Bryan Ott
Geo 327G
Fall 09 Semester Project

What areas in the Aure fold and thrust belt of Papua New Guinea are most prone to erosion?

Background:

In the late Miocene, transpression along the northern portion of the Owen Stanely fault zone initiated folding and thrusting in the Aure trough region of Papua New Guinea. A previous study used offshore seismic lines to map the outer 75km of the fold and thrust belt. Crestally eroded anticlines overlain by volcanic deposits helped to narrow the timing of deformation in the area. This study will focus on locating the modern day areas of erosion in the onshore portion of the fold and thrust belt. If the same tectonic processes that caused the late Miocene unconformities (now seen offshore) are still in effect today, then you should see that the most erosion is occurring at the crests of the onshore anticlines. For this study, a slope calculation will be combined with present day rainfall totals, soil type, and major rivers, to determine the areas that are most affected by erosion. Results will be ranked from low (green) to high (red) rates of erosion, and be shown on a map of the 19,000km^2 study area.

Data Collection:

This project used GIS data from multiple online sources, and a few files taken from the Paul Mann PNG directory at UTIG. ASTER data was downloaded from the California Institute of Technology's Jet Propulsion Laboratory website (http://asterweb.jpl.nasa.gov/gdem-wist.asp). This data was used to create a DEM of the country. Political boundaries for PNG were downloaded from www.geocomm.com in E00 format. Soil and precipitation maps were found at the European Digital Archive of Soil Maps website (http://eusoils.jrc.ec.europa.eu/esdb_archive/EuDASM/Asia/lists/cpg.htm). Bathymetry maps for PNG were already created in the PNG directory, and came from the GEBCO one minute global bathymetry grid. A digitized geologic map was also taken from the PNG directory, but was not used in the final results (explained later). Shapefiles containing river and stream drainage systems were used and taken from the PNG directory.

Preprocessing:

GIS data for this project came from three sources and used three different preprocessing techniques to make the files ArcGIS compatible. The first preprocessing technique was applied to the ASTER data. ASTER data was downloaded from the JPL website as image (.tif) files. A search was performed on the website to obtain the ASTER images for the desired coverage. In my case, a search was done for the entire island of Papua New Guinea. After the files are selected, they are accessible via FTP download. Once the files are downloaded they must be unzipped and saved. After this, each file can be brought in to ArcMAP to be quilted together. Once the entire country is assembled, the files are merged and saved. The data is then projected in UTM55S, and only the mainland values above 0 are preserved. This will cut off the ASTER data at the coast. Once this step is done, a hillshade was created for the country. A natural looking color ramp was applied to the file to enhance the relief (Figure 1). Metadata was then added to show where the images were obtained from.

The next preprocessing step used for the political boundary shapefile. This file was downloaded from www.geocomm.com in E00 interchange format. To uncompress this file, I used "Import71.exe" found in the ArcGIS/bin folder. This process does the same thing as the "Conversion->To Coverage" tool. Once converted, it was projected in the same coordinate system as the project. Metadata was added to show where the file was downloaded from.

The final method used in preprocessing was used to digitize the soil and precipitation maps. These maps were found online and saved as JPEGS. The maps were then imported to ArcGIS and georeferenced. I picked notable coastal features from these maps, and used the political boundary shapefile to match these features. Metadata was added describing the origin of these maps, as well as adding the project's coordinate system.

Processing:

To process my data and arrive at a conclusion, a processing scheme was set up. First, all the files that are to go into the erosion equation must be clipped to my area, and be polygons. The next step is to create rasters from the polygon shapefiles. After that, each raster must be reclassified to specific values, in this case, numerical values of one, two, three, and four were used. The number four was determined because the soil and precipitation maps each had four values in the study area. After each raster was reclassified, a raster calculation was done. No weighting was used because not variable tested seemed to have a greater affect on erosion than the other.

The first map that was digitized was the soil map (figure 4). Figure 4A shows the map that was downloaded from the internet. The map was clipped to the study area and digitized (4B). The shapefile was originally a polyline file, but was converted to polygon in ArcCatalog after completion. The four soil types and ranks (from least to most erosive) were: 1. Saline Peats, Muds, and Sands, 2. Half Bog/Alluvial Soils, 3. Red and Yellow Latosols, and 4. Regosolic Brown Soils (4C and 4D). Once named, each polygon was reclassified using the spatial analyst toolbar to the fore mentioned values. Latosolic and Regosolic soils tend to be immature soils and are found in rainforests. Peats and bogs tend to be more mature soils, and are more compacted. This was the rational behind the rankings.

The next map digitized was the precipitation map. This was done in the same manner the soils map was digitized. The original map (5A) was clipped, digitized, and converted to a polygon shapefile. Each polygon was then appropriately assigned values from the map (5B). The amount of rainfall and ranks (from least to most erosive) were as follows: 1. 1000mm/yr, 2. 1500mm/yr, 3. 2500mm/yr, and 4. 3500mm/yr (5C and 5D). Once each polygon was assigned a value, the feature was converted to raster using the spatial reference toolbar. Naturally, the more rainfall an area sees, the higher the rates of erosion will be.

After this, a slope calculation was done using the ASTER data (Figure 6). The clipped aster data from Figure 3 was used. The tool used was a surface spatial analyst tool called slope. Once the calculation was done, slope intervals were assigned and ranked as follows: 1. 0-10°, 2. 10°-20°, 3. 20°-30°, and 4. 30°-88°.

