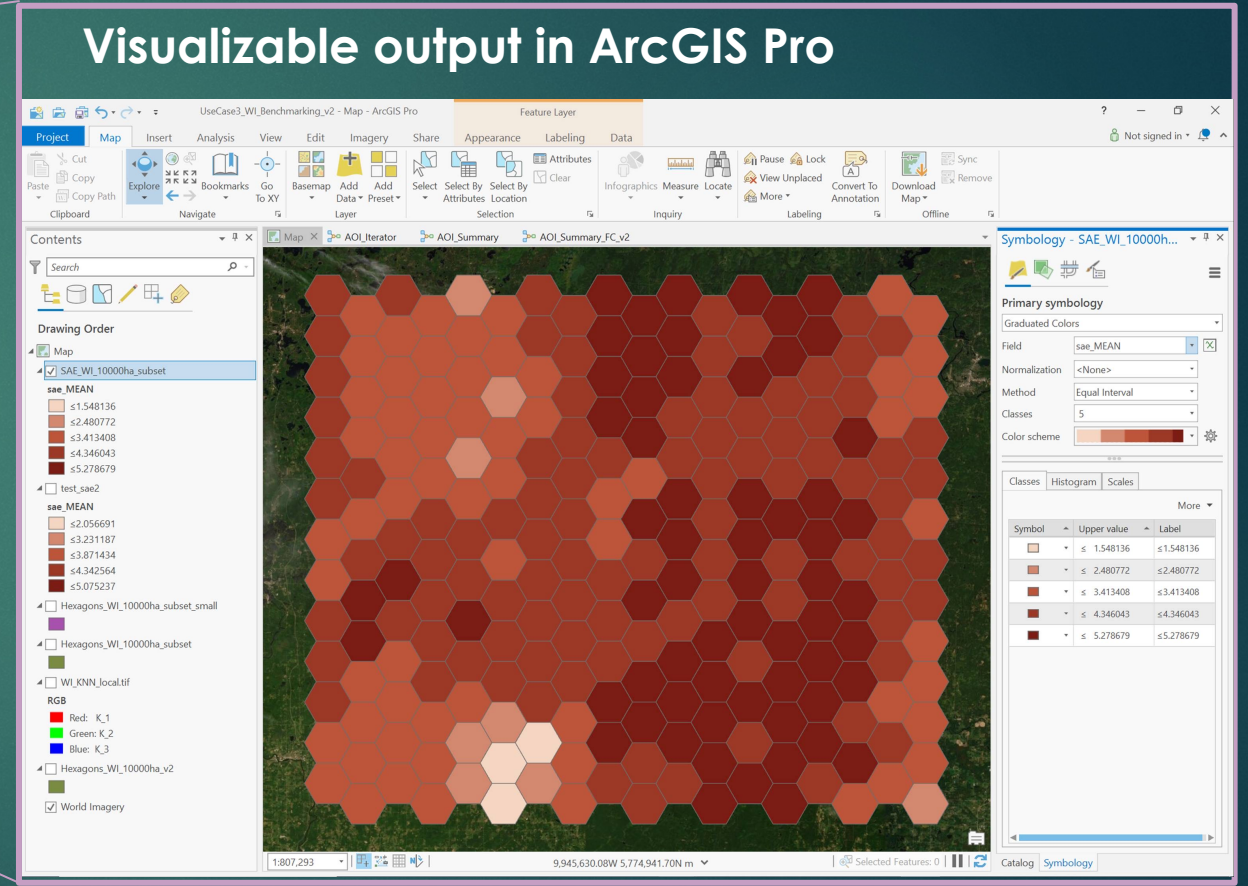
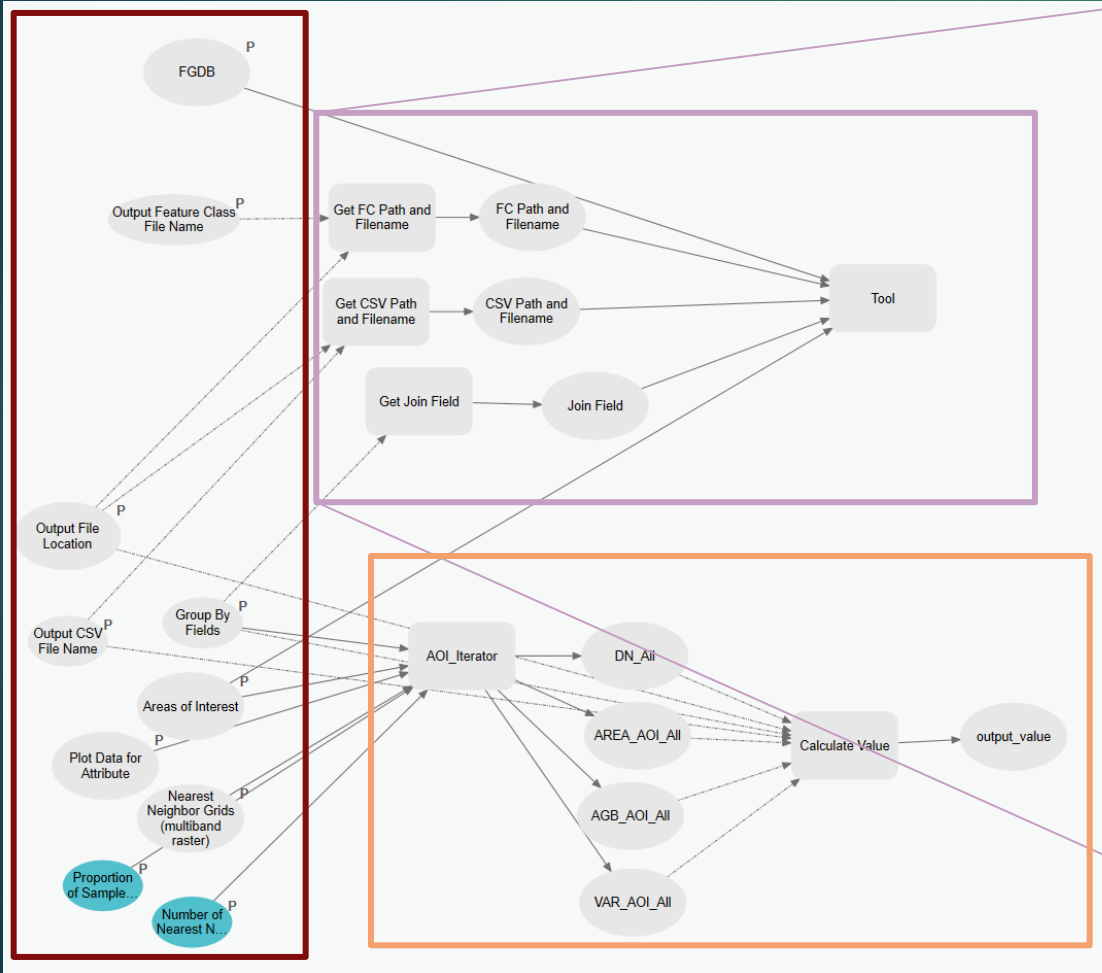


