Methodological Proposals for Documenting and Searching for Missing Persons in Colombia

equitas

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Introduction

METHODOLOGICAL PROPOSALS FOR THE DOCUMENTATION AND SEARCH FOR MISSING PERSONS

EQUITAS, as a victim-centered, evidence-based scientific and humanitarian organization, provides independent scientific contributions and psychosocial assistance to families of victims of crimes committed in the context of serious, mass or systematic human rights violations and armed conflicts. We have invested most of our energy in the last 5 years in developing contributions related to the search, identification and forensic analysis of victims of forced disappearance in Colombia. As we develop our work, we have identified structural methodological and scientific issues , which evidence a complex scenario of a long, changing on-going conflict, combined with transitional peace processes and a complex state bureaucracy.

Our approach to these challenges has been to develop tools and scientific contributions, which we believe will improve official as well as private forensic practices, guide public policies and raise public awareness. With this emphasis, we have generated interdisciplinary questions and, together with professionals and groups, made initial proposals in order to understand the magnitude of the crime and the challenges that surround search processes in the country.

WHO IS BURIED WHERE?

Forensic identification is based on matching information from a missing person with human remains found. Therefore, it is fundamental to understand the universe of people that have disappeared in conflict and which must be found. Information on who and how many people are missing will lead to methodologically adequate, sustainable and planned technical processes such as: search and recovery in different scenarios, human identification, forensic analysis and judicial investigation.

In its casework, EQUITAS has been scientifically challenged to make contributions to search processes in scenarios such as large *haciendas* or farms, next to river flood areas, non-identified bodies' sections in legal cemeteries, and even cases in which the bodies were allegedly thrown into rivers. These scenarios constantly remind us of the intention of perpetrators of the crime of forced disappearance to leave no trace. The victim was not killed and left in public, but rather, disappeared. Therefore, answering the question of *who is buried where?, is key when it comes to* bridging that gap between non-identified remains that are found and reports of missing persons who still have not been found.

SPECIFIC CONTEXT CHALLENGES

There are additional factors that challenge interdisciplinary work around this key question.

The implementation of the 2005 Justice and Peace Law as a transitional peace process, has greatly impacted the search for missing persons in Colombia. Issues that in the past did not receive much interest, became more visible and revealed more widely the drama behind stories of missing Colombians. Based on information provided by demobilized paramilitaries[1], over 3,000 bodies have been recovered to date in mass exhumations carried out nationwide by different teams from the Prosecutor General's Office, and other CSI teams from the Police (DIJIN), and the Security Administrative Department (DAS). As bodies are being recovered, families have begun to report their missing relatives to state entities, to the point that by 2009, the official figure reports over 27.000[2] cases of disappearances.

Important efforts have been carried out on behalf of state entities to coordinate their work through the National Search Commission, trying to implement the National Search Plan approved in 2007, focusing efforts in the National Register of Disappeared Persons (SIRDEC), and creating public policy tools, such as Policy Paper CONPES 3590 from June 2009. However, the magnitude of the task ahead appears overwhelming: The percentage of identified bodies over non-identified bodies remains below a third, state entities responsible for these processes lack complete information of those missing, further disappearances continue to occur, paramilitary testimonies are incomplete, and consistent evidence has involved dozens of members of the Armed Forces in alleged extrajudicial executions under the "false positives" scandal[3].

All these challenges reveal the difficult task of finding and identifying missing people in Colombia – a task that will be carried out for decades to come. Committed to it, EQUITAS, BENETECH and other experts, are working together to better document *who is buried where*, in order to support the search for those disappeared. This publication explores four different scenarios that have not been systematically studied in Colombia: legal cemeteries, rivers, clandestine burials in flood areas, and construction middens or debris dumps. The articles propose interdisciplinary methodologies, with the purpose of offering alternative lines of evidence that

1. Consolidated figure by January 6, 2010 according to the Justice and Peace Unit. See http://www.fiscalia.gov.co/justiciapaz/EXH/EXHUMACIONES.htm
2. Cases reported in the SIRDEC National Disappeared Register System, in approximately the last 20 years. See page 38, Documento Conpes 3590, Consolitating Search and Identification Mechanisms of Missing Persons in Colombia, National Planning Department, June 2009.
3. Professor Philip Alston, UN Special Rapporteur on extrajudicial executions, in his mission to Colombia in June 2009, reports close to 1800 cases, and explains in his report how this term and evidence of some of the cases he studied, refer to a sort of technical aura to describe a practice which is better characterized as cold-blooded, premeditated murder of innocent civilians for profit. "The phenomenon is well known. The victim is lured under false pretenses by a "recruiter" to a remote location. There, the individual is killed soon after arrival by members of the military. The scene is then manipulated to make it appear as if the individual was legitimately killed in combat. The victim is commonly photographed wearing a guerrilla uniform, and holding a gun or grenade. Victims are often buried anonymously in communal graves, and the killers are rewarded for the results they have achieved in the fight against the guerillas."

do not depend on human testimony, but can be cross-referenced with it, in order to maximize search efforts in the field. We believe good scientific practice is key to sustainable scientific work in Colombia, and will ease the pressure already stemming from political and security issues of working in on-going conflict. In the longer run, it is only this way that Colombia will be able to understand its past, and build on it a better future.

ABOUT AUTHORS AND COLLABORATORS

Our permanent team member **Ana Carolina Guatame**, MSc., forensic anthropologist, presents a proposal based on her masters' degree dissertation. She uses computer simulation as a reliable tool for predicting possible travel trajectories that an object similar to the human body may have, and the travel times it could take to reach specific locations in a river. This type of work can provide key insights to prioritize search areas in meanders, riverbeds and flood areas in cases where there are testimonies that people were thrown into rivers. Archaeology in dry seasons, dredging material archaeology, as well as documenting areas close to rivers where inhabitants have recovered floating bodies and disposed them in improvised or legal cemeteries, will be the future steps derived from the application of this tool.

Benetech, is a partner organization to EQUITAS. Its Human Rights Data Analysis Group has over 17 years of experience applying rigorous scientific analysis to data on human rights violations, and has worked with nine Truth and Reconciliation Commissions, U.N. missions and official human rights bodies, and international criminal tribunals. In an effort to support the search for the disappeared in Colombia, Benetech has used statistical methods and explored the utility of incorporating indirect, non-testimonial data into quantitative analyses. A first effort was in the region of Casanare, where they used a statistical method called "Multiple Systems Estimation" to account for unreported missing victims - those missing not only from society and their families but also from any record of disappearance.[4] In its 2007 study, Missing People in Casanare, Benetech estimated that between 30 and 40 percent of missing people in Casanare remained unreported between 1986 to 2007.[5]

EQUITAS and **HRDAG** detected the need to explore the usefulness of data from non-identified bodies in cemeteries, as a source of information for searching for missing persons. By analyzing the parish book of deaths, the gravediggers' notebook and a census of the gravestones at a legal cemetery, the pilot study revealed interesting temporal patterns of the identified and non-identified dead. Institutions involved in identification efforts may compare these cemetery patterns with reports of conflict-related disappearances and accounts of combats in the area in order to determine more clearly whether certain disappearances could match individual remains in a cemetery. Improved documentation practices on behalf of cemetery administrators and analysis of other existing sources, will lead to more effective search and identification processes of the NN in the cemetery, and to understanding the patterns of conflict and most likely perpetrators.

We have invited **Kevin Lane** Phd Archaeologist and Research Fellow at the Archaeology Department, University of Manchester UK, to propose a desk-based assessment for an extremely difficult recovery scenario: a construction midden or debris dump. Applying complete survey and excavation methodologies to these large-scale scenarios is effectively impossible. However, this assessment

4. Multiple systems estimation (MSE) is a technique that uses two or more separately collected but incomplete lists of a population to estimate the total population size. HRDAG uses the multiple systems estimation technique in human rights cases to project the total number of violations, including those that were never documented.
5. Guzmán, Daniel, Tamy Guberek, Amelia Hoover, and Patrick Ball. 2007. "Missing People in Casanare." Benetech. Also available in Spanish - "Los Desaparecidos de Casanare."

proposes to verify reliable evidence of the state and geography of the dump during the main period of activity associated to the time of deposition of bodies. For example, aerial or satellite imagery, could help to establish a depth and intervention area in the dump, which will maximize search efforts. Geo-referenced trenches, coffer-dam excavation and midden removal through JBC excavators are part of an archaeological activity plan that seeks to reasonably invest efforts to search for the remains of missing persons in the dump.

Geologist and researcher on geological applications of teleobservation at Ingeominas, Colombia, **Adriana Guatame**, explores remote analysis in order to identify terrain modification patterns as potential indicators of clandestine burial sites. This pilot study finds that these sites clearly tend to be located in areas of river marginal activity, particularly in flood plains. Understanding rivers as a changing landscape and observing their evolution through time can be extremely useful when interpreting testimonies of various actors on the location of burials. A geostatistic perspective using accurate and systematic information related to fluvial activity, land use, soil type, rain and flow patterns, will further develop tele-detection studies as a key element to plan regional search efforts with the aid of specific geophysical tools according to terrain characteristics.

We hope these proposals set a baseline for an interdisciplinary approach around the question of *Who is buried where?*, that will result in successful search, investigation and human identification results of deaths related to conflict. Open discussion, future tests, and most importantly, accurate documentation of all experiences, will be fundamental in developing new solutions for the humanitarian and scientific task before us: contributing to return the remains of missing persons to their loved ones, as well as offering evidence of the circumstances in which they died, that may be used in justice and reparation processes.

Finally, we wish to thank the **United States Institute for Peace** for supporting this work as a contribution to building knowledge and creating innovative tools for peacebuilding.

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Using computer simulation as a tool for the search of missing persons: tracking object drift trajectories in the Magdalena River (Colombia)

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Rivers

Abstract: **One of the main strategies that illegal armed groups in Colombia have used to hide their crimes is concealing bodies by throwing them into rivers. However, forensic scientists need to exhaust efforts in finding ways to recover bodies with the purpose of returning them to their families, and finding evidence of their circumstances of death. Controlled simulation is a tool that helps us observe the drift trajectories of bodies in water flows. This article presents a theoretical model that predicts the location of objects disposed into the river at certain times and locations, based on a model built along a 339km transect of the Magdalena River in Colombia. This model can be applied to any river where discharges and the geometrical constitution of several cross-sections have been documented.**

Key words: **Computer modeling, forensic science, human body density, drift trajectories, Magdalena River.**

INTRODUCTION

Since the 1980s the Magdalena Medio region has been one of the most important zones of paramilitary action in Colombia (Taussig, 2005). The brutality and terror in the paramilitary war can be observed in crime patterns of massacres, selective and systematic homicides of civil population: torturing, killing, dismembering and discarding victims' bodies into the closest rivers (CIDH, 2005; Brittain, 2006).

The *modus operandi* of concealing dead bodies by throwing them into rivers poses specific logistical difficulties for judicial investigators in terms of both the recovery and the identification of victims, especially given the lack of taphonomic studies of non-terrestrial deposition in Colombia and elsewhere (Gómez-López and Patiño-Umaña, 2007).

Both the unique legal and social context of the missing in Colombia, challenge forensic sciences to develop scientific methods that will improve human remains search techniques, especially in particularly difficult locations, such as rivers.

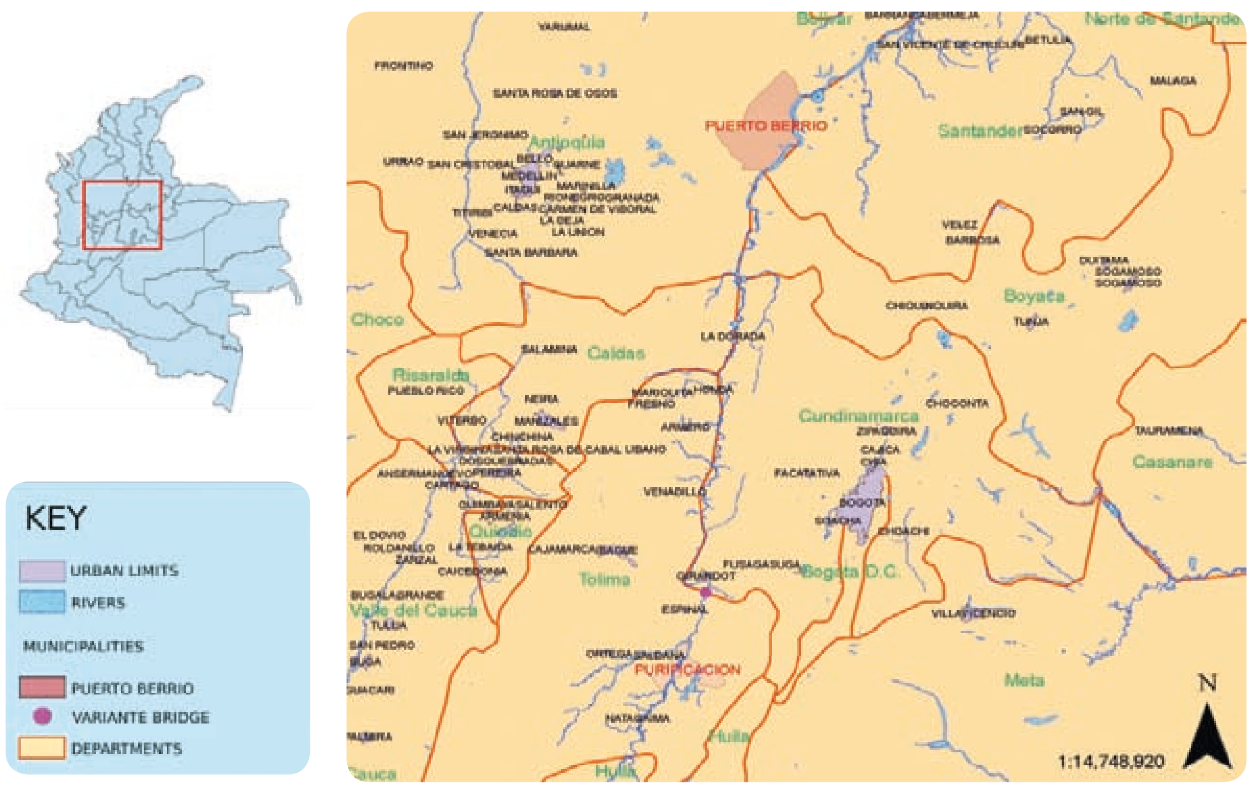
The use of prediction models to infer drift trajectories and establish patterns in order to describe likely scenarios in which victims can be found, becomes necessary considering the highly complex nature of the dynamics of fluvial behavior. However, the development of these tools depends on the amount and quality of information that can be used to make predictions, especially those regarding the behavior of rivers.