Lastly, the river shapefile was processed (Figure 7). The river shapefile covered the extent of the entire country and was clipped to the study area (7A and 7B). A buffer was applied of 400m on either side of the river (7C). This value was picked because it is twice the width of the widest measured portion of the river. Once the buffer was applied, a raster conversion was done (7D). Values within the buffered area were assigned four, while areas with no data were assigned 0. Four was determined due to the fact that these are wide, meandering rivers, with origins at higher elevations at the base of mountains.

Two other shapefiles were processed in the same way as these, but were not used in the project. Figure 8 shows a digitized geologic map that was found in the PNG directory. A raster was applied, and units were ranked. However, the person who made this file made a mistake when entering data in the attribute table. The file was made by digitizing multiple smaller maps and merging the tables. The smaller maps did not have a uniform lithologic description, so units do not correspond over map boundaries. This is evident in a linear feature along the left hand side of the map, and across the top. This problem could be feasibly fixed when ranking each unit, but the resulting calculation showed the same linear features, and corrupted the map.

The other shapefile that was thrown out of the project was a streams shapefile (Figure 9). This was processed in the same was as the rivers shapefile, with a buffer of 30m. However, due to the high concentration of steams, and small buffer zones, the converted raster came out illegible. This could have perhaps been fixed by using a smaller cell size, but the same occurrence happened when the cell size was set to the smaller increment ArcGIS could go. Since the distribution of streams seemed to be almost uniform in the deformed region, this variable was thrown out.

Once the four variables were in raster format, and reclassified accordingly, a raster calculation was done. As mentioned above, no weighting was used. The syntax of the calculation was: [Soils] + [Precipitation] + [Slope] + [Rivers].

The resulting map was ranked from three to sixteen. This scale was modified in the final figure (Figure 10) from numerical values, to low, moderate, high, and extreme rates of erosion, with numerical values in between.

Conclusions:

The highest rates of erosion occur around major rivers, especially at higher elevations, and in the highly folded region of the Aure fold and thrust belt. Two areas that receive noticeably higher erosion are a band through the center of the AFTB, and at the Aure scarp (Figure 11). The central band has a higher erosion rate than its surroundings due to steep slope, high precipitation, and erosive soil. The second area of high erosion occurs at the Aure scarp, where steep slopes (50^{o}-80^{o}) are the main control of erosion. The area of least erosion occurs in an area of low relief near the coast. The main controls here are flat slopes and low precipitation.

When comparing areas affected by erosion onshore today, the likelihood that offshore unconformities were formed by the same tectonic mechanisms acting today is slim. Perhaps the driving mechanism for deformation is the same, but the duration the anticlines were sub-aerial would have to be much less to only crestally erode the anticlines. The erosion today is much more extensive than the offshore counterparts. Due to the high rainfall, steams have incised valleys into the limbs of anticlines, and large rivers have cut through the landscape. No evidence of this much erosion has occurred in seismic sections. It is likely that the offshore anticlines were exposed for a short period of time during low stand. It is also possible that these anticlines were exposed and then covered by sediment due to local rapid subsidence of the area.

