1998

Cadaver Dogs, Taphonomy, and Postmortem Interval in the Northeast

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Second Edition

FORENSIC OSTEOLOGY

Advances in the Identification of Human Remains

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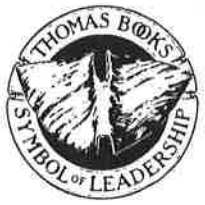

CHARLES C THOMAS • PUBLISHER, LTD.
Springfield • Illinois • U.S.A.

1998

Chapter 6

CADAVER DOGS, TAPHONOMY, AND POSTMORTEM INTERVAL IN THE NORTHEAST

MARCELLA H. SORG, EDWARD DAVID, AND ANDREW J. REBMANN

INTRODUCTION

The purpose of this article is to discuss the investigation of outdoor death scenes in which either (1) a death is suspected and a search for a decomposed body is undertaken, or (2) the decomposed remains of an unknown individual are found and need to be fully recovered. In both of these situations, an understanding of the natural processes which influence outdoor death assemblages (taphonomy) as well as the proper use of search strategies, including decomposition scent dogs, are important in both the recovery process and the interpretation of evidence. This article will focus particular attention on two related topics: the utilization of decomposition scent (cadaver) dogs and the interpretation of time since death in terrestrial settings.

Although published research on the relationship between sarcosaprophagous insects and time since death is now readily available (Haskell et al., 1996), research about the interpretation of time since death in exposed decomposed or skeletal remains using non-insect indicators is scant (Mann et al., 1990; Vass et al., 1992; Willey & Heilman, 1987; Yoshino et al., 1991), and research using a case series approach has focused on data bases from the western United States (Duffy et al., 1991; Galloway, 1996; Galloway et al., 1989; Haglund et al., 1988, 1989; Rhine, this volume; Schoenly et al., 1991) or from marine settings (Boyd et al., 1996; Haglund, 1993; Sorg et al., 1996). Some authors have researched scavenger behavior patterns in order to improve interpretation of the postmortem interval (Haglund, 1996a, 1996b; Haglund et al., 1988, 1989, this volume; Murad & Boddy, 1987; Willey & Snyder, 1989; Skinner et al., 1988).

Since 1974, cadaver dogs have been increasingly used in the recovery of decomposed and skeletal remains, particularly in cases involving burials (France et al., 1992, 1996; Rebmann, 1993, 1994; Sachs, 1996; Tolhurst, 1991; Tolhurst & Reed, 1984). Research about their use has not, however, been generally available in the forensic science literature (but see France et al.,

1996). Their role in recovery strategies can be expected to vary depending on the climatological and geographical context, the postmortem interval and, in some cases, the cause and manner of death. Clearly, regional and local differences in climate, vegetation, terrain, and fauna will influence decomposition processes, requiring a context-specific approach to evidence interpretation. Differences in decomposition processes and scavenging behavior of local fauna may also affect the use of dogs trained to find human remains, particularly in terms of search strategies (see also Haglund, 1996b) and estimating postmortem interval.

CADAVER DOGS

Dogs have been used in a variety of forensic contexts because of their superior sense of smell. It is estimated that their ability to smell some scents, particularly fatty acids, is as much as a million times more sensitive than that of humans. In general, there are two basic types of scent work for which dogs can be bred and trained: tracking and air scent. Tracking dogs are epitomized by bloodhounds who can follow a specific scent associated with the object they are tracking.

Air scent dogs, by comparison, learn to recognize a generic odor, such as accelerant, drug, or decomposition chemicals. Search and rescue dogs locate a living individual, or one only dead several hours, responding to the "live" scent. Cadaver dogs, on the other hand, locate recently dead bodies (even those lacking external signs of decomposition), decomposing bodies, skeletal remains, and the products of human decomposition in the soil. They are trained to exhibit an "alert," a specific behavior which signals to their handler that they have located the source of a human decomposition scent. In fact, it has been shown that cadaver dogs are alerting specifically to human (rather than other animal) decomposition. It is still unknown which specific chemical triggers their reaction (see Vass, 1992); however, artificial chemical combinations can now be produced which mimic the scent well enough for training purposes (Sachs, 1996). It helps that dogs are naturally attracted to the smell of putrefaction.

Cadaver dogs are used in a variety of search contexts, including surface, buried, and underwater deposits. In most situations, the dog is searching for a missing individual. However, since the dog can find decomposing blood, body fluids, or tissues, searches can be made for small body parts, for weapons, or for other physical evidence which may have come in contact with the victim. Dog/handler teams properly trained for this work will not disturb a scene or damage evidence they locate.

UNDERSTANDING PROBLEMS OF CADAVER SEARCHES

It is critical to the success of a search using cadaver dogs to understand the concept of the scent cone. The decomposing body or body part sheds molecules of scent-containing compound. These scent-containing compounds disperse through the air, forming a cone whose apex is at the source. To find the object, the dog must enter the scent cone and then work within that cone to locate ever-increasing scent levels until arriving at the source. With buried bodies the scent may rise and pool above ground, becoming more diffused and less cone-like; the pool may also change location with air movement as explained below. Dispersal of the scent increases the chance of the dog locating its source.

Multiple factors affect the scent cone. Basic variables to be considered include air temperature, humidity, and wind (air movement). The terrain can also critically influence the scent cone. Trees, open areas, hills, valleys, and bodies of water can all affect the movement of air and, therefore, scent. Soil type and hydrology can also affect the probability of finding a buried body by preventing or enhancing dispersal of scent molecules into the air. With frozen ground a vapor barrier may be formed preventing scent from entering the air above a gravesite.

Warm air rises; therefore, a differential between ground and ambient temperature will affect scent dispersal. Heat radiating from the ground is most conducive to releasing scent. Equilibration of earth and air temperature will therefore create difficulties. Searches carried out with very high (ambient) air temperature, such as in the heat of the day, when ground and air temperature are most similar, or when air temperature exceeds ground temperature, may fail because of the lack of scent dispersal. Extreme temperature differential, however, can cause a "chimney effect" in which the scent rises so quickly from the source that it fails to spread out as a cone. As the chimney effect diminishes with altitude, the scent can then be carried (laterally) at a higher level and may or may not return to earth within the defined search area.

Dense, moist air will generally reduce scent dispersal; hypothetically this is due to water molecules impeding the flow of decomposition scent molecules. Ground fog, high humidity, and actual precipitation may all decrease the likelihood of success of effective scent cone definition and distribution.

The presence of air movement (wind) is perhaps the variable most critical to search strategy. An absence of air movement requires a much more detailed search strategy. On the other hand, high winds may cause too rapid a dispersal with disruption of a cohesive scent cone. Obstructions, such as stands of trees or buildings, can block scent or, in combination with wind patterns, cause the scent to rise above the dog. The scent may fall back to

earth at distances far removed from the source causing "false" alerts. Scent rising will cause a greater likelihood of detection on hilly terrain if the higher elevations are searched first rather than the valleys.