In studying bodies disposed in moving waters, many problems arise due to decomposition, as well as transportation, disarticulation and dispersion. In such cases, computer modeling has proven to be an invaluable tool leading towards the understanding of former cases and the prediction of the flow pattern of bodies (Ebessmeyer and Haglund, 1994; Carniel et al., 2002).

MATERIALS AND METHODS

The trajectory of objects was modeled in a 339km section of the Magdalena River between the Puente de la Variante (department of Cundinamarca) and the city of Puerto Berrío (department of Antioquia) (Figure 1). The modeling process considered buoyant, hydrostatic and dynamic forces, calculated by using velocity, discharge, and depth, computed in a numerical hydraulic model developed by Camacho and Lees (1998). Results and information from previous research studies were incorporated into the modeling framework to represent the trajectory of bodies with different densities and specific gravities.

Figure 1 **Magdalena River Section Puente de la Variante – Puerto Berrío**



Map provided by Procálculo Prosis S.A. Colombia

The theoretical (mathematical) model was calibrated by means of physical experiments carried out in the Teusacá and Magdalena rivers. These experiments provided detailed hydraulic data, observations on the orientation of the object, flood effects on the object's movement, and on travel time according to each object for comparison. These elements offer an accurate representation of the real flow pattern of the river section as well as the simulation of the object's movement and distance traveled.

After calibrating the computer model, 972 tests were performed to observe the predicted movement of objects in the Magdalena River. The first set of experiments (n=486) was implemented for the experimental stretch Puerte de la Variante – Girardot's Gas Pipe (10.7kms), called RM1 for the purposes of this study, and the second one (n=486) was carried out for the complete section of study Puente de la Variante – Puerto Berrío (339kms), called RM2.

COMPUTER MODEL OPERATION

The model takes into account 5 external and 4 intrinsic variables (Table 1). These variables define the environmental conditions in which the body will move, and the drift pattern it is likely to display. The object's movement pattern (model output) consists of five features: mean travel time, minimum travel time, velocity, flotation depth, and mass loss.

Table 1 Variables and values used as data entry on the computer model

	Variable	Model predefined range	Used values	Description
External	River Q	Undefined*	444.7 1118.9 2170.9	Lowest Magdalena River daily discharge reported to occur 95% of the year at Nariño station (Universidad de los Andes Acuagyr, 2005) Middle Magdalena River daily discharge reported to occur 50% of the year at Nariño station (Universidad de los Andes Acuagyr, 2005) Highest Magdalena River daily discharge reported to occur 5% of the year at Nariño station (Universidad de los Andes Acuagyr, 2005)
External	Water temp ºC	Undefined	22 26 30	Lowest water temp. considered for the range 20–30ºC Middle water temp. considered for the range 20–30ºC Highest water temp. considered for the range 20–30ºC
External	Init. position	0–1	0.3 0.6 0.9	Object initial position, as a fraction of the total width from the
External	K Degrad	Proportional to water temperature	0.03 0.04 0.05	Mass loss ratio calculated for a human body taking into account the degradation of organic material in water at 22ºC Mass degradation ratio calculated at 26ºC Mass degradation ratio calculated at 30ºC
	Trapping factor (Trap. F)	0–2	0.5 1 1.5	Body external trapping ratio, where 0=free motion, 2=highly trapped.
	Object Mass (Kg)	Undefined	50 75 100	Lowest body weight Middle body weight Highest body weight

* An "Undefined" range means any value can be used according to the specific conditions of each case.

Table 1. Variables and values used as data entry on the computer model (continuation)

	Variable	Model predefined range	Used values	Description
Body	Density (g/cm^3)	Proportional to body length and diameter (V)	0.9 1.06	Low density High density (Human density for young male adults according to Krzywicki and Chinn, 1967)
	Trunk diameter (m)	Proportional to body weight	0.21 0.24 0.27	Waist diameter for male adults based on Miyatake (2005) measurements of waist circunference
	Length	Maximum feasible body length proportional to body	1.5 1.65 1.8	Body lenght calibrated from physical experimentation Body lenght calculated as the proportion of calibrated body length to body weight

To illustrate how the model works, an example of a test is shown below:

1. Data entry: A specific value for each of the 9 variables must be established (Figure 2). In this example data are: River discharge: 850m/s; Water temperature: 220C; Object mass: 75kg; Object density: 1.07g/cm3; Trunk diameter: 0.27m; Object length: 1.7m; Mass degradation k: 0.03; Initial position: 0.85; Trapping factor: 1.

2. Run: On the main panel, the route that will be simulated is introduced, and the key “enter” pressed. Immediately, results from the data previously introduced are displayed (Figure 3).

Figure 2 Data entry chart

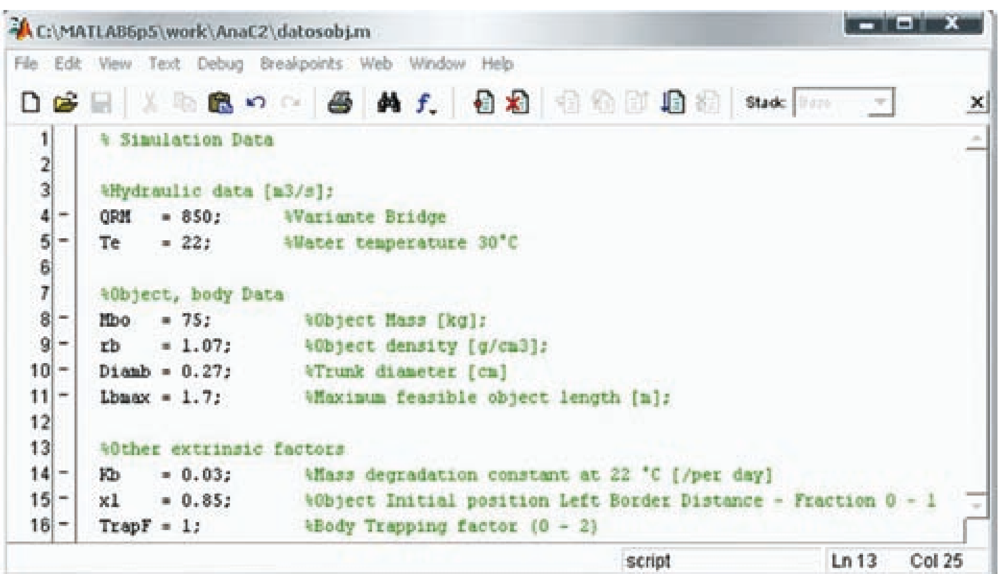
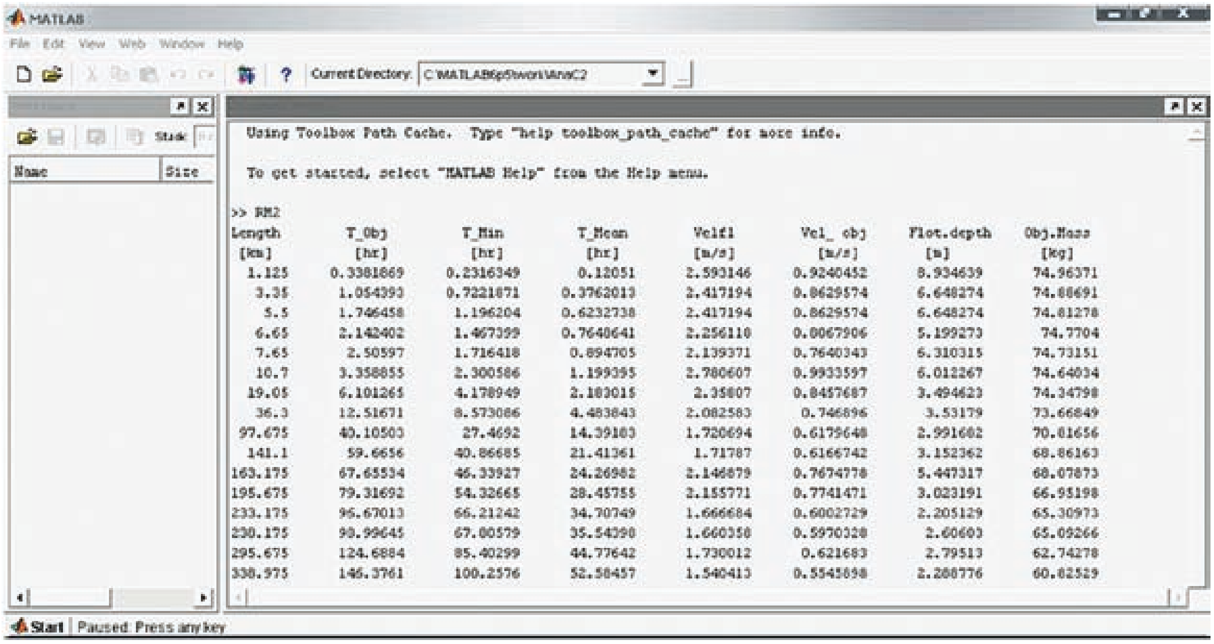


Figure 3 Output interface



3. Interpretation of results: On the main panel eight columns are displayed, table 2 shows this example's results.

The first column shows the distance from km Cero (*Puente de la Variante*) to the point at which each subsection finishes; the second column indicates the accumulated mean travel time the object takes to reach each subsection in hours; the third column shows the accumulated minimum travel time the object takes to reach each subsection under ideal conditions; the fourth column indicates the predicted flow mean travel time (the time a section of water moving downstream takes to reach a specific point); the fifth column shows the predicted flow velocity; the sixth column indicates the predicted object velocity; the seventh column shows the depth at which the object is travelling in the water column; and finally, the eighth column registers the residual object mass after being transported over an x time interval.

Table 2 Example results

Stretch Length (kms)	Object Mean time (hrs)	Object min. time (hrs)	Mean flow time (hrs)	Flow velocity (m/s)	Object velocity (m/s)	Flotation depth (m)	Object residual mass (kg)
1.125	0.33819	0.23163	0.12051	2.5931	0.92405	8.9346	79.964
3.35	1.0544	0.72219	0.3762	2.4172	0.86296	6.6483	74.887
5.5	1.7465	1.1962	0.62327	2.4172	0.86296	6.6483	74.813
6.65	2.1424	1.4674	0.76486	2.2561	0.80679	5.1993	74.77
7.65	2.506	1.7164	0.89471	2.1394	0.76403	6.3103	74.732
10.7	3.3589	2.3006	1.1994	2.7806	0.99336	6.0123	74.64
19.05	6.1013	4.1789	2.183	2.3581	0.84577	3.4946	74.348

Table 2 Example results (continuation)

Stretch Length (kms)	Object Mean time (hrs)	Object min. time (hrs)	Mean flow time (hrs)	Flow velocity (m/s)	Object velocity (m/s)	Flotation depth (m)	Object residual mass (kg)
36.3	12.517	8.5731	4.4838	2.0826	0.7469	3.5318	73.688
97.675	45.105	27.469	14.392	1.7207	0.61796	2.9917	70.817
141.1	59.666	40.867	21.414	1.7179	0.61667	3.1524	68.862
163.17	67.655	46.339	24.27	2.1469	0.76748	5.4473	68.079
195.67	79.317	54.327	28.458	2.1558	0.77415	3.0232	66.952
233.17	96.67	66.212	34.707	1.6667	0.60027	2.2051	65.31
238.17	98.996	67.806	35.544	1.6604	0.59703	2.606	65.093
295.67	124.69	85.403	44.776	1.73	0.62168	2.7951	62.743
338.97	146.38	100.26	52.585	1.5404	0.55459	2.2888	60.825

It is worth mentioning that regarding flotation depth, the model is not able to predict a transitional depth (i.e. the depth at which the object is moving while sinking to the bottom), and hence, the flotation depth either corresponds to the maximum depth of the river at each subsection minus the body's transverse length when the body composition makes it sink (i.e. 8.9m), or to the predicted submerged area for bodies which composition makes them to move to the surface (i.e. 0.25m).

RESULTS

Based on the results of 972 tests performed, we conducted additional calculations such as Pearson's R correlation coefficients on every pair of variables within each set of tests, and statistical analysis of variance (ANOVA).

General observations from physical experimentation on the Teusacá and Magdalena Rivers

Objects disposed at high flow velocity sections were observed to travel downstream with the main flow. Along bends, the objects typically followed a path close to external riverbanks. In most cases, the objects moved after the bends with the main surface flow from the external riverbank towards the opposite bank.

The presence of debris and snags in the river-banks altered the direction and velocity of the surface flow, producing whirls and eddies where the floating bodies got trapped, reducing their effective longitudinal velocity. The bodies were forced to get back into the main flow because of the tangential force of the water at the border of eddies.

Objects drifting downstream display a circular pattern of movement as result of the driving forces exerted by the water on different sections of the objects' surface. This pattern is altered by the presence of debris and shrubs on riverbanks, which invert the direction of circular movement and reduce the objects' longitudinal velocity.

External factors affecting the drift of objects along the Magdalena River

Analysis of results of RM1 and RM2 demonstrate that the minimum and maximum travel times and velocities were reached by tests in which the data entered was similar in terms of discharge, object initial position, and trapping factor. Highest discharge (2170.9) produced the lowest travel times and the highest object velocities, meanwhile the highest values in object initial position and trapping factor (1.5) derived on the highest travel times and lowest object velocities. These results are consistent with the ANOVA tests, which demonstrate that these three variables have a significant influence on the object's rate of movement.

Discharge, understood as the longitudinal velocity of the flow passing through a particular cross section (Smith and Stopp, 1979), produces an effect on travel time and object velocity that can be explained by the sequence: high discharge ⇛ high flow velocity; high flow velocity ⇛ high object velocity; high object velocity ⇛ low travel time.

However, since the velocity in a river cross-section decreases at the banks and at the bottom due to the friction produced along the channel walls and the riverbed (Chow, 1998), objects disposed at the center of the channel described the highest velocities, whereas those disposed at the borders described the lowest velocities.