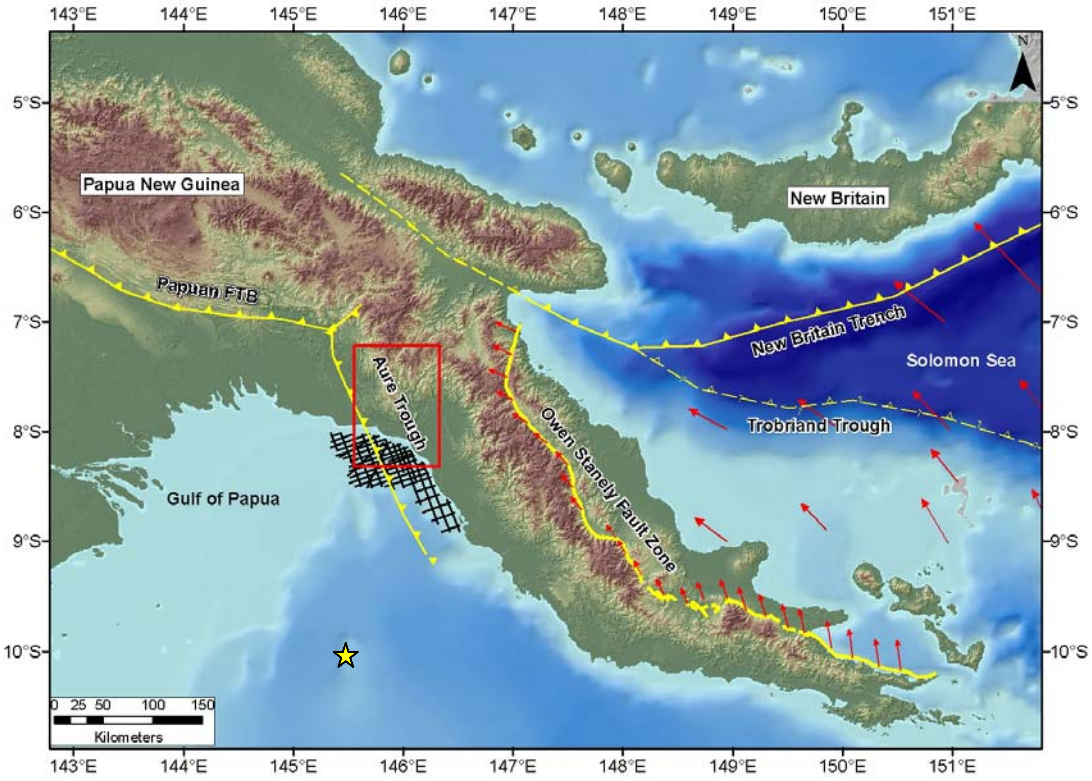


Figure 1

This figure shows the tectonic setting of the study area. Red arrows in the Solomon Sea represent GPS vectors for the Woodlark plate, while red arrows along the Owen Stanely fault zone (OSFZ) represent motion along the fault. The yellow star in the southern Gulf of Papua represents the pinning point of these vectors. Motion along the southern portion of the OSFZ is transtensional. This motion changes to strike-slip as you move toward the center of the fault zone, and becomes transpressional near the northern portion. This transpression is thought to be the origin of the Aure fold and thrust belt.

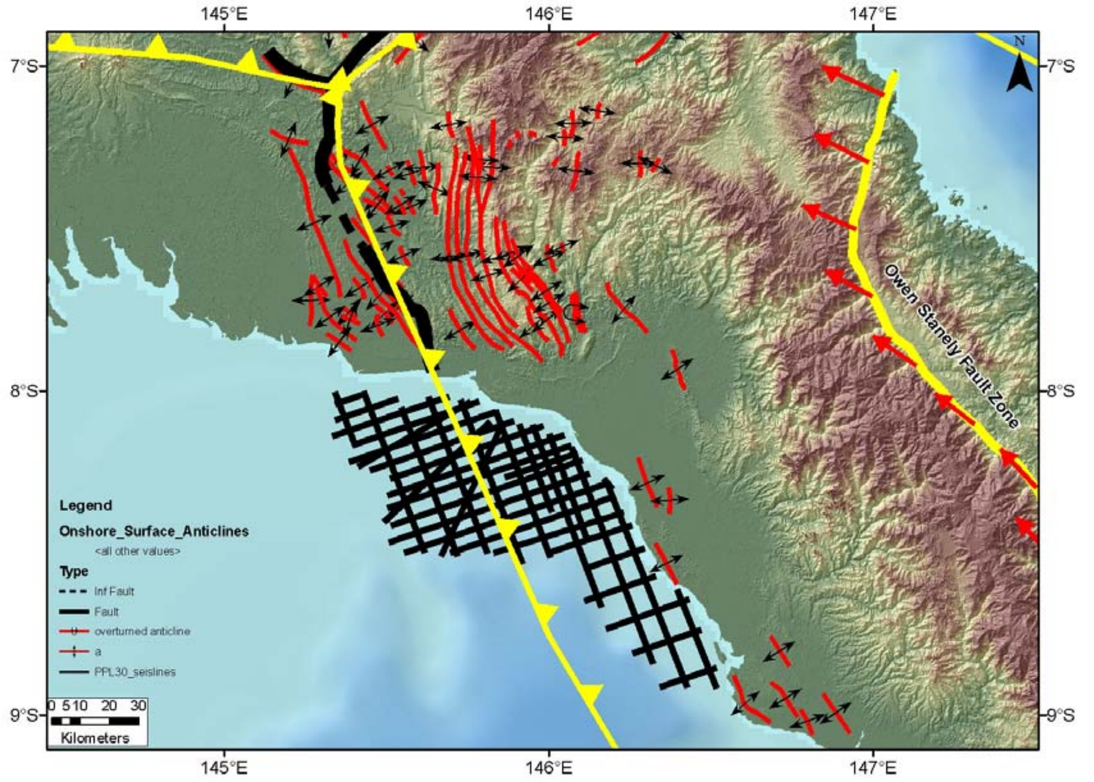


Figure 2

Here we see a close up of the study area. The major anticlines are labeled, as well as the seismic survey mentioned in the background information. The north-south trending yellow thrust represents the approximate location of the thrust front in the Aure trough.

