THE EXPLOSIVE TRUTH

Using Remote Sensing to Analyze the Environmental Effects of the 2011 Eruption of the Puyehue-Cordón Caulle Volcanic Complex

BACKGROUND & PROJECT GOALS

The 2011 eruption of the Puyehue-Cordón Caulle Volcanic Complex (PCCVC; Figure 1) is widely considered to be the worst volcanic eruption of the twenty-first century. Earthquakes rocked the surrounding area for several months prior to the eruption, and the ash cloud itself from the eruption rose to above 12km in height and 5km in width. The ash plume itself moved primarily to the east, effecting farming towns on the Argentinian steppe greatly. The nearby farming village of Pueyhue, Chile, however, was also dramatically affected by the violence of the eruption (Bignami et. al., 2013).

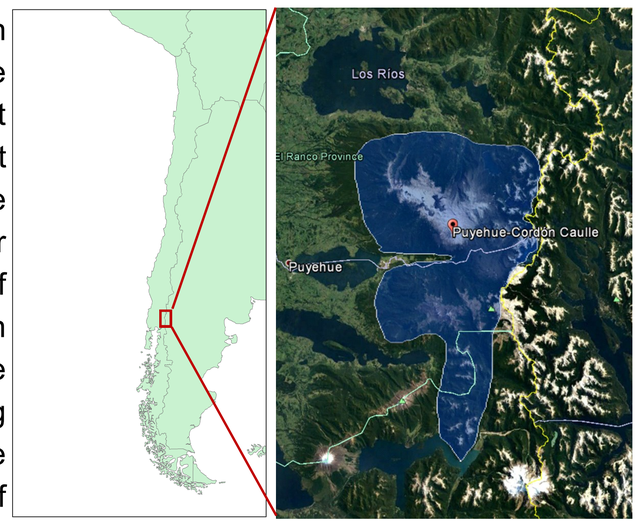


Figure 1. Map of South America, and a map obtained from Google Earth. The map of South America shows the processing extent for this project, and the Google Earth image has a blue polygon displaying the boundaries of Puyehue National Park. The yellow line represents the border between Chile and Argentina.

Examining the environmental effects of the 2011 eruption can help us understand how this volcano could do damage in the near, or distant, future. That is why this project was undertaken.

METHODS

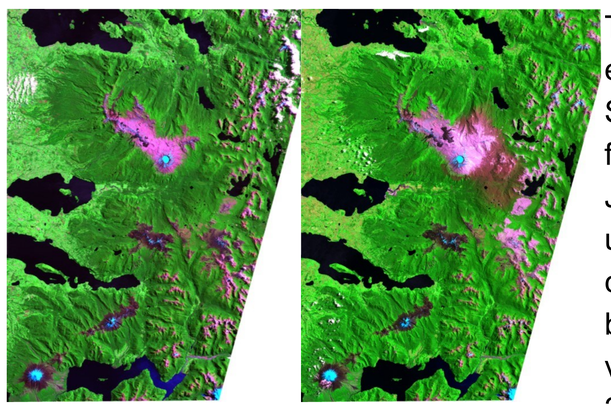


Figure 2. Multispectral Images; 2011 (left) and 2015 (right). A linear 2% stretch has been applied.

Two images were obtained from earthexplorer.org, and are both Higher Level Surface Reflectance Landsat dataset; one from February 18th, 2011, and one from January 28th, The images were displayed using the RGB = 7, 4, 2 (7, 5, 3 for L8) band combination. This is the preferred method because of how well it shows different vegetation features and rock types (Figure 2). The images were resized and masked to just include the area of Puyehue National Park.

Image Classification A supervised image classification using the Maximum Likelihood method was performed. Ground truthing was performed for this classification using Google Earth and documents from the Chilean National Park Service. The classes were Andesite, Basalt, Forest, Crop 1 (health), Crop 2 (fallow), and Crop 3 (dead; Figure 3).

