



Review

Forensic geomorphology

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ABSTRACT

Geomorphology plays a critical role in two areas of geoforensics: searching the land for surface or buried objects and sampling scenes of crime and control locations as evidence. Associated geoscience disciplines have substantial bodies of work dedicated to their relevance in forensic investigations, yet geomorphology (specifically landforms, their mapping and evolution, soils and relationship to geology and biogeography) have not had similar public exposure. This is strange considering how fundamental to legal enquiries the location of a crime and its evolution are, as this article will demonstrate. This work aims to redress the balance by showing how geomorphology featured in one of the earliest works on forensic science methods, and has continued to play a role in the sociology, archaeology, criminalistics and geoforensics of crime. Traditional landscape interpretation from aerial photography is used to demonstrate how a geomorphological approach saved police time in the search for a clandestine grave. The application geomorphology has in military/humanitarian geography and environmental/engineering forensics is briefly discussed as these are also regularly reviewed in courts of law.

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1. Introduction

Forensic in the context of this article is taken to be pertaining to the law, and thus commonly includes the criminal investigations that are central to this review (e.g., homicide [murder in some countries], kidnap, theft, rape, smuggling, and extortion), but also scientific investigations that may be anticipated as coming before a court of law. The word has been placed in front of almost every area of study one can imagine, from the well-established forensic chemistry or biology to geology and pedology, but rarely forensic geomorphology. What is most surprising is that most, if not all, of the geoscience sub-disciplines have found application in criminal or legal investigations, from forensic archaeology, pedology, geology, geophysics, geoscience to geoforensics. The diversity of terms is baffling: Ruffell (2010) attempted to define the origin and scope of the above. To add to the *milieu*, but also to redress the balance, the application of geomorphology to investigations into serious criminal activity (see above for scope) is here considered. This is somewhat surprising, given that one of the earliest handbooks on forensic science (or criminalistics), included sections on geography and geomorphology (by Hans Gross in 1983, translated by Adam and Adam, 1962). Indeed Schumm (2005) implores his geomorphologist colleagues to not be afraid of being involved in cases of litigation, they being the best qualified scientists available to comment on changing water courses, the causes of landslides or environmental pollution and the reasons for buildings failure on unstable ground. We hope this article reinforces and perhaps expands on that of Schumm (2005). In this article, 'forensic' aspects of physical geography, geomorphology and

landform mapping are considered. We briefly include environmental, military, humanitarian and engineering enquiries, these being too vast in their scope for one review. Also not considered here in detail is the association between the psychology of the perpetrator and/or victim and landscape morphology. This area of what is essentially criminal profiling is a huge subject beyond the scope of this work, although elements are mentioned where relevant of course, as all acts subject to forensic analysis were conducted by people in a place. This reflects a fundamental principle in this work: that the shape of the land influences or controls human activity, and that this can be applied to geoforensics, in the above sense. The articles chosen for review reflect personal preference for each of the subject sub-headings and are not exhaustive. Many of the works, especially edited volumes, contain sufficient literature to allow the reader to explore the literature in each of the sections (below) discussed.

Soil, sediment and rocks have all been used in criminal investigations since 1854 (Scientific American, 1856). However, the first use of any of the geoscience disciplines with the word forensic was by Brooks and Newton (1969), who used the term 'forensic pedology'. This was followed by Murray and Tedrow (1975), with their book 'Forensic Geology'. Although the shape of the land or Earth's surface and the way it has evolved is critical to many investigations such as searching, sampling and how people behave in a landscape, the term forensic geomorphology has never been used in a stand-alone publication, which is peculiar given the importance of the landscape in investigations (knowingly or not on the part of the investigator), as this work will hopefully demonstrate. The closest publication to this work in terms of scope is Ruffell and McKinley's (2008) chapter of the same title, where some aspects of geomorphology in criminal investigations were discussed. The current work differs in concentrating on a

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review of publications that use the morphology of the land, changing soil/landuse types and or associated biogeography in forensics. The article is arranged roughly chronologically (the section on the FBI perspective by [Boyd \(1979\)](#), is placed later, to fit with the sociological perspective) and where appropriate by author name, as many individual workers have developed their work in successive articles. This layout hopefully reflects the development of the uses of geomorphology, as well as demonstrates how advanced some early works were.