Soil type and context affect the release of scent into the air. Most homicidal burials are shallow, averaging less than 18 inches of cover, and therefore frequently detectable by scent-trained dogs. Because decomposition fluids may soak into the ground, scent evidence of the body may remain in the grave long after a body is removed. Loosely compacted or sandy soils will permit scent to escape more readily. Densely compacted or clay-like soils will retard scent dispersal or even block it completely. Less permeable soils may be more resistant to scent absorption. Soils subjected to surface water runoff may lose scent. Better drained or sandier soils may lose scent more rapidly. Scent may be carried by groundwater and emerge great distances from the actual source. It is therefore important to have some idea of soil type and hydrology when undertaking a search.

Preparation is critical to the success of any search. Most important is the investigative work that has lead to the designation of an area as possibly containing human remains. Even searches with the best air scent canines require good, old-fashioned police investigative work to be successful. Time spent communicating the background details to a handler will improve the handler's ability to design an appropriate search.

The handler should understand the area to be searched. He or she must become aware of changes in terrain, cover types and patterns, of man-made alterations and obstructions, of soil type and hydrology. If the search is undertaken in a residential or formerly residential area, the handler should inquire about the location of septic systems which can cause "false" alerts.

Searches are best scheduled at a time when the differential between ground and ambient temperature is maximal and when the wind is conducive to creating cohesive scent cones. Searches will be most effective when done across the prevailing wind direction. It may be necessary to postpone a search due to wind direction or speed, extreme temperatures, or pronounced precipitation, until snow cover has abated or (in the case of burials) until the ground has thawed to the level of the suspected burial.

Focused attention must be given to variations in the dog's behavior, as well as the presence of the trained alert response. For example, when remains are buried, when the postmortem interval is long, or when an area is diffused with scent due to scattering of body fragments (such as in a plane crash) the dog may manifest a more subtle alert. The handler should not be distracted by other activities but be able at all times to attend to the dog.

Because of individual personalities of the canines and because of variation in training experience, the handler is the only one equipped to interpret the dog's behavior during a search. While there are certified trainers

who can "read" a dog's response due to long association with handler/dog teams, search team members other than the handler should not be relied upon to observe or interpret the cadaver dog's actions.

Since the search is being carried out because of the heightened sense of smell that the dog possesses, the handler should allow the dog to participate in generating the search strategy. Although the handler may be able to direct the search in areas where there is a high probability of finding something, the dog should be given latitude to follow other leads. Allow the dog to cross both natural and man-made barriers as long as there are no other contraindications to doing so. Such contraindications include both physical/safety concerns as well as legal issues.

SEARCH STRATEGIES AND COUNTER STRATEGIES

The development of a search strategy is a complex task which depends on an array of interrelated variables. Final decisions about strategy cannot be made prior to arrival at the site. Additionally, the strategy may have to be changed while at the site, particularly if variables change. The intellectual challenge presented by the unique interaction of variables must be met, not by the dog, but by the handler, who gives the search its direction and structure. The trained dog will be successful the vast majority of the time if put into the situation in a manner which allows it to do its job. Training of the handler to manage the dog, to interpret the dog's behavior, and to design the search is at least as critical as training the dog. The experience of both dog and handler in particular search types is also important.

A canine cadaver search can be defined as the investigation of a particular area deemed by forensic investigators to contain human remains according to a strategy designed for that particular context. The investigation of a death might involve multiple searches. Similarly, the investigation of a single, but heterogeneous area may also involve multiple searches, each with a different strategy. Conversely, a single search may take many days.

Table 1 outlines three major search types according to what initiates the search. Each type requires a different approach. In particular, the orientation to the scent cone will differ depending on whether remains have been located previously and whether those remains were scattered. Speculative searches (Types II and III) may produce positive information (locate the body) or negative information, allowing investigators to "clear" the area. It is also important to mention that, even in areas which have been cleared, the remains may be located later, due to subsequent animal scatter. Nevertheless, a search may be considered "successful" whether a body is located or not.

Type I, **Recovery Expansion Searches,** are done to extend a recovery effort begun previously, to find missing parts in an area already searched, or to

Table 1
THREE MAJOR CADAVER CANINE SEARCH TYPES

Search Type	*What Initiates Search*	*Orientation to Scent Cone*
Type I. RECOVERY EXPANSION SEARCH: Locate additional scattered remains	Remains were previously discovered in the area.	One or more scent cone sources are known and, unless a specific scatter pattern dictates otherwise, should be lowest priority for searching.
Type II. FOCUSED SPECULATIVE SEARCH: Locate remains in specific area	Specific location is suspected on the basis of investigatory evidence.	One or more scent cone sources are suspected and should be highest priority for searching.
Type III. NON-FOCUSED SPECULATIVE SEARCH. Locate remains in general area	General location is suspected on the basis of investigatory evidence.	Scent cone source is unknown, and strategy focuses on covering wide territory.

search adjacent areas for that purpose. For example, an informant leads the police to the shallow but now empty grave of a homicide victim a month after death. Near the grave they find and recover most of the postcranial bones, scattered within a 50-foot radius of the grave, but the cranium is missing; the cadaver dog team is brought in to locate the cranium. In this type of search, even when the previously discovered remains have been removed, there may be one or, if remains were scattered, many scent cones in the area, due to scent in the soil and the prevailing wind. Additionally, cones may overlap creating somewhat confusing sensory signals and complicating the search strategy. If the postmortem interval is short and the recovery recent, scent cones may be quite strong. The handler may initially orient the dog to the scene by allowing or leading him to "discover" these sources of scent, giving the dog a chance to alert and be rewarded, thus enhancing motivation. Or, the dog may be directed (or self-direct) to do a preliminary perimeter search. Such "hasty" or "scanning" searches hypothetically provide an overall sensory image, allow the dog to identify areas which offer the most interest, and allow the handler to perceive the patterns of interest and refine the strategy. If the area is perfused with scent, it may take some time for the dog to begin to discriminate stronger scent amidst a background of decomposition odor.

Searching within the cone(s) in a Type I search situation, however, will be of less utility the shorter the postmortem interval, and the closer to the primary location one is. If the overall area to be searched includes terrain outside the known cones, it is usually more efficient to begin finer searches in these areas, rather than within the cones, in order to enhance opportunities for new discoveries. In general, such searches outside known cones

would begin at the source(s) and move at right angles to and into the wind. In cases where scavengers have dispersed remains, the search may be refined to focus on animal trails, areas of higher ground, or go in directions implied by the anatomical distribution of the scatter. The handler needs to consider the pattern of finds. What parts are still missing? What is being searched for? Are the other remains likely to be articulated or disarticulated and fragmented? In this situation, the quality of previous scene investigation, including documentation of already removed remains, and marking of the scene, will bear on the success of the canine search.

Type II, **Focused Speculative Searches,** center on a specific area identified by an informant or by other evidence as likely to contain the remains. The boundaries of the site are fairly well-defined. For example, a suicide is suspected and the victim is known to regularly go fishing at a favorite wooded location near the bend of a river. In this type of search, the dog can be led to that location and directed to begin there or at the downwind perimeter of the site. Expansion of the search area may involve a spiral or radial search pattern.

