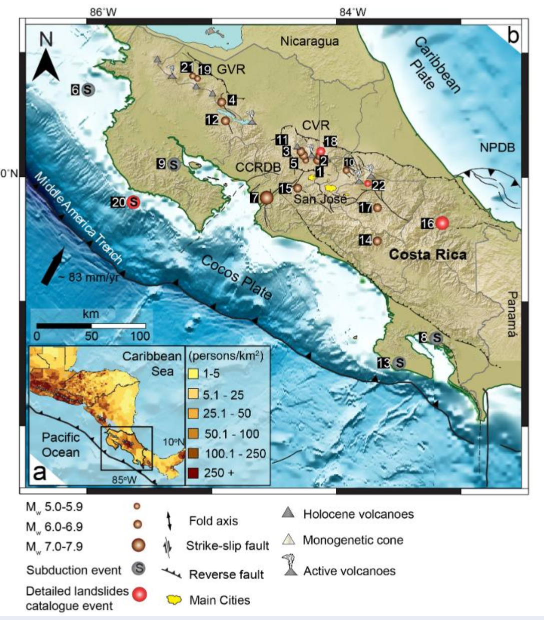


Figure 9 (Left): Map of Costa Rica with the detailed landslides catalogue events marked as well as main cities and volcanoes. (Paulo Ruiz)

Rutgers
Aresty Research Center for Undergraduates

Mapping Historical Landslides to Develop a Local Probabilistic Model in Costa Rica

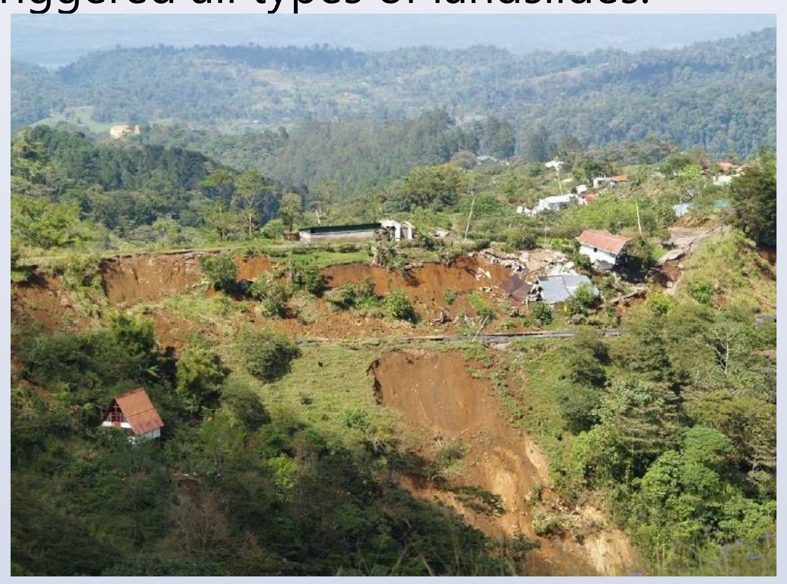
Andrew Marden, Lea Vecchiarelli, Paulo Ruiz

Aresty Research Center for Undergraduates, Rutgers University

University of Costa Rica

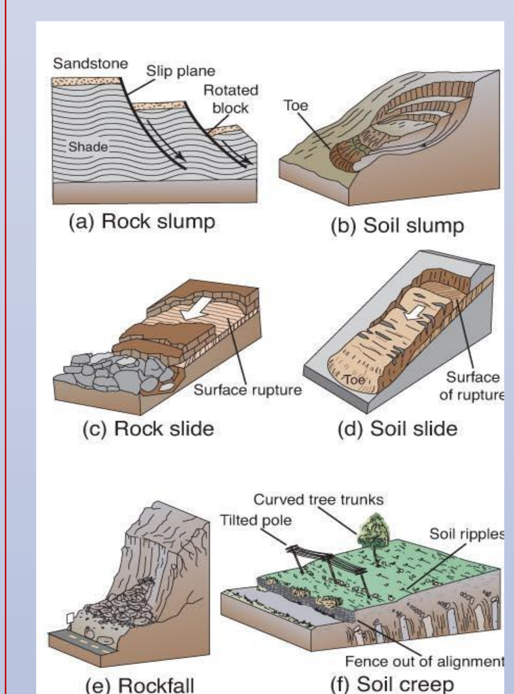
Introduction

A landslide is the movement of a mass of rock, debris, or earth down a slope, and they can be triggered by volcanic activity or an earthquake event. Landslides in Costa Rica are common, destructive, and the primary cause of death during recent earthquakes. Costa Rica has experienced at least 22 earthquakes of a magnitude of 5.5 or greater since 1772 that have triggered all types of landslides.



