Diane L. France,[1] Ph.D.; Tom J. Griffin,[2] B.A.; Jack G. Swanburg,[3] A.S.; John W. Lindemann,[4] M.S.; G. Clark Davenport,[5] B.S.; Vickey Trammell,[6] M.A.; Cecilia T. Armbrust,[7] M.S.; Boris Kondratieff,[8] Ph.D.; Al Nelson,[9]; Kim Castellano,[10] A.S.; and Dick Hopkins,[11]

A Multidisciplinary Approach to the Detection of Clandestine Graves

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ABSTRACT: A multidisciplinary team that is comprised of professionals from industry, academia, and law enforcement who are studying methods to locate clandestine graves has been formed in Colorado. This article describes this team, research conducted, and preliminary results directed toward identifying the most effective means of locating buried bodies.

KEYWORDS: forensic science, clandestine graves

In 1986, Colorado law enforcement officials were presented with the following situation: according to rumor and stated by an informant, approximately a dozen bodies were buried over several square kilometers on a large ranch on the eastern Colorado plains. These bodies were allegedly interred over the course of several years. How could law enforcement best approach the problem of location, evaluation, and exhumation of a clandestine grave in such a manner as to preserve evidence and maximize its eventual use in a court of law?

The above incident was a catalyst for the formation of Project PIG ("*P*igs *I*n *G*round"), because of the limitations found with the traditional methods in the location and excavation of clandestine graves. Although a few graves were found on the eastern Colorado ranch, it is believed that additional bodies are still undiscovered, so the techniques learned

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[1]Department of Anthropology, Colorado State University, Fort Collins, CO.
[2]Colorado Bureau of Investigation, Denver, CO.
[3]Arapahoe County Sheriff's Department, Littleton, CO.
[4]Consultant, Broomfield, CO.
[5]Ebasco Services, Lakewood, CO.
[6]Consultant, Littleton, CO.
[7]Consultant, Aurora, CO.
[8]Department of Entomology, Colorado State University, Fort Collins, CO.
[9]Jefferson County Sheriff's Department, Golden, CO.
[10]Douglas County Sheriff's Department, Castle Rock, CO.
[11]Arapahoe County Sheriff's Department, Littleton, CO.

from the study described herein are expected to produce additional discoveries if the search on this ranch is reconvened. Project PIG continues to evolve as a research project designed to investigate methods and technologies that will prove even more effective in locating clandestine graves and recovering the contents. The study addresses the applicability of techniques and methodologies in identifying, monitoring, and where possible, quantifying the changes in the clandestine grave system. This system as defined by the authors is the dynamic interrelationship among the grave, its contents and total surroundings (see glossary for additional terms).

Project PIG involves professionals from academia, industry, and law enforcement assembled to share methodology, data, and information. To this end, a resource bank of interested specialists, has been established and continues to be updated to facilitate intercommunication relating to clandestine graves.

The purpose of this article is twofold:

(1) to share the results of the in-progress study being conducted in Colorado, and
(2) to encourage similar studies in other geographical areas and climates.

It is hoped that this article will encourage other professionals to cross those real or imagined barriers segregating their specialized fields of interest, and to pool knowledge, skills, and techniques in addressing the detection of clandestine graves.

Background

Only a few studies listed in the literature concentrate on multidisciplinary methods directed toward the location of buried human remains. The Boyd [*1*], Imaizumi [*2*], Andermac [*3*], and Bass and Birkby [*4*] (which also offers the rationale behind proper excavation techniques) studies offer overviews of some of the techniques also used in the PIG research. The most recent publication offering a comprehensive survey in search techniques is by Killam [*5*].

Although no group has undertaken a study of as many multidisciplinary techniques as presented in the Project PIG research, many articles address individual methods for locating clandestine graves. Davenport et al., [*6,7*] discuss the ways in which geoscientists work with law enforcement, while Hoving [*8*] describes the use of a small ground penetrating radar (GPR) unit for locating buried bodies.

Other studies have used pigs to research individual aspects of clandestine grave systems. Haglund et al. [*9–11*] and Haskel[12] have studied the scavenging and scatter patterns of pig and human remains. Haskel[12] in addition, researched decay processes.