The calculated ratios object velocity/flow velocity, indicate that under ideal circumstances (no obstruction) the object may travel slightly faster than the mean flow velocity, and that the minimum object velocities are equivalent to half-mean flow velocity.

The effect produced by the trapping factor must be understood as an abstraction related to the likelihood that an object is trapped by substances that are not directly related to the hydraulic behavior of the river, such as shrubs and debris. The trapping factor variable acts as a "hold mechanism" that allows the simulation of situations in which the body gets trapped by eddies. Consequently, its increment will considerably reduce the rate of movement. Since the trapping factor is an abstract variable, its value resides on the capability of interpreting the external conditions of the river (vegetation, intrusive structures) as a ratio of trapping.

The relationship identified by the two-way ANOVA between discharge - initial position with regard to the object's velocity is explained as a "lag" effect. This means that despite the assumption that an object will describe high velocity due to high flow discharge, the velocity will be slightly reduced by the decreasing velocity at the borders. In the same way, the relationship amongst initial position and the trapping factor can be explained as a "double-lag" effect when both variables increase. Conversely, when both variables decrease it is a catalyst producing increased velocity.

In both, RM1 and RM2, water temperature appeared not to have any significant effect on the object's movement rate. However, the correlation between water temperature and mass degradation factor ($r= 1$) appeared to be almost exclusive. This relationship is explained by the model's assumption that an increment on temperature will produce a higher degree of degradation of organic material. This assumption arises from previous studies that state that temperature is the main factor affecting the rate of soft tissue decay. Consequently, mass decomposition was defined as a ratio of weight loss acting in function of temperature and time.

Concerning the relationship between water temperature and residual mass, the correlation analysis for RM1 does not display any significant relationship between variables. The most likely explanation is that to have a statistically considerable weight loss, a minimum time is required. This time was not reached by this set of tests, since the maximum travel time identified was 7.29hrs, an interval that is unlikely to describe high rates of mass loss. On the contrary to RM1, RM2 demonstrates a high but not unique correlation between water temperature and residual mass ($r=-0.316$). This can be explained by the longer time intervals, which allow the observation of soft tissue decomposition over extended periods of time at different temperatures (i.e. T232 and T444 yielded the same travel times but their residual masses significantly differed because T232 was run at 220C while T444 was run at 300C).

Flotation effects on the object's movement rate

The model does not consider flotation depth as a pre-defined variable. However, it is calculated from mathematical reasoning related to buoyancy and hydrostatic forces (i.e. specific gravity) that act once a body is deposited into a fluid. The one-way ANOVA revealed a very significant effect of flotation depth on the object's movement rate (p=0.000). It is consistent with the theory that object travel times and velocities depend, among others, on the vertical coordinates that indicate the position at which an object moves downstream.

There is an actual difference on travel times and velocities as a result of changes in flotation depth; however, they do not meet the decreasing scale with depths found in trapezoidal channels. This indicates that the channel displays an irregular geometric configuration that makes velocities irregularly distributed. However, given that the model structure relies on available information of the geometric configuration of the river at spaced cross-sections, the model is capable of identifying velocities at each point of the vertical column, allowing the prediction of the object's velocity at a calculated flotation depth.

In addition to the irregular distribution of flow velocities, the low gravity force displayed by a buoyant object can explain high object velocities close to the water surface. This kind of drift only has a longitudinal direction that reduces the resistance force, and then increases the object's velocity.

Examining the Pearson's correlation coefficients, it can be stated that in spite of the importance given by flotation depth on the object's travel time and velocity, variables such as initial position and trapping factor have higher influence on the rate of movement. Thus, these variables cannot be single-handled, but their influence must be analyzed as a coalescence of interrelations in which the impact is to some extent predictable.

It is worth mentioning that the calculated flotation depth remains the same along the whole route followed by the object, and hence, it does not describe the movement of the body in the water column. According to Cotton et al. (1987) a human body disposed in water initially sinks, and may resurface depending on water temperature. With fairly warm water temperatures, a body can be expected to surface within a few days, whereas with cold or near-freezing water temperatures, resurfacing of the body can be delayed for several weeks to several months.

However, because the model is not able to simulate these changes in flotation depth, the significance of the relationship between flotation depth and water temperature cannot be established at this time.

Intrinsic factors affecting the object's rate of movement

A preliminary hypothesis based on Donoghue and Minniguerode (1977) and Boaz and Behrensmeyer (1976), stated that body density is correlated with the average rate of movement. The one-way ANOVA proved this hypothesis yielding a significance of p=0.014 per object mean travel time and p=0.000 per object velocity. Also, the strong proportional relationship between density and flotation depth (r=0.93) demonstrated a direct effect of density on the vertical location of the body and its "transitive" effect on the object's movement rate. Nevertheless, density appears not to be the only factor affecting wether a body will float or sink, although it seems to have a high influence.

When the data introduced into the model slightly varied the body volume with respect to the body mass, results differed considerably in terms of flotation depth. This phenomenon obeys to the fact that human density is very close to water density, and small variations in body density, defined as the ratio of mass to volume, will critically affect body buoyancy (Donoghue and Minniguerode, 1977). It demonstrates the fragile equilibrium of buoyant forces at densities very close to 1, which is the case of the human body.

While decomposing, putrefactive gas formation in the chest and abdomen decreases the density of the body; it creates sufficient buoyancy to allow it to rise to the surface and float (Donoghue and Minniguerode, 1977). However, the model is not able to simulate the changes on the body's density, and the pattern of both vertical and longitudinal movement cannot be studied at this time.

With regard to body weight, ANOVA tests proved that there is no considerable effect of this variable on the object movement rate. This finding concurs with Boaz and Behrensmeyer (1976) who also proved that there is no correlation between weight and movement rate. A possible explanation to this observable fact is that weight is acting more as one of the variables defining density than a factor affecting movement itself.

Residual mass appears to be mostly correlated to the object mean time ($r=-0.428$), and less to water temperature ($r=-0.316$). This correlation was expected, since residual mass results from the mass degradation constant, which is time and temperature dependent.

DISCUSSION AND CONCLUSIONS

A computer hydraulic model was adjusted and used to simulate how bodies drift along 339km of the Magdalena River. Results and information from previous research studies were incorporated into the modeling framework to represent possible trajectories of living and dead human bodies with different densities and specific gravities. Nevertheless, basic assumptions and simplifications were made from the simulation tests, therefore its application is certainly constrained to particular conditions and its accuracy must be carefully interpreted.

Discharge, object initial position, and the trapping factor were established as the most important extrinsic factors affecting an objects' travel time and velocity. Body density, affected in turn by body volume (mass, length and diameter), was identified as the only intrinsic factor affecting the movement rate, since it determines the body position in the water column. This initial experimentation supports the Nawrocki et al. (1997) statement that suggests that if the features of a specific water environment are available, relationships between decomposition, drift trajectory, and time since death can be established.

The assessment of these variables affecting the transportation of objects along the river led to identifying factors that may become critical when evaluating cases. The prediction of points of entry and recovery become key elements in the search for victims.

Since the mathematical testing of the model has supported its accuracy with regards to the prediction of body velocity, mean travel time, and flotation depth, it can be said that the model is capable of calculating the time a particular body requires to arrive at certain locations under specific environmental conditions.

The model must be used according to the analysis of its limitations, and later adjusted to complex body composition and motion, in order to predict an object's movement pattern in a water column according to other variables such as changes in body volume resulting from inhaled water; changes in body density due to decomposition; mass loss due to disarticulation; as well as the simulation of drift trajectories of body parts.

However, despite these shortcomings, the model is a reliable tool for predicting possible travel trajectories that an object similar to the human body may have, and the travel times it could take to reach specific locations. Although these experiments mainly refer to drift and submersion intervals, they constitute a preliminary proposal for further experimentation. At this time, the model can be applied to any river in which discharges and geometrical constitution at several cross-sections are previously documented.

ACKNOWLEDGMENTS

This project would not have been possible without the knowledge of Dr. Luis A. Camacho, professor of hydraulic resources at the National University of Colombia, who provided his scientific expertise in developing the mathematical computer model.

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Using Cemetery Information in the Search for the Disappeared: Lessons from a Pilot Study in Rionegro, Antioquia

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Abstract: Documentation and analysis of multiple sources of information from cemeteries, such as inscriptions on graves and administrative records, are a useful contribution in search and identification processes of missing persons. Through a pilot study we learned that the pattern of non-identified bodies (NNs) at the Rionegro cemetery in Antioquia is different from that of identified deaths, suggesting unrelated causes and that there is a disproportionate concentration of N.N.s in 2003. This article outlines the cemetery sources found in the pilot study and how the analysis of the data can be useful as part of an interdisciplinary approach in successful search, investigation and identification processes of deaths related to conflict.

Key words: indirect data, unidentified deaths, cemetery, disappearances and search processes.

Legal cemeteries

INTRODUCTION

Cemeteries contain a wealth of information: They maintain administrative records on bodies arriving there, including their names, dates and sometimes cause of death. The gravestones bear inscriptions with data on the deceased. The gravediggers often keep an account of their work, listing the corpses recently arrived and interred and those that are moved from one tomb to another. Therefore cemetery data is a source of indirect information (also called "found data") that can help in the process of accounting for deaths and disappearances[1]. Based

1. Found data exists independently of the investigator, it is not collected directly and does not have as a specific objective to study human rights violations. Found data can be complementary to the traditional sources of information and has been key in research of forced migration patterns in Kosovo, enforced disappearances in India, command responsibility for violations in Chad, and police involvement in counterinsurgency in Guatemala.

on a previous experience of the Benetech Human Rights Data Analysis Group (HRDAG) in Timor-Leste conducting a census of all the public graveyards in the country and comparing this data source with other datasets of human rights violations, we conducted a pilot study in the cemetery of Rionegro, Antioquia in Colombia, between May and July 2009.

The purpose of this study was twofold:

a. To explore the hypothesis that the N.N.s in the Rionegro cemetery could correspond to the remains of missing persons according to time and circumstances of death[2].

b. To test whether the method of gathering "found data" could be useful in the search for disappeared persons in the limited context of Rionegro, Antioquia, and if it can eventually be scaled to a broader context.

We chose the Rionegro cemetery for the pilot study for the following reasons:

a. As a result of armed conflict, Eastern Antioquia was one of the sub-regions of Antioquia with many unidentified remains in the cemeteries.[3], and Rionegro is considered the capital of this region.

b. To support EQUITAS's ongoing efforts to contribute to the identification of N.N.s in the Rionegro cemetery in a joint project with the University of Antioquia and the CSI team from the General Attorneys Office in Medellin since February 2008.

2. According to the Final Report of the International Observation Mission on Extrajudicial Executions and Impunity in Colombia. 2008, the Coordinator of the Working Group on the Identification of N.N.s and Disappeared Persons, from the Prosecutor General's Office provided information on the seriousness of the situation of the disappeared in Antioquia: since 1990 7,000 persons have been reported as disappeared and each day 10 new cases from previous years are reported to that office. He explained that the majority of the extrajudicial executions show a pattern in which the victims are buried as N.N.s in cemeteries.

3. Observatory for Peace and Reconciliation in Eastern Antioquia (OPROA). Informe Sobre la Situación de los Derechos Humanos y el Derecho Internacional Humanitario en el Oriente Antioqueño. 2008.

c. The cemetery's size, the significant number of N.N.s it contains, relationships with the parish and mayors office, and good security conditions made it an informative place to carry out the pilot research.

METHODOLOGY

A pilot study is a limited, practical exercise to test a new methodology or hypothesis in a small scale and a controlled environment. Due to the pilot study's limited nature, its errors are limited and therefore not too costly – an ideal learning situation. The limitation of a pilot study in this particular case is analytical: It is a first step geared towards evaluating and learning from the methodology rather than focusing on analytical results. Thus, this particular pilot study explored the usefulness of cemetery data to ascertain whether the knowledge gained by this method would make it worthwhile to use on a greater scale. We also wanted to know what elements we could modify in order to make its implementation more practical in the future.

Use multiple cemetery sources of information

a. Parish book of deaths

The local parish church, as administrator of the Rionegro cemetery, keeps two kinds of records: the book of deaths and the map of graves. Although we reviewed both of these sources, we included only the parish book of deaths in the pilot-study analysis.