BIGMAP Data



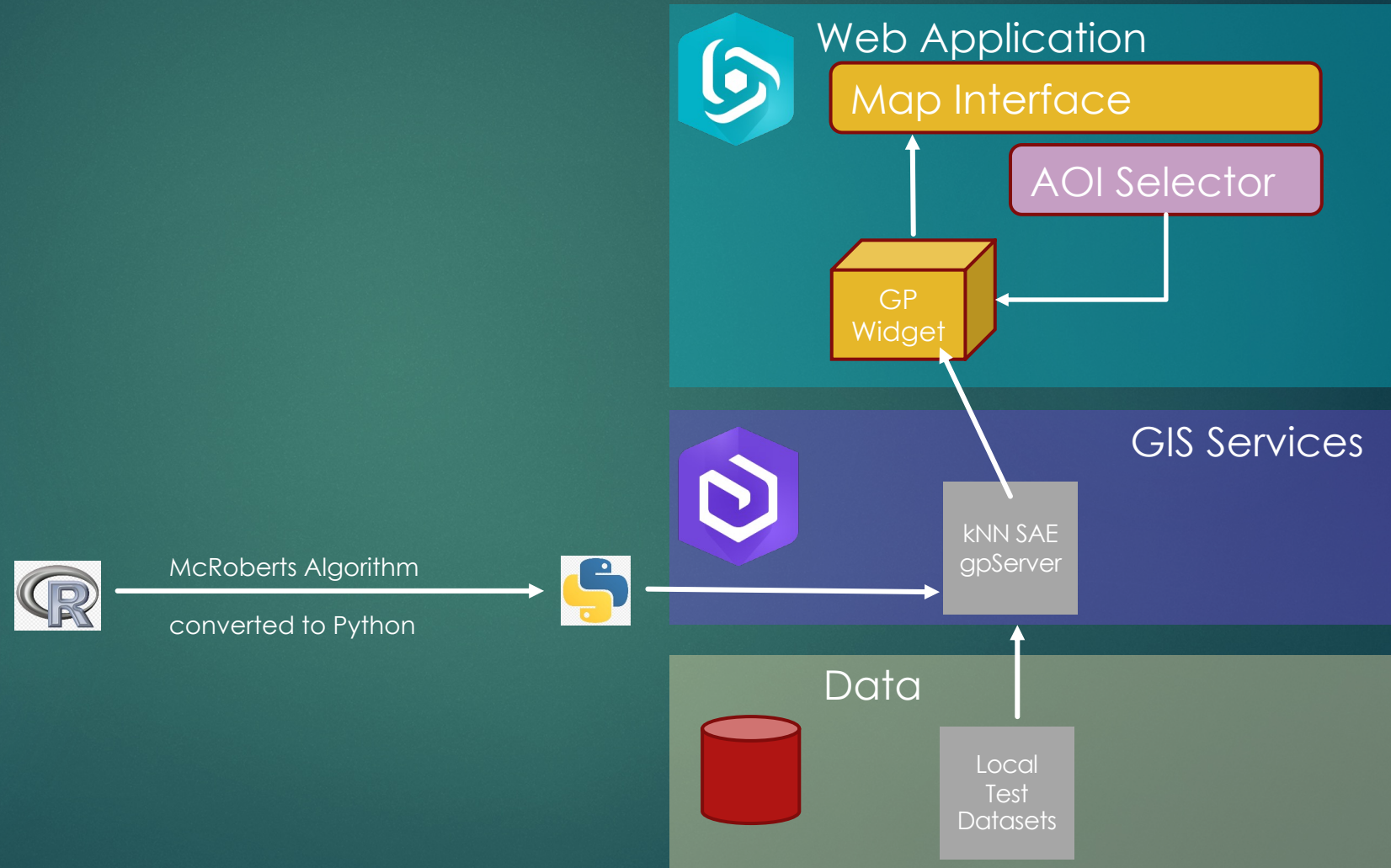
Zhai, Y., D.P. Roy, V.S. Martins, H.K. Zhang, L. Yan and Z. Li, 2022. Conterminous United States Landsat-8 top of atmosphere and surface reflectance tasseled cap transformation coefficients. Remote Sensing of Environment 274, doi:10.1016/j.rse.2022.112992.