Occasionally in focused speculative searches, the story of the witness regarding a death may be questionable. In one case (D9402) a woman told police that her father had killed her infant nine years previously and buried the baby near a shed on the family property. The story was thought to be false for various reasons, but the search had to be done to rule out the possibility. The "shed" turned out to be an outhouse; because the dogs naturally alert to outhouses, the response of the dogs could not be considered indicative of the presence of human remains.

Type III, **Non-Focused Speculative Searches** focus on a more general area. For example, a teenager is missing, and his home is at the edge of a large, wooded expanse which he knew well and frequented. In this type of search, where the perimeter of the search area is not well-defined, a common strategy is to assign an arbitrary perimeter based on the terrain and to begin the search along the perimeter at greatest distance away from the wind, working the dog in a side-to-side grid perpendicular toward the wind, and moving toward it. In an ideal situation, if the scent conditions are good and the terrain presents no impediments to scent or dog/handler team, the search will either locate the victim or allow investigators to clear the area with a fairly high degree of certainty.

In speculative searches, when remains are not found, it is imperative that the ruling out of the area be done with good attention to, and documentation of, the weaknesses of the search. For example, a search area is identified as a large field bounded on one side with a narrow band of woods adjacent to a busy mall, and the wind is coming from that direction. Searching the band of woods might require putting the dog on lead (for safety near the mall),

the hour might be late, and the handler might decide not to extend the search area to include the woods. But, even though the band of woods is fairly narrow, the handler needs to acknowledge to investigators that the wooded area was not searched and cannot be ruled out. In other words, areas not actively searched by the dog, even if they are upwind and/or visible to the handler, must be clearly documented as uncleared. In this example, although the narrow wooded area was upwind, the presence of trees would obstruct the flow of wind (and therefore scent) as well as visibility.

The first goal in any case is to locate a scent cone. But, for the handler who cannot smell it, the scent cone is only a hypothetical construct which the dog must be directed to find. Since the cone is oriented with the direction of the prevailing wind, the probability of the dog encountering the cone is enhanced if the search paths are perpendicular to the cone. Once the dog locates the cone, it must be allowed to follow it to its area of highest intensity, the source. Keeping in mind that the alert the dog gives is to the scent, not necessarily to the source itself, the handler may have to interpret the context of an alert.

The dog's job is to work out the relationship between the scent and the source, but the handler must be alert to possible causes of scent or potential distortions of scent cones. Since the handler cannot sense the scent cone, he or she can only broadly direct the dog. As mentioned previously, the scent cone can be distorted in a variety of ways. Some characteristics of the terrain can, in association with the direction and strength of wind, modify the shape and orientation of the cone. This can cause the cone to "disappear" suddenly, to come and go in an erratic fashion and confuse the dog, to lead nowhere, or to produce false alerts. Scent can travel a mile or more, thereby producing constraints on the time and energy required to locate the source. The wind can change or disappear, forcing the search to be postponed, or changing the direction of the search before an area has been covered.

Many behavioral factors can interfere with a successful search. When large areas are searched and no remains found, the dog may become bored and fail to work properly. The handler may have to take a play break, change dogs, or change the routine. Some sites may have locations which present a danger either to the dog or the handler. Highways or crowds of people in the area may force the handler to put the dog on a lead, which can in turn limit the capability of the dog to search, or change how the dog transmits a find. The dog's motivation to work can vary due to known and unknown reasons; it may be necessary to postpone a search slightly, or to work with the dog to increase motivation or attention span while on-site.

The context of the search is vitally important. The factors that prompt the search should be thoroughly known to the handler. Choices about what locations in a large area to search can be made differently depending on the

suspected cause of death. Homicides tend to be hidden, yet related to ease of body disposal. Suicides by gunshot wound may happen in a hidden area, but often (at least in the Maine woods) occur in a picturesque area, or a place familiar to the victim. Accidents tend to be associated with particular terrains, depending on the time of year, or the victim's habits. For example, with a cliff in the search area, a suspected natural death might be found at the bottom of the cliff, but a homicide would likely not be. Or, if a homicide is suspected, searchers might not look above ground for a hanging. Clues relevant to the search, such as noises heard by witnesses, objects found in the area, or known patterns of the victim's behavior, should be incorporated into the search strategy.

Human searchers are frequently needed to team up with the canine/handler, preferably searchers who are trained to recognize and recover human remains. In situations where remains are known to be in the area, inclusion of the forensic anthropologist is helpful in expediting the search process. These individuals should be searching within the cones coming from the previously found remains, if there have been any. They can assist, for example, in identifying bones found, helping to map out the anatomical pattern of distribution, and note which bones are still missing. They can also identify non-human remains which can then be ignored.

The success of a search should only be measured within the context of that search. A search may "fail" to produce human remains under a number of conditions, including: (1) the missing person is not actually dead; (2) the body was never in that location; (3) the body has been moved or scattered and is no longer there; (4) the body's scent is inaccessible to the dog; (5) the dog or handler is inadequately trained; or (6) the search strategy was not appropriate to the area. Thus, success in searching is maximized by: (1) high quality, pre-search investigative work; (2) experience and training of the dog/handler team; (3) good communication between investigators and handler; (3) careful scheduling of the search during advantageous weather and time; (4) allowance of adequate time for the search; (5) appropriate search strategy and strategy refinement; (6) appropriate human response to areas the dogs indicate; (7) appropriate interpretation of search results in areas lacking dog alerts; and (8) good documentation.

DOCUMENTATION OF CANINE CADAVER SEARCHES

Unlike many search and rescue operations, most cadaver searches are extensions or initiations of forensic death investigations. As such, the careful documentation of the search, including both positive and negative results, is critical. In speculative searches which do not produce human remains, the interpretation and documentation of search results may very well be pivotal

to the subsequent conduct of the investigation. When human remains are found as a result of a search, the documentation may become part of the case record and admissible in court, particularly related to the chain of custody of the remains or other artifacts.

The area being searched is frequently a crime scene. For this reason, dogs and handlers must be well-trained to maintain the integrity of the scene in order to mark, collect, and document evidence properly.

The report of the search should address a number of issues consistently. The following components are recommended:

1. Credentials and auspices of the handler and canines
2. Date of the report
3. Who requested the search and for what purpose
4. Information about the search:
   - A. Date
   - B. General location
   - C. Time conducted
   - D. Personnel present
5. Information about the atmospheric conditions
   - A. Precipitation
   - B. Temperature
   - C. Wind speed and direction
6. Information about the scene
   - A. Terrain
   - B. Ground cover
   - C. Impediments to wind
   - D. Potential areas of false alert
   - E. Potential areas of danger to dog and/or handler
7. Information about the victim and/or location
   - A. Identity
   - B. Potential cause and manner of death
   - C. Last seen alive and estimated postmortem interval
   - D. Unique identifiers
   - E. Background information related to scene location
8. Details of the search
   - A. Strategy
   - B. Implementation of strategy, alterations needed
   - C. Dog behavior: interest expressed, alerts, problems
   - D. Interpretation of behavior and results
   - E. Relation to chain of custody if remains discovered or recovered
   - F. Evaluation of search results and need for further search
   - G. Sketch map of search area and recovery patterns

The handler's evaluation of the success of the search, either negative or positive, may play an influential role in decisions about further searching of the area, initiating new searches, or mobilizing personnel and resources for a recovery. Because of this, it is important that the evaluation be written, well-reasoned, supported by experience, and well-communicated in a timely fashion. It is usually not possible to achieve 100 percent certainty about the absence of the victim given the absence of the dog's alert, or about the completeness of the recovery of scattered remains. It is the handler's responsibility to note the weaknesses in the search on hindsight, document false alerts, and report variables which produced altered strategies.

