

Project Description

**Mantle: A Data Fusion and Modeling Application to Forecast
Livestock Infectious Diseases**

Principle Investigator: Andrew Huff, Ph.D., M.S.

ETHA Proprietary

Executive Summary

The spread of infectious disease through livestock populations has the potential to deteriorate animal production systems, expose food systems to dangerous pathogens, stagnate the economy, and put the health of humans and animals at risk. The biological and economic consequences of a livestock infectious disease outbreak are costly, and recovery is often difficult or impossible. There is a growing need for tools that can anticipate these outbreaks before they happen to maintain the health and sustainability of these highly interconnected systems. Mantle, an open-source web application that allows users to share, curate, analyze, and visualize public and animal health data to help analysts identify the next infectious disease outbreak. Mantle will house diverse environmental and health data sets, and provides researchers with powerful tools to analyze and visualize infectious disease threats before they occur. This gives analysts and policy makers more time to prevent and respond to infectious disease threats.

Background & Motivation

The health of humans, animals, and the environment are inextricably linked, and infectious disease outbreaks in livestock populations profoundly affect health systems on multiple levels. Mitigating risks of infectious disease in livestock is also essential to protecting food production systems and the global economy. Increasing globalization of animal markets intensifies the need for integrated and adaptable real time biosurveillance tools to detect and respond to infectious disease threats, before they manifest and damage these tightly coupled systems. Rapidly increasing animal and human populations reaffirm the need for healthy food production systems, especially in the face of environmental degradation due to climate change and other anthropogenic causes (e.g., bioterrorism, agroterrorism, ecoterrorism).

Additionally, 60 percent of new diseases introduced into the human population are zoonotic (Jones 2008). Domesticated animals are often vectors through which host species and humans interact (e.g., Nipah virus spread from fruit bats to humans through domesticated pigs) or are themselves the locus of pathogen evolution, particularly in anthropogenically modified ecosystems like industrial food production environments (Leibler et al 2009). Additionally, urbanization, the intensification of animal production, and lengthening of production supply chains are increasing the risk of global spread of animal pathogens (FAO). Counter measures to infectious disease outbreaks in domesticated animal populations (e.g., culling, importation bans, selected slaughter) are costly and crippling to the public and private sectors as was evident with the United Kingdom's Bovine Spongiform Encephalopathy outbreak in the 90's, or the 2015 Avian Influenza outbreak in the U.S., which cost the U.S. egg and poultry market over 900 million dollars USD (Fortune). For diseases like African Swine Fever (ASF) where no vaccines exist and mortality rates are 100%, preventative action is especially crucial to protecting global trade of these affected animals (Penrith 2009). A tool that enables real time biosurveillance and risk assessment of these potentially catastrophic outbreaks is necessary, and Mantle fills this gap in analytical capability.

Opportunity Statement

Mantle is a software application that enables scientists and policy makers to explore highly complex public and animal health questions in real time through a user friendly interface. Mantle will address the biosurveillance and risk assessment gaps outlined above by providing the necessary tools to upload, curate, and share large data sets, and model and visualize the most pressing livestock disease threats. Mantle will offer analytic tools, and a repository of existing data and knowledge to enable non-data scientists to easily and efficiently analyze and

model disparate big data to increase the speed and efficiency of public health research and action.

Mantle will allow faster response to livestock infectious disease threats as data can be continuously uploaded, validated, and modeled via Mantle's API, rather than waiting for data to be collected and integrated after infectious disease threats are identified. Open access health and animal data, and open source biosurveillance software, will help infectious disease and biosurveillance research advance, and Mantle will fill a critical gap in emerging infectious disease knowledge and infectious disease preparedness.

By incorporating previously developed metadata standards, public health ontologies, environmental data sets, and existing animal disease models, Mantle will be designed to meet the data needs of a wide variety of public health users. Public health researchers, in the office, field, or the lab, will be able to upload a wide variety of unstructured and structured datasets to Mantle in a variety of commonly used formats. Mantle will also feature a mobile app component to easily collect and upload data from the field.

Mantle will feature a number of open-access datasets from EcoHealth Alliance's partners that will be openly available for users to combine with their own data or content. Using these existing data sources, Mantle engineers and scientists will design, test and implement models into a Mantle forecasting application. Modeling development efforts will be focused on forecasting diseases affecting domestic livestock populations most integral to the maintenance of healthy production systems (e.g., cattle, pigs, buffalo, deer, elk). Development will focus on high risk diseases currently affecting this sector globally (e.g., Foot and Mouth disease, Brucellosis, Trypanosomiasis, Leptospirosis, and Q-Fever, African Swine Fever) and diseases will be selected in combination with EcoHealth Alliance's partners at CEEZAD, DHS, USDA, FDA, DTRA, and DoD.

