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Fertilizer in the Identification and Analysis of Cultivated Soil

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Chapter 2

Fertilizer in the Identification and Analysis of Cultivated Soil

Naomi F. Miller and Kathryn L. Gleason

Many archaeological traditions treat soil simply as the medium in which artifacts or environmental remains are embedded, the context rather than the object of study. For the archaeologist of gardens and fields, the soil itself reveals traces of ploughing, fertilizing, terracing, and other human actions that turn land into landscape. Studies of stratigraphy, soil chemistry, artifacts, and environmental inclusions provide critical evidence that can strengthen and augment interpretations based on surface survey and aerial photography.

Cultivated land is commonly improved land, because agricultural activities can degrade soils. Farming cultures have long understood that dung and organic debris may enhance or restore soil productivity. By detecting the ancient use of fertilizer, an archaeologist can recognize a buried land surface or archaeological deposit as cultivated. Inorganic inclusions in fertilizer such as potsherds, coins, and other artifacts are not uncommon and help date the cultivation site. Charcoal and highly organic soils can be radiocarbon-dated directly (see Stein 1992). For historical periods, texts documenting the nature and application of fertilizer potentially shed light on many archaeological situations. In the absence of texts, it is possible to reconstruct these practices through stratigraphic, chemical, and botanical analysis. In turn, studies of fertilizer can reveal aspects of past gardening practices and local environment.

Finding loci of probable past cultivation is the first step in garden and field archaeology, but one must then demonstrate the soil was once cultivated. The structure of cultivated soils is distinctive: frequent disturbance by digging and ploughing tends to even out the distribution of soil particles and prevents the natural development of soil horizons. (On the use of remote sensing to detect these changes,

see Bevan, this volume.) A common characteristic of these cultivated soils is that fertilizer has been worked into them.[1] Fertilizer usually consists of material that has been redeposited from elsewhere, and so possesses features that reflect its circumstances of origin. Therefore, plant materials, notably phytoliths, pollen, and seeds found in situ are at least as likely to have originated in fertilizer as from the plants grown on the plot. Careful examination of these materials can reduce some of the uncertainties inherent in the interpretation of cultivated soils.

Although it can be difficult to identify and interpret the practices that produced characteristic features of cultivated soils, the task is made easier if one takes control samples from outside the former cultivated area. In the context of garden and field archaeology, such soil samples should be treated as any other sample for a given analysis. A control sample may be taken from a modern, known situation that is analogous to the presumed ancient conditions. Other types of control samples may be taken from an ancient surface where it is thought cultivation did not occur, or from the modern surface at the top of the excavation, in order to enable the analyst to assess the significance of the materials found in the deposit of interest or to test for differences in the chemical characteristics of the soils (see Sandor and Eash 1991:32 for an example of how one might define suitable control samples for soils analysis). Analogue and other control samples are discussed below and in later chapters in the context of specific studies.

Soil as a Medium for Plant Growth

Soil is a substance that has mineral and organic components and a characteristic structure (see Buol et al. 1980; Limbrey 1975; Steila 1976; Young 1976). Soil development is a result of regular chemical and mechanical processes operating on a parent material over time; it is influenced by climate and vegetation. Different "zonal" soils, which have developed enough to reflect climate and other soil-forming processes, characterize the major climatic regions of the world; "azonal" soils consist of sediments, perhaps transported from elsewhere by wind, water, or gravity, that have not had time to develop characteristic horizons. Describing the results of the regular course of soil development, soil scientists identify various soil horizons, including "O" (humic) horizon on top, which consists of organic matter; "A" horizon (accumulation of organic matter in a mineral