THE USE OF CADAVER DOGS IN NORTHERN NEW ENGLAND

A review of Maine cadaver dog searches from the last five years reveals the types and proportion of searches that are characteristic in this region. Table 2 itemizes the searches. A team of two cadaver dogs certified by the Maine State Police and handled by one author (E.D.) have been in use since 1991 for cases in Maine, New Hampshire, and Vermont. They and their handler have received initial and weekly ongoing training from experienced police K-9 trainers and have been trained and tested on multiple occasions by a recognized cadaver dog trainer.

These dogs have been trained to process a scene either on or off lead in response to commands which direct it to search certain locations, find the scent, and show the handler the source of the scent. Dogs are trained to signal a positive "alert" by sitting or lying at the site, or by gently digging. They are trained to alert rather than pick up a found item; if they do mouth the item, they are trained to release it immediately on command. Ongoing training occurs with semi-weekly or weekly sessions using single and multiple "finds" of items with artificial human decomposition scent applied to them and samples of scent-soaked gauze collected in previous cases.

Between 1991 and 1996, 41 searches for 24 individuals have been conducted. The data base presented in Table 2 also includes six (additional) training searches conducted at sites of previous recoveries. Additionally, other dog/handler teams have been involved in one of the searches (D9001) and two of the training sessions (T9103 and D9202, #3).

Of the 41 total searches conducted, nine (22%) resulted in the discovery of human remains, three (7%) being initial discoveries of a body and six (15%) discoveries of additional bones following a previous discovery of remains in the area. Searches were usually outdoors (95%); in two cases, basements were searched.

In twelve (29%) of the 41 searches, recovery expansion searches (Type I) were requested, usually by the office of chief medical examiner, in cases

Table 2
CADAVER DOG SEARCHES IN NORTHERN NEW ENGLAND

CASE	CANINE CASE RESULTS	SEARCH	TYPE	PMI*	RESPONSE	FINDINGS	SEARCH RESULTS
D9001	CANINE LOCATED BODY	1	II	9.00	1 ALERT	BODY LOCATED	RECOVERY COMPLETED
D9101	NO REMAINS FOUND: QUESTIONABLE DEATH	1	II	10.00	2 ALERTS	BURIAL INDICATED, EXCAVATION NEGATIVE	AREA PROVISIONALLY CLEARED
D9102	CANINE INDICATED BURIAL (SEE PAPER FOR	1	II	3.20	1 ALERT	BURIAL OR PREVIOUS BODY LOCATION INDICATED	SEARCH EXTENDED
	DETAILS)	2	II	3.20	NONE	NONE	AREA CLEARED
		3	III	5.00	NONE	NONE	INCONCLUSIVE: SUGGEST SEARCH AGAIN
		4	II	8.50	NONE	NONE	AREA CLEARED
		5	III	8.50	NONE	NONE	AREA PROVISIONALLY CLEARED
		6	TRAINING	14.00	1 ALERT	GRAVESITE INDICATED	N/A
T9103	REVISIT OF 1981 HOMICIDE CASE	1	TRAINING	144.00	3 ALERTS	GRAVESITE INDICATED	N/A
T9104	REVISIT OF 1990 HOMICIDE CASE	1	TRAINING	12.00	1 ALERT	BODY SITE INDICATED	N/A
T9105	REVISIT OF 1989 SUICIDE CASE	1	TRAINING	24.00	1 ALERT	BODY SITE INDICATED	N/A
D9201	NO REMAINS FOUND: STILL MISSING	1	III	72.00	INTEREST	BURIAL SUGGESTED, EXCAVATION NEGATIVE	AREA PROVISIONALLY CLEARED
		2	III (REPEAT)	72.00	NONE	NONE	AREA PROVISIONALLY CLEARED
		3	III	72.00	NONE	NONE	AREA PROVISIONALLY CLEARED
		4	II	72.00	NONE	NONE	AREA CLEARED
		5	II	72.00	NONE	NONE	AREA CLEARED
D9202	CANINE LOCATED SCATTERED PARTS	1	II	1.25	4 ALERTS	BODY SITE AND PARTS LOCATED	PARTIAL RECOVERY
		2	I	1.25	4 ALERTS	PARTS LOCATED	RECOVERY COMPLETED
		3	TRAINING	1.75	1 ALERT	PARTS LOCATED	N/A
D9203	CANINE LOCATED SCATTERED PARTS	1	I	1.25	2 ALERTS	PARTS LOCATED	RECOVERY COMPLETED
D9301	CANINE LOCATED SCATTERED PARTS	1	I	1.00	1 ALERT	PARTS LOCATED	RECOVERY COMPLETED
D9302	CANINE DID NOT EXPAND RECOVERY	1	I	72.00	1 ALERT	BODY SITE INDICATED	RECOVERY COMPLETED
D9303	CANINE DID NOT EXPAND RECOVERY	1	I	19.00	2 ALERTS	BODY SITE INDICATED	RECOVERY COMPLETED
D9304	CANINE DID NOT EXPAND RECOVERY	1	I	4.50	1 ALERT	BODY SITE INDICATED	RECOVERY COMPLETED
D9401	NO REMAINS FOUND: JANE DOE	1	I	UNK.	NONE	NONE	AREA PROVISIONALLY CLEARED
D9402	NO REMAINS FOUND: QUESTIONABLE DEATH	1	II	108.00	1 ALERT	OUTHOUSE INDICATED: EXCAVATION NEGATIVE	AREA PROVISIONALLY CLEARED
D9403	CANINE DID NOT EXPAND RECOVERY	1	I	5.00	3 ALERTS	BODY SITES INDICATED	RECOVERY COMPLETED
D9404	NO REMAINS FOUND: STILL MISSING	1	II	144.00	NONE	NONE	AREA PROVISIONALLY CLEARED
		2	II	144.00	NONE	NONE	AREA CLEARED
D9501	CANINE LOCATED SCATTERED PARTS	1	I	1.50	6 ALERTS	BODY SITE INDICATED, PARTS LOCATED	RECOVERY COMPLETED
D9502	BODY FOUND BY HUMAN SEARCHER	1	II	0.25	NONE	NONE	AREA PROVISIONALLY CLEARED
	IN AREA NOT SEARCHED BY DOGS	2	II	0.25	NONE	NONE	AREA CLEARED
		3	II	0.25	NONE	NONE	AREA PROVISIONALLY CLEARED
		4	II	0.25	NONE	NONE	AREA CLEARED
		5	II	0.25	NONE	NONE	AREA CLEARED
		6	II	0.25	NONE	NONE	AREA CLEARED

