



Developing a National-level Equine Population Model for Disease Emergency Planning and Preparedness

Jairo Palomares, DVM, MSc, PhD. Quantitative Analyst, Postdoctoral Fellow

Joshua Reyling, PSM. Geospatial Analyst & AI Modeling, Geospatial Centroid, Morgan library

Sangeeta Rao, BVSc, MVSc, PhD. Associate Professor, Analytical Epidemiology

Project funded by:
USDA's Animal and Plant Health Inspection Service through the National Animal Disease Preparedness and Response Program (NADPRP)



CLINICAL SCIENCES
COLORADO STATE UNIVERSITY



Background and Rationale

Knowledge of the location, distribution, size (number of animals), and density of equine operations is critical to Emergency Preparedness and Response activities such as:

- developing movement control, surveillance and response plans
- estimating resource needs, predicting the potential number of impacted operations
- facilitating decision making before and during outbreaks

A national, comprehensive dataset of individual equine operation locations is NOT currently available in the U.S.



This Photo by Unknown Author is licensed under CC BY-SA



This Photo by Unknown Author is licensed under CC BY



Limitations of Potential Information Sources

National Agricultural Statistics Service (NASS)* – commercial-only, aggregate county or state level.

National Animal Health Monitoring System (NAHMS)* reports – based on NASS, periodic, sample-based, regional level.

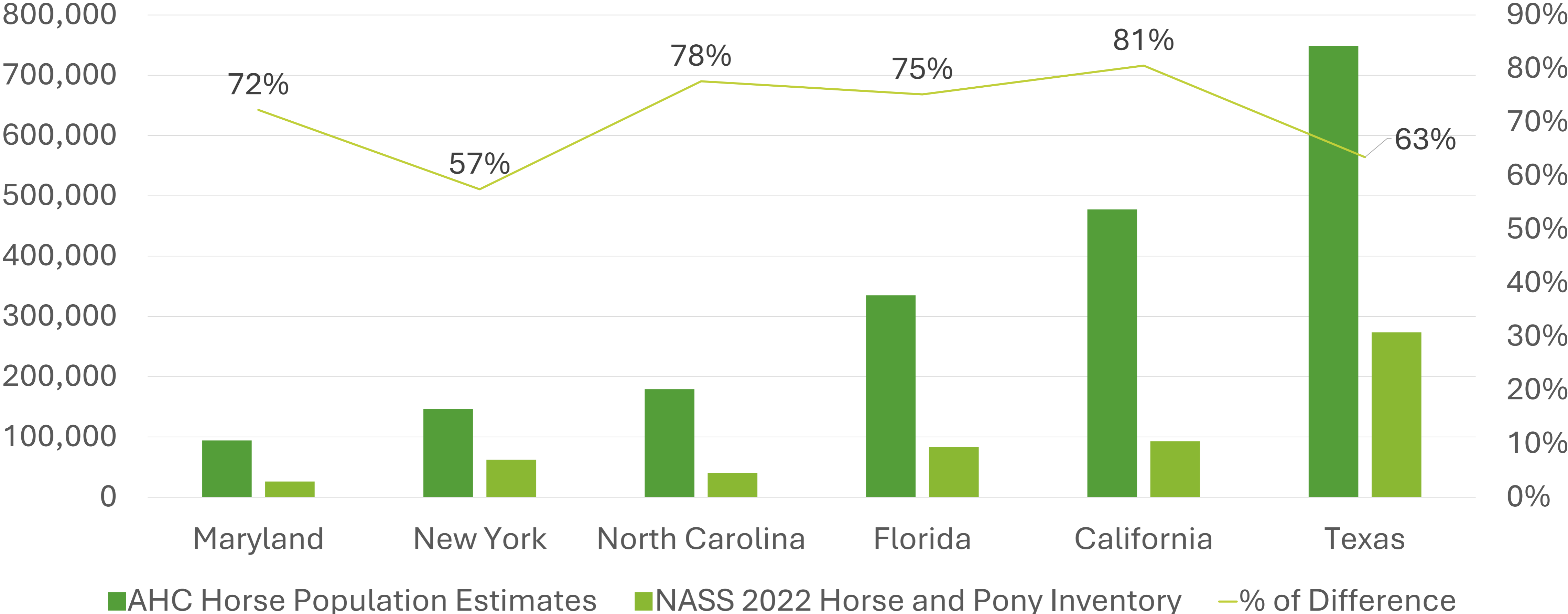
American Horse Council (AHC) economic report – extent of economic impact of industry, no exact locations, state level, volunteer-based participation.

Other sources (local reports) – incomplete, fragmented, inconsistent, membership affiliations.

* The National Agricultural Statistics Service (NASS) and the National Animal Health Monitoring System (NAHMS) are part of the U.S. Department of Agriculture (USDA).

Comparison of Horse Population

AHC Economic Reports vs NASS Census



Project Overview

Where are equine operations located across the U.S.?

How can we estimate their numbers and sizes at the national scale?

- **Main goal:**
 - Develop a national-level equine operation location and population dataset using geospatial tools and modeling techniques
- **Application:**
 - Used by State/Federal Animal Health Officials and Scientists planning, preparing for, and responding to:
 - Outbreaks of equine diseases, such as, African Horse Sickness virus , Equine Infectious Anemia, Vesicular Stomatitis virus, and Equine Piroplasmosis
 - Natural disasters such as fires, floods, tornadoes or hurricanes



Previous Work

Simulating the Distribution of Individual Livestock Farms and Their Populations in the United States: An Example Using Domestic Swine (*Sus scrofa domesticus*) Farms

Christopher L. Burdett  , Brian R. Kraus , Sarah J. Garza , Ryan S. Miller , Kathe E. Bjork 

Published: November 16, 2015 • <https://doi.org/10.1371/journal.pone.0140338> *PLOS One*

Modelling the domestic poultry population in the United States: A novel approach leveraging remote sensing and synthetic data methods

Kelly A. Patyk Mary J. McCool-Eye David D. South Christopher L. Burdett Susan A. Maroney Andrew Fox
Grace Kuiper Sheryl Magzamen