1. For a discussion of techniques used in traditional European agriculture see Murphy and Scaife (1991).

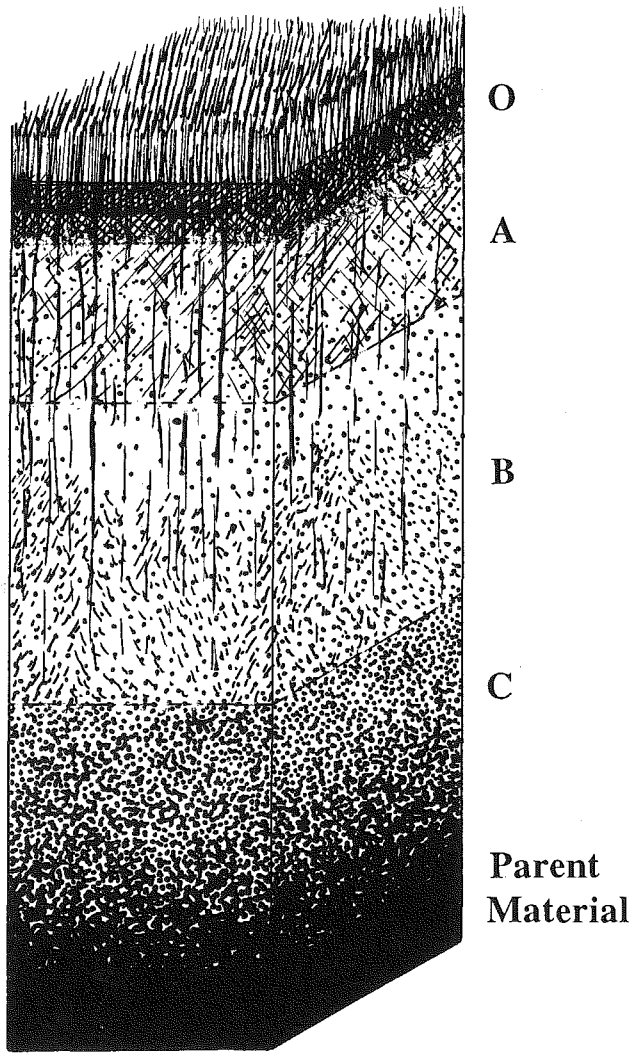
horizon); "E" horizon, from which some particles of clay, iron, or aluminum are lost; "B" horizon, a mineral horizon that accumulates the particles translocated from above. The zone containing unaltered or slightly altered parent material is called the "C" horizon. Cultivation disturbs the O and A horizons. Where ploughing occurs, an agricultural horizon may be recognized as a subcategory of the A horizon (see Holliday and Goldberg 1992) (Figure 2.1).

Fertilizing affects the soil factors critical for plant growth, which include nutrients as well as soil texture and structure. Soil texture refers to the relative proportions of different size mineral particles (clay, silt, and sand), and soil structure is the "arrangement of primary soil particles into secondary . . . units" (Steila 1976:203). Fertilizing therefore not only adds nutrients but may also improve a plant's ability to use air, water, and nutrients to full advantage.

Fertilizer

Many of the farming cultures of the world, both past and present, have intentionally improved the soils on which they planted (see Erickson, this volume). Edgar Anderson has even argued that food production began on (unintentionally) fertilized soils on the "dump heaps" surrounding settlements (Anderson 1967). Archaeologists can test such hypotheses by studying the nutrients that fertilizers add to the soil, especially phosphorus, nitrogen, and potassium. Phosphorus, for example, persists in inorganic form by chemically bonding with the calcium, iron, and aluminum in the soil. The soils around dwelling areas, middens, and burials have been shown to be high in phosphate concentration (e.g., Eidt 1984; Woods 1984), as have some ancient fertilized fields (e.g., Sandor 1992:240).