Table 2 Continued

		7	II	0.25	NONE	NONE	AREA PROVISIONALLY CLEARED
D9503	CANINE NOT NEEDED	1	I	180.00	NONE	NONE	RECOVERY COMPLETED
D9601	NO REMAINS FOUND: STILL MISSING	1 A & 1 B	III (2 DAYS)	1.00	NONE	NONE	INCONCLUSIVE: AREA TOO LARGE,BOGGY
D9602	NO REMAINS FOUND: STILL MISSING	1	II	0.50	NONE	NONE	AREA PROVISIONALLY CLEARED
D9603	CANINE LOCATED SCATTERED PARTS	1	I	0.10	5 ALERTS	PARTS LOCATED	AREA PROVISIONALLY CLEARED
		2	I	0.10	2 ALERTS	PARTS LOCATED	AREA PROVISIONALLY CLEARED
		3	TRAINING	0.50	2 ALERTS	BODY SITES LOCATED	N/A
D9604	NO REMAINS FOUND: STILL MISSING	1	II	0.50	NONE	NONE	AREA CLEARED
		2	III	1.00	NONE	NONE	INCONCLUSIVE: SUGGEST SEARCH AGAIN
		3	II	1.25	NONE	NONE	AREA CLEARED
D9605	NO REMAINS FOUND: STILL MISSING	1	II	264.00	NONE	NONE	AREA CLEARED

where decomposed remains had been discovered and canine assistance was needed to assure that all remains were recovered. In six of the twelve Type I searches (50%), additional parts were located by the canines.

Twenty-nine (71%) of the 41 were speculative searches (Types II and III) requested by state or local police in cases of thirteen missing individuals who were presumed dead, including one questionable infant death (D9402) and one questionable adult death (D9101). Thus, cases involving missing individuals involved an average of 2.2 searches each. Of the eleven known missing individuals for whom one or more speculative searches were conducted, three (27%) were found by the canines, one (9%) was found by a human searcher in an area not searched by the dogs, and seven (64%) are still missing.

The behavior of trained dogs still requires careful observation and interpretation. During their 41 searches and 6 training searches on the sites of previous cases, the dogs had 45 positive alerts (see Table 3). In all but one of these instances (discussed below) the dog manifested the specific behavioral response to a scent source for which it was trained. Out of 45 alerts, 42 (98%) were associated with human remains. Twenty alerts (44%) occurred at sites where remains had previously been recovered (eight of these occurred during the training searches in the data base), and 22 (49%) marked new discoveries.

Table 3
SCENE CONTEXTS FOR CANINE ALERTS

N (%)	*Context*
20 (44%)	Human remains discovered: normal alert
1 (2%)	Human remains discovered: idiosyncratic alert
20 (44%)	Human remains known to be there previously: normal alert
1 (2%)	Human remains not found at the time: later discovered buried nearby
2 (4%)	Human remains absent: reason for alert is unknown
1 (2%)	Human remains absent: alert to outhouse
45 (100%)	Total positive alerts

It is not always possible to know what prompts a dog's alert. In one situation (D9102, #1) the dog alerted in a basement. When police used Luminol in that area, they discovered an outline suggesting the prior location of the body. Believing they had discovered the cause of the alert and assuming the body had been subsequently moved, they resumed the search elsewhere. Eleven months later the body was found buried in the basement a very short distance from where the dog had alerted. It is uncertain on retrospect whether the dog had alerted to the surface location of the body (based on the Luminol) or to the burial.

The dogs are trained to display their alert in specific circumstances and in the course of certain routines. For example, a special collar is put on the dog to signal "work time." Because that collar is associated with the search behavior routines, the dog may behave differently without it. In one case (D9501) remains had been scattered in a wooded area and much of the body had been located by the canines. While one of the finds was being recovered, the canine was taken to a nearby area for "playtime" and then was put on lead to go to another area. As she and her handler were walking along, she suddenly sat down (her normal alert is to lie down). When the handler looked to see what had prompted her to sit, he discovered an articulated arm lying across an adjacent stump covered with leaves. This idiosyncratic alert was perhaps a result of the fact that she was not actually "working" when she detected the scent of these remains.

Sometimes a dog may alert when no human remains are likely to be present. They are known to alert to human feces and swamps, for example, due hypothetically to the similarity of the scent to that of human decomposition. One case in the data base (D9402) was such a "false" alert in the area of an outhouse. However, an excavation was conducted to rule out the remote possibility the alert was related to remains. In another case (D9101) the search was being conducted by two dogs with two different handlers. Both dogs alerted independently in a specific area. Excavations ensued, but no human remains could be found, nor any explanation for the alert.

Although a "valid" positive alert in a trained dog is a very specific behavior, dogs may indicate interest in an area associated with human remains without an actual alert. One training situation (D9603, #3) in the data base was at the crash site of a small plane where two people had been killed, with fragments scattered, two weeks previously. Following the recovery, the site had been bulldozed, further distributing the scent. The scent was so strong it was perceptible to the humans. In this context, the dogs indicated interest in many areas where there was valid scent, but gave a full alert only in one area associated with residual hair, and another associated with an article of fabric. In three additional recovery expansion cases not included in Table 3, the dog showed interest but not an actual alert in areas where human remains where known to have been found previously. In a few other situations, the dogs appeared "interested," expressing that interest as digging or repeated smelling of a limited area, but did not exhibit an alert. One of those "interesting" locations was a deeryard and another was associated with a decomposing deer skeleton—both situations known to interest dogs regardless of training.

It is important to remember that the dogs are responding to olfactory and not visual cues. In 24 instances, including eight during training at previous scenes, the dogs were deliberately exposed to areas where remains were

known to have been recovered. In 20 instances (83%), with the postmortem intervals ranging from 0.5 to 72 months, the dog responded with a full alert at the specific site. In two instances (8%) where the postmortem interval was 4.5 months the dog showed interest but not a full alert. In two instances (8%) where the postmortem interval was 5 months there was no indication of interest on the part of one dog, but the other dog in the team responded with a full alert. No human remains have been found in areas where dogs appeared interested but did not alert.

In only one situation have human remains been present but the dogs did not alert. This was a surface deposition just inside a lightly wooded area on the side of a hill with a 15-year postmortem interval (October death). The hill was a fairly steep and well-drained area sloping down to a large river. Interestingly, the location was near a recreational spot and close to a town, yet the decomposing body had not been noticed all those years. Additionally, there was a known fox den nearby, yet the body was undisturbed by carnivores. The clothed skeleton was entirely free of flesh and found in a seated position under a tree with the legs oriented down slope. Except for one lower leg and both feet which had "migrated" a few feet further down slope from, but still in line with, their apparent original position, the remains were in anatomical position. That this decomposing body had not provoked interest by the local fauna nor human notice suggests it may have decomposed rather rapidly and that the scent had been removed, perhaps due to the excellent surface drainage. The dogs were introduced to the scene prior to removal of the skeleton, and neither alerted nor showed any interest in the remains. The bones were obviously degreased and quite dry.