Figures 1 (Left): Cinchona Earthquake (Magnitude 6.1) Costa Rica (2009, Paulo Ruiz)

Figure 2 (Right): Limon Landslide, Costa Rica (1991, Paulo Ruiz)



On the left are different types of landslides such as rockfall, rockslide, debris flow, and rock slump. These depend on the magnitude of the earthquake, the soil type and vegetations, and water content.

Figure 3: Landslides Types, Anna Nowicki Jesse

Below is a susceptibility model for the Cinchona landslide using LiDAR and remote sensing techniques to determine the likelihood of the area experiencing a landslide after an earthquake trigger event of magnitude 6 or higher.

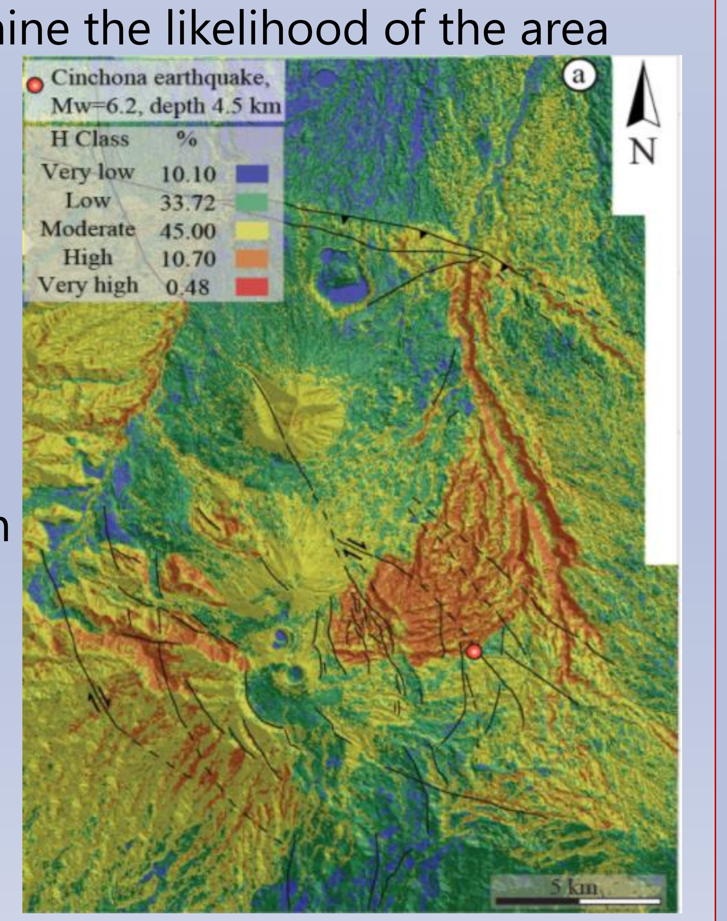
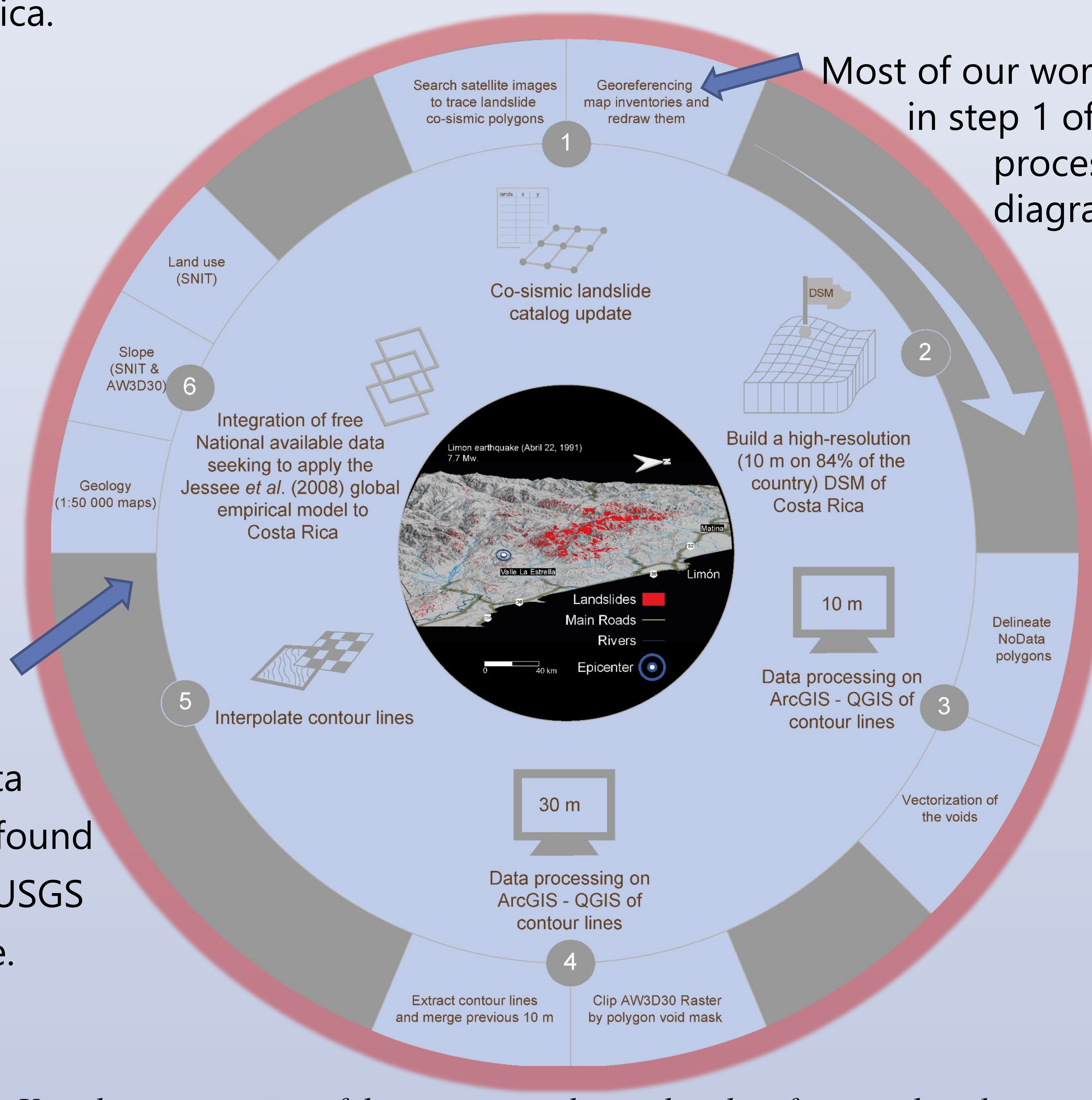


Figure 4 (Right): Cinchona Susceptibility Model (Paulo Ruiz)

By analyzing the factors typically resulting in a landslide event in Costa Rica, we aim to improve a local probabilistic model for the assessment of coseismic landslides in Costa Rica. This model can then be used to improve the monitoring and alert systems in the country.

Objectives

The goal is to utilize the inventory and data available from past earthquake triggering events in order to find the total area of landslides from Limon, Capellades and Cinchona. This data will then be incorporated into a program to analyze land use, slope, and geology to create a global empirical model of Costa Rica.



Most of our work was in step 1 of the process diagram.

This data can be found on the USGS Website.