2. The historic perspective: Hans Gross's (1893) Handbook for the Coroner's System of Criminology

This book is important in forensic science in that it is one of the first comprehensive texts on conducting crime scene examinations. The original German text is now a rarity, with most scholarly articles citing [Adam and Adam's \(1962\)](#) translation as a more widely-available volume. Gross's book is all the more remarkable in that it includes many sections on physical geography/geomorphology, as well as urban and peri-urban geography: all far in advance of many later works on forensic geoscience and geoforensics. Gross saw the whole landscape as a dynamic and interacting environment, indicating that an investigator should familiarise themselves with both the concept of scale as well as geography: 'hotels, public houses, clubs and brothels, because of the brawls that may take place in them. Ponds and wells in villages on account of possible accidents by drowning, forests because of poaching and illicit felling.' The most relevant (to this review) section of Gross's book is as visionary as the rest of his text is to forensic science in general. The section in [Adam and Adam \(1962\)](#) is entitled 'Sketch of a Larger Portion of Country' (p. 247) and it disguises what is actually contained, which is the first landscape-based crime scene map ever published to such detail (see below). Gross starts with a comment that making a drawing of landscape features is a challenge, all the more so as he was working in a time before the kinds of topographic maps geomorphologists are used to working with (e.g. 1:25,000, 1:50,000 scale produced by most of the government mapping departments of the world had been completed. Gross was also working prior to the invention of accurate measuring devices. As well as mapping being 'difficult' he makes an initial statement 'at times it is important to know whether the spot may be seen from a distant point', an obvious reference to the shape of the land, to covert activity, to viewability from afar, and years ahead of Geographic Information Systems (or Science: both GIS) applications such as viewshed analysis. In his Fig. 34 (p. 248 in [Adam and Adam, 1962](#)) Gross

attempts to integrate physical and human features of the environment that were pertinent to his view as a crime scene investigator. Such is the historical importance of this figure, plus the fact that many readers of *Geomorphology* may be gratified to see such maps in a book on criminalistics, prompted us to re-draft his drawing ([Fig. 1](#)). Gross returns to considering the shape of the land in his section on topographic modelling, and considers contour maps, then actually making a model of the land from clay, partly to understand the environment of the scene of crime, but also he points out, to communicate with witnesses as to where they were in relation to other places, features and locations. Gross notes that the making of such models is time-consuming, especially if forests, buildings and annotations are included. His ultimate aim is to create a representation of the landscape both for his and other investigators understanding, as well as (presumably) a jury. Gross would have been amazed at the invention of stereo-pair aerial photography, digital terrain models and computer-assisted three-dimensional visualisation of the land, which are after all, very clever ways of doing what he was doing with clay models. Gross further demonstrates this in his Fig. 35, where he depicts what is visible, or hidden, from a certain location. In this, he was demonstrating line of sight, or what is modelled digitally in a viewshed analysis using GIS. Again, this visionary concept of the use of physical geography in understanding covert activity has prompted us to re-draw Gross's diagram ([Fig. 2](#)). What Gross does not amplify on is the applied use of his models: the search specialist or behavioural scientist investigating a missing person's case can instantly see the benefit. It is a pity that no photograph of Gross's clay topographic models now exist, as (like his 'Sketch of a of a Larger Portion of Country', our [Fig. 1](#)) it would have been excellent to examine what he made and how he represented landscape features. Below, we will see how ahead of his time Gross was in that some recent studies have effectively been using Gross's ideas in geomorphologically-based searches.

3. The sociological perspective: Rossmo's (2000) geographic profiling

[Rossmo \(2000\)](#) states that 'geographic profiling is an investigative methodology that uses the locations of a connected series of crime to determine the most probable area of offender residence ... developed from research conducted at Simon Fraser University's School of Criminology, the method is based on a model that describes the criminal hunt.' Rossmo goes further, in examining the spatial patterns produced by the hunting behaviour and target locations of serial violent criminals.

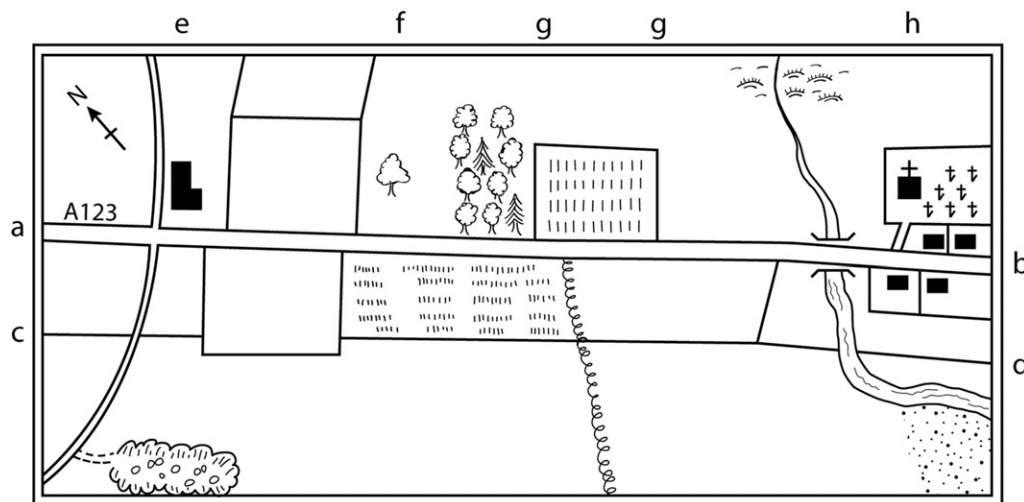


Fig. 1. Reproduction of Gross's (Fig. 34 in [Adam and Adam, 1962](#)) 'Sketch of a larger portion of country'. Gross's original was hand-drawn, this version is digital but otherwise faithful to his original. Gross provided no key or scale to the diagram, and we have not imposed one, both being logical. We presume (from left to right) the features shown are: roads and lanes; a quarry (lower left); field boundaries different crop types and small forest (centre); a river, houses and church/graveyard (far right). The lettering represents his xy grid notation.

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