Of course, in ancient times, chemicals were not added directly to the soil. Common "packages" were animal dung, trash, and settlement debris. Other organic-rich materials like leaf litter and sod have also been used. Animal dung adds nitrogen and phosphorus, but it also contains plant residues of several sizes: straw and seeds, phytoliths, pollen, and spherulites (see below). Household trash typically includes residues of food preparation and fireplace sweepings, which contain charred macroremains (wood and, if dung was burned, seeds, straw, and other plant materials). Plants that grew nearby or some distance away have also been recognized as a source of fertilizer in ancient fields (e.g., Dimbleby and Evans 1974). Though *uncharred* macroscopic plant parts tend not to be preserved in such deposits, pollen and phytoliths might be. Fertilizer originating in settlement debris may also include items not particularly useful to the plants but



2.1. Soil profile. See text for explanation of the horizons. (E. Brescia)

very useful to the archaeologists, like potsherds, coins, and other datable objects (see Ford et al., this volume).

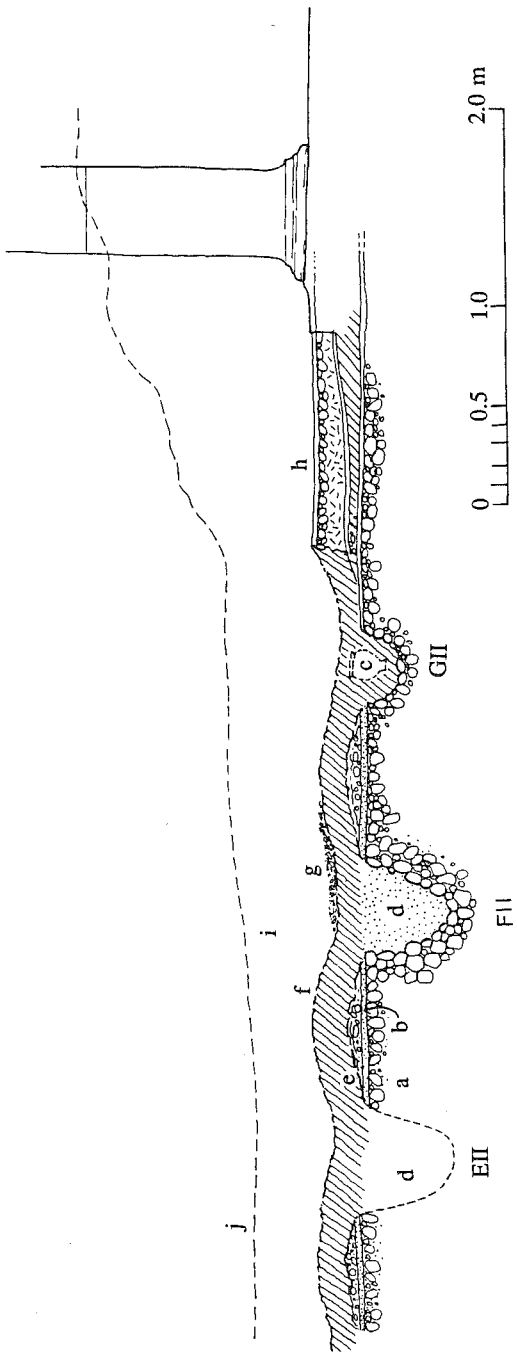
The distinctive composition and structure of fertilizer thus allows the archaeologist to distinguish cultivated land from surrounding soils (Figure 2.2), but the contents of fertilizer are not solely products of the garden or field itself. Since manures and other fertilizers may incorporate environmental remains originating outside the plot, such evidence is not a direct reflection of the ecological processes taking place within it. Particularly unambiguous examples of fertilized soils are seen in the Roman gardens at Fishbourne and at Jericho (Cunliffe 1971:125; Gleason 1987/88). The importance of this practice for the identification of garden beds on archaeological sites cannot be overstated.

Phosphate

Soil phosphates are derived from decomposed organic matter that is converted into a nearly insoluble inorganic form (see Eidt 1984; Hamond 1983; Woods 1975). Soil contains both organic and inorganic phosphate, though most is inorganic. By binding with calcium, iron, and aluminum, organic phosphate not utilized by plants is converted to an insoluble, inorganic form that accumulates in soil. An advantage of inorganic phosphate analysis is that once phosphorus becomes unavailable to plants, it tends to remain in place in soil as long as the sediments stay there. Phosphate "available" to plants is of interest to farmers, but the total inorganic phosphate concentration is at least as important for archaeologists trying to identify ancient fertilized fields.