ArcGIS Pro Model Builder – Improving Outputs

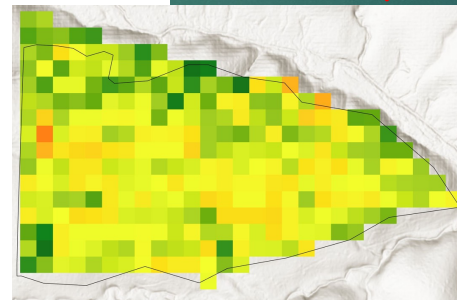
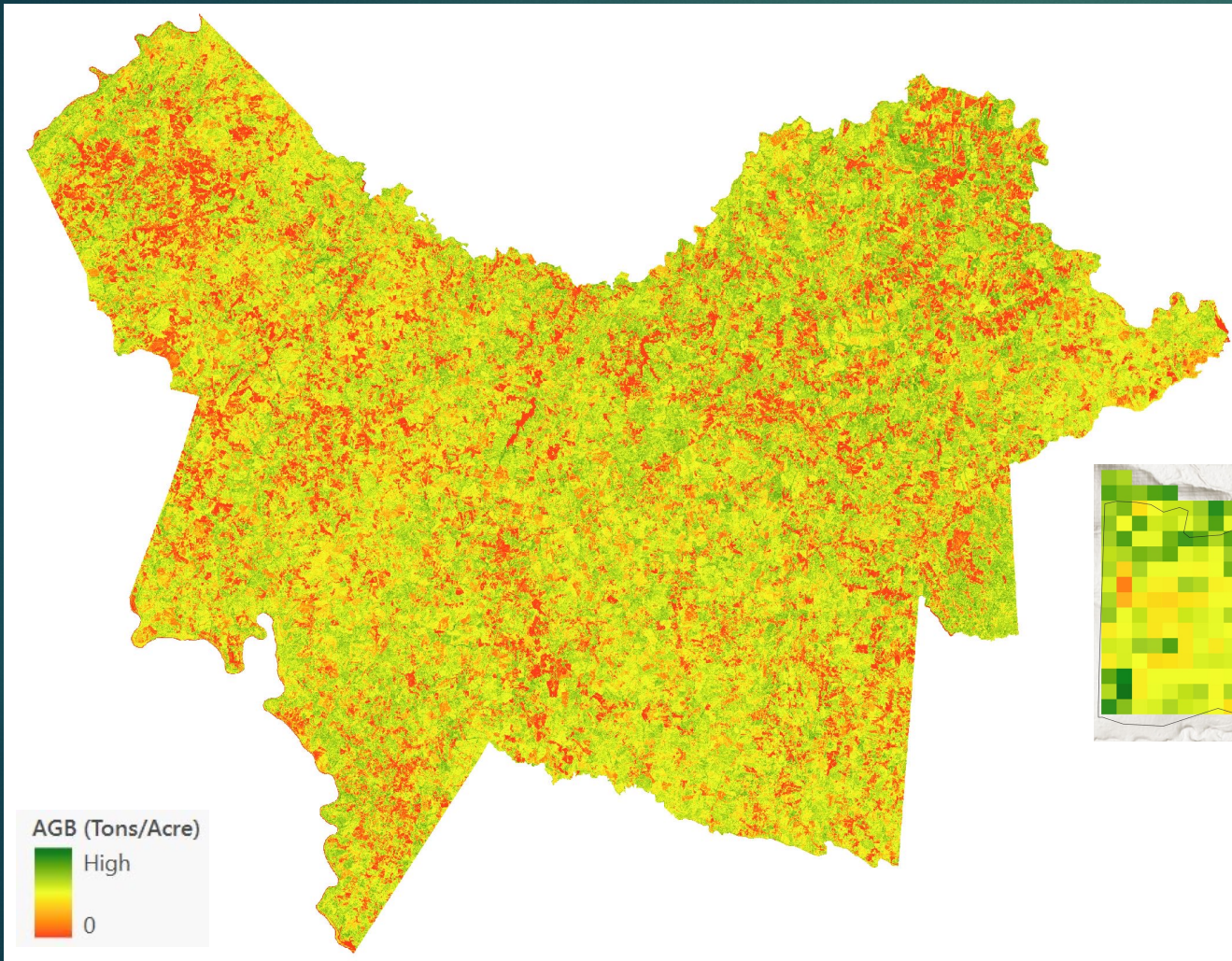


