

## **Modeling Pathogen Transmission in Long-tailed Macaques (*Macaca fascicularis*) on Bali using Agent-based GIS Modeling: Performance Considerations and Enhancements**

**Ryan C. Kennedy<sup>1</sup>, Kelly E. Lane<sup>2</sup>, Hope Hollocher<sup>2</sup>, Agustin Fuentes<sup>3</sup>, Gregory R. Madey<sup>1</sup>**

<sup>1</sup>Department of Computer Science and Engineering, University of Notre Dame

<sup>2</sup>Department of Biological Sciences, University of Notre Dame

<sup>3</sup>Department of Anthropology, University of Notre Dame

We combine agent-based modeling and GIS data to develop a useful and informative model that gives insight on pathogen transmission in macaques (*Macaca fascicularis*) on the island of Bali. Specifically, we use the Repast modeling toolkit coupled with the OpenMap, Geo Tools, and JTS Topology Suite spatial tools. This combination of technologies allows us to merge GIS data with our model, enabling us to more accurately investigate the effects of spatial dynamics on pathogen transmission. The agents in the model are macaques that are capable of carrying and spreading infection through interactions with each other and their environment. Their movement and decision making are influenced by Bali's geographical data. For a performance improvement, the macaques in the model interact with the landscape by mapping their latitude and longitude coordinates to a preprocessed array that holds geographic data. In our case, this is much faster than simply using functions from the spatial tools to mathematically calculate a macaque's local landscape based on its latitude and longitude. Our model features a rich GUI and is extensible to both new GIS data and additional agents. Currently, we utilize 8 GIS layers in addition to the macaques. To date, we've found that landscape has a significant effect on pathogen spread. This work will help us better understand the nature of such pathogen spread and is particularly important because of the emergence of several zoonotic diseases on the Asian landscape.