Bone is particularly rich in phosphorus, as are other animal parts and products. Plants concentrate it in lesser proportions. Burials are therefore notoriously rich in phosphate, and settlement debris also generally shows high concentrations. Fields, refuse pits, fertilized planting pits, paddocks, trackways, and burials have all been identified using phosphate analysis (Cook and Heizer 1965; Mees 1982), but the interpretation of phosphates in fields is particularly complex.

Cultivated soils generally show lower concentrations than settlements, and depending on farming practices, less or more than surrounding uncultivated areas. For example, phosphorus is soon depleted from unfertilized fields, which therefore exhibit lower concentrations than comparable uncultivated ground (Sandor et al. 1990; cf. Eidt 1984:29). Fertilized fields, on the other hand, tend to show higher concentrations than uncultivated land, but lower concentrations than settlements (Eidt 1984:31). If the natural phosphate



2.2. Ancient garden soil profile at the Herodian palace at Jericho. (a) alluvial subsoil; (b) plaster construction surface; (c) ceramic planting pot; (d) planting pit with humic soil; (e) fertilized garden soil; (f) garden surface contoured for irrigation; (g) fluvial deposition of pebbles; (h) perimeter walk; (i) destruction debris; (j) modern surface before excavation. (K. L. Gleason, courtesy of the Anglo-Israel Archaeological Society)

level in the parent soil is low, then fairly small additions from human or animal use can be readily detected. Complications arise if land is used after the period under investigation, as any additions of phosphorus will give an incorrect high reading. Hamond (1983) points out that if there is little vertical movement of phosphorus in the soil, more accurate measurements can sometimes be made on buried soils than on the surface. It is, however, possible for phosphorus to move downward below the A horizon (Sandor and Eash 1991).

Several methods have been developed for measuring phosphorus, though the experts disagree on their utility. A simple field spot test for detecting relative quantities of inorganic phosphate in soils is useful in non-destructive surveys of landscape features. It involves adding a chemical to a small soil sample (ca. 50 mg), putting it on some filter paper, and measuring the intensity of the blue color that forms. The spot test is quick, easy, and cheap (Hamond 1983). It is not as precise as the fractionation method for garden and field interpretation, but it has proven useful as a rough measure of intensity of settlement. At Castle Copse, England, phosphate analysis was used initially in an attempt to locate the gardens. Unfortunately the readings on the building walls gave far stronger readings than the soil areas themselves (Hostetter forthcoming); this proved to be the case at Jericho as well.

The fractionation method distinguishes three types of inorganic phosphate (I, II, III), and gives the total concentration (Eidt 1984). It requires at least 5 to 10 g of earth per sample (Woods 1975:12). For the intermediate phosphate levels associated with fields, one can look at the proportions of the three types, and match with modern samples to interpret the results. Eidt (1984:59) gives an example from the site of Billar, Colombia, where residential sediments showed very high total phosphate compared to garden soil; the garden soil showed very high type I phosphate and total phosphorus comparable to that found in analogue samples taken from modern fields of traditional crops (Table 2.1).

Archaeologists frequently use phosphate analysis to define settlement boundaries or to identify features, especially burials where the bone has decayed. When gardens surround a settlement, phosphate analysis can be used to define the area, or, in conjunction with other data, to confirm the presence of fertilized ground. The most appropriate way to sample is to take soil samples along transects. The interpretation of a phosphate analysis may require a general soils analysis. Also, it is important to take control samples to determine the concentration of the naturally occurring phosphorus in the area.