Figure 5: Visual representation of the process used to gather data from earthquake events and to process it and put it in the model (Paulo Ruiz)

Results

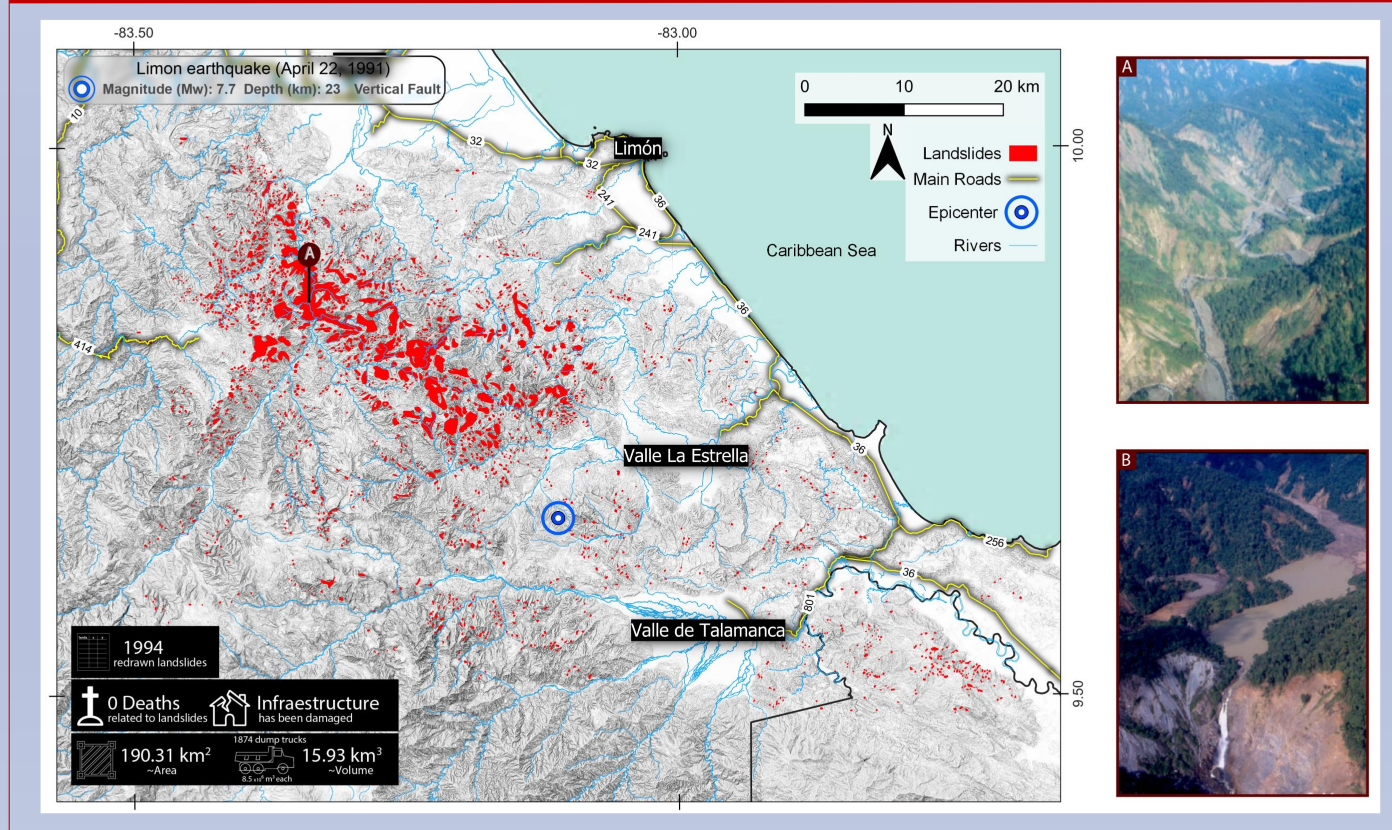


Figure 8: The final landslide map created from the 1991 Limon(Magnitude 7.7) Earthquake combining all of the polygon areas (Paulo Ruiz)

The landslide data gathered from the four earthquake events was put into a global predictive model, which is meant to better predict where landslides will occur. The model did not have data from Costa Rica, so data was contributed from a new region with a different set of factors that might cause landslides. This will help improve the accuracy of the model so it can have broader applications.