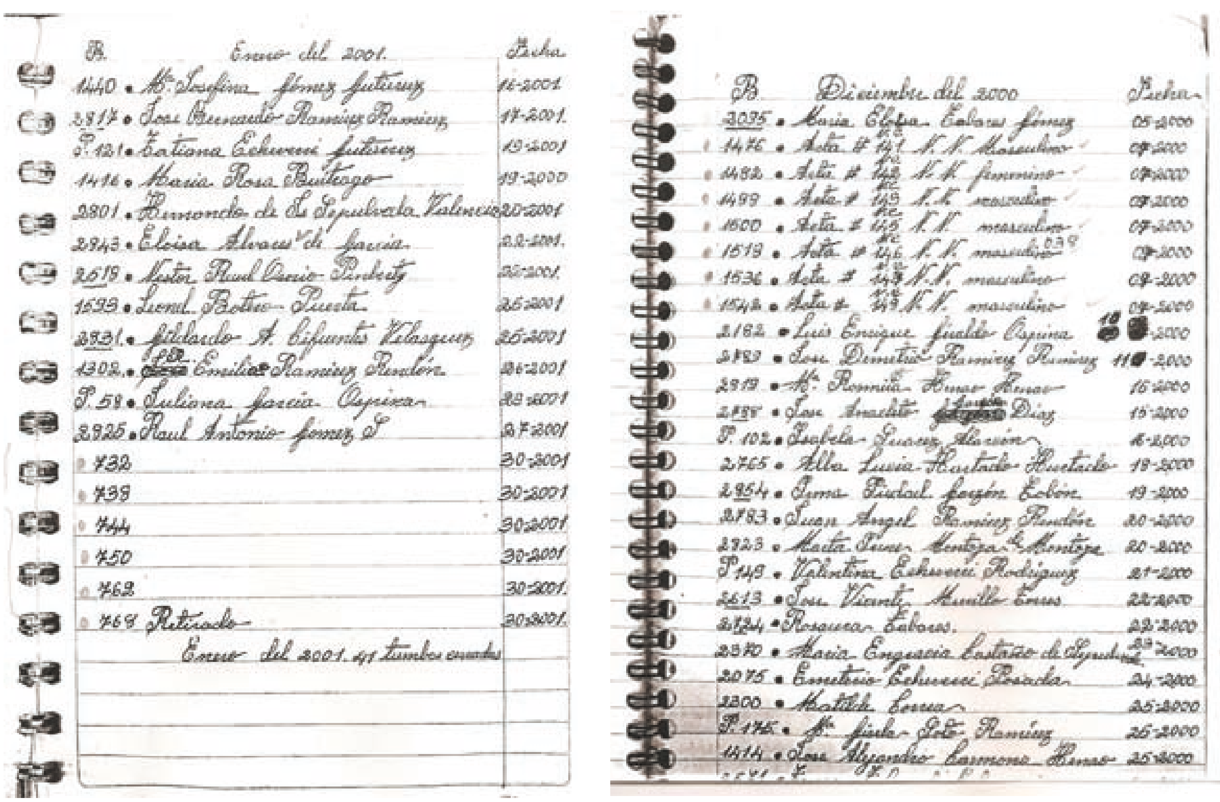
The Rionegro parish book of deaths includes records from 1986 to 2004. It contains the following variables: grave number; name of the dead person (if known) or if N.N.; the cadaver's origin (whether a hospital, funeral home, municipal authority, etc.); the date of death; and sometimes the number of the autopsy report number. There is also a field for the duration of rental of the grave (four years for adults, two years for children). The limitation of the Rionegro parish book of deaths is that it does not appear to have been systematically and consistently kept throughout time; in particular, it has not been updated since 2004. The map of graves documents the current occupant of each grave. Although the project team did review the Rionegro map of graves, we did not include its contents in the analysis. The primary reason was that the map is difficult to read because it is kept in pencil, and the entries are often smudged or erased. Also, each time a cadaver is removed from its grave to be transferred elsewhere, usually because the grave rental has expired, the corresponding entry is fully erased, thereby obliterating the dead person's history in the cemetery.

b. The gravedigger's notebook

A simple notebook provides a wealth of information about the population of the cemetery. At Rionegro, the gravedigger keeps a set of records going back to 1990 and up to the present. The variables it includes are the grave number; the name of the dead person or whether N.N.; sometimes the autopsy report number; the date of death or, if N.N., of arrival at the cemetery or of burial. The gravedigger registers the information provided to him by legal, health, or parish personnel about each corpse.

Unlike the parish map of graves, these entries are not erased when the remains are moved from their cemetery location, when grave leases expire, or when N.N. remains are transferred to common graves. Thus, the gravedigger's notebook is probably the most complete set of historical records about the cemetery population. However, the accuracy and completeness of such records depends on the quality of the gravedigger's notes and on how systematically and consistently he keeps them. The gravedigger's notebook complements the analysis: in this case, while the parish book's records begin ten years earlier than those of the gravedigger, his notebook covers more recent years.

Photo 1. Gravedigger's notebook



c. Census of gravestones

The census provided us with a full enumeration of the cemetery population – that is, all the individuals *currently* buried in the graves at the cemetery.[4]

We analyzed the data from the book of deaths, the gravedigger's notebook and the census data together to get a more complete understanding of the cemetery population. We used information about the named dead in a study about N.N.s and disappeared persons in order to address our hypothesis that the N.N.s could be the remains of the disappeared. We first need to reject the possibility that the N.N.s are caused by "normal" circumstances[5].

DATA COLLECTION FOR GRAVESTONE CENSUS

Of the three sources used, only the gravestone census required a data collection effort. In this section, we describe the steps in the process.

a. Reference frame

The first step in any census is to obtain a reference frame. A reference frame delineates the population to be studied and includes each unit of the given population. In the case of the cemetery, a map would have been a good reference frame. The existing map held by the parish was considerably out of date and so the project hired an architect to draw a new one.

Photo 2. The architect with his map of the cemetery

That became our reference frame, with which the project team counted each grave in the cemetery. It also helped us organize the field team in the different areas of the cemetery.

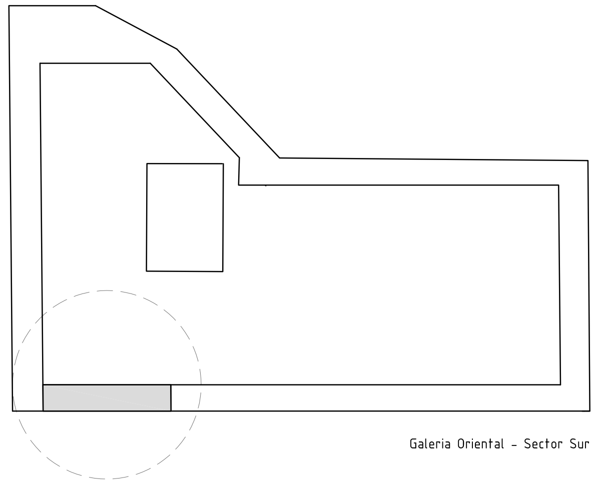
In the mapping process we discovered that the Rionegro parish had underestimated the number of graves in the cemetery. Thus, while the number of graves registered by the parish was between 3,000 and 4,000, the census counted 7,834.

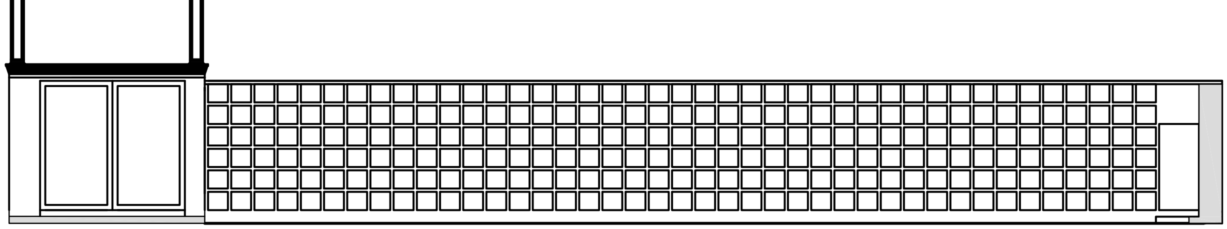
b. Unique identification

With the cemetery map as reference frame, the project team went on to design a unique identification scheme for each of the graves in the cemetery. The unique identification, which can be thought of as the "address" of each dead person in the cemetery, tells us exactly where each cadaver is buried.

4. We did not include the common graves in the census, as they are generally unmarked and there is no register of how many corpses each contains. According to the gravedigger, the Rionegro cemetery has seven common graves that could contain hundreds and possibly thousands of human remains.
5. Societies usually produce unidentified dead as a result of "normal" events such as decedents' mental illness, poverty and social marginalization. One would expect the relation between the unidentified and identified dead to remain constant. Thus we might expect to see an increase in the number of unidentified cadavers when the general mortality rate rises, and fewer N.N.s when the overall number of deaths drops. By comparing the patterns of the named and the unnamed dead, we can detect an "excess" of unidentified cadavers or any unusual patterns that can then be investigated. Unusual patterns may be due to natural disasters, epidemics and armed conflict, among other reasons.

Layout of Rionegro Cemetery drawn by project architect





The unique identification created a consistent reference to specific locations in the cemetery. It was structured as follows: a code for each gallery in the cemetery, where the graves are located on walls; a code for each wall in the gallery; the row number of the grave, assigned from bottom to top, and the column number of the grave, assigned from left to right; and a consecutive unique number for each person buried in the grave (often more than one, especially in the case of family graves). The only exception was the five mausoleums, each of which was assigned a unique number. It should be pointed out that many graves had existing identification numbers, but they were often repeated; frequently they were missing. With the system of unique identification, it is possible to keep track of each dead person arriving at the cemetery.

Unique identification code structure:

1. Gallery - Wall- Row - Column – Person No.
2. Example: GW-D-09-30-01

c. Coding

Using a predetermined structure, a team of five people systematically collected the following information from each gravestone:

- Location of grave, using a unique ID assigned by us
- Information on conditions of the grave
- Information on the cadaver(s) in the grave
- Photo of the grave

Inter-rater reliability is the degree of agreement among coders. It measures how much consensus there is among the coding team in the application of the criteria defined in the controlled vocabulary. We calculated 97% reliability during the data collection for this project. This high level of consistency gives us great confidence in the reliability of the census data (Silva, Romesh 2002).

d. Database

We created a dataset of all the information inscribed on the cemetery gravestones. Using Martus, a free

Photo 3. Wall of tombs at Rionegro Cemetery

Photo 4. Tomb at Rionegro Cemetery

Photo 5. Coder at work

and secure information management tool created by Benetech, the project team entered all the information collected from the gravestones, including photos of the gravestones for later analysis, in electronic format. Each Martus bulletin corresponds to one grave. Martus is a good choice for any qualitative data project because it is user friendly and can be customized to the specific structure of the information. The user can easily search all the information stored in the database, attach supporting documents (photos, death certificates, etc.) and keep all versions of the information as it evolves over time.

Description of the Data

The analysis carried out for the pilot study compared the data from the book of deaths, the gravedigger's notebook and the gravestone census.

Counts

From the cemetery census, we found that the Rionegro cemetery has 7,834 graves (excluding the common ossuaries) holding 8,432 cadavers from 1876 (the oldest grave in the cemetery) to July 2009. Of the 7,834 graves, 1,057 are observably empty – there was no tombstone covering an empty tomb. Of the tombs that are closed, 802 of these have a completely blank tombstone – with no written information about buried people.

Type of cadaver	Quantity
Identified	8,249
N.N.s	145
Posible N.N.s	38
Total	**8,432**

Of the 8,432 known corpses in the cemetery, 8,249 are identified and 145 are recorded as unidentified bodies – N.N.s according to the markings on the graves. However, the precise count of N.N.s as determined by the census can be confused by the inconsistent way in which some N.N.s are marked (or not marked) on the gravestones. The confusion is exacerbated by the sometimes-contradictory information provided in the written sources of the cemetery about N.N.s, and by the gravedigger's qualitative accounts of marking practices: Some NNs are buried in a tomb that is covered with a blank tombstone, others are in the top and bottom rows of certain galleries in the cemetery and other are marked with an NN. Consequently, in addition to the 145 N.N.s counted by the census, there are 38 tombs that the project team coded as holding "possible N.N.s" (based on the combination of their location and lack of markings).

Of the known 145 N.N.s, 45 (31 percent) have a medical-legal autopsy report number written on the tomb. The lack of gravestones with this report number and of a unique identification has posed serious legal problems, at the time of exhumation and identification of the remains when information does not coincide, is incomplete or non existent. Improved records at all levels will facilitate eventual investigation and identification of N.N.s.

While the gravestone census provides a snapshot of the cemetery population at one specific moment in time, it does not provide a historical account. Obviously the population size of the cemetery changes constantly due to new arrivals and the expiration of grave rentals (this is not the case for graves purchased by families). In addition, in Rionegro the N.N. cadavers that are not identified within approximately four years may be transferred to the cemetery's common ossuary, making it difficult – perhaps impossible – to identify them. This highlights the importance of complementing the census with the administrative records of the cemetery.

Overlap of records of N.N.s in three cemetery sources at Rionegro	Quantity
N.N.s ever buried at the cemetery according to 3 sources	462
N.N.s currently buried at the cemetery according to gravestone census	145
N.N.s currently buried at the cemetery and also recorded by at least 1 of the 2 non-census sources	73

The exercise of comparing the data from the three sources indicates that 462 unique N.N.s have at some point been buried at Rionegro, as shown above.[6] And while the gravedigger's notebook seems to be the most complete source, only 73 of the 145 N.N.s buried in the cemetery at the date of the study are also recorded in one of the other two sources. Again, this underlines the need to review all the cemetery sources to understand the status of N.N.s more fully. Based on qualitative accounts, we know that some of the N.N.s in the Rionegro cemetery were brought from other neighboring regional municipalities. Unfortunately, none of the cemetery data sources record the bodies' place of origin.

Graphs over time

In this section we compare two of the three sources. Figure 1 (next page) shows the entire cemetery population with a year of death recorded on the tombstone. The graph starts with the oldest death in the cemetery from 1876 and plots through 2009 (July, when the census ended). Obviously this graph does not reflect the deaths that have been removed from the cemetery over time. The overall pattern of steady growth should not necessarily be interpreted as death tolls increasing: cadavers are removed from the past and the cemetery has grown in capacity over time. Most notably, there was a drop in identified deaths in 1986 and more recently in the early 2000s. It remains an open question as to why there are less identified deaths in the cemetery at this time. The 2003 spike in N.N.s occurs when identified death was at the lowest point in the last 30 years. Figure 2 (next page) shows the cemetery population by year of death (or entry, not always consistent) according the gravedigger's notebook. The benefit of looking at the two sources over time is that the census reveals the current burials and the gravedigger's notebook

6. It is possible that there is still under-registration, if the N.N.s in the common ossuary were never included in any of the cemetery's administrative records.

Figure 1: Identified and unidentified cemetery population according to gravestone census, 1876-2009

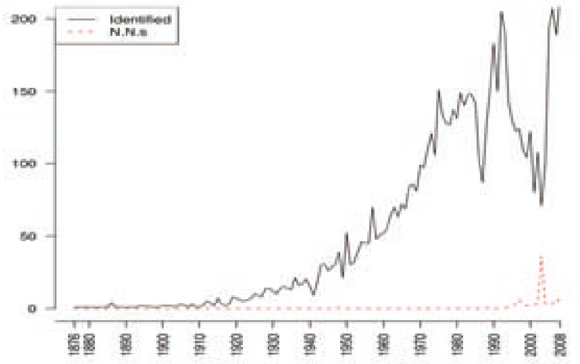
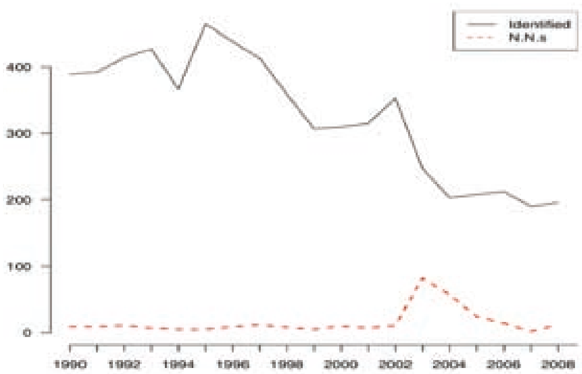


Figure 2: Identified and unidentified cemetery population according to gravedigger's notebook, 1990-2008



a broader view of the historical landscape of the cemetery. As shown in Figures 1 and 2, both the census data and gravedigger's notebook indicate a low correlation between the patterns of identified and unidentified dead. The number of N.N.s does not rise when the total number of identified dead increases, nor does it fall when the number of identified dead drops. That is, the pattern revealed about the N.N.s is independent from that of the identified dead and appears to have its own specific causes.