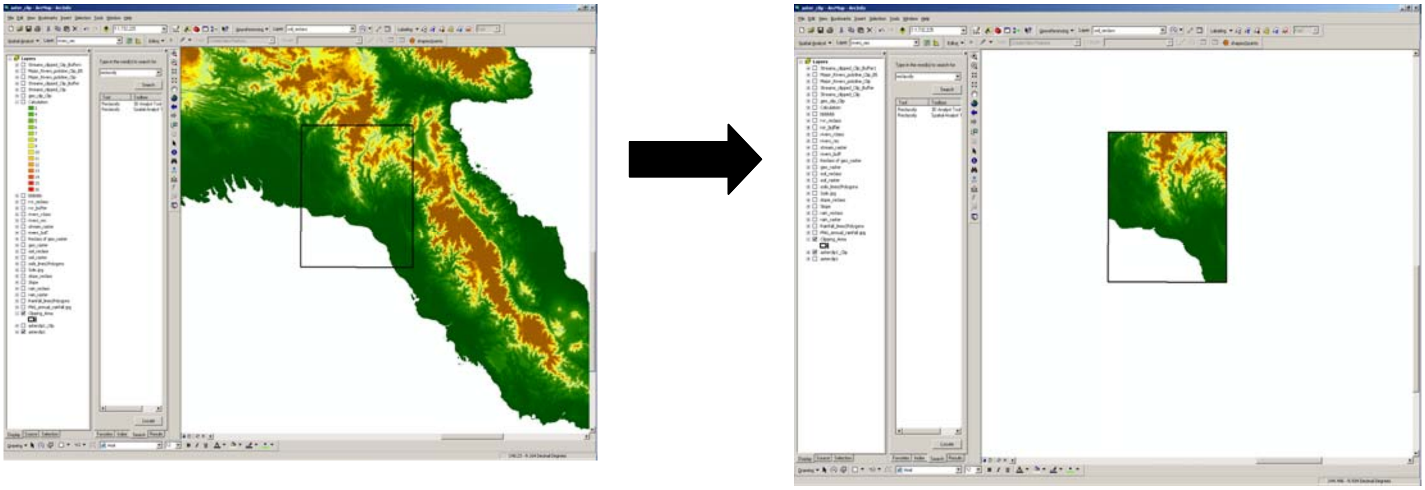
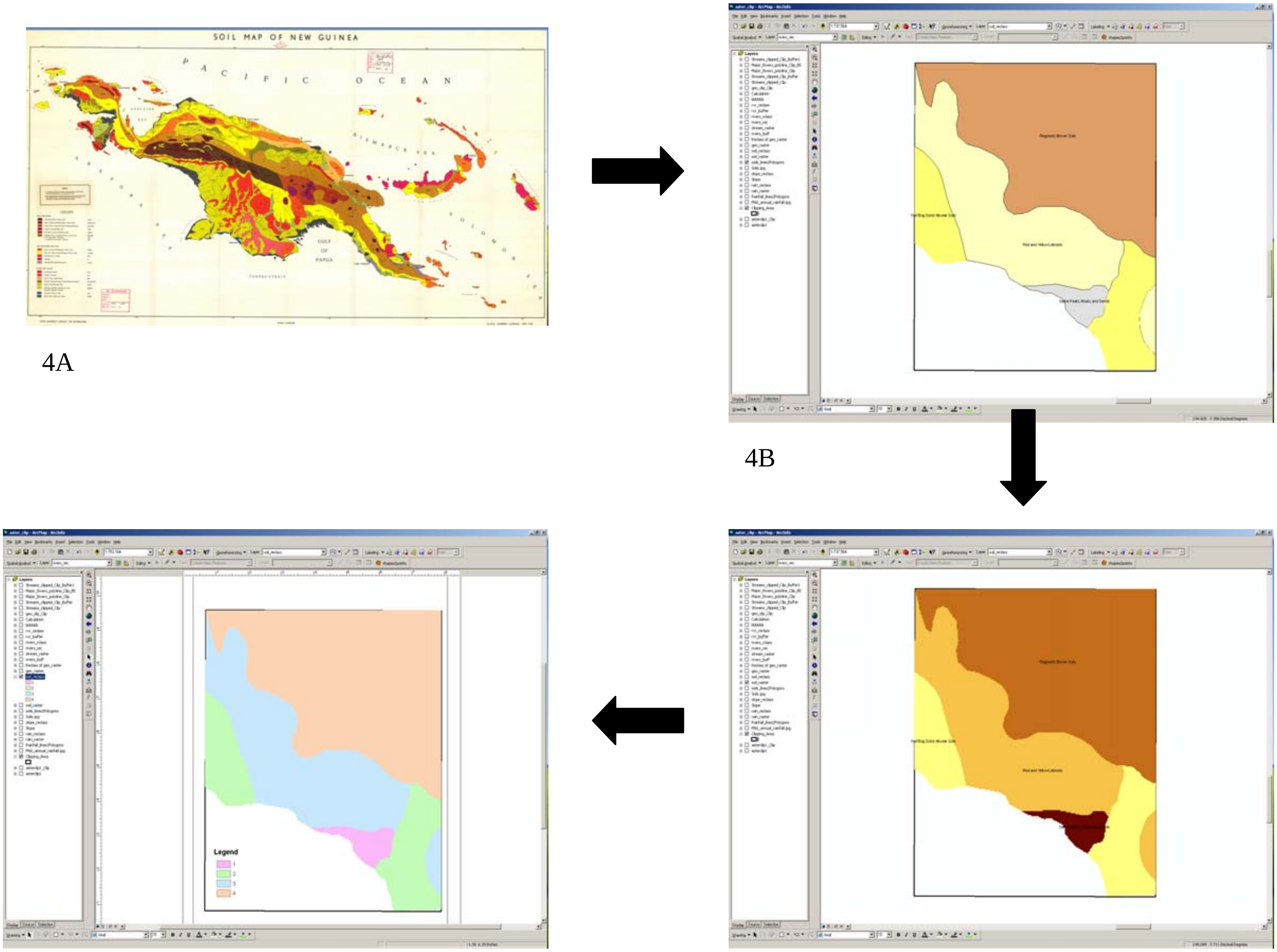