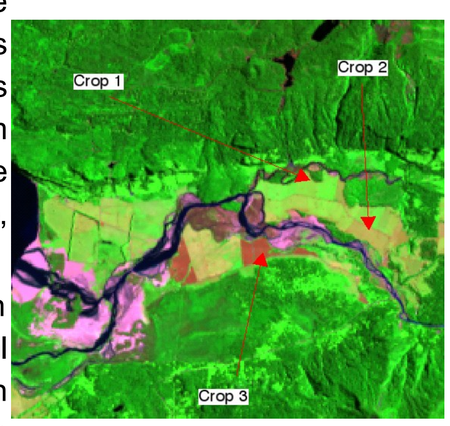
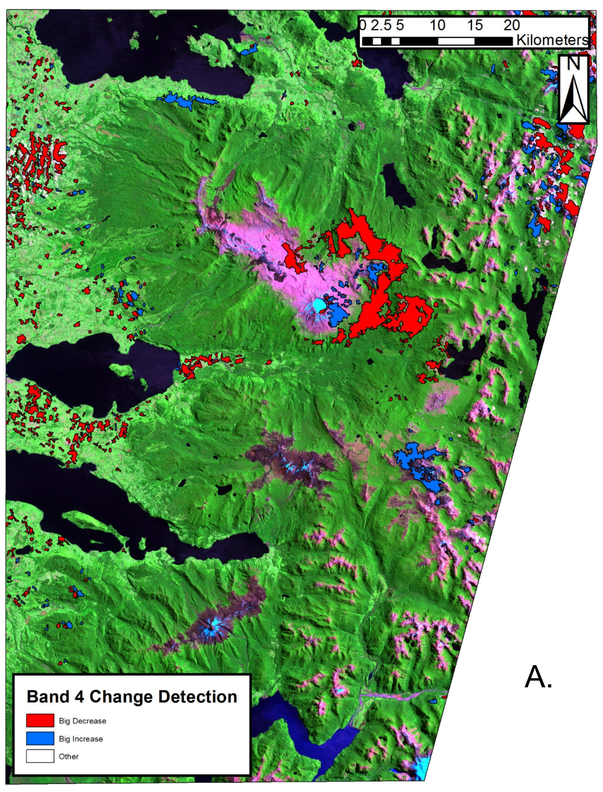


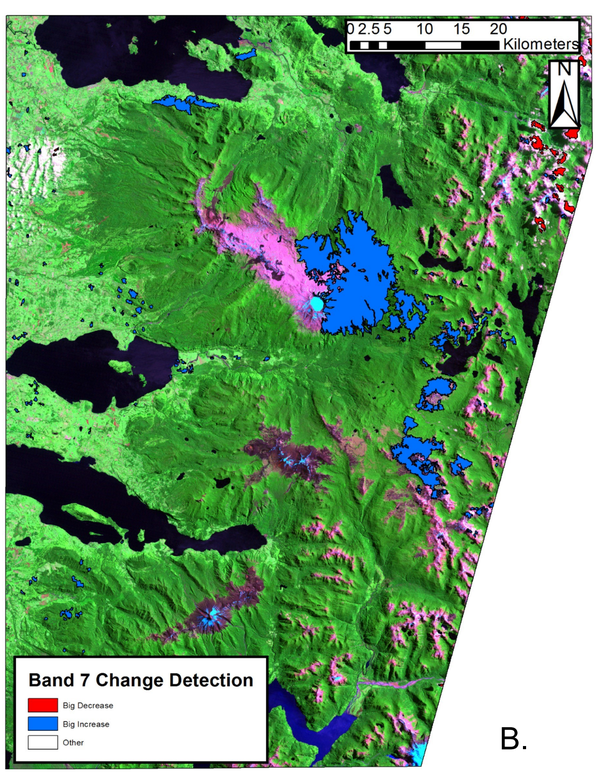
Figure 2. Image indicating the differences between Crop 1, Crop 2, and Crop 3.