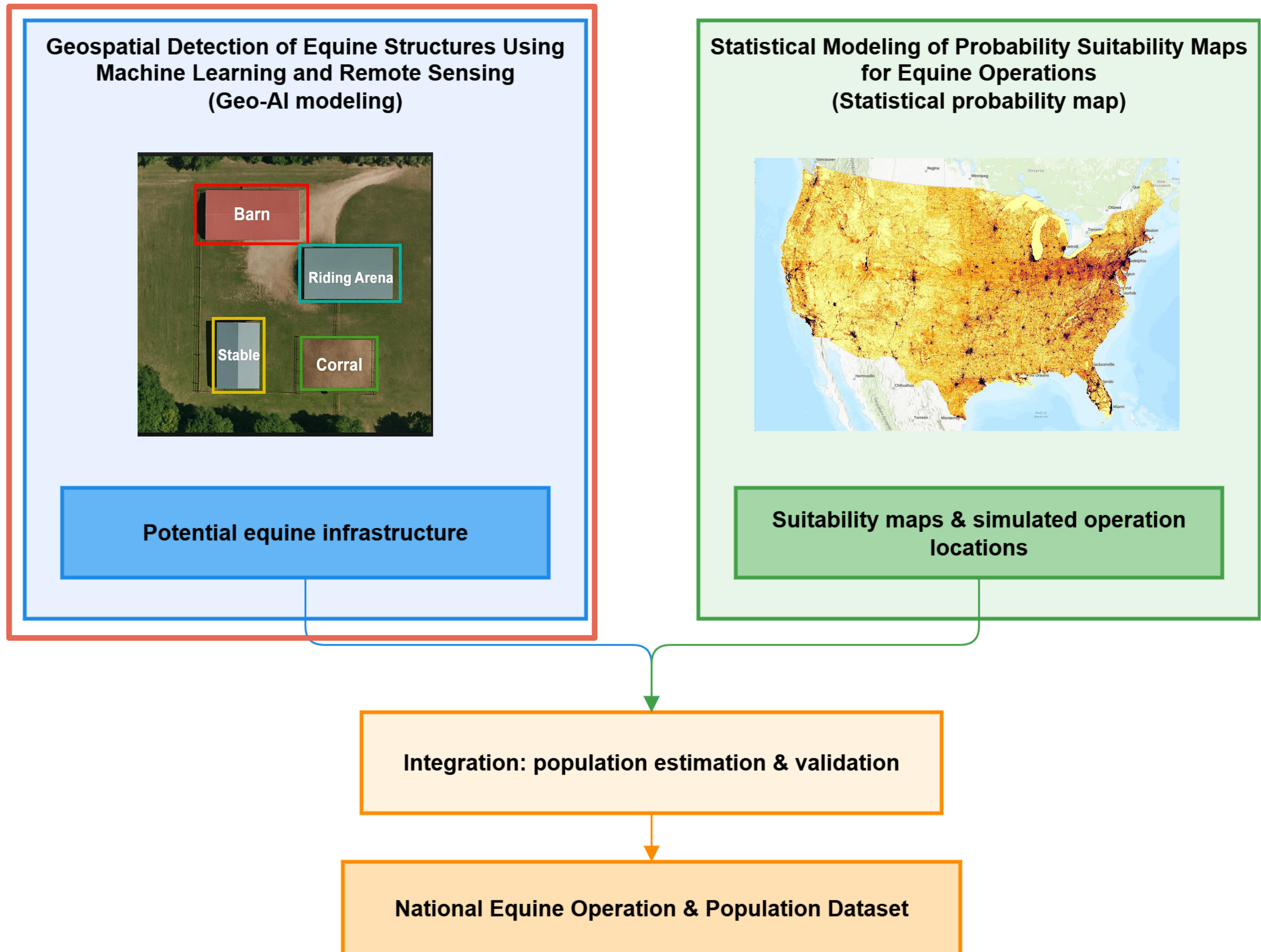
Published: September 3, 2020. <https://doi.org/10.4081/gh.2020.913> *Geospatial Health*

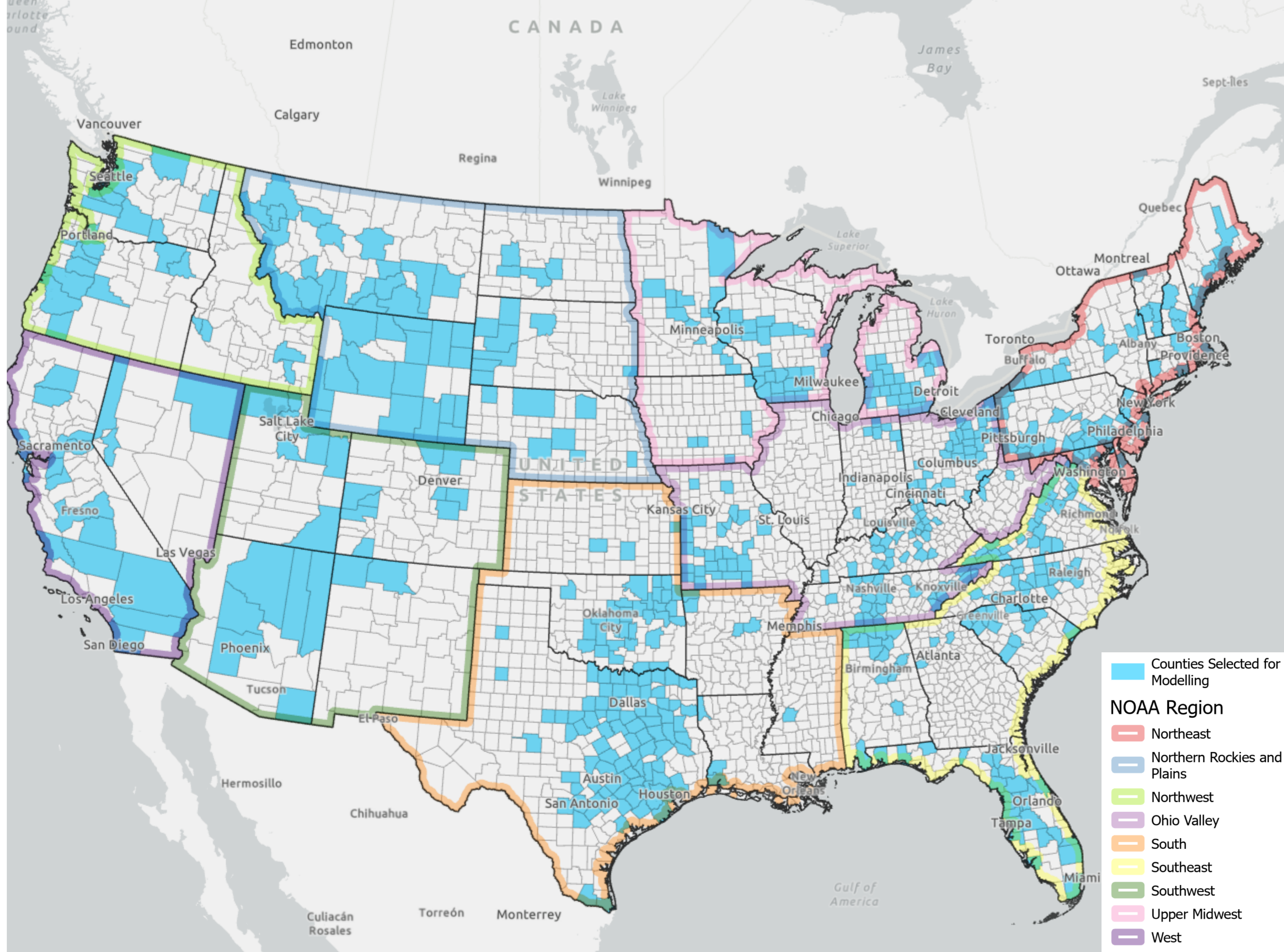
Using object-based image analysis to map commercial poultry operations from high resolution imagery to support animal health outbreaks and events