Current State of Architecture

- ▶ McRoberts algorithm was ported to Python and exposed as a geoprocessing service, currently hosted at Virginia Tech
- ▶ Web UI enables layer-based and dynamic interactive AOI selection



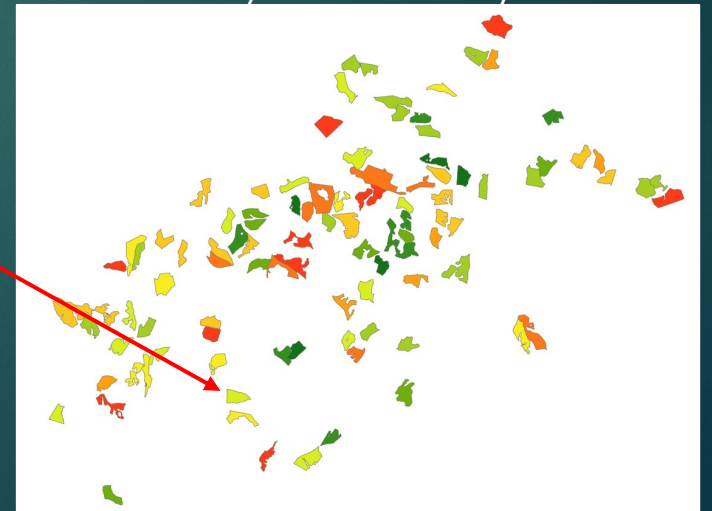
Results for Aboveground Biomass



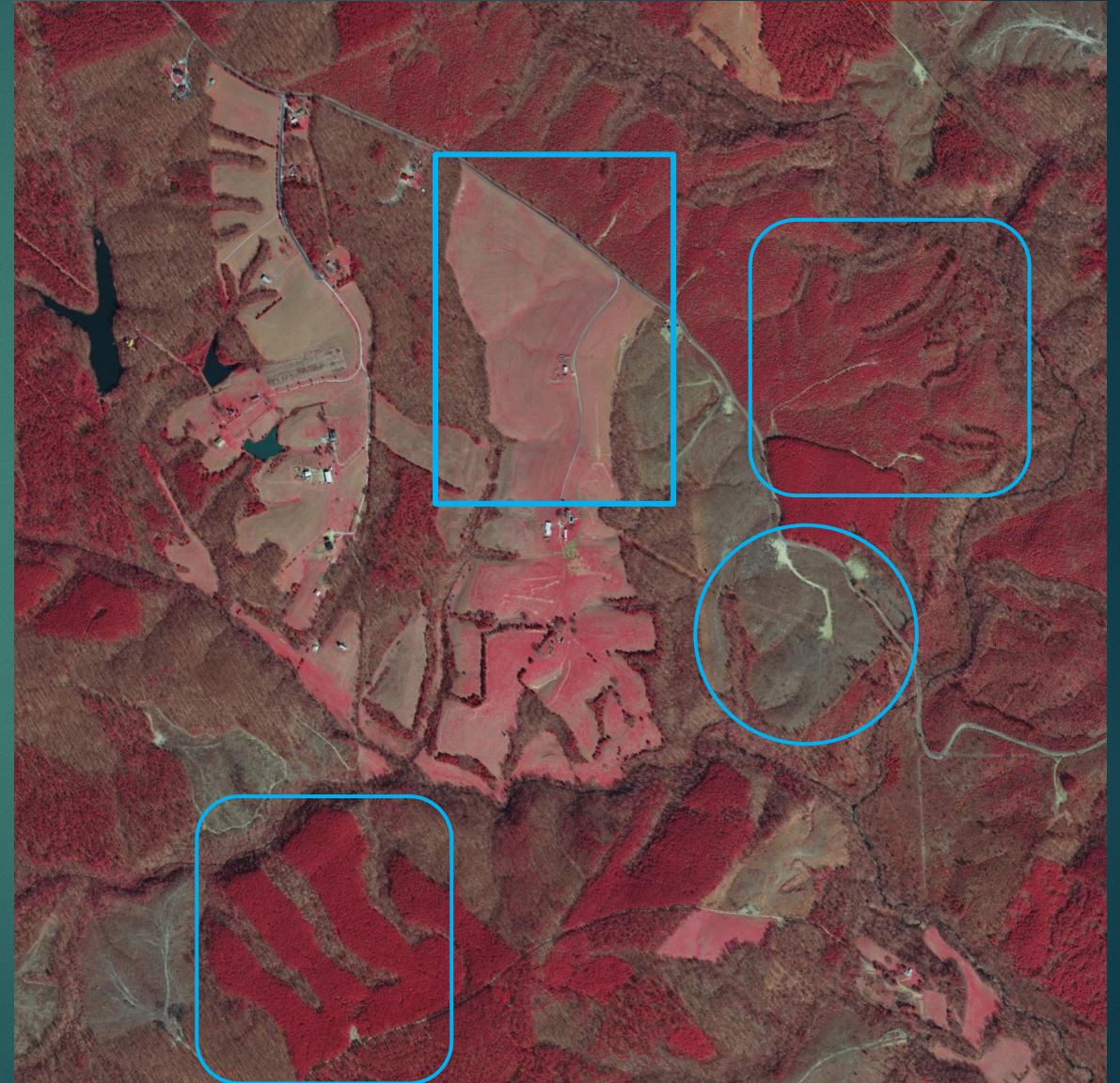
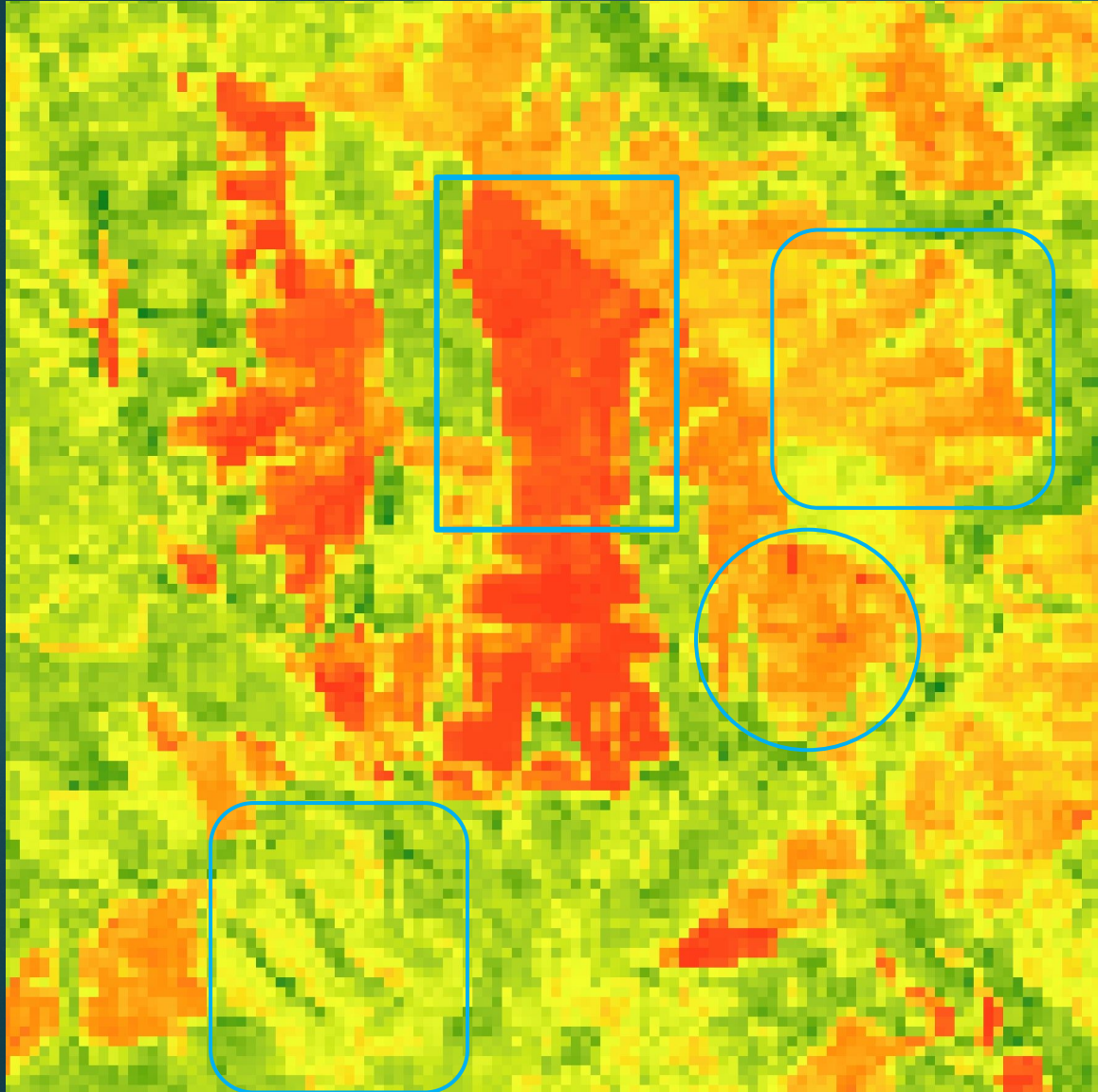
Feature Class Table Joined to CSV Output