The role of insects and other arthropods in the decay process of human remains has been reviewed by Nuorteva [*12*] and Smith [*13*]. Studies using unembalmed cadavers or pigs have elucidated a specific succession of arthropods and the resulting decompositional process [*14–19*]. Rodriguez and Bass [*20*] have addressed entomological methods and their relationship to depth of burial and local climatic conditions. Tolhurst and Reed [*21*] present information in the training and use of dogs for locating shallow graves.

In an effort to enhance a multidisciplinary approach, many techniques for clandestine grave-site location are being applied at a research area in Colorado. Preliminary results of the study were reported at the May 1989 conference in Denver of the Rocky Mountain Division of the International Association for Identification.

Currently the Project PIG team consists of experts in crime scene and laboratory analysis, aerial photography, thermal imagery, geology and pedology, geophysics, geochemistry, petrology, botany, entomology, wildlife biology, scent-detection dogs, archaeology, and forensic anthropology.

[12]Haskel, personal communication 1990.

Materials

The primary research site is located on the Highlands Ranch Law Enforcement Training Facility in Douglas County, Colorado, approximately 29 km (18 miles) south of Denver. As part of a 0.47 square km (117 acre) law enforcement training facility, it offers an area of controlled access. The training facility occupies a west-flowing drainage that feeds Plum Creek, a major tributary of the South Platte River. Elevation at the site averages 1829 meters (6000 feet) above sea level. The research site is on undeveloped ranch land that borders the western edge of Daniels Park, one of the parks of the Denver Mountain Parks system. Topographically the country surrounding the training facility consists of gently rolling, brush-covered uplands that change into partially developed badlands and low mesa topography with increasing elevation. The upper slopes of the badlands/mesa country support stands of conifer.

To date, six pigs have been buried at the research site. Their weights, burial information, gravesite descriptions, and other pertinent information are listed in Table 1.

Pigs are currently being used for two reasons. At present, human cadavers are unavailable for studies of this kind in Colorado. Also, these pigs are similar to humans in their weight (70 kg or 154 lb), their fat-to-muscle ratio, and in the fact that their skin is not heavily haired. Pigs have been considered to be biochemically and physiologically similar enough to humans to be used in studies of patterns and rates of decay and scavenging [*22–25*]. Of equal importance, dog handlers recognize that if a dog can detect pig remains, it can also detect human remains.

Methods

Prior to burial of the first pig in September of 1988, baseline data consisting of black and white aerial photographs, geophysical measurements, and geological observations, were acquired for the research site.

Near-field and far-field data gathering were performed prior to and after burial. The definitions of near- and far-field are dependent on the specific discipline, in that near-field refers to anything that is interacting within the burial system, while far-field is outside of the range of influence of the burial system. For example, measurements of soil gas may only be above background levels within a few centimeters of a burial, whereas arthropod activity related to a burial may cover a much broader area.

Far-field observations contemporaneous with burial for this study include botany, entomology, geology/pedology, aerial photography, geophysics, thermal imagery, soil gas, scavenging patterns, and the use of cadaver-scenting dogs. Near-field observations contemporaneous with and after burial include all of the above. A disturbance is a physical disruption associated with burial processes. A control site is undisturbed both at the surface and subsurface, and therefore is remote from the burial site. A calibration pit is a grave without an interred pig, while a grave contains a pig. Back dirt is excess soil deposited near the perimeter of the grave or calibration pit. It is understood that there are disturbances geographically close to the burial system but still identified as far-field in that they are not part of the burial process, for example roads, animal burrows, building foundations, etc.

Aerial Photography

Aerial photography was performed far-field, in an attempt to identify near-field parameters from the air. Aerial photographic surveying was performed on a periodic basis, consisting of both visible spectrum color and black and white film. A turbo-charged Cessna 206 Aircraft containing two Zeiss RMK/A 15-23 aerial cameras and one KA-2 12-inch aerial camera were used. Film types used are Kodak Aerocolor negative type