Susan Maroney MaryJane McCool-Eye Andrew Fox Christopher L. Burdett

Published: August 6, 2020. <https://doi.org/10.4081/gh.2020.919> *Geospatial Health*

Approach







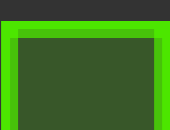
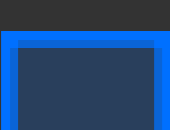


Counties Selected for Modelling

NOAA Region

- Northeast
- Northern Rockies and Plains
- Northwest
- Ohio Valley
- South
- Southeast
- Southwest
- Upper Midwest
- West

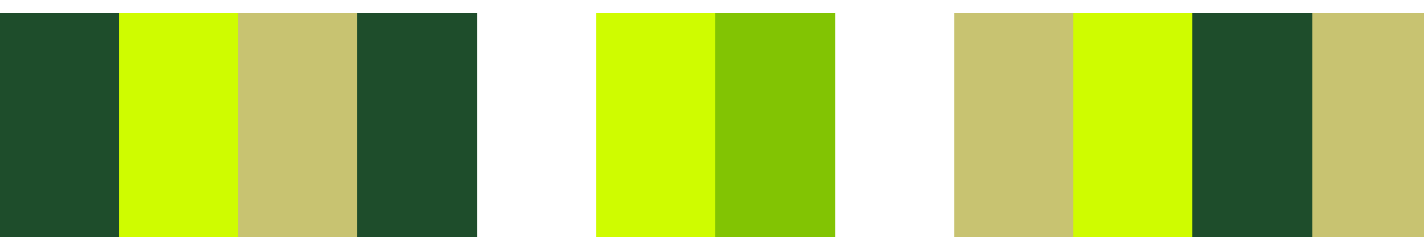
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community, Sources: Esri, TomTom, Garmin, (c) OpenStreetMap contributors, and the GIS User Community

Geo-AI Modeling - Training Labels & Annotations

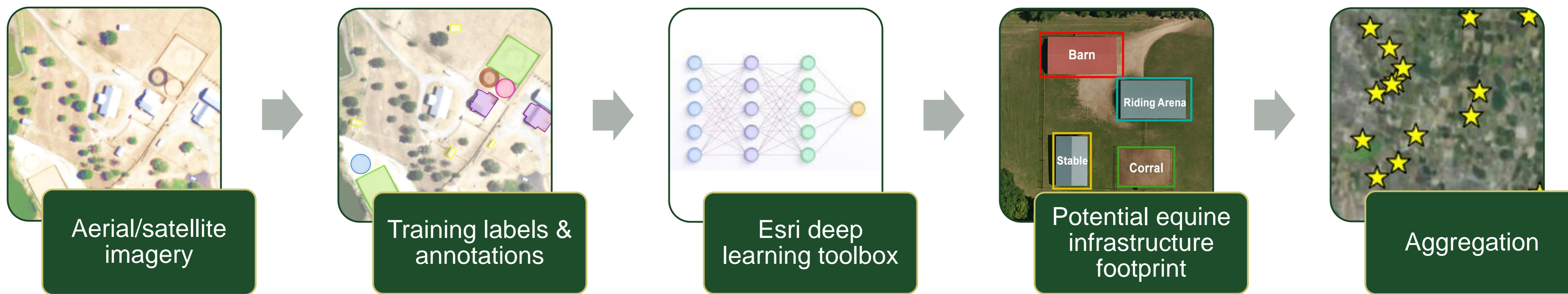
Structure	
	Barn with exterior pen
	Hot Walker
	Outdoor Arena
	Practice Track
	Round Pen/ Corral
	Run-in Structure