Figure 3: Clip of study area



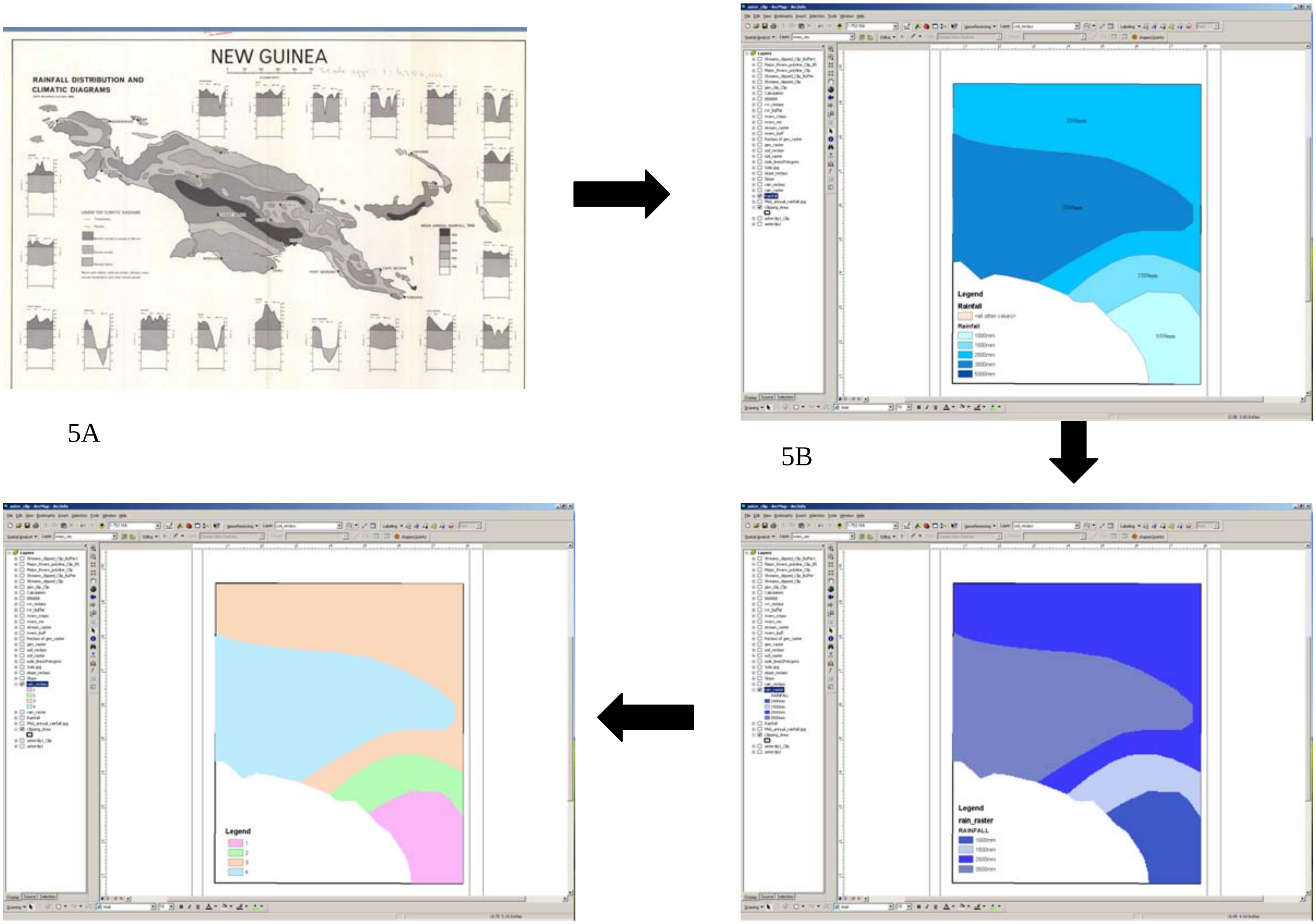
4A

4B

4C

4D

Figure 4: Workflow for the soils map



5A

5B