Market Analysis

The goal of Mantle is to put this advanced technology into the hand of industry and policymakers. The field of infectious disease forecasting is expanding rapidly, and there is increasing demand for real time biosurveillance and risk analysis tools to inform both public and private sectors. While some disease forecasting tools are under development (DTRA's BSVE), these tools are aimed at human diseases. Mantle will uniquely provide access to high fidelity infectious disease data and forecasts that will help enable scientists, practitioners, and policymakers to tackle the world's biggest infectious disease threats. Mantle will be developed in a generalizable, reusable, and scalable manner.

Co-sponsors

Mantle is primarily sponsored by the Department of Defense, Defense Threat Reduction Agency. DTRA's investment will aid the development of machine learning metadata prediction and assignment capabilities, which will improve Mantle's ability to ingest and process a wide variety of data feeds and sources to be used in livestock infectious disease models. This enables forecasts to be made continuously in near real time.

Expected Outcomes (long-term)

Once development of Mantle is complete, Mantle will become an application for sharing data and knowledge regarding the livestock diseases most integral to the health of human and animal populations, and animal and food production systems.

1. Mantle will store powerful and flexible livestock disease models to spatially and temporally visualize disease risk across multiple animal populations.
2. Mantle will enable analysts to identify areas at risk of spread before an outbreak happens.

3. Mantle will build a community of interdisciplinary users (e.g., scientists, policy makers, the public) and provide a platform for these groups to upload, share, integrate, and analyze their data and models.
4. Mantle will provide users a library of large environmental datasets for use in livestock disease risk assessment and will have a powerful mobile app version that allows users to view their data visualizations outside the lab or office.
5. Mantle will be able to ingest disparate data sources (APIs or uploaded data sets) and will offer a RESTful API for others to ingest or use Mantle data (back-end).

Measures of Success

1. Mantle's disease forecasts will be able to accurately identify geographic regions at heightened risk of infectious disease spread risk.
2. Scientists and key public health stakeholders will become Mantle users and upload their datasets for use in the Mantle's forecasting interface. Mantle will attract an interdisciplinary community of diverse users through development of a powerful and easy-to-use user interface.
3. Mantle users will be able access and build upon a rich library of models and disease visualization tools to use in their own livestock risk assessments.

Planned Meetings, Workshops, & Conferences

Articles on Mantle's library of animal forecasting models will be submitted to risk analysis, information systems, infectious disease, animal health, food safety, and public health periodicals. Publications on Mantle's infrastructure will be submitted to computer science and information technology journals. Mantle will be presented at relevant regional and national public health and safety conferences. The budget includes funds to support travel costs associated with these conference presentations.

Intellectual Property & Licensing

Mantle is a free and open-source research and software development project, developed under the Apache License 2.0.

Transition Goal, Strategy, & Implementation

Once development of Mantle is complete, the technology will be open sourced and made available to developers, scientists, policymakers, and the general public. Mantle will be made freely available to biomedical researchers, and educators in the nonprofit sector within 1 year of project completion. Components of Mantle with discrete functionality will be hosted as separate software packages so that other projects can benefit from their advances.

Potential Issues, Risks, & Challenges

The primary challenge to Mantle is obtaining adequate funding to rapidly develop and test the software. Additionally, a potential barrier is gaining access to up to date human and animal viral occurrence and case count datasets to better model the spread of our target diseases. While the scientific community is moving toward open access data sharing practices, barriers still exist to free and public sharing of large data sets. A small budget is allocated to purchase data sets in cases where free collaboration is not possible.

Appendix A: 2 Year Mantle Budget

Cost Element	Year 1			Year 2		
	Rate	Hours	Total	Rate	Hours	Total
Principal Investigator	\$72.12	20	\$1,442.31	\$74.28	20	\$1,485.58
Engineer	\$57.69	416	\$24,000.00	\$59.42	416	\$24,720.00
Agriculture Epidemiologist	\$48.08	342	\$16,442.31	\$49.52	342	\$16,935.58
Research Fellow	\$24.04	416	\$10,000.00	\$24.76	416	\$10,300.00
Engineer	\$43.27	246	\$10,644.23	\$44.57	246	\$10,963.56
Total Direct Labor			\$62,528.85			\$64,404.71
Fringe Benefits (35.1%)			\$21,947.63			\$22,606.05
Total Labor Burden			\$84,476.47			\$87,010.77
Total Travel Costs			\$10,000.00			\$10,300.00
Student Tuition			\$30,000			\$30,000
Tuition Fees			\$900.00			\$927.00
Data Processing Services			\$8,000.00			\$8,240.00
Data Purchasing			\$1,400.00			\$1,442.00
Total Direct Costs			\$39,244.00			\$40,417.00
G&A (44.1%)			\$58,970.73			\$60,737.94
Total Costs			\$192,691.20			\$198,465.71
Kansas			\$50,000.00			\$51,500.00
TOTAL			\$244,212.89			\$250,242.38