	TYPE	AGE	Acres	Id_Stand	Mean_AGC	Var_AGC
1	LP	16	10.04	AB04031	14.9	2.2801
2	LP	21	17.85	AB06014	16.2	6.76
3	LP	12	34.35	AB09034	10.8	1.7161
4	LP	18	57.77	AB23032	15.6	2.0449
5	LP	18	38	AB23031	13.9	1.5876
6	LP	15	27.59	AB11055	13.7	1.6129
7	LP	11	35.01	AB21061	12.8	1.4161
8	LP	14	34.17	AB11054	12.1	1.7424
9	LP	12	52.36	AB07033	10.2	1.1236
10	LP	11	33.88	AB01045	13.7	2.8224

Stands Symbolized by AGC Mean



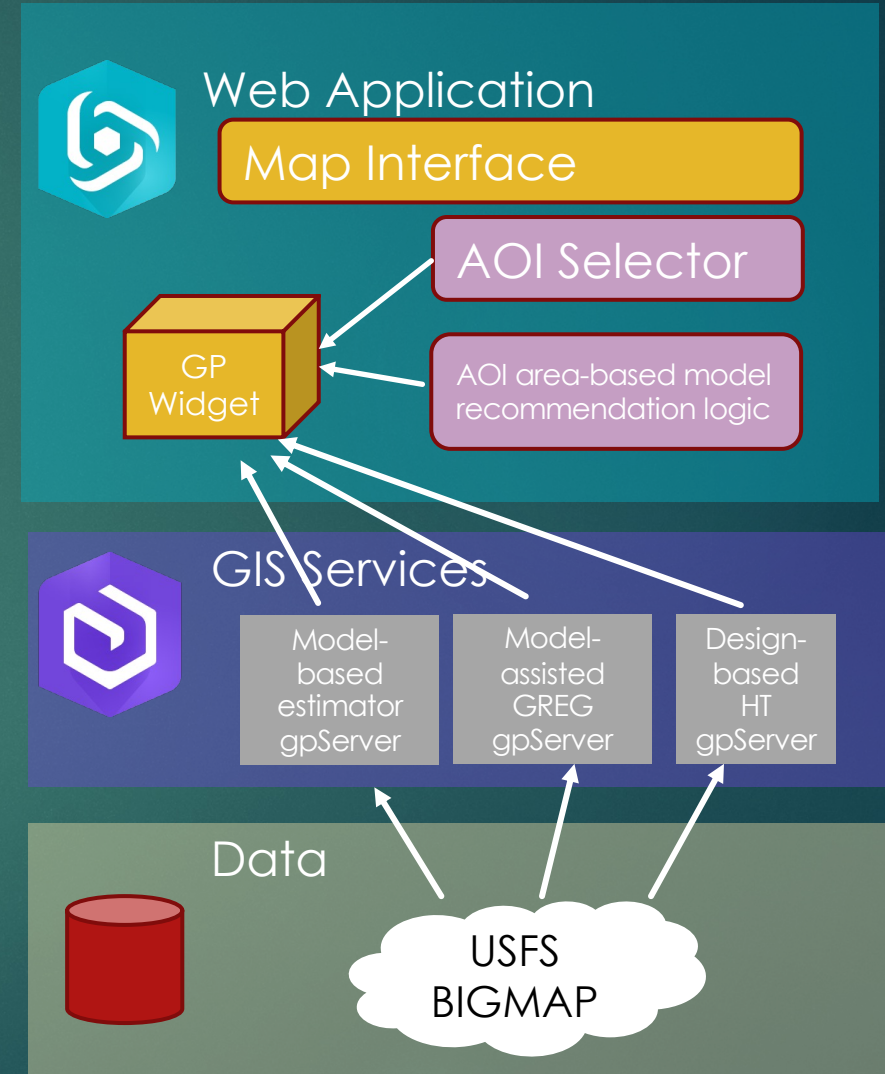
AGB Estimates & VBMP CIR 2018