TABLE 2.1. Phosphate Analysis from Billar, Colombia, with Modern Comparison[a]

Sample	Phosphate fractions[b] (%)			Total phosphate (ppm)
	I	*II*	*III*	
Billar 1 (garden)	81	11	8	110
Billar 2 (residential)	66	10	24	615
Jiguales (yuca-maize)	83	12	5	116
Jiguales (yuca-plátano)	80	14	6	115

[a]Source: Eidt (1984:59)
[b]Fraction I: P moderately available to plants
Fraction II: P occluded within Al and Fe oxides and hydrous oxides
Fraction III: P occluded in calcium phosphates and apatite (Sandor et al. 1986; pers. comm. 1993)

At North Thoresby, Lincolnshire, high phosphate readings were obtained from an irregular grid pattern of ditches dated by Roman pottery and other refuse (Webster and Petch 1967). These were interpreted as planting ditches, perhaps for grape vines. At Kurban Höyük, in southeastern Turkey, soil phosphate analysis yielded only weak correlation with sherd scatters thought to have resulted from manuring with sherd-rich settlement debris (Wilkinson 1990b:73–78). A more conclusive study of an Iron Age farm site in Norway documented a zone of elevated phosphorus concentrations over an area larger than could be accounted for as a "haphazard accumulation of organic waste." As high phosphate concentrations could not be associated with sheep pens, either, the best hypothesis was that the areas of high phosphate concentration had been cultivated, fertilized fields around the farmstead (Provan 1973).

Dung

Animal dung is a common fertilizer. The dung of domesticated herbivores is sometimes found in situ on archaeological sites. If it has not disintegrated, it is readily recognized in comparison with modern specimens. It is well worth overcoming squeamishness and enduring the ridicule of colleagues in order to collect and study the dung of living animals. One can observe, for example, that sheep and goat pellets are fairly distinctive, short cylinders, flat on one end and coming to a small point on the other. They are somewhat larger than, say, gazelle scats and about the same size as those of deer. Cowpies are unlikely to be found whole, but their fibrous mass of incompletely

digested straw and other vegetal material can be recognized. Courty et al. (1989:114) describe it thus: "The faecal residues of herbivores have a high porosity and contain many undigested plant fragments and amorphous dark brown organic matter that act as a type of binding matter." Even if worked into the soil, dung fragments might be recognizable, especially with a micromorphological study of soil thin sections (cf. Courty et al. 1989).

The grasses eaten by herbivores contain phytoliths, which remain in the dung (see below). Herbivore dung also contains spherulites, which are calcite bodies formed in the gut of some herbivores. They can be recovered from soil samples, and are good evidence for the presence of dung (Brochier 1991), though this type of analysis is not yet widely known or practiced.

Troels-Smith (1984) recognized an ancient field contemporary with and adjacent to the Neolithic lake village at Weier, in Switzerland, that dates to about 3100 B.C. (Robinson and Rasmussen 1989). In addition to charred plant material and sherds, he saw some housefly pupae. Since "houseflies do not place their eggs in cowpats . . . it is evident that the manure has been carried out from the stables along the plank-road unto the terraced field," which supported the interpretation that the animals had been stall-fed (Troels-Smith 1984:23).

Dung would be most likely on sites of cultures that had domesticated, penned animals, though in some situations one can imagine it to have been collected from free-ranging animals, like bison (cf. Miller and Smart 1984). If the material comes from a site where dung was used for fuel, residues of burnt dung might nonetheless wind up in the fields as part of household trash (see below). The ash would still be rich in phosphorus because combustion concentrates the phosphorus in the ash of dried cow manure (Anon. 1908; Sandor, pers. comm. 1993).

The mere identification of dung on an archaeological site is insufficient to document a field, for animal pens and dung piles are rich in the same materials. In a cultivation situation, however, one would not expect the dung to be found in a thick uniform layer. But even if fragments are found broken and mixed in with the sediments, additional argument is necessary to identify a deposit as cultivated.