The census and the gravedigger's notebook show an inverse pattern of identified cadavers in the most recent years (one from a current, the other from a historical perspective) as seen in Figure 3 (next page). Both sources are consistent in showing the pattern of N.N.s, shown in Figure 4 (next page). However, although the sources present different patterns for identified deaths, neither show a strong relationship between the patterns of N.N.s with identified deaths, as seen in Figures 1 and 2.

The patterns of unidentified bodies in the Rionegro cemetery are not random: they are marked very clearly in specific moments in time. We present a monthly view of 2003 and 2004 in Figures 5 and 6 (next page). In the peak month April 2003, N.N.s accounted for 67% of all the dead buried in the cemetery. For that month, both sources show more N.N.s than identified bodies. The N.N.s recorded in the gravedigger's notebook in 2004 appear to no longer be buried individually at the cemetery. Were they identified?

These statistical data raise qualitative questions for a joint analysis with local experts and researchers of other disciplines. In the effort to match disappearances with remains, these patterns can guide search efforts by time period, location, and, according to local reports, perhaps also by type of victim.

The data reveal that the population of N.N.s buried in the Rionegro cemetery is concentrated in the year 2003. These deaths were not random events in a period of overall elevated death rates. Rather, they occurred when identified deaths were low. This finding allows us to conclude that these are not N.N.s who one might expect to see in a society without armed conflict; 2003 is a sui generis year in which there was an "excess" of N.N.s arriving at the Rionegro cemetery. We know that the Colombian army carried out extensive military operations in 2003.[7] Families in Eastern Antioquia who are looking for relatives who went missing during 2003 may have a higher probability of successful identification in the Rionegro cemetery than people searching for

7. Observatory of the Presidential Program for Human Rights and Humanitarian Law: http://www.derechoshumanos.gov.co/observatorio_de_DDHH/04_publicaciones/orienteantioqueno.pdf

Figure 3: Identified cemetery population according to census and gravedigger's notebook

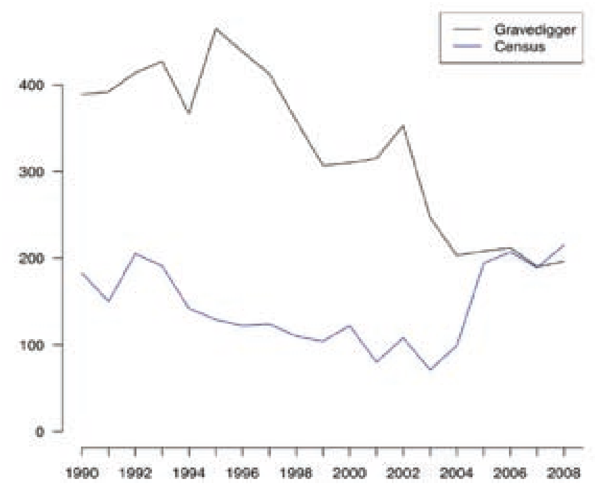


Figure 4: N.N. cemetery population according to gravestone census and gravedigger's notebook

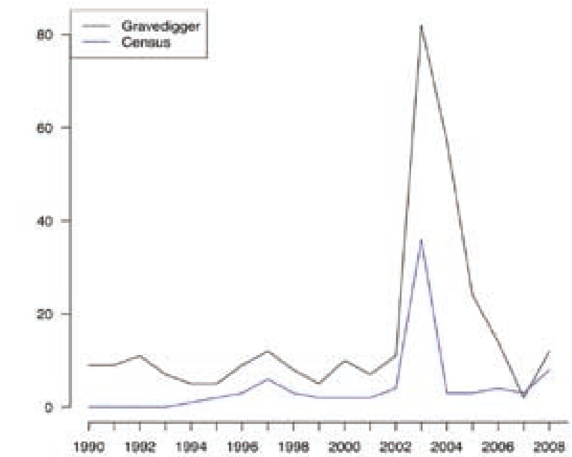


Figure 5: Percentage of unidentified cadavers according to census and gravedigger's notebook by month

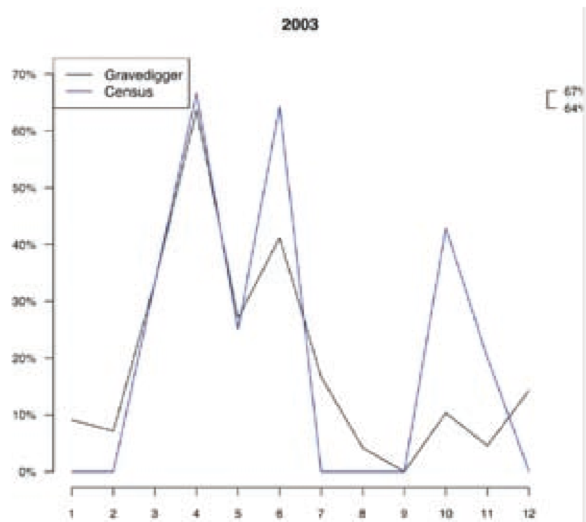
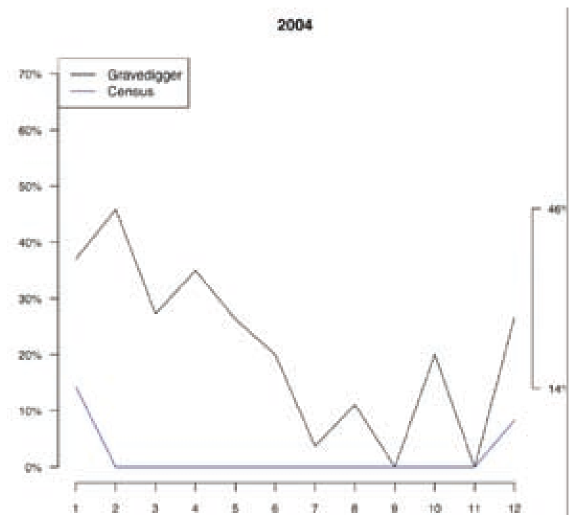


Figure 6: Percentage of unidentified cadavers according to census and gravedigger's notebook by month



victims of other periods of time. Thus, reviewing temporal patterns of data from cemeteries can contribute to devising strategies for the search for the disappeared.

Results and Discussion

There are advantages in examining all available sources of information to understand the patterns and magnitude of the N.N. population in a cemetery in the context of a search process. If examined separately, each source provides a partial perspective of the population of a cemetery across time. By comparing the various sources, search missions will gain a more complete understanding of the phenomenon of unidentified bodies in cemeteries. The patterns, by time and density of N.N.s, can indicate to search initiatives whether it is likely that the remains in a cemetery could be those of the disappeared. The data can be collected and analyzed relatively quickly in a preparatory phase of a search mission.

- Cemetery administrators should keep accurate records – for their own bookkeeping and for the contribution they will make to the process of identification of the N.N.s in their cemetery. In particular, we recommend that cemeteries keep an historical and up-to-date "census" of the graves and the remains they contain.
- Cemetery administrators should create a unique identification system for each single grave, so that individual remains can be located and tracked when moved. A unique identification system will help cemetery administrators as well as local authorities to locate each grave and individual buried in the cemetery.

While this was a pilot study to test the potential of a data source in search and identification missions, the analysis has raised some important questions, noted throughout this paper. With additional qualitative research and quantitative data, these substantive questions could be investigated. For instance, the sources of information reviewed in this pilot study could be compared with reports of conflict-related disappearances and accounts of combats in the area in order to determine more clearly whether certain disappearances match individual remains in a cemetery.

Also, the knowledge gained through the quantitative study of the population in the cemeteries could be complemented with qualitative contextual research. The quantitative study can corroborate or invalidate qualitative hypotheses, such as whether N.N. from other regions were buried in municipal cemeteries, which actors may be likely perpetrators, etc. The data from Rionegro could be combined and analyzed with other existing sources, such as official deaths and homicide records, population data, registries from other cemeteries in region, etc.

ACKNOWLEDGMENTS

We wish to thank the Rionegro parish church for generously sharing the cemetery records with Benetech and EQUITAS, as well as for letting us carry out the gravestone census in the cemetery. We wish to thank the British Embassy for financing the pilot study. We would also like to thank the Sigrid Rausing Trust for their support to Benetech projects in Colombia. Our thanks also to Diana Garcia for leading the team in the cemetery and to all the coders for collecting the data and organizing it in the database.

Tamy Guberek coordinated the project, trained the field staff and wrote the report. Daniel Guzmán conducted the data analysis. Beatriz Vejarano edited and translated the report.

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ANNEX • CEMETERY GRAVESTONE CENSUS CARD

A. General Information					
	Year	Month	Day		
1. Date of registration					
2. Name of coder					
B. Information on the location of the gravestone					
	Gallery	Wall	Row	Column	Person No.
1. Unique ID assignment					
2. Cemetery ID Number					
C. Summary of information on gravestone					
1. Type of gravestone	Individual Gravestone	Family Ossuary	Common Ossuary	Mausoleum	
2. Gravestone	Cover	Plaque	Does not apply		
3. Inscription	Written information	Erased information	Overwritten information	Blank	Does not apply
4. Condition of gravestone	Open	Partially open	Closed	Empty	
5. Total number of persons in tomb					
D. Photograph					
1. Number of photo					
2. Number of camera					

Archaeological desk based assesment for the search of missing persons in La Escombrera construction debris dump (Medellín, Colombia)

Kevin Lane, PhD

Construction debris dump

Abstract: Archaeological methods such as survey and excavation are key to the search and investigation of missing persons. Human Rights and Victim organizations have reported The Escombrera construction debris dump in Medellín, Colombia as a place where approximately 400 missing persons could be deposited, in to armed activities perpetrated by the military operation Orión in 2002 followed by paramilitary activity. Finding remains of people in such a scenario has been discarded by state investigators due to the technical and economic costs it might entail. However, this is one more of the challenging scenarios in which archaeology can offer techniques and recovery possibilities that should be explored in order to scientifically exhaust efforts to investigate and return these missing persons to their loved ones.

Key Words: Forensic archaeology, construction debris dump, archaeological survey, missing persons.

INTRODUCTION

Why does forensic investigation require archaeology? The simple answer is that forensic investigation requires the excavation of a grave or deposition of human remains and the fact remains that the best tried and tested method for excavation is the archaeological method. Archaeological method becomes even more relevant when the location of the buried is unknown. Detection by archaeological means is an increasingly sophisticated affair.

Everything that is buried, be it Prehispanic or from yesterday, becomes essentially 'archaeology' and its recovery through archaeological survey and excavation must be pursued through the application of rigorous methods applying to all places and at all

Photo taken from: ipc.org.co

times. Archaeology encompasses a slew of methods that allows for the systematic and precise recovery of facts from the ground; facts that elucidate the deposition history of an object through the pursuit of precise extraction methods, and especially recording techniques. The same degree of rigour and exactitude applies to both excavation and to survey.

SURVEY

Since the 1960's field survey has increasingly become more complex and precise. Although many archaeologists see survey as the poor cousin of excavation it does have some distinct advantages; it is only through survey that extensive extra-site activity can be gauged and the relationship between place and landscape examined. Through surveys soil disturbance and areas of activity can be detected and examined. Also, survey works on the premise that you might not know exactly what you are looking for and thus provides a broad-brush technique to the detection of sites.

As in excavation, all survey must follow a precise research design that will determine what tools and methods will be used as well as the scale which they operate. Indeed crucial to all archaeological work is the central tenet of planning. For example survey comprises a series of specialities such as aerial photography. Aerial photography is conducted on flights between 8,000 and 10,000m. Although most aerial photography runs were undertaken after the 1940's, many of these are increasingly being digitised and provide a high resolution tool that can be used to detect ground disturbances and changes in landscape use through time.

The identification of cropmarks, understood as the differential growth of crops which produces negative and positive marks visible on angled aerial photographs, can be very useful in detecting past and recent ground disturbances. This method can be especially pertinent for the recovery of mass graves in cultivated fields, considering that the historical context is better known than those of the past. For example information such as conditions at time of burial; conditions since burial as well as the testimonial record of witnesses can be forthcoming in present cases. Although the resolution of satellite imagery in many areas is still not optimal, there is a great potential in these tools as it possible to analyze multiple images at different times of a same place.

Another method is transect field-walking. It is a the systematic survey of a smaller area of a landscape to detect concentrations of material or of ground disturbance. The central concept is that groups walk the landscape in a planned pattern, pausing and recording any potential sites encountered along the way. Recording is done on a scaled and gridded map of the area, which has been geo-referenced by GPS (Geographic Positioning System).

Again exactitude is a necessary component of this method with ample and dedicated recording, photography and drawing of all possible features.