5D

5C

Figure 5: Workflow for the precipitation map

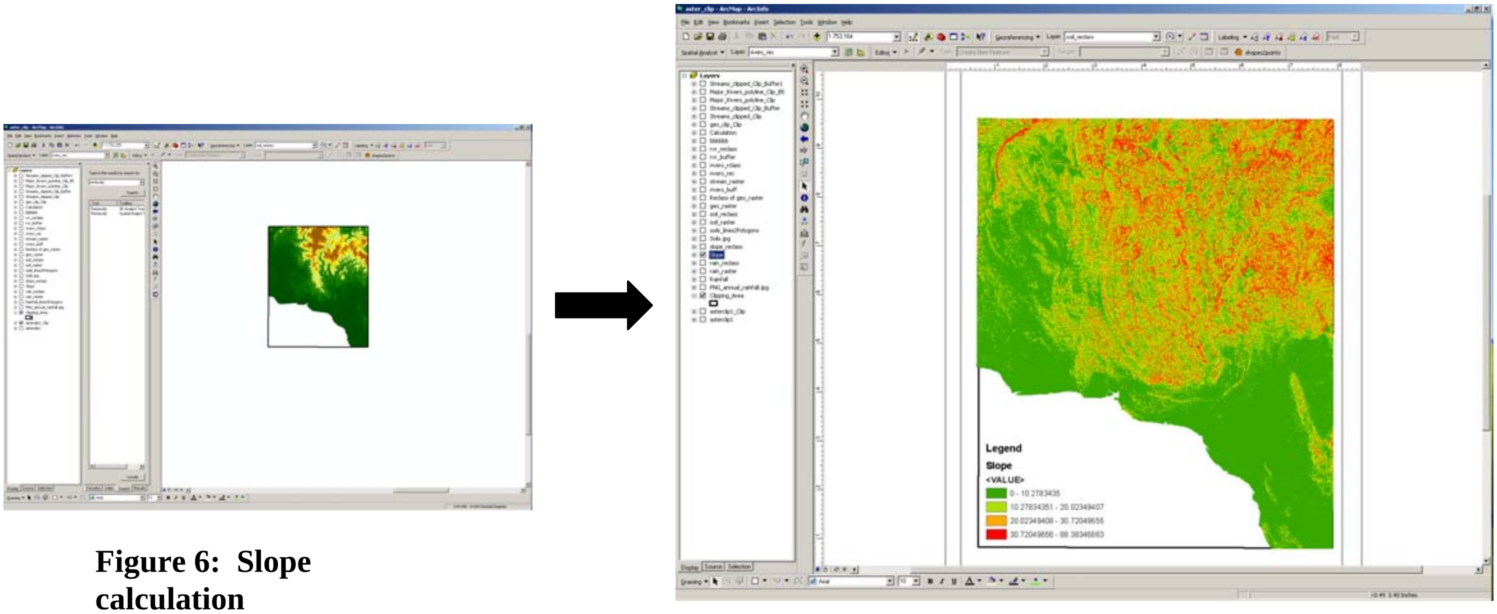
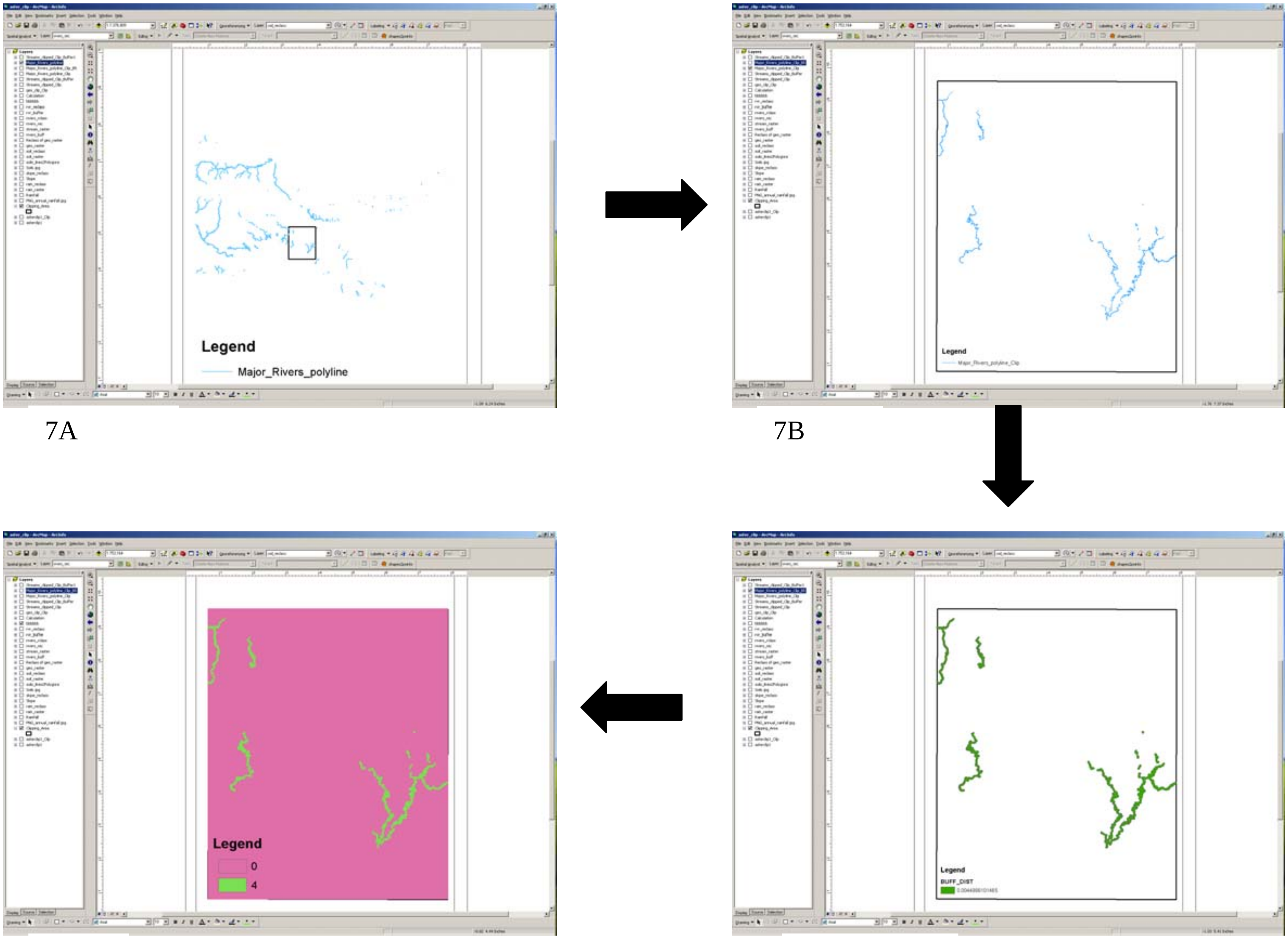