Note that this version is for research purposes only and does not have nonforest visible. Virginia Base Mapping Project imagery from the Virginia Geographic Information Network

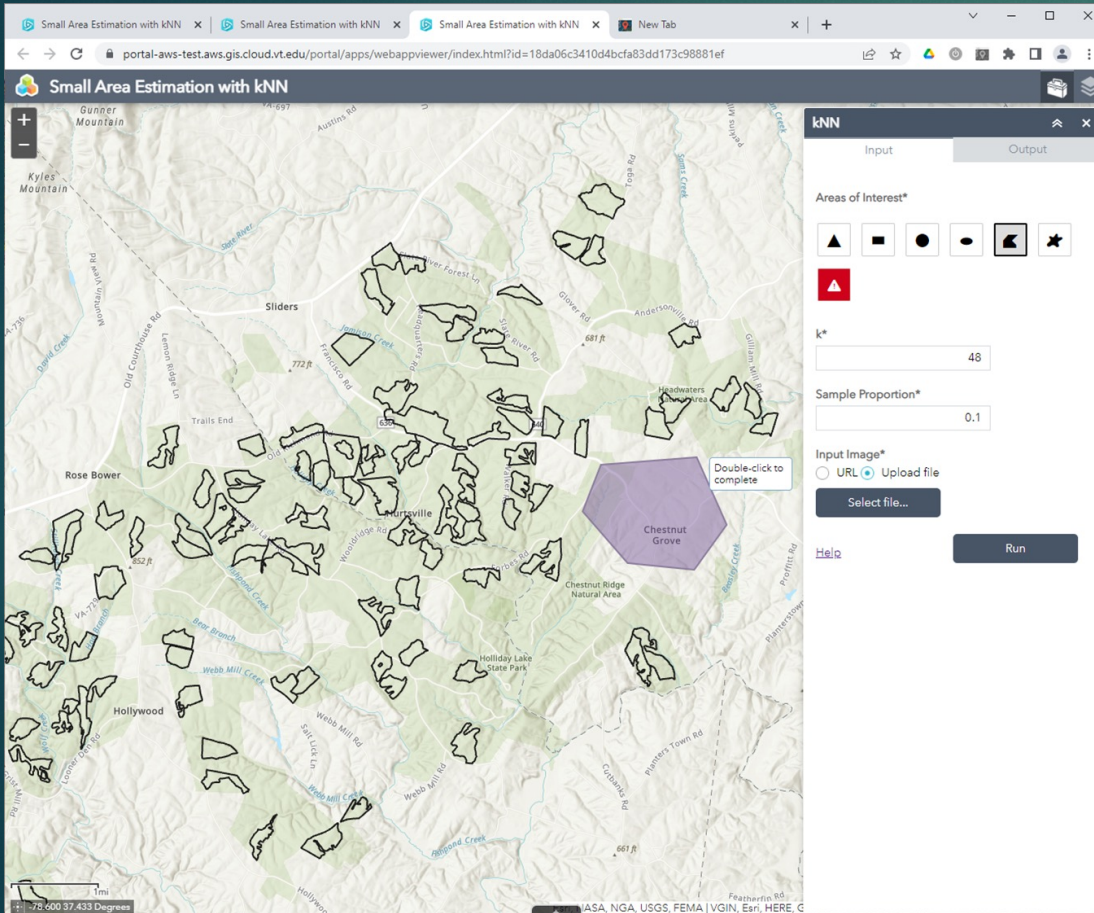
Future Architecture Vision

- ▶ gpServer endpoints access FIA BIGMAP directly
- ▶ Additional gpServer services for model-assisted (GREG) and design-based (HT)
- ▶ Appropriate GP tasks will be recommended based on AOI size
 - {
 - 0-25000ha : Model-based kNN
 - 25001-64800ha : Model-assisted GREG
 - >64801ha : Design-based HT
 - }
- ▶ GIS Services tier may eventually be migrated to USFS infrastructure