Photo 1. Cropmarks example

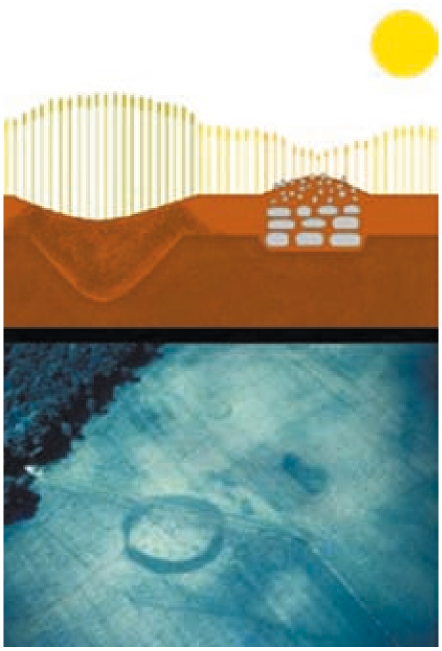
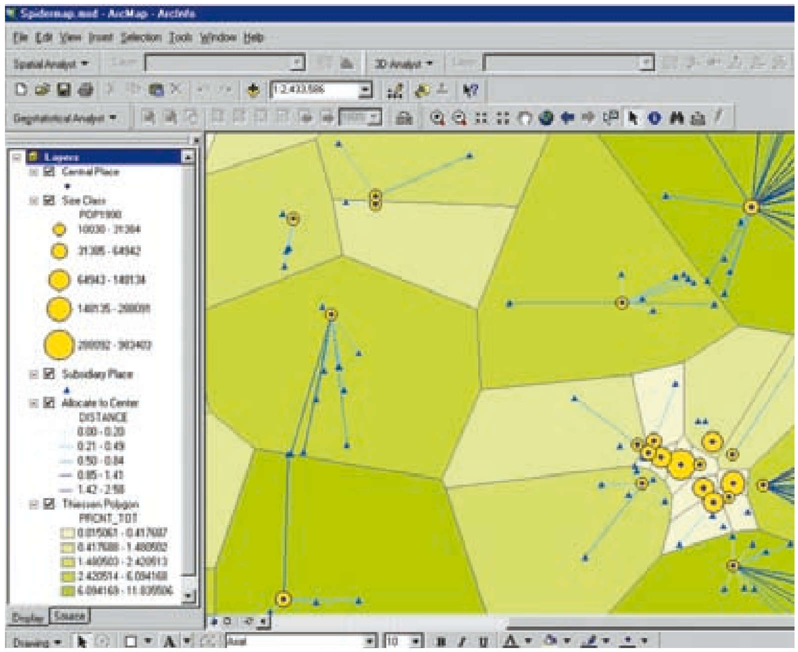


Photo 2. [GIS] Geographic Information Systems



There are problems with survey such as biases or unevenness in survey coverage; inconsistency in methods and definition of analytical units; attrition of the evidence through erosion, construction, burial and other processes; as well as lack of visibility. Yet, walking surveys can be augmented by recourse to geo-physical or non-intrusive remote survey such as metal detecting, ground penetrating radar and electromagnetic survey.

All these non-intrusive field method systems have their limitations and in no way do they provide a panacea for detection in forensic conditions. For instance metal detecting is a good fast method of detecting metal and thus could be important for detecting graves of people with metal object with them. Yet it does not differentiate between types of metal and it is not usually good at great depths. Ground Penetrating Radar or GPR is not good on silts or clays but is good on sand and rock. In dry conditions GPR can help penetrate down to 5-8m and can give very good depth resolution, in other climatic conditions it can be severely limited.

Unfortunately GPR is also slower than electromagnetic survey (EM). EM is a cheap, good and fast method for detecting metals and ground anomalies down to a depth of 6m, and considering that individuals might have been buried with metal objects it is possible that EM survey could be the favoured solution for many surveys. The resulting geo-physical survey maps can also indicate underground features such as trenches, ditches and pits, which will appear as anomalies on these maps. Nevertheless, it is important to remember once again that geophysical survey is not the solution to everything; it is just another method to employ with its own set of limitations.

Excavation

For a true perspective on what is under the ground all survey must eventually end with excavation. Developed since the early part of the nineteenth century excavation has become increasingly complex and multi-layered, yet the information that can be gleaned from this endeavour is immensely valuable for identifying patterns of stratigraphical (or layered) deposition. As in survey, excavation depends on precision and strategy, knowing what you expect to find and planning adequately for this is a crucial aspect of archaeological excavation.

There are many types of excavation from large open-plan to keyhole excavations as well step trenching for mounds and refuse middens, and coffer-dam excavation in waterlogged or sandy sites. (See last page). Alongside excavation are a range of sampling techniques that can also aid in the extraction of relevant information such as wet and dry sieving to recover small objects, geomorphology of soil samples to identify chemical inclusions in the earth and pollen analysis to reflect on seasonal conditions at the moment of deposition.

Types of excavation. Step trenching

Types of excavation. Vertical excavation

Types of excavation. Coffer dam

Photos: Kevin Lane

As in survey adequate gridding and sectorisation of the site is a crucial precursor to any work. Recording is always conducted systematically through pro forma recording sheets known as context forms, photography, and drawing. Attention to detail is incredibly important for all archaeology but especially so for the excavation of bodies. Special recording forms exist for body excavations and special delicacy should be employed in the recovery of the dead so as to extract the maximum amount of information. This information includes systematic and well documented excavation and significant amounts of photography that charts the process of recovery.

In all archaeology, survey, excavation and especially body recovery there is no excuse for shoddy practice. The bare minimum of documentation will always cover the following, ample photography and the triangulation of potential sites through standard coordinates obtained using an Electronic Distance Measurer (or tape measures) and a good compass (such as a Brunton or high calibre Silva compass). For even greater accuracy a differential GPS can be used.

Lack of time or resources is not a valid reason for bad forensic archaeology, others depend on the rigour of our fieldwork recovery.

CASE STUDY

This case involves the disappearance of more than 400 individuals within the construction debris dump La Escombrera, of Terrigenos Agregados SA located near to the Comuna 13, El Salado district of Medellin (Antioquia, Colombia). The Escombrera has been in constant use since 1990, although the first deposition of bodies was probably carried out in the mid-1990's by effectives of various paramilitary groups. The main period of body deposition though would have occurred during and after the Colombian Armed Forces 'Operación Orion', the main phase of which was undertaken between the 16th of October and 30th of November 2002. Further deposition of bodies occurred throughout 2003, and subsequently, as part of mop-up operations conducted by legal and illegal armed groups.[1]

An adjacent escombrera (Proparques El Sol) does not seem to have been the object of body deposition but is included within the general area of impact. The main site, given the available evidence, is that of Terrigenos Agregados, which is divided into three main terrain types:

1. The escombrera construction debris dump;
2. a small natural lake;
3. a sand extraction area known as 'Arenera Alta' or 'Arenilla'.

Of these three terrain types it is possible to disregard the last one as sand extraction activity is not propitious to the internment of bodies. Constant references to deposition in the 'arenal' by victim's families should therefore be taken more as a reference to the general area rather than the sand extraction site specifically (see Fig 1).

Deposition in the other two environments differed considerably from each other. Within the natural lake it is likely that the bodies where weighted down and sunk near the lake shore (note: the shoreline would have differed depending on the season). It is hard to gauge the rate of sedimentation

1. Human Rights organizations such as Corporación Jurídica Libertad and Codhesel have documented more than 70 reports of people who were illegally taken from their homes after November 2002, as part of the military Operación Orión with the purpose of finding guerrilla members at the El Salado Comuna (neighbourhood) of Medellín. See: http://www.prensarural.org/spip/spip.php?article1885 (IPC Press Agency website). Also, paramilitary testimonies under the Justice and Peace law, during 2007 have described how dozens of people were assassinated, dismembered and buried in the highest section of El Salado by the Metro section of the Autodefensas Campesinas de Córdoba y Urabá (Accu) Cacique Nutibara, Magdalena Medio and Héroes de Granada de las Autodefensas Unidas de Colombia (Auc). In: The Escombrera in Medellín, should be a symbol, article in Semana.com. http://www.semana.com/noticias-conflicto-armado/escombrera-medellin-debe-simbolo/117428.aspx

Figure 1. **'Arenera Alta' or 'Arenilla', sand extraction site.**

Photo: EQUITAS 2009

of the lake, although this probably occurs through two different actions, natural sedimentation from upslope alluvial deposition and human dumping of midden refuse.

The dump itself is composed of a large variation of construction refuse such as stripped tarmac, brick, mortar, concrete, metal, plastic, etc. There is no homogenous nature to the deposition and it varies depending on where the refuse is coming from. The refuse has been built against the natural slope of the hill on which the dump is located and evidences significant landscape construction. In areas the dump is up to 50m in height (see Fig 2), where it is not possible to assess the vertical width of deposition through a visual reconnaissance.

Truck driver testimonies, suggest that the bodies were deposited in the dump and then covered by the contents of between 5-8 trucks; these trucks displace between $5m^3$ and $9m^3$ each. Subsequently, the deposited area would have been levelled by a JCB leveller. This action could probably produce crushing and dislocation of body parts.

Figure 2. Terrigenos Agregados S.A. escombrera, located near to entrance.

Photo: EQUITAS 2009

It should be noted though that deposition of the bodies was not done through digging into the dump, rather they where lain there and subsequently covered by new refuse material. Hence identification of the areas of body deposition is therefore not based on finding pits, as these do not exist. Also, given the fact that the refuse is all of different types of landfill it would be very difficult to distinguish cuts or pits, if these existed, within the construction dump.

ARCHAEOLOGICAL PROBLEM

The essential problem is a strategy for evaluating and investigating the two main areas of possible body deposition: a. the lake and b. the dump. These two areas will necessitate very different strategies of archaeological investigation.

Nevertheless, prior to excavation the setting up of a grid will be essential, this is necessary so that subsequent investigative outings can be coordinated through a central grid system. Given the changing nature of the dump and the immediate landscape it will not be necessary to fully grid the site. Rather the setting up of a series of permanent benchmarks or datums across the whole of the site would be necessary.

These should be set in such a manner that it should be possible to triangulate any new excavation trench or area of investigation on the site. These datums should be accurately geo-referenced to established topographical benchmarks to a maximum error of 5cm.

It has been suggested that ground penetrating radar (GPR) or remote sensing methods may be used on this site. Although remote sensing is a possible methodology for use on the lake site (see below), it is considered inappropriate for use on the dump. The reasons for this are manifold and some of the more salient points are summarized below:

1. Most GPR systems function on the basis of finding underground features, as we have stated above neither the lake site nor the midden have recognisable archaeological features such as pits or ditches;
2. GPR and remote sensing are accurate to a total maximum distance of 5-8m; given that the dump is up to 50m in depth it is highly unlikely that these methods will yield significant results. This assumption is taken on the understanding that the deposition of the bodies occurred mainly in the 2002-2003 bracket, so that given the increase of the midden it is very likely that the bodies are at depths below the range of GPR or remote sensing;
3. Most remote sensing techniques are very susceptible to the presence of metals, as this is a construction midden the presence of high concentrations of metal is assured. Therefore the survey will be heavily contaminated by these secondary, non-relevant signals.

In lieu of these problems we suggest a different more traditional approach to the problem, which utilises a sound desk-based assessment of the archaeology coupled with excavation and survey.

METHODOLOGICAL PROPOSAL

There is a significant problem of scale in tackling this site; essentially the site is too large, vertically and horizontally, to effectively propose the complete excavation of the area. Given these circumstances it is crucial to establish limits of what is possible, as such we propose a preliminary coordinated investigation of the site to see the potential of the methodologies suggested here.

To prioritise this investigation of the site we propose to study both the lake and the dump. The separate methodologies for both are described below:

LAKE INVESTIGATION:

The lake has an advantage over the midden in that it is a relatively natural, and self-contained site. As mentioned above, deposition of the bodies in the lake was possibly through weighting of the bodies and then through natural silting and possibly some dumping. Given that the lake is still visible we can assume that dumping has not been a significant factor in the infilling of the lake.

Firstly, the recommendation is for draining of the lake so that we achieve a dry surface; underwater archaeology would not be viable given the lack of visibility in this lake. Once the lake has been dried off, it would be necessary to set up a geo-referenced grid (5m x 5m grid squares) that covered the whole of the lake. Care should be taken to include at least 5m of bank as it is possible that the lake has shrunk over time so that the original lakeshore stood further back than is now the case.

Once the lake has been gridded, two methodologies may be employed; the first is the use of Electromagnetic (EM) conductivity equipment (this method is a good, fast method for detecting metals and ground anomalies down to a depth of 6m). Although we do expect any ground anomalies and given that metal contamination might be a factor this method might also locate victims that were deposited here with metal objects such as buckles, shoes, etc.

Secondly, the lake should be sampled through the trench excavation of a sample of no less than 20% of the lake area. These trenches should be no less than 1m in width and should be so placed that they intersect a series of terrains such as the lake bank, immediate shore and lake proper. Given that the bodies were probably deposited along the lakeshore particular attention should be paid to this area. Also, concentration along the motor access point to the lake should be particularly targeted. The trenches should be spaced so that the 20% sample encompasses a statistically significant area of the lake site.

Excavation of the lake can be undertaken through closely monitored machine stripping of the overlaying sediment as the deposition of the bodies in the lake will not have created any observable archaeological feature just silting over the remains. Stripping of the sediments should be done under close supervision and of depths of no more than between 5-10cm across the horizontal plane using a small excavator with a bucket of no more than 1.2-1.5m in width.

Excavation by hand will be undertaken immediately after the discovery of any item worthy of investigation. These excavations will be linked to the main grid set out during the initial survey of the lake. Excavation of all items in the lake sediment should be conducted meticulously by hand following the single-context excavation techniques standardised by MoLAS (1994); excavation of bodies should also use these standards and those set by the manuals of Bass (1992) and Roskams (2001). Registration of every archaeological context should include adequate photography (with scales and north arrow), profile and plan drawings, and context sheet descriptions of each cut, fill and internal features or objects (if any). After excavation, the opened tranches should be re-filled and covered. All objects of archaeological interest should be labelled and collected following the standards set by the manuals mentioned above.

DUMP INVESTIGATION:

The midden presents a much more serious problem for purposes of our investigation. The initial phase of investigation requires detailed information of the formation of the midden. Because of the scale of the midden it will only be possible to sample an area of it, as such it is recommended that this initial investigation focuses on the main period of body deposition, that pertaining to the Operación Orion. The reason behind this is simple, given the number of people eliminated during this period we are more likely to find evidence of this incidence than that of an isolated body deposited at a later or earlier date.

Given the extent of the midden and the nature of the deposit it is nevertheless essential to have verifiable and reliable evidence of the state and geography of the dump when the main period activity associated to Operación Orion was underway. This point is crucial, without this information it will be extremely difficult to archaeologically investigate the midden. As an adjunct it may be possible to access aerial or satellite imagery pertaining to the period in question to verify the geography of the midden at this time. This preliminary assessment should give us a depth and intervention area within which to maximise our efforts.