TABLE 1—*Burial characteristics.*

Data	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Pig wt. (kg)	79.5	45.4	79.5	No pig	45.5	59.1	68.2	No pig
Burial date	092488	102188	102188	N/A	102188	050989	050989	N/A
Time (hrs) death to burial	48	24	24	N/A	24	02	02	N/A
Preburial activity on corpse	Unwashed[a] refrig.	Washed refrig.	Washed refrig.	N/A	Washed refrig.	Taken to site directly	Taken to site directly	N/A
Cause of death	Animal attack	?[b]	?[b]	N/A	?[b]	Gunshot wound	Gunshot wound	N/A
Site depth (cm)	50.8	73.4	66.0	76.2	Laid in drainage	78.7	78.7	N/A
Soil depth over pig (cm)	25.4	53.3	40.6	N/A	7.6	50.8	53.3	N/A
First note of site disturbance	121388	121388	031789	N/A	121388	N/A	N/A	N/A
Date site scavenged by	020889	010689	N/A	N/A	121388	N/A	N/A	N/A
Site protection	None	None	032089 Chain link	N/A	None	050989 Chain link	050989 Chain link	N/A

[a]Stored in coroner's office refrigerator.

[b]Pigs died at packing plant, exact cause unknown, though there were no external injuries detected.

Protective measures consisting of placing metal screen over unscavenged and new burial sites have prevented further disturbance of the burials.

2445, Kodak infrared color film type 2443, and Kodak black and white XX film type 2405. This provides standard 9 in. by 9 in. stereophoto coverage.

Geology/Pedology

The purpose of the geologic investigation at the Project PIG site was to define the geologic character of the site, to relate this character to the individual burial sites, to establish site recognition and evaluation parameters, and to suggest lines of future geologic study and investigation.

Literature research and far-field studies were performed to establish the geologic character and stratigraphic setting of the project site. This involved definition of rock types, establishment of the age relationships among the rock types, and the evaluation of the effect of rock type on subsequent soil formation. Far-field studies also involved relating the physical character (geomorphology) of the project area to the distribution of underlying rock types (stratigraphy).

The near-field studies on the sites and the related far-field studies focused on the definition of soil profiles at specific burial sites, road cuts, and other excavations; the relationship of these soil profiles to the parent rock units; and how soil composition and character affects the recovery of a soil profile to a "normal" state. All burial sites have been and continue to be monitored and photographed to document the recovery of the soil profiles.

Botany

As part of the far-field study of vegetation, percent area cover for bare soil (back dirt), litter, and herbaceous vegetation was estimated, and a total species list was prepared listing the plants found within the training facility.

Near-field study of vegetation included listing the plants growing on each grave, calibration pit and back dirt area. For the near-field study, a 1-meter by 0.5-meter rectangle of PVC pipe was set at the approximate center of the test plot (grave, control pit, etc.) and vegetation was analyzed from within that test plot. Far-field study was tested in the same manner, with the 1-meter by 0.5-meter rectangle of PVC pipe set at various areas away from the test plots. The areas for far-field study are not the same for each test, but are taken approximately at random within the training facility in the general vicinity of the test plots. Frequency of species was determined by counting the number of rectangular plots on which a particular plant species was found. For example, Wheat grass was found on four disturbed plots (either a grave or calibration pit) and on two undisturbed sites, while Sunsedge was found on no disturbed sites and on three undisturbed sites.

After the pigs were scavenged from Sites #1, 2, and 5, members of the team decided to cover the unscavenged grave sites with heavy chain link fencing to protect those graves from further scavenging. Although vegetation on the grave is potentially altered, some plant growth is allowed, and the fencing can be easily removed for near-field investigations such as geophysical surveying.

Entomology

A control site was established to examine the airborne and surface insects. A BioQuip Malaise trap was erected to monitor aerial dispersing insects, and was cleaned of all insects 1, 2, 4, 7, 12, 15, 25, and 30 days after pigs were buried. In addition, this type of trap was erected directly over burial site #1 and cleaned of all insects at the above schedule. Additionally, five pit traps were placed around the site to sample surface dispersing arthropods, and were monitored and cleaned at the above schedule.

Geophysics

Three specific geophysical methods were selected for evaluation at the PIG site: magnetics (MAG), electromagnetics (EM) and ground penetrating radar (GPR). The selection of these methods was based on the direct experience of one of the authors (Davenport) in implementing geophysical investigations on archaeological projects.

Far-field geophysical investigations entailed measuring total field magnetic intensity, establishing background conductivites and correlating subsurface stratigraphic horizons with ground-penetrating radar all within the Project PIG site.

The near-field studies included performing total field and gradient MAG profiles, EM profiles in both quadrature and in-phase components and GPR profiles over each burial site and calibration pit. MAG surveys were performed on some of the planned gravesites prior to interment of the pigs.