POSTMORTEM INTERVAL AND CONDITION OF REMAINS IN NORTHERN NEW ENGLAND

The analysis of cases for which postmortem interval and recovery methods are known can contribute to establishing guidelines for recovering and interpreting future cases. Understanding the taphonomic context for cases exposed outdoors, including climatic factors, the response and recovery patterns of trained cadaver dogs, the scavenging patterns of local fauna, and the decomposition rates for undisturbed remains depends on the development of regionally specific data bases.

The study population includes a 20-year anthropological case series (see Table 4) of 36 recoveries of 34 decomposed and skeletonized individuals from Maine, New Hampshire, and Vermont in which (1) the remains were exposed outdoors, (2) the individual was positively identified, (3) the approximate or exact time since death was known, and (4) the recovery circumstances and methods were known. All cases were surface recoveries, although

two had been in shallow graves unearthed by scavengers. Two of the recoveries were some time, in one case months and in another case years, after the initial recovery of the same individual. (One of these recoveries had been postponed due to the weather; the other occurred when additional remains were found a mile from where the original recovery had taken place.) These cases were selected for study because of their relative homogeneity of exposure and because the condition of the remains was documented.

Table 4
CONDITION OF REMAINS AND POSTMORTEM INTERVAL

CASE	CANINE CASE	PMI*	DEATH MONTH	CARNIVORE MODIFICATION	BRAIN OR VISCERA	SKIN, MUSCLE OR DURA	EXTREMITY LIGAMENTS	TORSO LIGAMENTS	LIVE INSECT LARVAE	ODOR OF DECOMP.
880652	N/A	0.50	JUL	NO	YES	YES	YES	YES	YES	YES
830921	N/A	0.75	SEP	NO	YES	YES	YES	YES	YES	YES
840766	N/A	1.00	JUL	NO	YES	YES	YES	YES	YES	YES
920463	D9202	1.00	MAY	YES	NO	YES	NO	YES	YES	YES
940760	N/A	1.00	SEP	NO	NO	YES	YES	YES	YES	YES
920781	D9203	1.25	AUG	NO	YES	YES	YES	YES	YES	YES
880896	N/A	1.25	AUG	NO	YES	YES	YES	YES	YES	YES
950390	D9501	1.50	APR	YES	YES	YES	YES	YES	YES	YES
801056	N/A	3.00	JUL	NO	UNK	YES	YES	YES	YES	YES
860850	N/A	4.00	JUN	NO	NO	YES	YES	YES	YES	YES
930909	D9304	4.25	JUL	YES	NO	NO	YES	YES	YES	YES
940807	D9403	5.00	JUN	YES	NO	NO	YES	MISSING DATA	YES	YES
890980	T9105	6.00	MAY	NO	NO	YES	YES	YES	YES	YES
900240	D9001	9.00	JUL	YES	NO	YES	YES	YES	YES	YES
930691	N/A	9.00	JAN	NO	NO	YES	YES	YES	YES	YES
860008	N/A	9.00	JUL	YES	NO	NO	YES	YES	YES	YES
810153	N/A	13.00	JAN	YES	NO	YES	YES	YES	YES	YES
950603	N/A	13.00	JUL	NO	NO	NO	NO	YES	NO	NO
860009	N/A	14.00	JUL	YES	NO	NO	YES	NO	NO	NO
821032	T9103	15.00	AUG	YES	ADIPOCERE	YES	YES	YES	YES	YES
831012	N/A	16.00	JUL	YES	NO	NO	YES	YES	YES	YES
841047	N/A	18.00	MAY	NO	NO	NO	YES	NO	NO	YES
930874	D9303	19.00	APR	YES	NO	NO	YES	YES	YES	YES
831012	N/A	22.00	JUL	YES	NO	NO	NO	NO	NO	NO
860007	N/A	23.00	MAY	YES	NO	ADIPOCERE	YES	YES	NO	NO
800381	N/A	24.00	AUG	YES	NO	MISSING DATA	YES	MISSING DATA	MISSING DATA	YES
881058	N/A	42.00	MAY	YES	NO	NO	NO	NO	NO	NO
875662	N/A	45.00	AUG	YES	ADIPOCERE	NO	NO	NO	NO	NO
810967	N/A	48.00	UNK	NO	NO	NO	NO	NO	NO	NO
850771	N/A	52.00	MAY	YES	NO	ADIPOCERE	NO	NO	NO	NO
810498	N/A	58.00	AUG	YES	NO	NO	NO	NO	NO	NO
840964	N/A	76.00	AUG	YES	NO	NO	NO	NO	NO	NO
930828	D9302	76.00	JUN	YES	NO	NO	NO	NO	NO	NO
801112	N/A	83.00	NOV	NO	NO	NO	NO	NO	NO	NO
875762	N/A	120.00	UNK	YES	NO	NO	NO	NO	NO	NO
950684	D9503	180.00	OCT	NO	NO	NO	NO	NO	NO	NO

*POSTMORTEM INTERVAL IN MONTHS

The northern New England region includes the states of Maine, New Hampshire, and Vermont. These three states range in latitude from 42°42′ to 47°28′ and 73°26′ to 66°57′ in longitude. The predominantly forested land ranges in altitude from sea level to 1916 m. The climate is termed

humid continental and includes temperature fluctuations typically ranging from about 33°C in summer to about −35°C in winter. Most of the region occupies USDA hardiness zones 3 through 5. The population density is low, with fewer than 10 persons per square kilometer.

The anthropological case recoveries range from two weeks to 15 years in postmortem interval, 72% occurring in the first 24 months after death. Ten cases (28%) extend beyond two years, and these range from 42 months to 15 years. There are no cases having a postmortem interval from 25 to 41 months in this sample. The taphonomic context for most of these cases is similar, second growth woods or meadow with access to large carnivores such as bear, coyote, and dog. The vast majority of deaths (84%) occurred in the warmer months of the year, May through September, presenting an opportunity for significant decomposition and insect infestation prior to the onset of freezing temperatures.

Of the 36 cases in this sample, 12 have occurred since cadaver dogs were available; of these, nine included the participation of dogs trained to locate decomposition scent. The other three were discovered by other means and were complete, not requiring the dogs. The nine cases involved 10 canine searches, two of which were done to locate the body and eight to expand the previous recovery of partial remains. The dogs searched for remains in seven carnivore modified cases and two relatively undisturbed cases. They alerted for remains in all but one case (discussed earlier), with postmortem intervals ranging from 1 to 76 months. In addition, three of the dogs revisited one scene (821032) 144 months after the death and 129 months after removal of the remains from the site; all three dogs alerted to the grave site. Canines were used for seven cases, with postmortem intervals ranging from one month to 19 months, as well as one case exposed 6.3 years and one exposed 15 years.

The cases can be easily sorted into two types, **Relatively Undisturbed** (sample of 15) and **Carnivore Modified** (sample of 21), according to whether or not they were subjected to modification and scattering by large carnivores, probably canines or bear. The relationship between decomposition stage and postmortem interval differs according to type. Both types have a similar distribution range of postmortem interval in this sample.