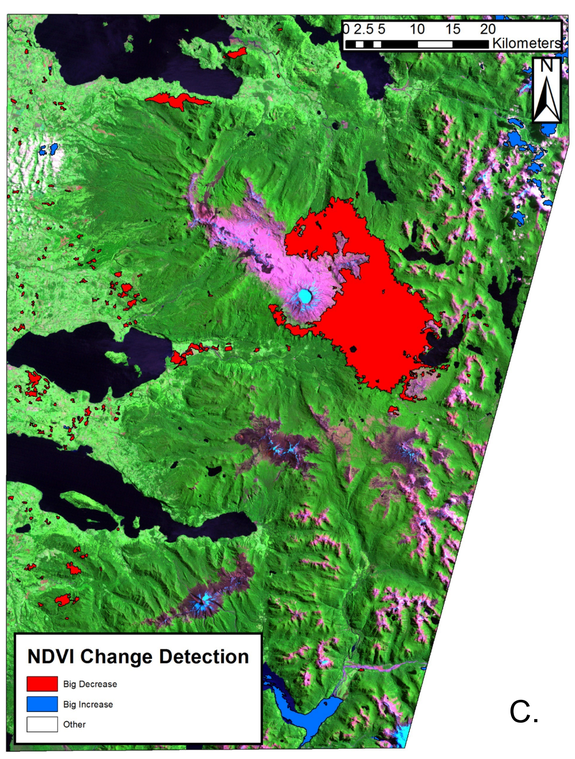
NDVI The NDVI (Normalized Difference Vegetation Index) tool on ENVI was used to transform multispectral data into a single image band representing vegetation distribution. Specifically, it was used to identify the amount of green vegetation present in each pixel.

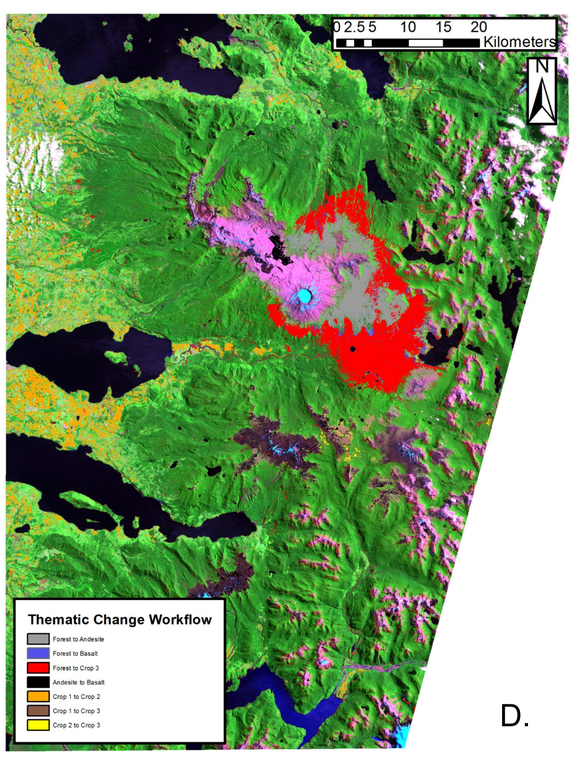
Change Detection Several change detections were performed in order to calculate the total area of the farming community and Puyehue National Park that was affected by the volcanic eruption. The first used the Image Change Workflow tool to compare two images from two different times, and identify the differences between them. This was performed on Band 4, Band 7, and the NDVI images. The second used the Thematic Change Workflow tool to compare the two classified images and identify their differences.

RESULTS & DISCUSSION









Figures 4a-d. The four different change detections performed on the 2011 and 2015 images. Figure 4a is Band 4, figure 4b is Band 7, figure 4c is the two NDVI images, and figure 4d is the Thematic Change of the two classified images.

The two biggest changes were the ***decrease in forest area and also the shifting of many Crop 1 fields to Crop 2 fields***, which suggests that there was a fallowing of the crop fields. In order to calculate the area that was affected by the eruption, the class statistics of each image were used to compute the amount of pixels that changed. This number was converted into kilometers (Table 1).

Change Detection	Area Affected (km^2)
Band 4 (image chg.)	221.76
Band 7 (image chg.)	239.02
NDVI (image chg.)	330.39
Thematic Change	328.77

Table 1. Various areas affected by the eruption, depending on the Change Detection method

The eruption caused a significant loss in crops which not only affected the amount of food available to citizens of Puyehue, but it also caused the ***birth rate to drop from 60% to 10-30%, and caused the death of 225,000 sheep and 60,000 goats*** (Wilson et. al., 2012). The eruption would also have led to the loss of habitat and death of *Vesula spp.* (invasive wasps), *Vultur gryphus* (Andean condor), and *Campephilius magellanicus* (native woodpecker). The Andean condor is already an endangered species, so this loss of habitat would have put the species even more at risk.

This project must be continued in order to accurately determine how the vegetation has been changing since the end of the eruption. It could be growing back now that it has been three years since the eruption ended, but this is impossible to tell unless we look at the years of 2016 and 2017 to model a vegetation growth rate. The project did, however, successfully show how Remote Sensing can be used to assess the

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