The equipment utilized has included an EG&G Geometrics G-856-AX memory magnetometer with gradiometer attachment, a Geometrics G-816 magnetometer, a Geonics EM-31 ground conductivity meter, and a Geophysical Survey Systems, Incorporated (GSSI) subsurface interfacing radar (SIR) Model SIR-3 with digital data recording and color display capabilities. The GPR system has been evaluated using 80 megahertz (MHz), 300 MHz and 900 MHz antennas. Self potential (SP) surveying and soil gas (SG) techniques have also been used at the PIG site, but not as extensively as the other geophysical methods. The SG surveying was performed utilizing a Photovac 10570 Portable Gas Chromatograph, while the SP surveying was done with a high impedance voltmeter and Tinker & Rasor electrodes. Geophysical surveying was performed in either linear or grid arrays, with data collection points spaced from 1 to 3 meters apart, except in the case of GPR surveying, which produces a continuous record of data collection. Geophysical arrays were arranged to provide data over undisturbed areas, graves, and calibration pits.

The results of geophysical surveys applied to the location and delineation of clandestine graves have been encouraging. Once suspected target areas are defined by other techniques, geophysical surveys can be rapidly run using portable equipment.

Thermal Imagery

Thermal imaging was performed using a Xedar Model XS-420 Infrared Camera System. Far-field thermal imagery consisted of obtaining high quality thermal images of steady-state and dynamic scenes by panning the camera across the terrain of the Project PIG site, whereas, near-field information was obtained by aiming the camera toward and fixing it on each grave and calibration pit.

Soil Gas

Soil gas sampling of the far-field consisted of determining background levels of methane and other volatile organic compounds throughout Project PIG Site. Near-field studies were performed by taking soil gas readings directly over graves and calibration pits.

Cadaver Dogs

Standard far-field and near-field investigations become less defined for work with scent-detection dogs, as the dog defines those fields itself. The ability of the scent detection dogs to locate the buried pigs was tested using the following standard search techniques. The dog was controlled on a lead of usually 5 meter (15 feet) in length at all times, and "worked" on a zig-zag pattern downwind of the suspected area. The zig-zag pattern was maintained for the dog until it alerted to a scent, at which point the dog was allowed to work its own search pattern to the source.

Scavenging Patterns

Naturalists trained in animal tracking and familiar with the habits of indigenous species were responsible for identifying scat and animal tracks. This information was used to develop scavenging patterns related to the burial sites. Patterns of bone modification related to scavenging were studied.

Standard far-field and near-field investigations also become blurred in studies of scavenging, as those terms are defined by where the scavenged remains, scat, and the agents of scavenging (coyotes, mountain lions, dogs, rodents, etc.) are found.

Results

Aerial Photography

Aerial photography can be very useful in delineating grave sites. Grave sites are revealed by a number of factors in the air photographs taken at the research site. These factors include changes in growth patterns and characteristics of near-field vegetation, anomalous soil marks associated with excavational boundaries, and settlement of snow within some grave surface depressions. Low sun angle oblique photographs tend to emphasize texture of the ground surface, and the associated long shadows can reveal minute topographic relief.

Geology

At the research site, short term (less than five years) geological effects are enhanced by climatic conditions. The climatic conditions that typify Colorado's eastern plains offer extreme consequences affecting both the soil character and the rate and nature of soil recovery over the graves. Climatic conditions during late spring, summer and fall, and often into early winter tend to be dry. The dry conditions are inhibiting plant reestablishment over the graves and retard breakdown of the disturbed clay-rich host soil horizon. Lack of moisture largely neutralizes mechanical breakdown of fill material that is characteristic of periodic freeze/thaw conditions.

The moist climatic conditions of winter, spring and early summer enhance rapid breakdown of clay soils. Excavation boundaries tend to become masked, fill material becomes generally more fine-grained, and the compaction of the fill material to the original surface grade is facilitated.

Excavations made during dry climatic conditions persist with little change throughout the dry season. Moisture enhances grave site recovery and plant establishment.

Botany

The graves and calibration pits are revegetating, though the mix of plants on the disturbed areas is noticeably different than on the undisturbed areas. Vegetation on the disturbed sites depends on several factors, including which plants are nearby and supplying seeds to the disturbed ground and where in the landscape digging was done (in drainage areas or in high ground). For example, the pig at Site 6 was laid on top of the ground in a drainage ditch, and dirt from another area was deposited on top of it. Even though the pig was taken by scavengers, the disturbed area is revegetating differently than the rest of the sites, because the seeds in the foreign soil are different from the indigenous plants, and the drainage ditch provides extra water for growth.