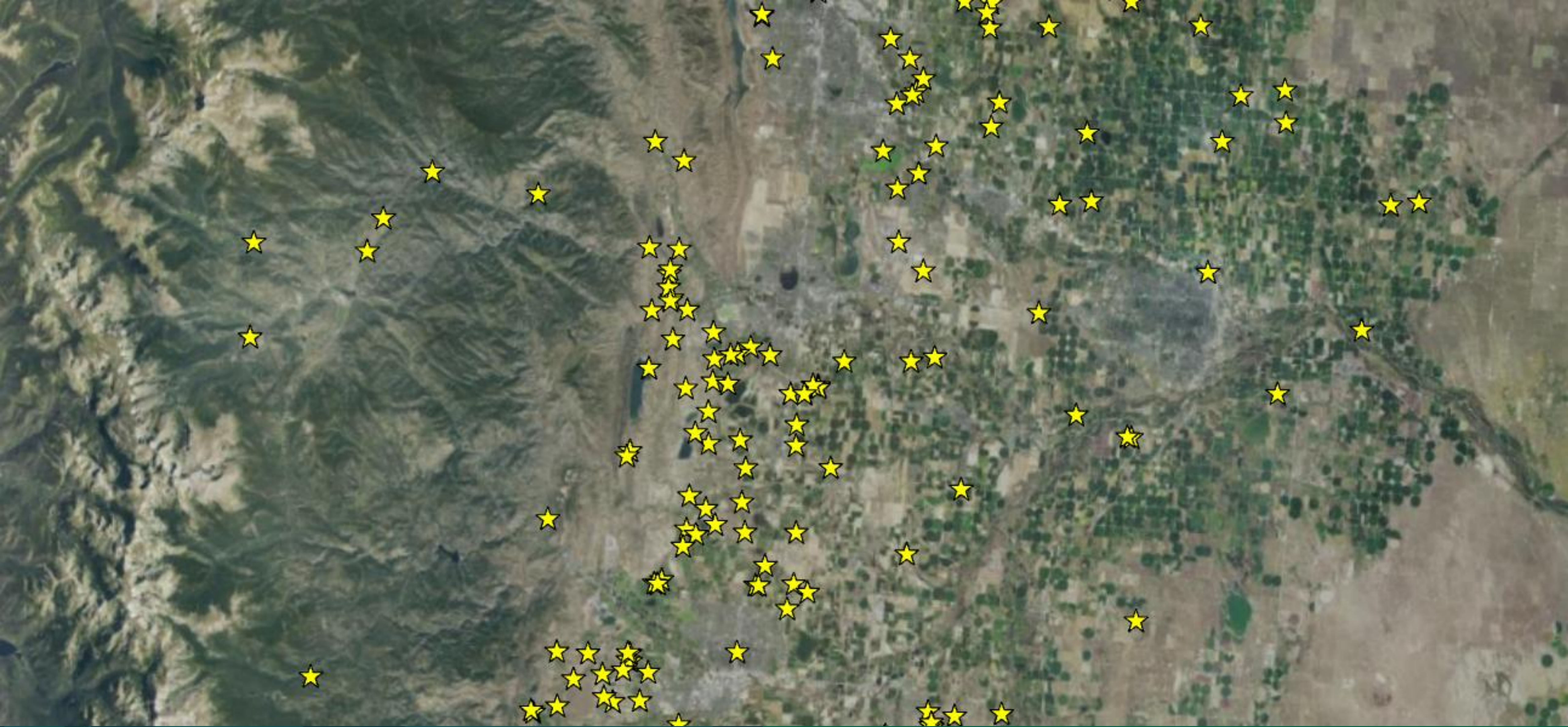


Data collected using National Agricultural Imagery Program (NAIP) Natural color imagery