Plant Macroremains

Macroremains are plant materials that are large enough to see without a microscope, though low magnification (up to about 50x) may be necessary to identify them. Seed and wood remains are the most commonly encountered types. Fertilizer may include plant materials

introduced directly into the soil (leaf litter, green manure) or incorporated in dung or trash from a settlement, in charred or uncharred form. One is unlikely to find evidence of plants that actually grew in the plot of land under excavation because those plants were harvested and removed.[2] Even if a crop plant drops seeds, uncharred seeds will decay; if they did not, there would soon be more seeds in the soil than dirt. For organic materials to be preserved, biological, chemical, and mechanical degradation must be stopped. Over the long term, and barring unusual circumstances of preservation, macroscopic uncharred remains are unlikely to persist, as they are food for soil organisms. On relatively recent sites, woody seeds of fruits like grape, peach, walnut may be an exception. At Morven, for example, a peach pit was found about a foot below the modern lawn in a nineteenth-century deposit (Miller 1989).

Charred remains are not subject to organic decay, but physical effects of moisture and abrasion can break them up. Even though cultivated soil is not the ideal medium for preservation, bits of wood charcoal and charred seeds and plant parts in ancient soils probably originated in efforts to fertilize the soil, a practice mentioned in classical literature (e.g., Pliny *Natural History* 17.50 and Columella 2.14.5).

Macroscopic plant remains can be retrieved by flotation, which concentrates the plant remains by separating them from the sediment matrix. Even so, ancient cultivated soils tend to have very low quantities of preserved macroremains. Flotation and screening for macroremains mechanically separate the plant materials from the dirt, stones, and artifacts. No special laboratory facilities are required, and indeed, it is most efficient if soil samples are floated during the course of excavation near the field site. For detailed instructions and discussion of different flotation systems, see Pearsall (1989).

The analysis of an assemblage of macroremains includes identification and quantification. Identification is usually based on shape. The degree of specificity possible to reach varies from plant to plant and from plant part to plant part. Some items are only identifiable at the very gross level of plant family, while others may be identified even to variety. Unfortunately, many specific and varietal distinctions are based on flower morphology, and flowers are only rarely preserved. One must therefore frequently be satisfied with identification to the genus level.

2. An exception might be where field stubble was routinely burned, allowing some charred seeds to avoid decay or predation. A more likely situation would be the modern practice of stubble-burning, which could introduce recent charred seeds into the archaeological record.

Plant Microremains—Pollen and Phytoliths

Pollen is the male germ cell of seed bearing plants. Produced by plants in varying quantities, it may be dispersed by wind, insects, animals, water, etc. Since some plants, like wind-pollinated pine, produce vast quantities of widely dispersed pollen, and others, like insect-pollinated orchids are very parsimonious in pollen production, palynologists take the biology of pollen production into account in reconstructing past vegetation. Spores, the germ cells of non-seed bearing plants, are recovered along with pollen (see Fish, this volume; Pearsall 1989).

Most pollen analyses are done on lake and bog sediments, and focus on reconstructing local and regional vegetation patterns. Under conditions that are neither very wet nor very dry, soil organisms, mechanical abrasion, and exposure to oxygen in disturbed soils (like gardens!) reduce pollen preservability. High in protein, pollen is eaten by earthworms. Pollen's distinctive exoskeleton can survive, but will be distorted by abrasion. However, under anaerobic, undisturbed conditions, the exoskeleton is virtually indestructible. As is true of macroremains, some pollen types are more distinctive than others. For example, members of the daisy family are generally not distinguishable from one another—all have spiny pollen, and the only distinction is between high spine and low spine pollen. But many members of the pine family, with two air sacs, can be distinguished from other conifers (see Fish, this volume, Dimbleby 1985, Pearsall 1989). Pollen has been used to identify olive orchards at Pompeii (Jashemski 1979) and maize fields in the southwestern United States (Fish, this volume).