Although the percent cover for each site does not differ, the species covering each site are different. After three years, the grave sites are revegetating similarly to the calibration pits, and the presence of a decaying pig has not significantly affected plant growth.

Vegetation analysis on the eight sites shows that:

1. Digging a grave will destroy existing vegetation and set succession in motion.
2. Pioneer plants will be the first to grow on the disturbed area. In lowland dry grass areas these might include alyssum (*Alyssum minus*), Japanese brome grass (*Bromus jaconicus*), and dandelion (*Taraxacum officinale*).
3. Vegetation changes as the grave progresses through the serial stages of succession.
4. Eventually the climax vegetation for the area will grow on the graves and calibration pits if they remain undisturbed. For lowland dry grass areas this includes blue grama grass (*Bouteloua gracilis*), other grasses and many wild flowers. The disturbed area (grave or calibration pit) will look different from the surrounding area for many years (exceeding so far, the duration of this study).
5. Knowledge of the plants of an area can supply clues to the discovery of a grave, particularly where the vegetation is largely otherwise undisturbed.

Entomology

There was no visible entomological indication of the buried pig, such as evidence of surface stains from saponification/liquification ca. 30 days after burial. The blowfly, *Calliphora vomitoria* was trapped by the Malaise trap within 24 h or burial, and *Phormia regina* arrived 48 h after burial. By day 15, significant numbers ($P = <0.05$) of blowflies were trapped over the burial site as compared with control sites. No arthropods typically considered to be forensic indicators were trapped by the pit traps.

Geophysics

In the case of MAG and EM surveys, data are gathered and presented in the field via use of a portable computer. These data can be presented in the form of contour maps or as individual profiles. The GPR data are acquired in real time format, that is, the results are immediately available to geophysicists in the field. Work at the PIG site has demonstrated that SP surveying has very limited application in delineating clandestine graves at this site.

Monitoring with MAG surveys after interment demonstrates that MAG surveys can be used at this site to detect areas of excavation, even when metallics are not present. This effect, a MAG anomaly, appears to be directly related to a reorientation of magnetic soil particles upon backfilling the graves. EM surveys have proven more useful than MAG as the ground conductivity changes over graves due to the increased porosity of the backfill materials. EM surveys can be utilized to determine changes in ground conductivity and to detect the presence of ferrous and nonferrous metallics. GPR surveys offer the investigator the most useful tool to delineate possible graves. Soil changes and/or excavation patterns can be readily identified by trained GPR operators. The addition of color monitoring to the normally black and white monitoring capabilities of the GPR systems allows investigators to easily identify changes in soil horizons.

Perhaps the most important result of the geophysical surveying at the PIG site has been the realization of the importance of constructing a calibration site to test any geophysical method prior to application on an actual investigation. Any information concerning the type and/or construction of the disposal facility should be used to construct a similar, albeit empty, facility near the actual area to be investigated. The geophysicists can utilize this "calibration" site to determine the following:

(1) Response of different geophysical methods
(2) Type and characteristics of the geophysical signal
(3) Profile and data station separation(s)

Soil Gas

The soil gas surveying performed at the research site holds promise of providing a useful, albeit labor intensive, technique to locate graves. Organic gases were detected within three meters of two of the grave sites; however, the investigators had the privilege of knowing in advance the locations of these sites. Soil gas surveying is best in soils with a low clay content (so as not to clog the probes) and over unfrozen ground.

Cadaver Dogs

The successful use of dogs is affected most significantly by weather conditions. There is a decrease in a dog's scenting ability at temperatures about 29°C (85°F). Excessive heat causes some discomfort to the dog and this may affect the dog's ability to locate a scent. When the temperature is extremely high the dog will still locate the scent; however in most cases, it will need to be within approximately a meter of the source. Even if the temperature is high, the results will improve if the ground is moist. Extremely low temperatures also limit the dog's ability to detect the scent from a distance, especially if the source is buried. If the source is buried in snow with temperatures allowing only minimal melting, the dog must be directly over the source to locate it. If the temperature is warm enough to allow for significant melting the dog can locate the source from a greater distance.