Relatively undisturbed remains are complete or nearly complete and are found in anatomical position. Included among these are cases in which only hand or foot bones are scattered or missing, or cases with gunshot wounds to the head in which cranial fragments are scattered. Of these, about half exhibited no scavenger damage whatsoever, while the other half had apparently been scavenged by small animals only, including rodents. The rates of decomposition for this type of case tend to be more homogeneous

and, unexpectedly, faster; estimates of postmortem interval estimates can be narrower.

Carnivore modified recoveries are those in which major body parts or bones are scattered, missing, or damaged, frequently requiring the use of cadaver dogs for maximal recovery. Due to carnivore modification, including defleshing, disarticulation, scattering, and chewing of bones, the process of decomposition for this type is interrupted and frequently accelerated. Furthermore, because recovery is often incomplete, and because the parts recovered may not be representative of the body as a whole, estimates of the postmortem interval based on stage of decomposition are subject to more error and generally need to be expressed within a wider range.

The relatively simple model used here to evaluate the condition of the remains divides cases into relatively undisturbed and carnivore modified types and records the presence or absence of five key variables: (1) identifiable internal organs; (2) skin, muscle or dura; (3) ligaments on trunk or extremities; (4) live insect larvae including "cheese skippers;" and (5) decomposition odor detected by humans. In cases where adipocere was present, having preserved the morphology of internal organs or soft tissues, the data are regarded as missing. In rare cases there may be some desiccation of skin accompanied by frank decomposition of the tissues beneath the skin, and in some cases ligamentous tissue can dry and persist longer than other less vascular tissue; however, these cases are not coded differently. We have not found instances of prolonged soft tissue preservation due to drying in these outdoor cases.

RELATIVELY UNDISTURBED REMAINS

It is somewhat surprising to find cases lacking major carnivore modification, particularly in the Maine woods where bear and coyote are common. It appears, however, that many bodies are actually avoided by these scavengers. Although the small hand and foot bones are almost always missing in these exposed remains, many bodies exposed for years in known carnivore territory suffer no additional modification or scattering. We suspect the explanation involves both unique and generalizable factors of microclimate, food availability, time of death, and presence of insects. Decomposing remains may be less attractive than other food sources, and rapid decomposition may reduce the time window during which the remains might be attractive.

Table 5 shows the case distribution by month of death according to whether the remains were modified by large carnivores or were relatively undisturbed. Although the subsample sizes are too small to have much confidence in generalizing the pattern, it appears that individuals who die in the fall are less susceptible to modification.

Table 5
MONTH OF DEATH AND CARNIVORE MODIFICATION

Month of Death	*Relatively Undisturbed* Case #—Postmortem interval	*Carnivore Modified* Case #—Postmortem interval
January	930691—9.00 mo.	810153—13.00 mo.
February		
March		
April		950390—1.50 mo. (bear) 930874—19.00 mo.
May	890980—6.00 mo. 841047—18.00 mo.	920463—1.00 mo. (bear) 860007—23.00 mo. 881058—42.00 mo. 850771—52.00 mo.
June	860850—4.00 mo.	940807—5.00 mo. 930828—76.00 mo.
July	880652—0.50 mo. 840766—1.00 mo. 801056—3.00 mo. 950603—13.00 mo.	930909—4.25 mo. 900240—9.00 mo. 860008—9.00 mo. 860009—14.00 mo. 831012—16.00 mo.
August	920781—1.25 mo. 88-896—1.25 mo.	821032—15.00 mo. 800361—24.00 mo. 875662—45.00 mo. 810498—58.00 mo.
September	830921—0.75 mo. 940760—1.00 mo.	
October	950684—180.00 mo.	
November	801112—83.00 mo.	
December		

Among relatively undisturbed cases, identifiable internal organs or brain tissue were present as late as 1.25 months postmortem, but absent as early as 1.00 month. Skin, muscle, or dura was present as late as 9 months and absent as early as 13 months. The presence of ligaments was observed as late as 13 months on the torso and 18 months on the extremities, but was absent as early as 13 months on extremities and 18 months on the trunk. Live insect larvae were observed as late as 9 months and absent as early as 13 months. Decomposition odor was observed as late as 18 months but was absent as early as 13 months. A sampling gap between 9 and 13 months slightly distorts the ranges for soft tissue and insect larvae.

CARNIVORE MODIFIED BODIES

Carnivore modification in the study sample is more likely, but not inevitable, in deaths occurring during the late spring and summer (see Table 5) and less likely during the fall. In northern New England snow stays on the ground in the woods into the month of May, limiting vegetation and some food sources. The two cases in the data base known to have been modified by bears died at a time when bears had rather recently emerged from hibernation and food was not yet abundant.

Among carnivore modified cases, identifiable internal organs or brain tissue were present as late as 1.5 months but absent as early as 1.00 month. Skin, muscle, or dura was present as late as 15 months but absent as early as 4.25 months. Live larvae were present as long as 19 months but absent as early as 14 months. Ligaments persisted as long as 23 months on the torso and 24 months on the extremities but were absent as early as 1.00 month on the extremities (chewed by bear in that case) and 14 months on the trunk. Odor of decomposition persisted as long as 24 months but was absent as early as 14 months.

Observations about the condition of the remains in carnivore modified remains are often limited due to scattered and missing remains. This can be particularly important if the recovery includes none of the trunk or, alternatively, none of the extremities. Of the variables in the model used here the presence or absence of skin, muscle, and dura is the one hypothetically most likely to be affected by carnivore feeding. Thus, these soft tissues can be absent due to removal by animals rather than decomposition. Conversely, the presence of identifiable brain tissue is not apt to be affected by carnivore activity.

Surprisingly, all of the soft tissue and decomposition-related characteristics in the model persisted longer in carnivore modified remains than in relatively undisturbed remains. This may be a result of the small sample size and warrants further investigation. It is possible that scattering of the remains reduces access to large numbers of insects feeding simultaneously, reduces the heat needed for chemical reactions, and increases the opportunity for desiccation. As expected, however, the presence of viscera, skin, muscle, and ligaments tends to be absent earlier in carnivore modified remains.

CONCLUSIONS

Properly trained cadaver dog/handler teams are an efficient and effective means for improving the likelihood of finding bodies and recovering scattered remains. Among the cases in northern New England examined in this study,

Table 6
CONDITION AND POSTMORTEM INTERVAL RANGES

Condition	*Relatively Undisturbed*	*Carnivore Modified*
Brain and viscera		
Latest time present	1.25 months	1.50 months
Earliest time absent	1.00 month	1.00 month
Skin, muscle, and dura		
Latest time present	9.00 months	15.00 months
Earliest time absent	13.00 months	4.25 months
Live insect larvae		
Latest time present	9.00 months	19.00 months
Earliest time absent	13.00 months	14.00 months
Ligaments on torso		
Latest time present	13.00 months	23.00 months
Earliest time absent	18.00 months	14.00 months
Ligaments on extremities		
Latest time present	18.00 months	24.00 months
Earliest time absent	13.00 months	1.00 months (bear)
Odor of decomposition		
Latest time present	18.00 months	24.00 months
Earliest time absent	13.00 months	14.00 months

dogs have been able to correctly indicate the site of human remains, with or without the remains actually present, with postmortem intervals ranging from two weeks to twelve years. Although the dogs very rarely alerted to human feces or unidentified scent sources, there was only one search in this sample (2%) in which human remains did not produce an alert; this was an exceptionally well-drained surface deposition of 15 years' duration which had also escaped the notice of local carnivores.