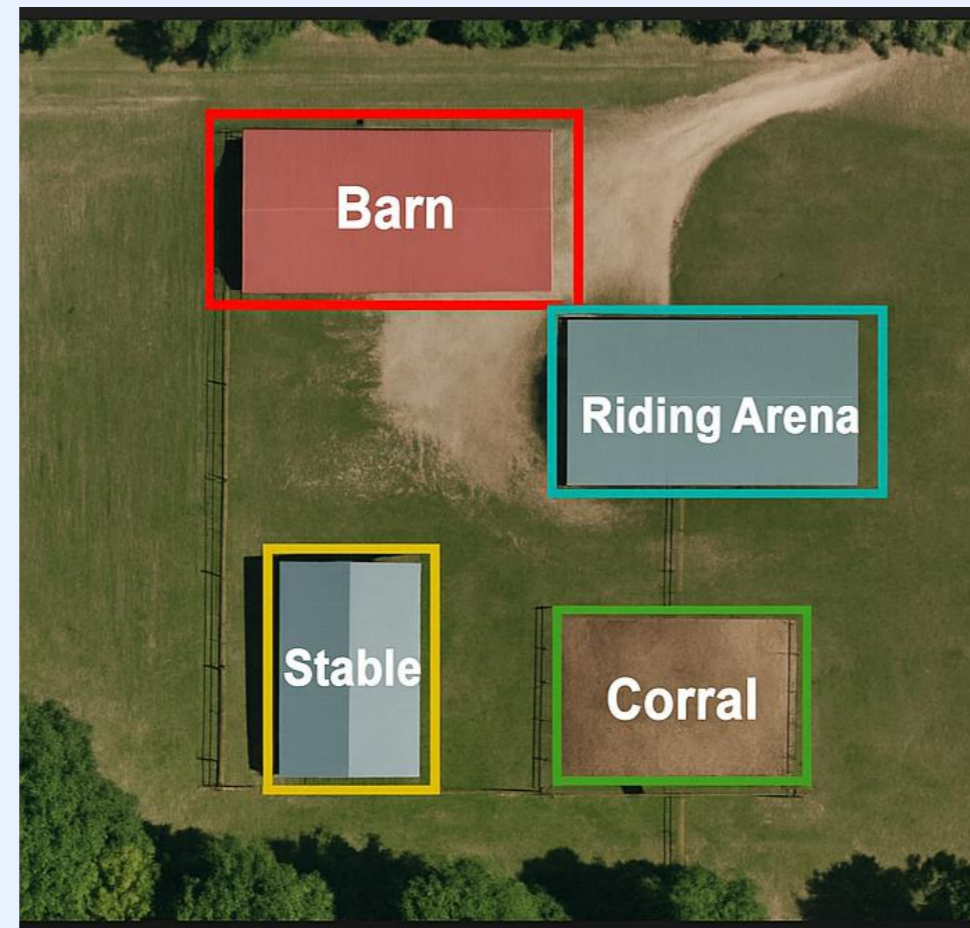
Remote Sensing + Deep Learning





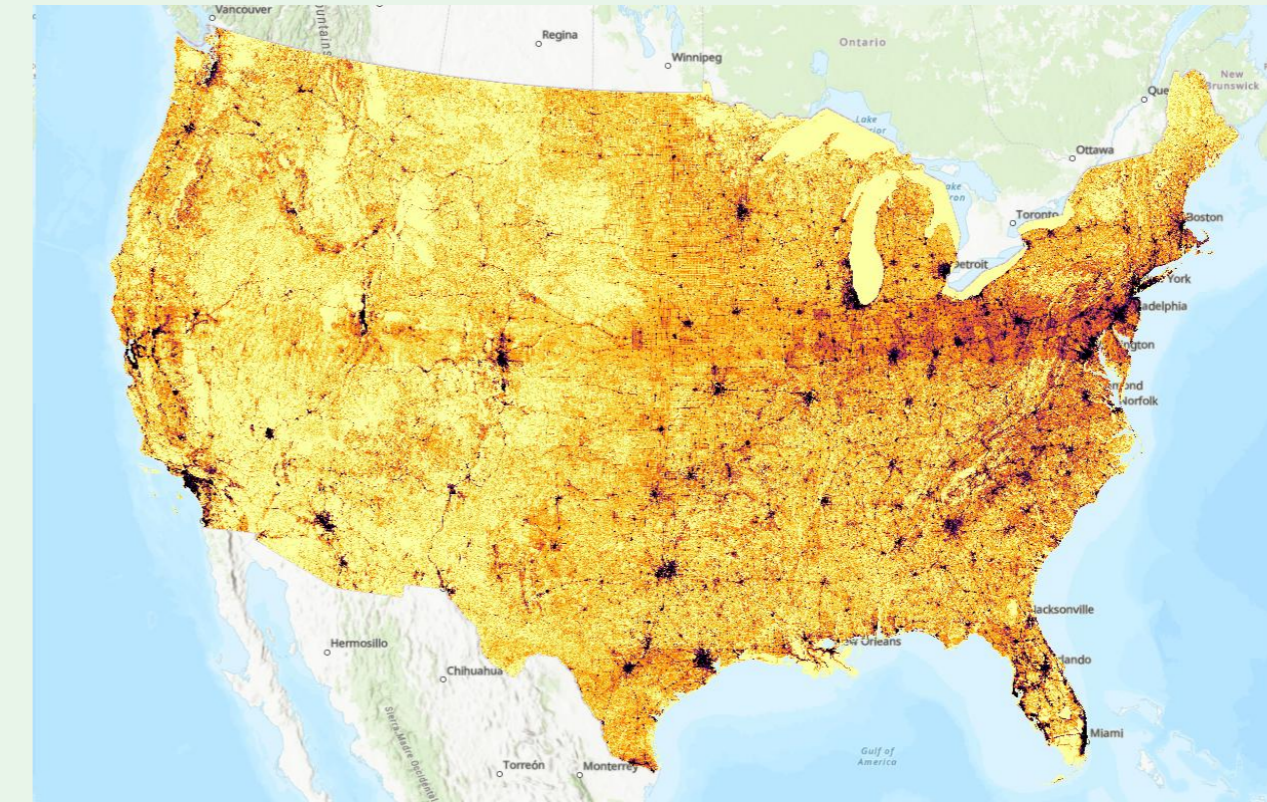
Geo-AI modeling - Potential Equine Operations

Geospatial Detection of Equine Structures Using Machine Learning and Remote Sensing (Geo-AI modeling)



Potential equine infrastructure

Statistical Modeling of Probability Suitability Maps for Equine Operations (Statistical probability map)