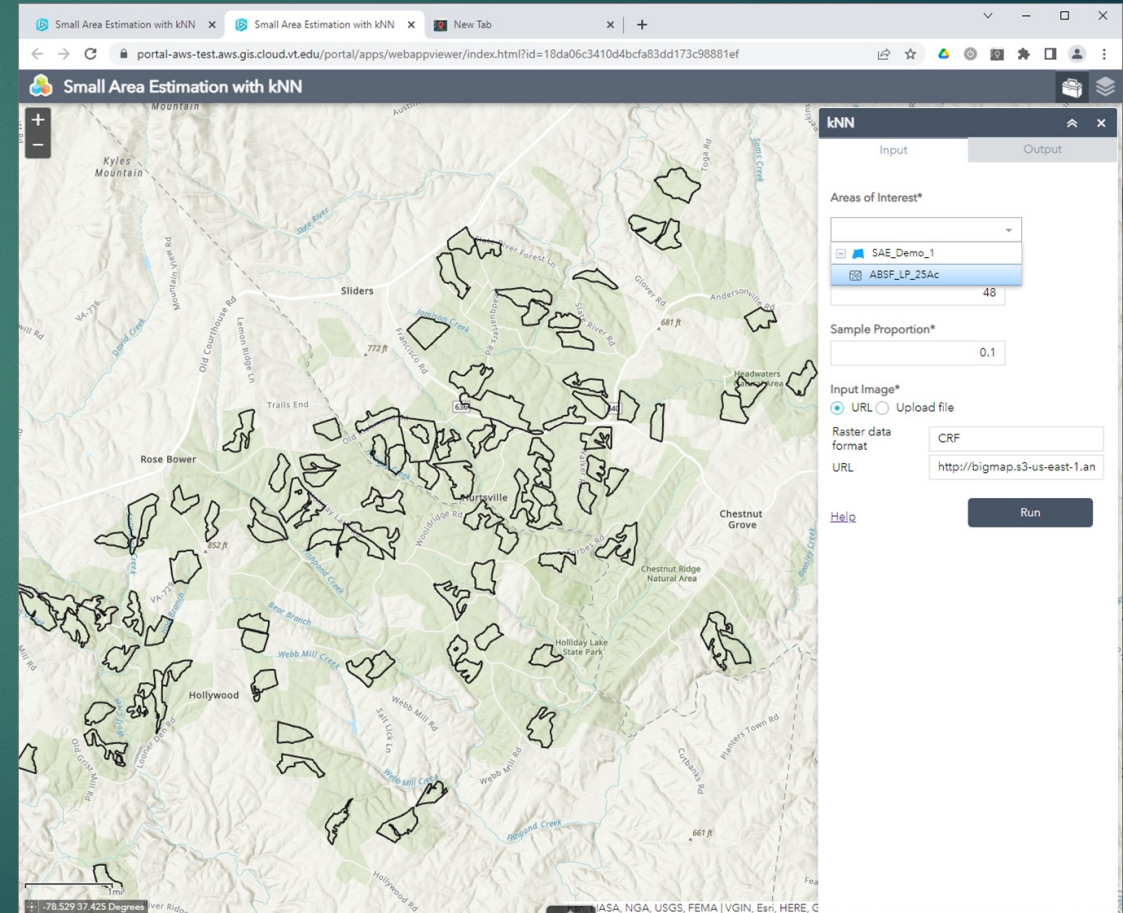


AOI Selection Options

16



Manually user-delineated



Using extant features

BIGMAP Team: A public-private partnership

The BIGMAP project is a collaboration between the USFS FIA Program, Esri, and Virginia Tech. The presenters would like to recognize some of the many people who have worked on this project and whose efforts have been showcased here.

USDA Forest Service

- ▶ James Gardner
- ▶ Hobie Perry
- ▶ Chris Oswalt
- ▶ Ty Wilson

Esri

- ▶ Gregory Brunner
- ▶ Paul Burgess
- ▶ Caitlin Cassisi
- ▶ Richard Cooke
- ▶ Kait Driessnack
- ▶ Peter Eredics
- ▶ Andrew Leason
- ▶ Robbie Richard
- ▶ James Sill
- ▶ John Steffenson

Virginia Tech

- ▶ Christine Blinn
- ▶ Seth Peery
- ▶ Phil Radtke
- ▶ Val Thomas

For additional information, please contact david.bell@usda.gov and wynne@vt.edu