This intervention area will have to be suitably gridded and then sampled to not less than 20% of the area through excavation using geo-referenced trenches, located across the area so as to maximise the possible location of the deposited bodies. At this stage we are essentially striving for excavation of the pre-determined intervention area. The conditions of the midden suggest two possible ways of progressing:

1. Coffer-dam excavation (see Roskams 2001) – this entails the shoring up of the vertical plane of the excavation. Although consolidated, it is likely that parts of the midden will only be weakly so, hence it is important for the safety of the investigators to shore-up the trench excavation down to the archaeologically significant level.
   The advantage of this method is that the area of excavation can be controlled and it will not be necessary to strip the whole of the midden down to this level. The problem is the unknown nature of the dump; should excavation uncover an area of large construction refuse that extends beyond the horizontal limits of the coffer-dam trench, then it will be impossible to continue the excavation. Furthermore, shoring will have to be of a strong enough material (thick wood or reinforced

corrugated iron sheeting) so that trench collapse can be averted.

2. Dump removal and excavation – in the end this might well be the desired method. This entails the laborious removal of the midden down to the level of possible body deposition. This would employ at least three JCB excavators and a number of trucks to remove the material to another part of the site. The main problem with this method is the time intensive nature of midden removal, the advantage is that the whole of the intervention is open for investigation and trail trenching.

Whatever the method employed, it is envisaged that excavation through the use of large JCB's will be to a depth c.0.5m before the desired level. The reason for this is to compensate for possible post-depositional movement of the midden and the possibility of error in the gauging of depth in the original dump depositional documentation. Once this level has been attained, further wok will be undertaken much more carefully, stripping in the region of between 5-10 cm. Dry sieving of all this material will be required at this stage given the possibly fragmentary nature of the evidence. All this work should be closely monitored by qualified archaeologists.

Excavation beyond this level will be done through trenching and dry sieving of all material uncovered. As with the lake investigation, excavation by hand will be undertaken immediately after the discovery of any item worthy of investigation. These excavations will be linked to the main grid set out during the initial survey of the midden area. Excavation of all items in the midden should be conducted meticulously by hand following the single-context excavation techniques standardised by MoLAS (1994); excavation of bodies should also follow these standards and those set by the manuals of Bass (1992) and Roskams (2001). Registration of every archaeological context should include adequate photography (with scales and north arrow), profile and plan drawings, and context sheet descriptions of each cut, fill and internal features or objects (if any). After excavation the opened tranches should be re-filled and covered. All objects of archaeological interest should be labelled and collected following the standards set by the manuals mentioned above.

It is estimated that an initial survey of the site to test the viability of this method will take a minimum of 4 weeks of continuous fieldwork.

ACNOWLEDGMENTS

We would like to thank forensic anthropologist Oscar Hidalgo from the CSI team of the National Prosecutors Office in Medellín, for his interest in this topic.

PRELIMINARY LIST OF EQUIPMENT AND TEAM COMPOSITION

- Standard excavation equipment – shovels, trowels, string, nails, stakes, scales, north arrow, etc
- 3 x Mechanical excavator with a 3-4m bucket
- 1 x Mechanical mini excavator with a 1.2-1.5m bucket
- Total station set [topographer and one assistant with prisms]
- Electromagnetic (EM) conductivity set [operator and assistant]
- As a minimum the core team should comprise a trained field archaeologist/anthropologist and three assistants aside from the topography and geophysical teams.

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Clandestine burials

Remote sensing analysis proposal for the location of clandestine cemeteries next to the Casanare River in Colombia

Luz Adriana Guatame

Abstract: This article suggests criteria for the preliminary evaluation of search sites through remote sensing analysis in order to identify terrain modification patterns as potential indicators of clandestine burial sites. The study of several previous exhumations pointed out that many of the burials were associated to river and stream natural drainages and to flood plains. This finding implies a comprehensive study of drainage behavior that would enable researchers to find out to what extend the burials have been affected by rushing water passing over them, either erasing superficial grave marks or covering them with water sediments or displacing them in some cases. Understanding how rivers change in time, is a key element when conducting regional search processes of missing persons, based on testimonies.

Key words: clandestine burials, remote sensing, natural drainages.

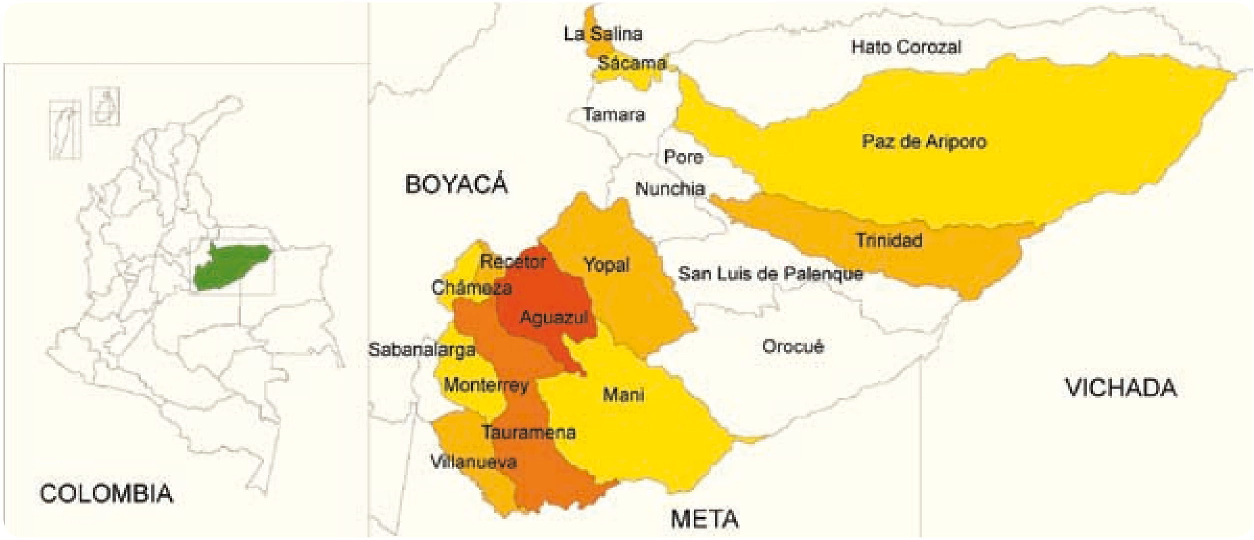
INTRODUCTION

Processing and analyzing information obtained through remote sensors such as satellite images or aerial photographs, have proved to be an appropriate methodology in various contexts in the search for clandestine burials (Kalácska M. y Bell, 2006.) The relevance of this methodology is based on the fact that it allows the study of land surface properties, characteristics and definition over considerable land extensions in short periods of time and at a lower cost than a field job would require. Furthermore, it involves a methodology where there is no physical contact with the field, offering abundant qualitative information on the area and the potential existence of clandestine burials, that will help to carry out search planning and recovery activities and offer better safety conditions for the personnel in charge of exhumations.

Historically one of the most utilized methods in order to locate clandestine graves in Colombia and other parts of the world, has been witness and informant declarations. In many cases, particularly related to events occurred several decades back or in areas of the country that are difficult to access, the information has been inaccurate and inexact, causing ineffective resource and time investments in the search for remains. This situation demands the application of new tools to help find victims and at the same time, allow the effective investment of resources available for this purpose.

To this end, the present study shows the results of a tele-detection study in an area of the Department of Casanare, Colombia (figure 1.) The purpose of this study was to identify terrain modification patterns, as well as landscape elements that could be perceived as clandestine gravesite indicators, so that they can be suggested as criteria for the preliminary evaluation of sites where field work can be carried out.

Figure 1. General location of the study area. Highlighted in color are the Department of Casanare municipalities where exhumations have been reported.



METHODOLOGY

Area Selection

The study area was determined according to a database of exhumations carried out in the Department of Casanare from February 2007 to November 2008, provided by the Justice and Peace Unit of the National General Prosecutor's Office[1] to EQUITAS. The information contained varied data of sites where 60 bodies were retrieved in graves containing from 1 to 3 individuals. Each datum was assigned an alphanumerical code formed by a consecutive number and the prefix CF (Casanare-Fiscalía.) Out of the 60 datums, only 20 were useful since in many cases, the geographical coordinates were missing or the data was not related to any location in Colombian territory; this issue will be discussed further on.

Once the exhumation points were located on the department's reference map corresponding to IGAC J-13 A L-14[2] quadrants, data was classified as follows:

1. The Justice and Peace National Unit was created by Law 975 of June, 2005 and has national jurisdiction for the investigation of crimes confessed by paramilitaries who demobilized under the law. One of the unit's main activities is the search and exhumation of the remains of victims of missing persons.

2. Colombian official cartography.

burials in mountainous areas; burials associated to drainage and flood plains; burials in cemeteries; burials not associated to any particular geographical feature.

The relationship between each type of burial and its frequency led to determining preferential location patterns in areas close to river beds; therefore, the study focused on exhumation sites associated to drainage points in "Piedemonte Llanero" (where the mountain ends and the plain starts.) The points are located close to the Güira, Los Tembladores, La Herradura, Casimena, and Piñalito streams and Cusiana, Casanare, Meta, Cravo Sur, Guafal, Chitamena and Unete rivers. The distance between these drainages and the exhumation sites was calculated to be up to 4 kilometers (table 1, figure 2.)

Table 1. Data associated to drainages

Casanare Fiscalía point	Municipality	Associated drainage	Approximate distance to the main watercourse
CF2	Tauramena	Tembladores Stream Güira Stream	500 meters
CF3	Aguazul	Cusiana River Minor Drainage	2 kilometers 100 meters
CF4	Orocué	Surimena Stream	900 meters
CF23	Tauramena	La Herradura Stream	2 kilometers
CF24	Tauramena	Caño Güira	1.8 kilometers
CF25	Tauramena	Cusiana River Casimena Stream	6 kilometers 200 meters
CF42	Monterrey	Cravo Sur River	700 meters
CF48	Paz de Ariporo	Unidentified	100 meters
CF50	Tauramena	Güira Stream	1.8 kilometers
CF51	Tauramena	Chitamena River	1.5 kilómetros
CF57	Monterrey	Guafal River	70 meters
CF59	Orocué	Cravo Sur River	1 kilometer
CF60	Aguazul	Unete River	100 meters

Considering point location and previous information that this area is affected by fluvial activity typical of rivers existing in the region up to 10 kilometers (Butzer, 1976), the distance between the exhumation points and the river main waterbeds were taken into account in order to determine the possible effects of such waterbeds on the burial areas.

Satellite Images

1991 Landsat TM y 2001 ETM+ images corresponding to the quadrants located at path 6 row 56 - 57 and path 7 row 56 - 57[3], were analyzed in order to carry out a multi-temporal analysis of waterbed and flood plain variations at the main drainages before, during and after the periods of time when the clandestine burials take place. Current Quick Bird type images from Google Earth were used as reference markers.

3. Landsat images have high radiometric resolution and use 7 and 8 spectrum bands covering almost all the electromagnetic spectrum.

Figure 2. Location of drainage associated points

Since most of the available images have low spatial resolution, analysis particularly refers to the flood plains of the main river beds. We identified areas followed by the main flow of rivers and streams, as well as areas that regularly suffer floods vs those that don´t.

For images 1991 and 2001 (figures 3 and 4, next page), a false color composition RGB 742 helped to highlight the water-bodies. Figures 5 and 6 (next page) show the image interpretation. This excercise includes discriminating different types of soil: active river valleys, areas prone to sporadic flooding, and areas where there is no flooding. The default composition in Quick Image Bird (figures 7 and 8, page 36) is in true color.

Figure 3. TM 1991 image

False color composition RGB 742. The water bodies can be seen in blue, vegetation in green and land areas in red.

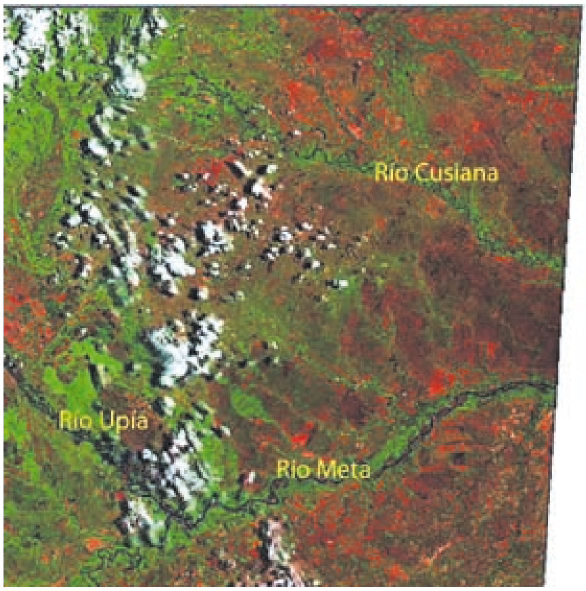


Figure 4. Landsat ETM 2001 image

False color composition RGB 742. The water bodies can be seen in blue, vegetation in green and land areas in red.