Other significant factors affecting the dog's work include air humidity, ground moisture and windspeed. Humidity seems to intensify the dog's ability to detect the source at a distance. The ground should be fairly moist, ideally to the depth of the source, or so dry that desiccation cracks intercept the source (Major Glen Rimbey, New Mexico State Penitentiary, personal communication). If no wind is present, the dog will have difficulty detecting a scent except from immediately above the source.

Based on experience at the research and other sites, the optimal conditions for the successful use of cadaver dogs includes temperatures between 4 and 16°C (40 to 60°F), 20% or higher humidity, very moist ground, and windspeed of at least 8 km (5 miles) per hour (there is no upper limit to windspeed, though the scent cone becomes narrower with higher windspeeds).

Scavenging

Animal tracks or scat identified in the research area include dog, coyote, fox, rabbit, deer, elk, skunk, raccoon, horse, cattle, porcupine, woodrat, and mouse.

Intensive, systematic searches within 1-km radius of the site have recovered bones of deer, cattle, horses,[13] canids, and rabbits. No large pig bones were found. A fragment of pig scapula was found within the 1-km radius. Many fresh bone chips were found around Site 1, indicating scavenging. Several incisors, as well as bone chips were found around Site 2. Pig hair was found on the surface of Site 5 and on the grave sides of Site

[13]An area within the research site was used for 57 years as a killing ground for old or diseased horses by a local hunt club. This was to attract coyotes so the club members could conduct English-style hunts. Numerous bones of horses are piled up in a nearby draw and many or these have been scattered by scavengers. Horse bones that may or may not be related to the killing site were found more than 2 km (1 mile) from that site.

1. Pig hair and fresh bone chips were found in coyote scat near burial Site 1. The most likely scavenging agent in this area is coyotes, and the modifications of recovered bone are consistent with those reported for canids. The absence of large bones within the 1-km search radius suggests that the remains were carried a greater distance than the approximately 0.2 km maximum reported by Haglund et al., though as Haglund mentions (personal communication), the ranges of coyotes vary considerably with differences in terrain and vegetation. Our research site provides an opportunity to study the scavenging distance in a relative open environment, to supplement Haglund's study in a heavily forested environment.

Conclusions

Table 2 summarizes the experiences gained by research done at the known pig burials. Based upon what it has learned at the site, the Project PIG team has applied these techniques to suspected criminal burial sites.

It is imperative that an agency requesting assistance in locating buried human remains consult specialists in each of the above disciplines to determine which of the techniques are applicable to the specific crime scene. In the multidisciplinary approach reported here, it is important to follow a progression from completely nondestructive to increasingly invasive procedures such that evidence collection is optimized while evidence disturbance is minimized.

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Although there are many authors of this article, there are many other individuals involved with the PIG team without whose contributions neither this article nor the research would be possible. These participants and their areas of specialization are listed below. If you wish to contact these researchers, please notify the senior author.

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Questions or comments about this article or about specific aspects of the research can be addressed initially to the senior author, who will direct requests for information. In addition, we are formulating a data bank of interested individuals, therefore if you wish additional information about setting up a group of this type in your area, please contact one of the following participants. We will help you contact other researchers or law enforcement personnel in your area.

Jack G. Swanburg, Arapahoe County Sheriff's Department, 5686 S. Court Place, Littleton, CO 80120, (303) 795-4772; or

Tom Griffin, Colorado Bureau of Investigation, 690 Kipling, Denver, CO 80215, (303) 239-4303.