Methods & Materials

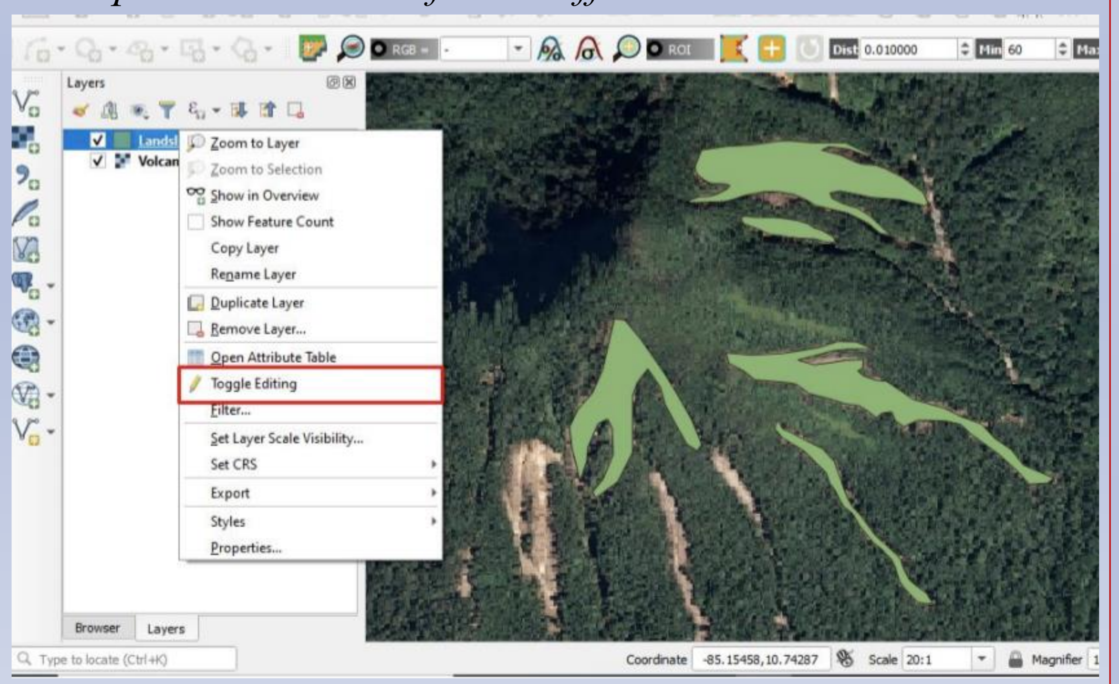
Gathering data on landslides required either finding an existing map of landslides or creating our own. Google Earth was used to look at the land immediately before and after the landslide to determine where they had occurred. The polygon function was then used to trace over the exposed areas that showed where the landslides had occurred. The polygons were saved into one shapefile and then transferred to ArcGIS where data about the landslides from the earthquake could be obtained, such as total area displaced and distance from the epicenter.

Figure 6: Google Earth Images for the 2016 Capellades Earthquake (Magnitude\ 5.5). Left: Before landslide, Center: After the landslide, Right: Area

This was done for multiple landslides triggered by different earthquake events throughout the country.

Figure 7: Limon landslide QGIS image during the polygon process of the data analysis. Using the 'toggle editing" tool over the Google Earth image we were able to use outline the outsides of each separate landslides for the effected area.

Statistics can be viewed about each separate landslide polygon such as the area, and latitude and longitude under the attribute table. This can then be used to find the total area affected and combined the results into a larger map to be overlapped with other data.



Future Work

After the work was incorporated into the first step of the process diagram in Figure 4, the rest of the team was able to integrate our data into the global model and submit the cataloged landslide data on the USGS website for public access along with further information about Costa Rica topography and landslide distribution data using field work and remote sensing techniques (LiDAR, satellite images and drone aerial photographs). Future work for this project includes repeating the same data analysis for more historical landslides to further improve the local model, and therefore the global model, as well as doing this same process in areas where they lack global public landslide data.

References: Paulo Ruiz, Anna Nowicki Jesse, Google Earth, QGIS

Acknowledgements

We would like to thank Paulo Ruiz and his research team; Joan Valverde, Natalia Rodriguez for teaching us about landslides, providing us with the images and background knowledge and giving us the tools to map the landslides. We would also like to thank Anna Nowicki Jesse, Dylan Seal and Michael Hamburger from the Indiana University for allowing us to be part of the global empirical model project for the USGS. As well as our research advisor Vadim Levin.