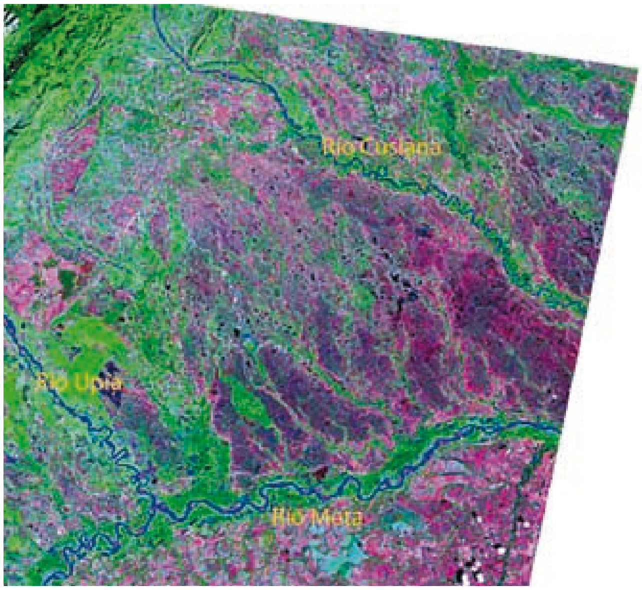


Figure 5. Landsat TM 1991 interpretation

Figure 6. Landsat ETM 2001 interpretation

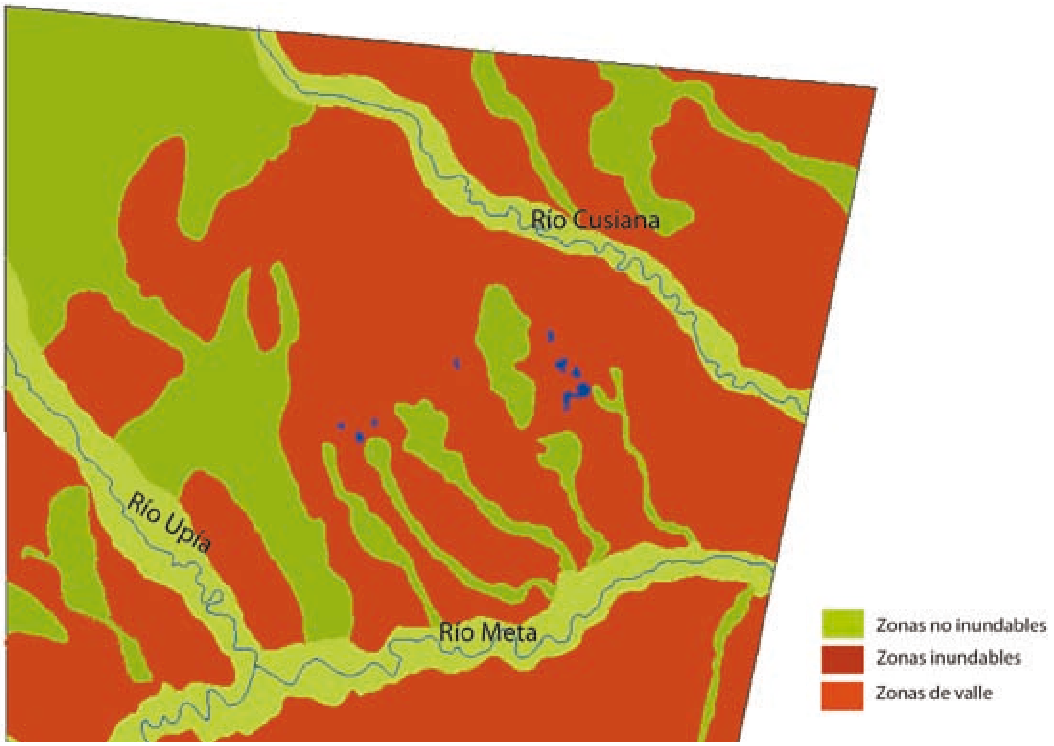
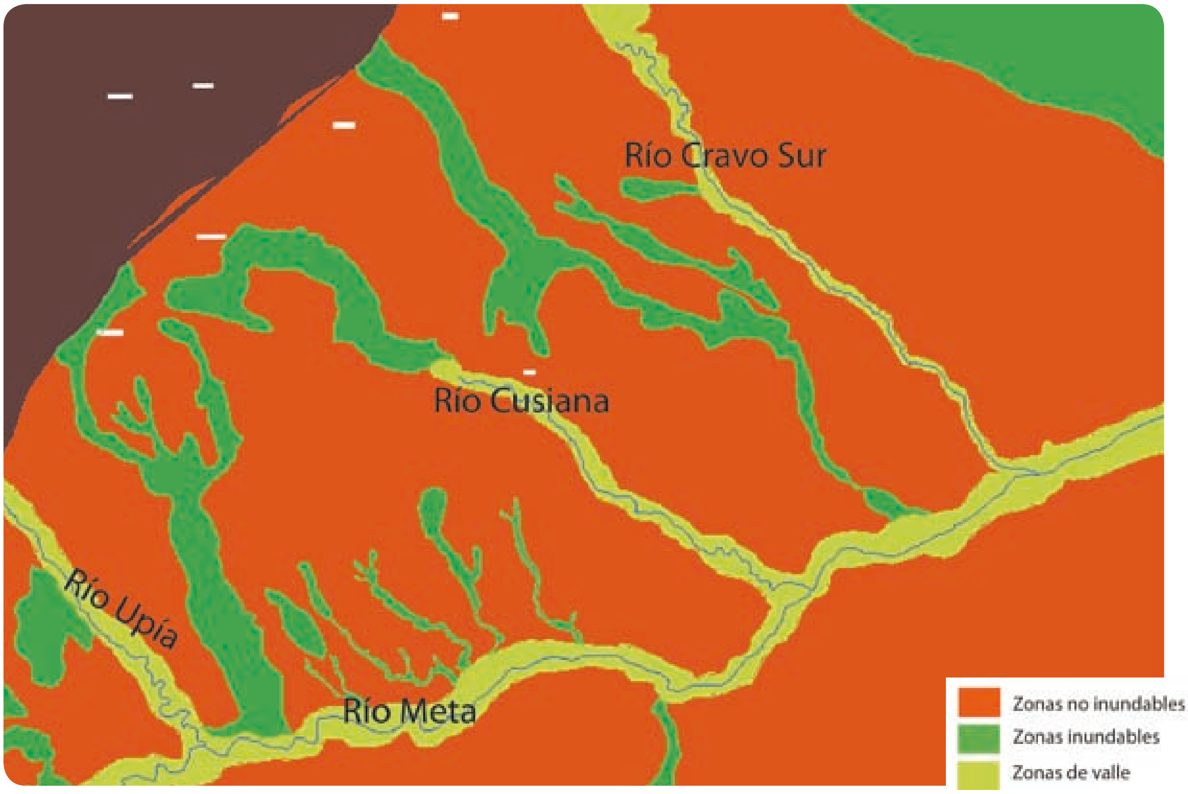


Figure 7. **Quick Bird 2009 image**

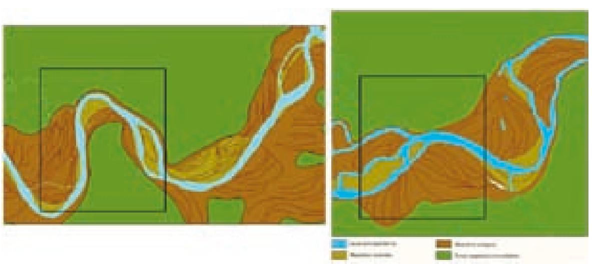
Figure 8. **Quick Bird 2009 interpretation**



Aerial Photographs

Aerial photographs were used to improve the spatial resolution of exhumation points near to rivers Meta and Cusiana, to observe the local condition of drainages, and, when possible, to carry out multi-temporal analyses of landscape variations that could be affecting the sites where there are clandestine burials (figure 9.) The observations focused on these two rivers because they were the ones that presented the best material to be analyzed, and their morphological characteristics are ideal for establishing parameters applicable to the rest of the drainages in the region. The scales used to work with the images were 1:15000 to 1:30000, corresponding to flights IGAC C2715, C2710, C2614, C2490, C2615.

Figure 9. Morphology variation of meanders and flood plains. Esc. 1:20.000



Software

Erdas 9.0® software was used for the analysis and interpretation of the material.

RESULTS

Geographical Characterization of the Target Area

The target area is located in the "Piedemonte Llanero" sector, which is is a transitional area between the Eastern mountain range and the Eastern plains. This has a direct effect on fluvial dynamics, producing a high energy system whwere high, steep mountainous areas transform into a system where energy must be dispersed throughout the plains, forcing the riverbed to adopt new forms of resulting in a meander and braid like system of rivers.

The fluvial dynamics in the mentioned area is in general, extremely rainy; this phenomenon is proven by the large water gushes at the base of the mountains. Some records show water flows between 40 and 150 m^3 per second in Guayuriba river; from 40 to 1700 m^3 per second in Guatiquía river; and from 390 to 860 m^3 per second in Meta river, according to data from the Institute for Hydrological, Meteorological and Environment Studies (IDEAM – in Spanish.) The alluvial force coming from the mountain range is deposited mainly in the "piedemonte" mentioned above, and this is why some water bodies raise their level causing flooding and riverbed switching.

Moreover, the "Piedemonte Llanero" presents different geo-morphological expressions caused by geological factors and natural processes occurring on the surface (Ingeominas, 2004.) These expressions can be divided in three geo-morphological categories: structural, fluvial (disected fans), and fluvial (flood plains.)

From the climate perspective, the "Piedemonte Llanero" is characterized by its 1500 to 2000 mm annual rainfall, which makes it a high rainfall region. There is a mono-modal regime with 7 or 8 month periods, and the dominant savanna vegetation and partially cloudy skies facilitate the transportation of sediments and superficial substances.

DISCUSSION

As shown in Figure 2, exhumations in the Department of Casanare have occurred mainly in areas close to riverbeds found in the "Piedemonte Llanero", a region characterized for having meander like river systems and greatly varied flood plains. These meander like river systems are known for having a main riverbed with minimum sinuosity of 1.5 meters and a great capacity to transport fine sediment (i.e. silt) as well as thick, heavy sediment (i.e. gravel, vegetable material), according to the flow energy. In the river valleys there are alluvial plains formed by deposited sediment where currents readjust their course by carving it out and re-depositing material. With time, meanders migrate down the river and tend to increase sinuosity. The maximum current speed occurs in the channels´ external part, thus producing higher erosion, and the carved out material is re-deposited in the inner part of the channel, thus producing pointed bars (Butzer, 1976.)

Through satellite image observation, the way flood zones have decreased during the last 10 years has been evident, making this area vulnerable to erosion, particularly in heavy rain periods when the areas closest to the bodies of water turn into sporadic flood areas. The decrease of the flood area extension could be due to climate changes or anthropic effects such as the use of flood areas for crop farming, riverbed control for agricultural purposes, or for gravel exploitation, etc.

Sporadic flooding periods can affect the location of clandestine burials in two fundamental aspects. First, flooding can erase any type of superficial mark indicating the existence of a grave; second, it can cause significant variation in the landscape, particularly in the riverbed shape, which can affect the interpretation of reference points identified by witness testimony.

It is worth mentioning the following precisions for future research: First, it is important that images used to evaluate changes in landuse, if possible, correspond to the same season of the year so that rain regimes do not alter conditions that are observed, like interpreting visible changes when it is really a recurring phenomenom. It is also important to take into account climatic phenomenoms such as the “Niño”, which start with dry periods followed by strong rains. Second, it is important to include other sources of information such as archive, oral, and archaeological references that can be cross-referenced for more accurate interpretation.

Study Development Difficulties

1. Data Obtained from the Justice and Peace Unit

There are multiple factors able to induce errors or lack of understanding related to the analyzed information. First of all, the exact coordinates of the locations where the exhumation took place were not contained in the provided records. In other cases, coordinates with minute and second values greater than 60 or grades in decimal quantities were observed, making it impossible to understand the exact value referred to by the data. Secondly, there was point repetition in the database, and some of them were mutually incoherent; for example, points CF2 and CF3 had the same coordinates as points CF56 and CF55 respectively, but some of the data, like the proceedings date and the body description, differed. Thirdly, inconsistencies were observed between the given coordinates and the referred district or farm for a single point when trying to locate the data on a topographic map. These three factors reflect errors in the database organization and in the standard parameters used in exhumation records done by the Justice and Peace Unit, making it impossible to have a real estimate of the work carried out and a workable data systematization to contribute to planning future surveys or exhumations.

Moreover, the database lacks important information. There is no information about the geo-reference system used, the equipment utilized to collect data, or its accurateness. There is no evidence that complete information on the exhumation such as the description of nearby infrastructure (houses, access roads, etc.), objective distance to a body of water, terrain conditions (flat, mountainous), and ground type, is systematically documented and included in the database for future analysis.

The available information about the exhumations carried out by the Justice and Peace Unit does not lead to other observations on clandestine burial patterns in the department of Casanare. For that reason, this study suggests:

- Having a standard geo-reference system, i.e. establishing fixed facts for determining coordinates.
- Designing a detailed recording format for the excavations to register clear, specific, and standard data about burial characteristics (i.e. unifying criteria for recording ground profiles.)
- Recording broader observations about the landscape (i.e. access roads, infrastructure, etc.) registering not only the location of other burial sites but also allowing a greater understanding of the armed actors' modus operandi.

2. Lack of Tele-Detection Material

A more detailed analysis of a larger area would have been possible with the interpretation of satellite images of high spatial resolution such as Ikonos, Quick Bird or Eros. Nevertheless, the scope of these images is scarce in the target area. It is important to complement and update aerial photographs, and topographic cartography obtained at IGAC .

CONCLUSIONS

The data provided by the Justice and Peace Unit on exhumations in the department of Casanare allow us to establish that clandestine burials in this region of the country clearly tend to be located in areas of river marginal activity, particularly in flood plains. This implies that fluvial dynamics, due to riverbed morphology and flood plain variation, have great effect over the landscape containing the burials. For example, this study allowed us to observe variations of up to 300 meters in the meanders' width in periods no longer than 10 years. Local variations of great scope in this region make superficial events occurred in short periods of time disappear due to the erosion-deposit activity, particularly when they involve small size modifications such as graves. However, it is possible to suggest priority search areas in old sedimentation areas that meanders have not reached during the period of time analyzed.

Although detail and types of data on exhumed graves varies in the records it is possible to establish that in all cases, burials are superficial and small in size since they contain 3 individuals at most. These burial characteristics, plus the variation of the ground surface in erosion-deposit areas, suggest a scale problem which makes it impossible to locate exact areas for clandestine burials using satellite images and aerial photographs.

Although these methods do not help determine places where burials could be found, remote sensors proved to be vital tools to understand landscape and observe its evolution through time. Cross referencing this information helps interpret testimonies of various actors more accurately.

It is not possible to determine if fluvial activity is able to expose, erode or even transport bodies, as there is no recording of burial conditions, such as the exact depth and the type of soil at the place. Relevant conclusions could be formulated based on a joint analysis of the grave information, flow data, plus the data on rain patterns in the region.

However, the way exhumations are currently planned and executed, on an individual testimony basis is not sustainable on a longterm situation.

The magnitude of the problem of missing persons in conflict in Colombia, requires immediate attention in order to document current findings, and carry out analysis that will lead to predictive models when testimonies are not available, and search teams have to rely on archaeological methods to find clandestine burials.

Based on this study, whenever remote sensing information (satellite images and aerial photographs) is available, tele-detection studies could become a key element to cross reference testimonies, find patterns and plan field work by prioritizing work areas and determining other *in situ* survey methods, such as the use of geophysical tools according to terrain characteristics. This will guarantee that exhumations will not follow individual graves, but try to recover all graves that are in a specific area, making human, economic and operational resources more effective. Future research should consider design project that includes georeferenced graves, and potential burial sites through a geostatistic perspective. This approximation could lead to a model or predictive map of potential gravesites, which will allow a better analysis of economic and operational fieldwork and success in the search for missing persons.

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