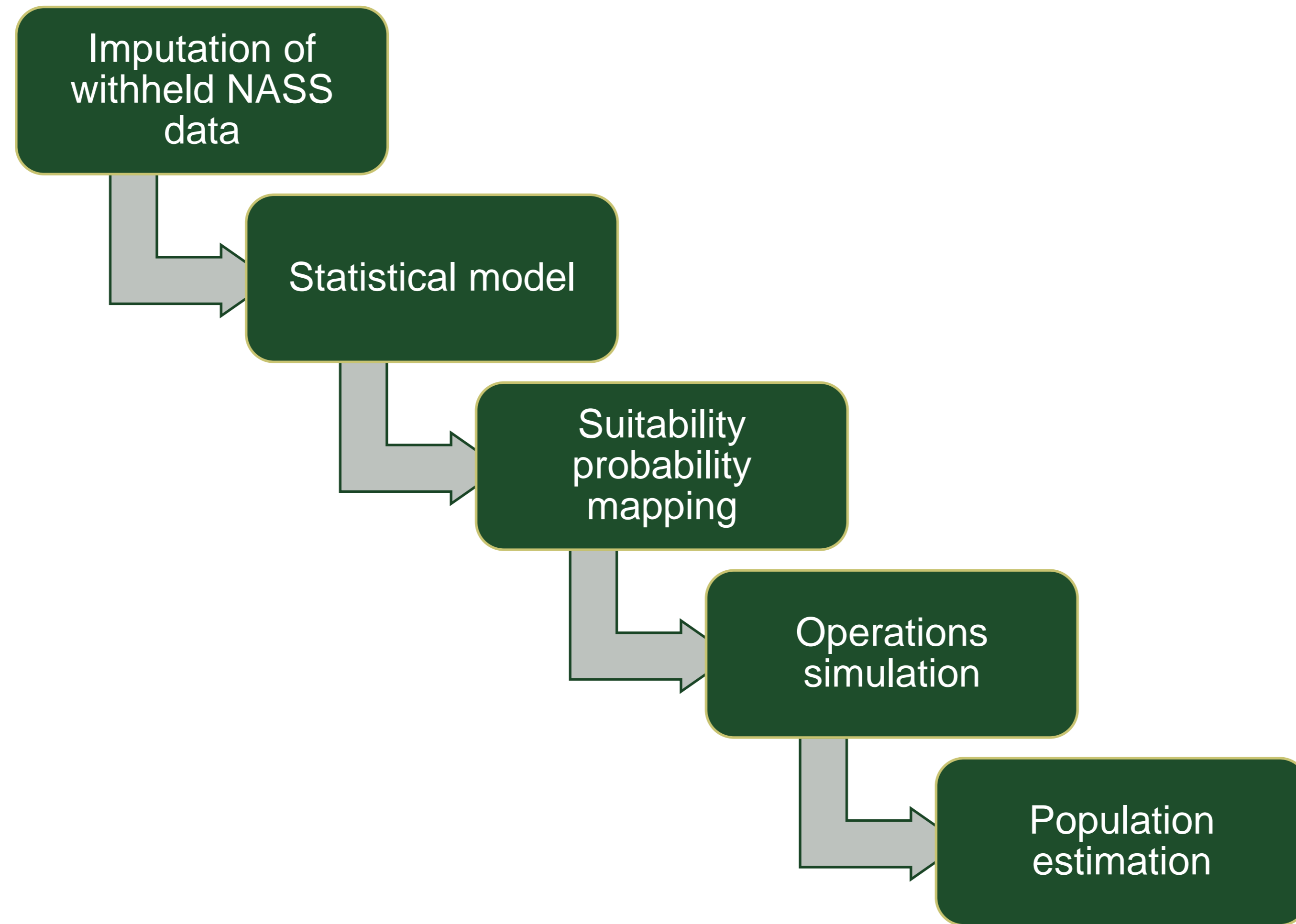


Suitability maps & operation simulation

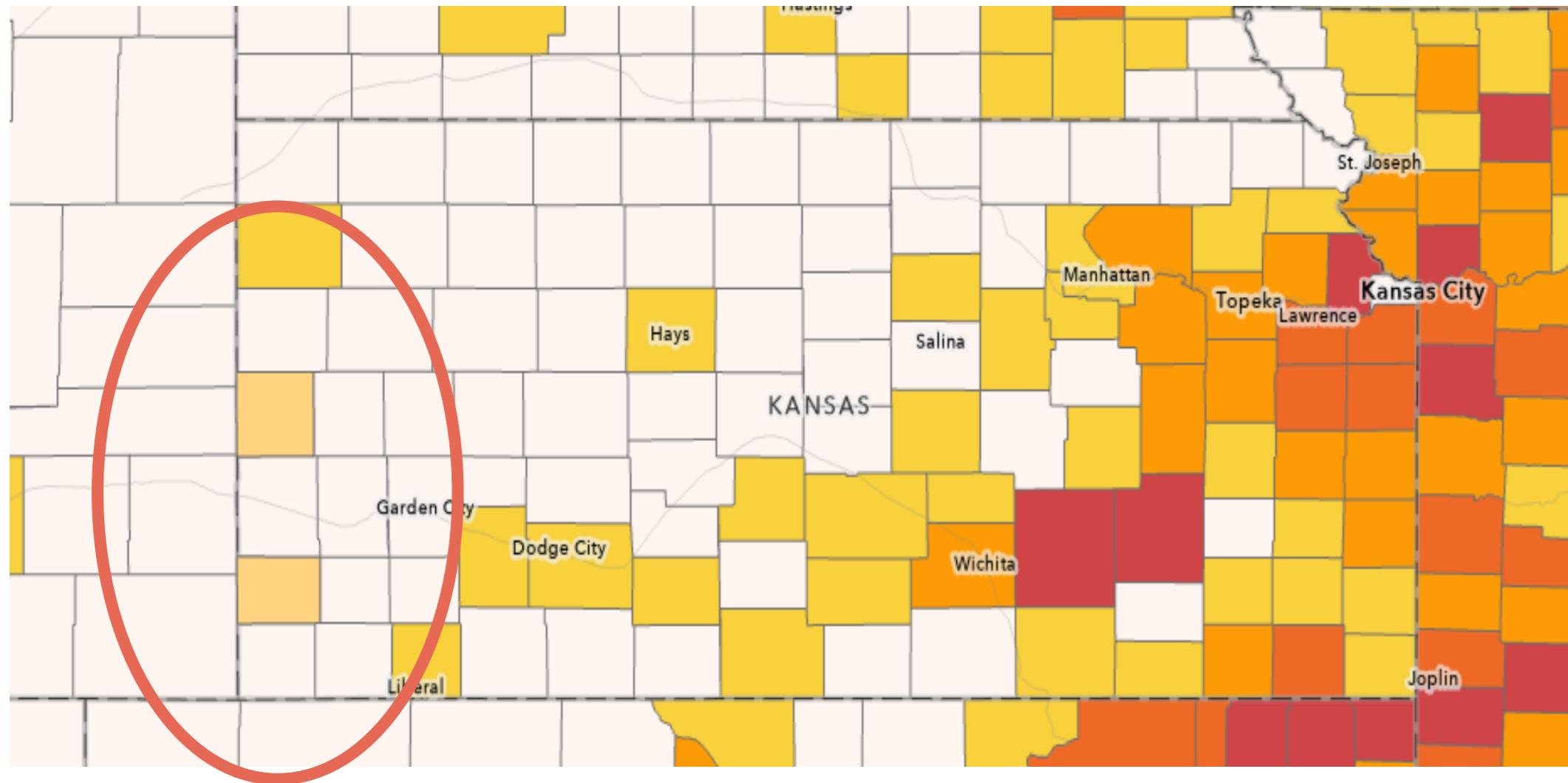
Integration: population estimation & validation

National Equine Operation & Population Dataset

Statistical Probability Map



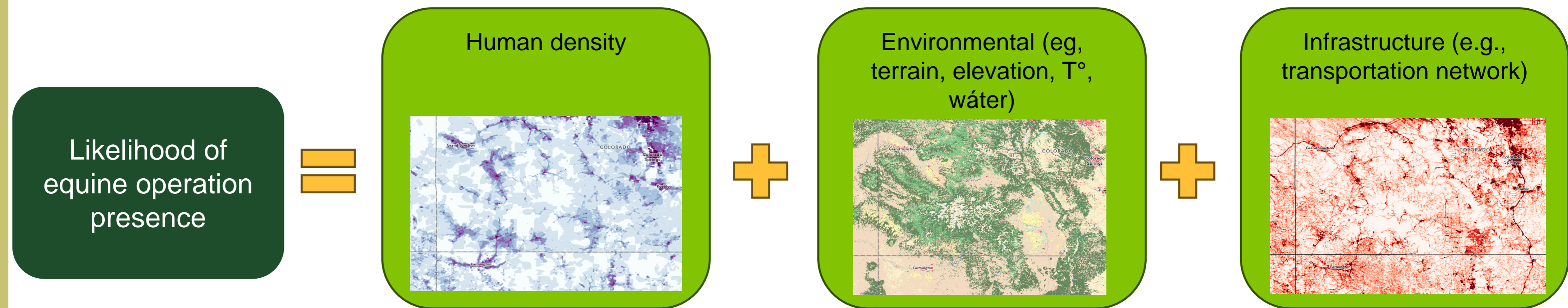
Statistical Probability Map – Imputation of NASS Data



- Deterministic imputation based on state totals

Statistical probability map – Statistical model

- Probability of equine operation presence modeled using environmental, demographic, and infrastructure covariates.



