## D2 A Forensic Analysis of Flora Damage Caused by an Environmental Disaster at Mariana, Brazil

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After attending this presentation, attendees will understand several of the techniques used for the characterization of damage to flora that occurred in a large area.

This presentation will impact the forensic science community by detailing the environmental expertise activities undertaken to assess the extent of flora damage in large areas.

On November 5, 2015, the worst Brazilian mining accident occurred in the city of Mariana, Minas Gerais, Brazil. This occurred as a result of a dam (Fundão) breach that produced a mud torrent for more than 600km along Vale do Rio Doce, affecting all the cities and communities along the way and impacting approximately 1.2 million people between the dam and the sea. An estimated 18 victims died; one person remains missing.

The Forensic Unit of Environmental Crimes of the Federal Police was assigned to examine the damaged area. Experts from this group were divided into teams according to specific types of damage, including vegetation, animals, drownings, causes of the dam collapse, and more. The purpose of this presentation is to describe the activities undertaken to assess the damaged vegetation.

The wave of mining waste caused contamination of mining tailings over the watercourse gutter limits, thereby destroying the existing vegetation. This wave reached the grassy vegetation, herbaceous-shrubby vegetation, and treed areas. Damage to vegetation encompassed a region approximately 117km in length, extending from the Fundão dam head to the beginning of the Risoleta Neves Hydroelectric Plant dam lake.

High-resolution satellite images of the damaged area were unavailable following the catastrophe. Later images were available from the Landsat 8 satellite, but the spatial resolution (15m) of these images limited the ability to quantify the extent of the damage.

Commercially available micro- Unmanned Aerial Vehicles (UAVs) were not an option to image and assess the damage as the range of these vehicles was limited to 6km, a distance incompatible with the location of the affected area. Thus, manned helicopter-based aerial surveillance was conducted over the affected riverbeds. A total of 940 aerial photographs were obtained by using a GoPro® HD2 camera equipped with a wide-angle lens to survey a large area in a single flight path. The photographs recorded approximately 80% of the available area viewed. Using these data, experts employed a photogrammetric technique of Structure from Motion (SfM) for generating 3D terrain models and, from these models, obtained georeferenced orthophotos (spatial resolution of approximately 30cm). Distortions due to geophysical relief and photographic angles were accounted for in these models by using a Geographic Information System app.

Simultaneously, a multispectral classification of high-resolution satellite images, taken before the dam disaster, was used to define the topography prior to the incident and provide “baseline” information. The processed information was verified by the use of data gathered in the field and with other prior aerial photographs. Atlantic forest, eucalyptus forest, woods, crops, pastures, and disturbed areas (roads and built-up areas) of physiognomy vegetation were characterized.

It was concluded that the extent of the destruction totaled 1,176,44 hectares (ha), distributed as: 240,880ha of Atlantic forest; 45,000ha of Atlantic forest with eucalyptus; 174,300ha of natural vegetation; 39,110ha of pasture areas; 1,380ha of commercial forests (eucalyptus), and 86,006ha of disturbed areas. This presentation offers attendees a learning experience regarding the methods available to quantify the extent of affected vegetation of large-scale environmental disasters.

**Photogrammetry, Flora Damage, Remote Sensing**