TABLE 2—*Advantages and disadvantages of methods used at Project PIG.*

Method	Advantages	Disadvantages
Aerial Photography	Least destructive. Provides good overall characterization of a site; access, culture, drainage, topography. Large area covered. Preburial photos may be available from variety of sources.	Best results with large film format (scale of readily available photography may be too small). May need to be performed at different times of growing season. Natural (trees, etc.) and man-made (power lines, etc.) may interfere with interpretation. Requires trained person for interpretation. May be moisture-dependent.
Geology	Relatively non-destructive. Nonintrusive if cores not taken. Determination of site stratification through core samples. "Real-time" on-site information about ground surface.	Intrusive if core samples taken. Entire search area should be viewed.
Botany	Relatively nondestructive. Can be performed with photographs and samples from area. Can be performed years later.	Similar succession patterns for any disturbance within ecosystem; not limited to burial.
Entomology	Nondestructive. Aids in narrowing site location. Provides information about time since death.	Requires limited area for searching. Best for relatively fresh grave. Different species for different geographical regions.
Geophysics Magnetics	Relatively nondestructive. Nonintrusive. Equipment easily obtained. Rapid coverage of large area. Works over snow, fresh/salt water.	Only for ferrous material. Target could be missed if search grid too large. Data not in "real-time," values must be plotted and should be contoured. Magnetic interferences (natural and man-made) confuse readings.
Geophysics Electro-magnetics	Relatively nondestructive. Nonintrusive. Rapid coverage of large area. Equipment relatively easily obtained. For ferrous/nonferrous materials. Records conductivity. Works over/through snow.	Subject to cultural (fences, etc.) interferences. Target could be missed if search grid too large. Difficult in rough terrain. Data not in "real time," values must be plotted and should be contoured.
Geophysics Ground-penetrating radar	Relatively nondestructive. Nonintrusive. Fairly rapid coverage of large area. "Real time" display. Works over/through snow, fresh water.	Equipment relatively difficult to obtain. Most units require moderately smooth and level terrain.
Geophysics Self-potential	Relatively nondestructive. Equipment easily obtained.	Intrusive. No worthwhile information from our research.
Geophysics Soil-gas	Relatively nondestructive. "Real-time information. Theoretically sound.	Intrusive. Must be positioned relatively close to burial. Site soil, ground moisture, climate, depth of probe critical. Detection of decomposition product(s) time and temperature dependent.

TABLE 2—*Continued.*

Method	Advantages	Disadvantages
Geophysics Metal detector	Relatively nondestructive. Nonintrusive. Equipment easily obtained.	Limited depth capability, detects only metal (ferrous/nonferrous) objects, presumes metal objects on or with body. Field applications often improperly conducted.
Thermal imagery	Nondestructive. Can examine large area.	Requires little or no wind. Requires special equipment and knowledgeable operators.
Scent-detection dogs	Relatively nondestructive. Proven effective even 170 years after burial. Effective over water.	Most effective when air, ground moist. Dog may be trained for other uses and not properly trained for this type of work; handler may overstate qualifications.
Naturalists	Excellent for information concerning scavenging cases and outdoor information.	Ability to recognize animal scavenging may be altered by climatic conditions. Tracking easiest in snow, mud, soft sand, or dust.
Archaeology	Experienced in mapping, data collection, preservation of information from excavated materials, and is therefore extremely valuable for building court cases.	Both destructive and intrusive. Though data collection can be modified to meet time demands, can be relatively slow.
Law Enforcement	Crime scene experience. Access to statements and information from victims, witnesses, suspects. Familiar with evidence recovery, legal concerns, court testimony. Contacts with other law enforcement agencies for similar M.O. checks.	Wants information immediately.

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Address request for reprints or additional information to
Diane L. France, Ph.D.
Department of Anthropology
Colorado State University
Fort Collins, CO 80523

Glossary

Back dirt: Soil from the digging of the grave or pit, which has been deposited near the perimeter of the grave or pit.

Calibration pit: A site that has been excavated and then immediately back-filled. It is used for response calibration of various investigative techniques; in essence, it is an "empty" grave.

Climax vegetation: The plant community that will reproduce itself and last a long time on a given site; the end point of succession.

Control Site: An unexcavated, undisturbed area used for the collection of base-line data.

Destructive: A term describing or referring to any technique that disturbs either near- or far-field areas in any way. The only nondestructive techniques discussed here are aerial photography, thermal imaging, and the viewing of the suspected site from a distance or elevation.

Far-field: "Field remote from the source [*26*]." Any event, effect, or action that occurs *outside* the range of influence of the burial system; far-field boundaries are variable for different investigative techniques.

Intrusive: A term describing a technique that disrupts the ground and subsurface in some manner or means.

Near-field: "The field near a source. Relationships near a source involve both effects which attenuate rapidly with distance as well as those which attenuate more slowly [*26*]." This term includes any event, effect, or action that influences the burial system; near-field boundaries are variable for different investigative techniques.

Nonintrusive: A term describing a technique that does *not* break the soil surface.

Real time: A term describing data recorded such that it is immediately available for viewing and interpretation by a specialist.