Figure 6: Slope calculation



7A

7B

7D

7C

Figure 7: Workflow for the rivers map

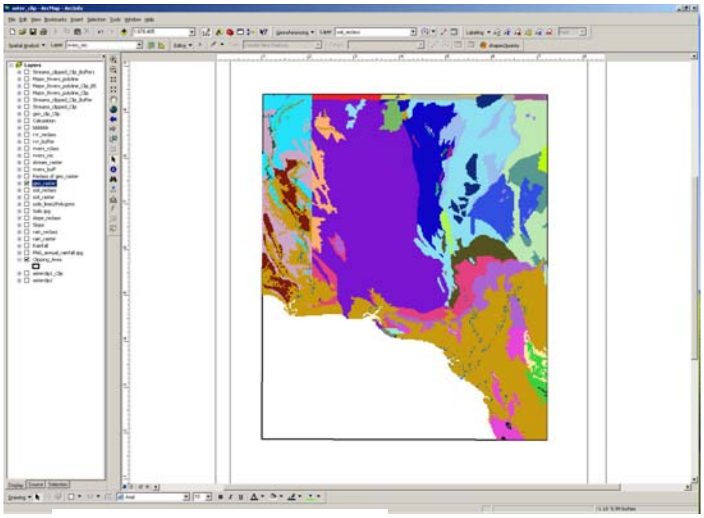


Figure 8: Geologic raster

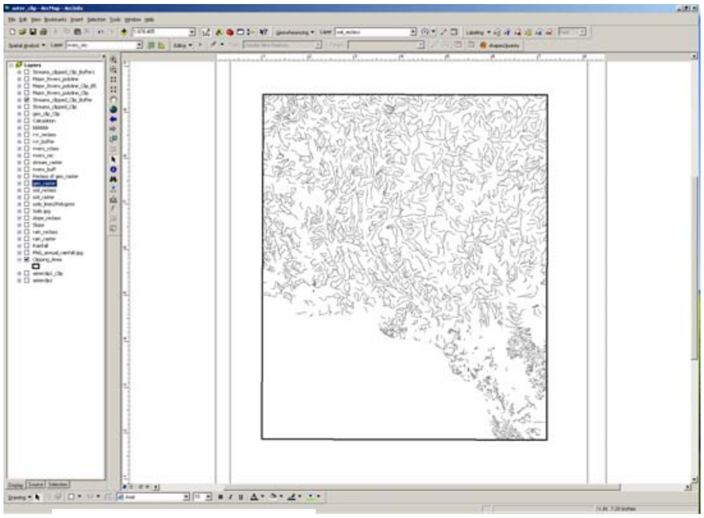


Figure 9: Streams buffer