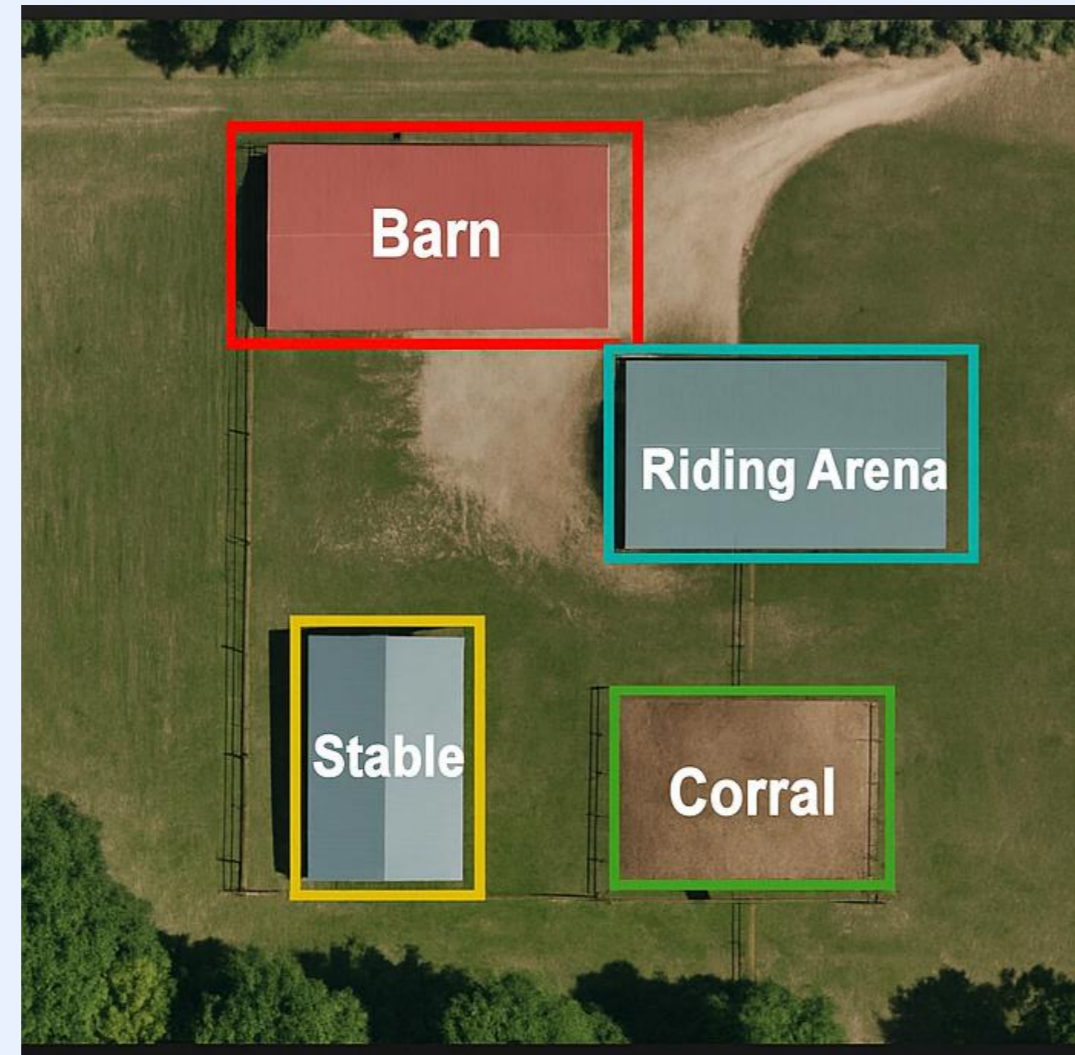
Data source: Living Atlas of the World (<https://livingatlas.arcgis.com/en/home/>); Esri's ArcGIS Pro v 3.x used for covariate development