An understanding of the taphonomic variables influencing site formation, including its attractiveness to scavengers, is necessary in order to develop effective cadaver search and recovery strategies, whether using canines or not. Climatological, geographic, and faunal variables which comprise the scene context must be included in the collection of information about the scene in order to properly process and interpret what is found there, or to reliably determine that an area is clear of remains. Data collected during cadaver dog searches, and during the recovery of remains, must be carefully documented in order to support further investigation, interpret findings, or become an effective part of the legal process.

The development and publication of case series data bases highlighting the relationships between regionally specific taphonomic variables is necessary in order to improve models for death scene interpretation. The series

presented here supports the premise of other researchers that carnivore modification can significantly alter both the process of decomposition and the approaches needed to interpret postmortem interval. Human remains altered by large carnivores are more difficult to assess, with wider ranges of variation in their condition than comparable remains of similar age in this limited sample. That is, they tend in some cases to lose skin, muscle, ligaments, insect infestation, and odor earlier; yet, in other cases they tend to retain soft tissues, insect larvae and decomposition odor longer. Additionally, this series suggests that deaths occurring in the fall are less likely to be subjected to large carnivore destruction and scatter. However, deaths which occur late enough in the fall for the body to be preserved until spring may be available in early spring as a scavenger food source, comparable to a spring death.

ACKNOWLEDGMENTS

We would like to thank the Offices of Chief Medical Examiner and State Police of Maine, New Hampshire, and Vermont, as well as the Maine State Warden Service, for their cooperation, especially Dr. Henry F. Ryan, Dr. Kristin Sweeney, Dr. Paul Morrow, Det. Michael Harriman, and Warden Specialist Deborah Palman. We also gratefully acknowledge the assistance of Lloyd Williams and Marcy Koenig.

REFERENCES

Boyle, S., Galloway, A., and Mason, R.T. Human aquatic taphonomy in the Monterey Bay area. In Haglund, W.D.; Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996, in press.

Duffy, J.B., Skinner, M.F., and Waterfield, J.D. Rates of putrefaction of dental pulp in the Northwest Coast environment. *Journal of Forensic Sciences, 36*(5):1492–1502, 1991.

France, D.L., Griffin, T.J., Swanburg, J.G., Lindemann, J.W., Davenport, G.C., Trammel, V.M., Travis, C.T., Kondratieff, B., Nelson, A., Castellano, K., Hopkins, D., and Adair, T. Necrosearch revisited: Further multidisciplinary approaches to the detection of clandestine graves. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996, in press.

France, D.L., Griffin, T.J., Swanburg, J.G., Lindemann, J.W., Davenport, G.C., Trammell, V., Travis, C.T., Kondratieff, B., Nelson, A., Castellano, K., and Hopkins, D. A multidisciplinary approach to the detection of clandestine graves. *Journal of Forensic Sciences, 37:*1445–1458, 1992.

Galloway, A. The process of decomposition: A model from the Arizona-Sonoran Desert. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The*

Postmortem Fate of Human Remains. Boca Raton, Florida: CRC Press, 1996, in press.

Galloway, A., Birkby, W.H., Jones, A.M., Henry, T.E., and Parks, B.O. Decay rates of human remains in an arid environment. *Journal of Forensic Sciences, 34*(3):606–617, 1989.

Haglund, W.D. Disappearance of soft tissue and the disarticulation of human remains from aqueous environments. *Journal of Forensic Sciences, 38*(4):806–815.

Haglund, W.D. Dogs and coyotes: Postmortem involvement with human remains. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996a, in press.

Haglund, W.D. Scattered skeletal remains: Search strategy considerations for locating missing teeth. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996b, in press.

Haglund, W.D., Reay, D.T., and Swindler, D.R. Tooth mark artifacts and survival of bones in animal scavenged human skeletons. *Journal of Forensic Sciences, 33*(4): 985–997, 1988.

Haglund, W.D., Reay, D.T., and Swindler, D.R. Canid scavenging/disarticulation sequence of human remains in the Pacific Northwest. *Journal of Forensic Sciences, 34:*587–606, 1989.

Haskell, N.H., Cervenka, V.J., and Clark, M.A. Insects' life stage presence, their postmortem artifacts, and entomological collecting procedures. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996, in press.

Mann, R.W., Bass, W.M., and Meadows, L. Time since death and decomposition of the human body: Variables and observations in case and experimental field studies. *Journal of Forensic Sciences, 35*(1):103–111, 1990.

Murad, T.A., and Boddy, M.A. A case with bear facts. *Journal of Forensic Sciences, 32*(6):1819–1826, 1987.

Rebmann, A.J. Cadaver dog training using pseudo scents. NASAR Conference Proceedings, 1993.

Rebmann, A.J. Cadaver dogs: A primary resource for the location of human remains. Redmond, Washington: Unpublished manuscript, 1994.

Sachs, J.S. The fake smell of death. *Discover: The World of Science, 17*(3):87–94, 1996.

Schoenly, K., Griest, K., and Rhine, S. An experimental field protocol for investigating the postmortem interval using multidisciplinary indicators. *Journal of Forensic Sciences, 36*(5):1395–1415, 1991.

Skinner, M.F., Syed, A., Farrell, J., and Borden, J.H. Case report in forensic anthropology: Animal and insect factors in decomposition of homicide victim. *Canadian Society of Forensic Sciences Journal, 21*(1–2):71–81, 1988.

Sorg, M.H., Dearborn, J.H., Monahan, E.I., Ryan, H.F., Sweeney, K.G., and David, E. Forensic Taphonomy in marine contexts. In Haglund, W.D., and Sorg, M.H. (Eds.), *Forensic Taphonomy: The Postmortem Fate of Human Remains.* Boca Raton, Florida: CRC Press, 1996, in press.

Tolhurst, B. *The Police Textbook for Dog Handlers.* Sanborn, New York: Sharp Printing, 1991.

Tolhurst, W., and Reed, L. *Manhunters! Hounds of the Big T.* Puyallup, Washington: Hound Dog Press, 1984.

Vass, A.A., Bass, W.M., Wolt, J.D., Foss, J.E., and Ammons, J.T. Time since death determinations of human cadavers using soil solution. *Journal of Forensic Sciences, 37*(5):1236–1253, 1992.

Willey, P., and Heilman, A. Estimating time since death using plant roots and stems. *Journal of Forensic Sciences, 32*(5):1264–1270, 1987.

Willey, P., and Snyder, L.M. Canid modification of human remains: Implications for time-since-death estimations. *Journal of Forensic Sciences, 34*(4):984–901, 1989.

Yoshino, M., Kimijima, T., Miyasaka, S., Sata, H., and Seta, S. Microscopical study on estimation of time since death in skeletal remains. *Forensic Science International, 49:*143–158, 1991.

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