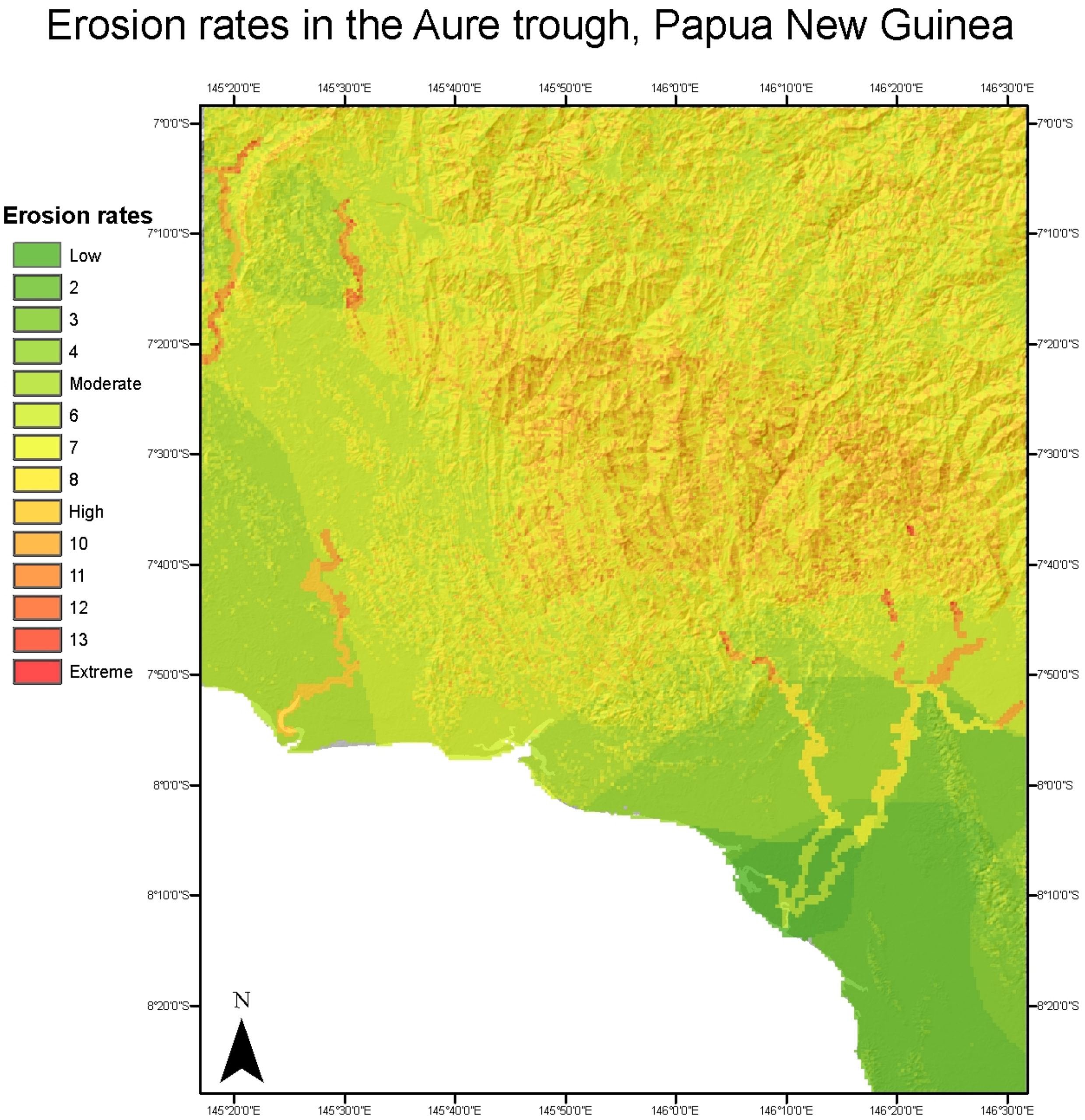


Figure 10: Highest rates of erosion are shown in red, while green shows low rates of erosion.

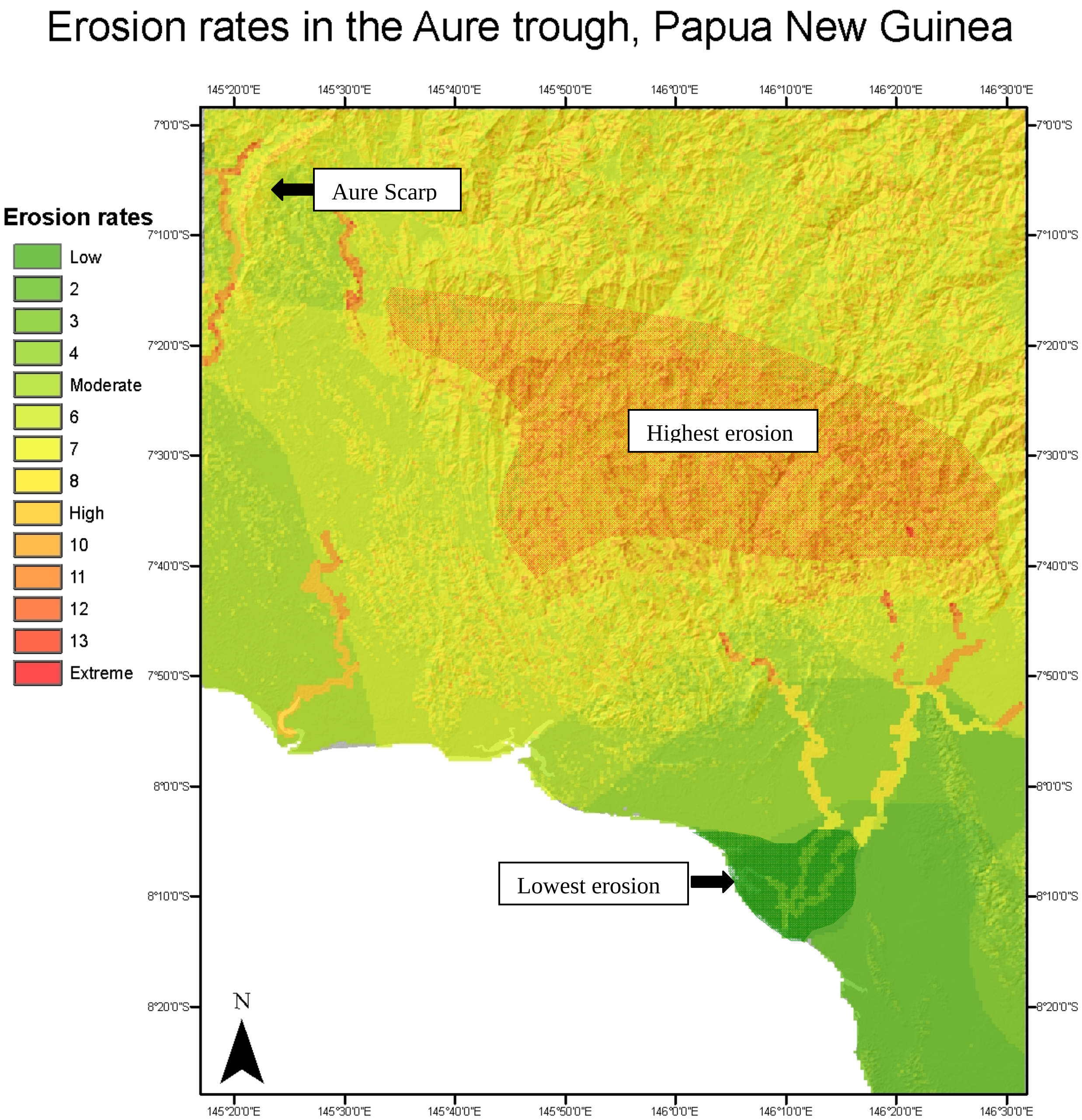


Figure 11: Erosion rates with labels