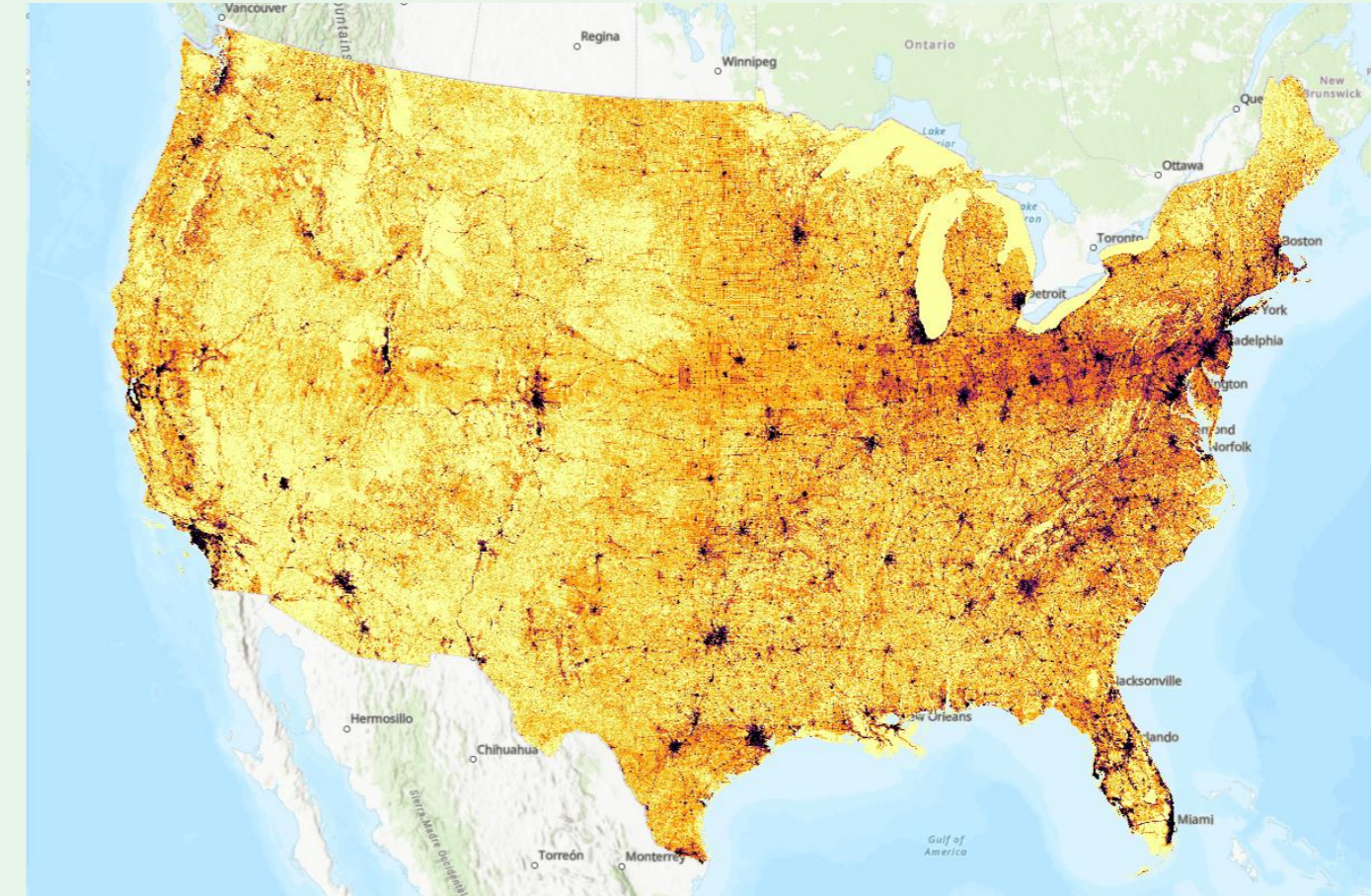
Preliminary Suitability Map

Geospatial Detection of Equine Structures Using Machine Learning and Remote Sensing (Geo-AI modeling)



Potential equine infrastructure

Statistical Modeling of Probability Suitability Maps for Equine Operations (Statistical probability map)



Suitability maps & operation simulation

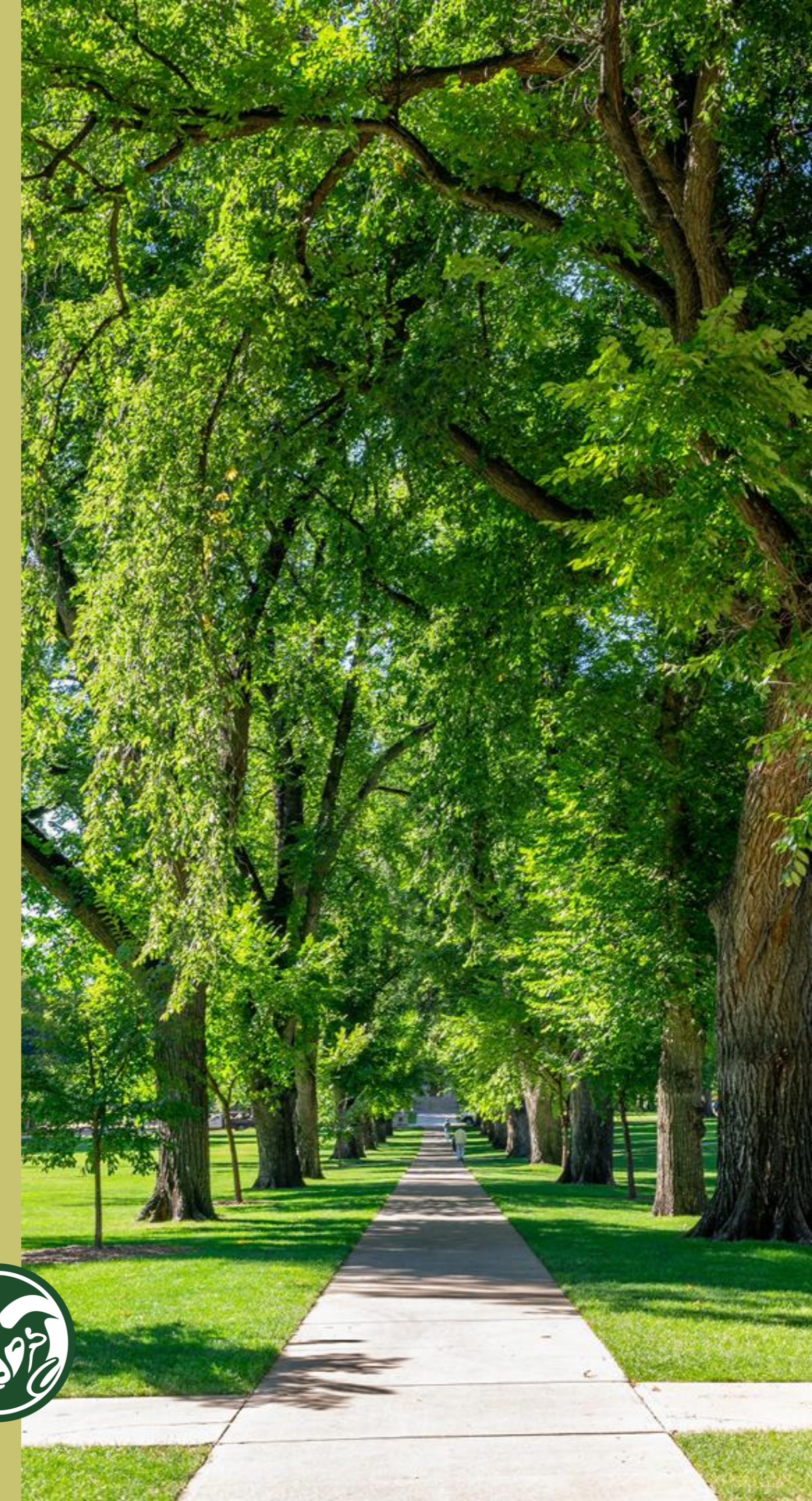
Next steps

Integration: population estimation & validation

National Equine Operation & Population Dataset

Takeaways & Discussion Points

- A national, operation-level dataset for equine populations does not currently exist.
- Our approach integrates two complementary methods:
 - GeoAI to identify and model equine operations
 - Statistical Probability Map to simulate operations.
- Integration provides population estimates adjusted for underrepresented horse populations.
- Density of operations is a critical factor in understanding disease transmission and outbreak dynamics.
- Results are designed to support preparedness, resource allocation, and epidemiological modeling.
- Feedback from industry and stakeholders will be essential for refinement and practical application.





**COLORADO STATE
UNIVERSITY**

Jairo Palomares:

jairo.palomaresvelosa@colostate.edu

Sangeeta Rao:

Sangeeta.Rao@colostate.edu

Joshua Reyling:

Joshua.Reyling@colostate.edu