Archaeological pollen profiles from settlements or fields are usually unsuitable for direct comparison with lake cores that are based on the overall "pollen rain." Not only are most archaeological sediments unsuited to pollen preservation, but the air currents and other means of pollen transport and deposition associated with lakes and settlements are not comparable to the processes that form archaeological deposits. In archaeological garden and field deposits, one would have to distinguish air-borne pollen and spores from those grains that were deposited in fertilizer, like dung and trash, or that were produced by crop plants, weeds, and vegetation growing on or near the field. For example, an analysis of sediments underlying South Street Long Barrow yielded bracken fern spores. The fact that the soil fauna in the archaeological sediments did not match that found in the modern analogue of fern-covered soils showed that ferns had not been growing on the spot before the barrow was constructed. Rather, the spores

probably came from ferns added to the soil as fertilizer (Dimbleby and Evans 1974).

Like pollen, phytoliths are virtually indestructible, but unlike pollen, they tend to remain in the sediments they were initially deposited in when the source plant died (see Piperno 1988). Phytoliths are formed when plants absorb silica from the water they take in through their roots. The silica is deposited in plant tissue, and a silica body forms which takes on the shape of the particular cell. Silica is differentially deposited in plant cells, frequently in distinctive shapes. Stem tissue, especially of grasses, is particularly rich in phytoliths. Phytoliths should therefore be particularly suited for locating in situ vegetation of phytolith producing plants (e.g., rice [Barnes 1990] and maize [Siemens et al. 1988]) or at least the location of open ground (Pearsall and Trimble 1984). Most of the grass phytoliths at Thomas Jefferson's home at Monticello were most readily explained as European introductions (Rovner 1988). Rovner (1988:162) points out that "if the samples containing grass phytoliths correlate strongly with the fodder plots," documented in Jefferson's archives, in situ plantings of these grasses would be strongly confirmed. On the other hand, phytoliths may be present in soils if plant parts or animal dung containing phytoliths had been deposited as fertilizer.

Pearsall and Trimble (1984) give a thorough discussion of sampling for phytoliths in former fields, and many of their procedures would apply to sampling for pollen as well. Note, for example, the importance of taking control samples (from deposits thought *not* to be agricultural) and surface samples from different cultivation and naturally vegetated sites, to develop analogs to aid in ecological reconstruction. Although Pearsall and Trimble do not deal with fertilizer, they point out that phytolith analysis can help identify an area as a field.

In contrast to flotation analysis, pollen and phytolith extraction require special laboratory facilities (see Pearsall 1989 and Piperno 1988 for details). For pollen analysis, one tries to mechanically remove and chemically dissolve everything that is not pollen—the organic materials, silicates, and carbonates that comprise the sediment matrix. Similarly, phytolith analysis uses mechanical and chemical means to concentrate the items of interest. Since hydrofluoric acid dissolves sand (i.e., silicates) and phytoliths are made of silica, pollen analysis will destroy phytoliths. Therefore separate sediment samples are required for the two analyses.

Where cultivated soils have been fertilized with domestic refuse or dung, care is needed in interpretation: the fertilizer is more likely to

contain phytoliths than the cultivated plants, as the grasses present in dung and refuse produce phytoliths abundantly.

Settlement Debris and Organic Litter: Examples from Archaeological Survey and Excavation

Sherd Scatters in the Near East

T. J. Wilkinson's archaeological surveys of surface sherd scatters around ancient settlements in Iran, Syria, Turkey, and Iraq provide evidence of ancient manuring (Wilkinson 1989, 1990a, 1990b). Settlement debris contains potsherds along with nutrient-rich soil. In the Near East, where people tended to live in houses that were more closely spaced than in many other parts of the world (Mesoamerica, for example), it is reasonable to suppose that the source of the characteristically small and weathered sherds found on the surface come from manuring practices rather than from the occupation debris of scattered settlements. Wilkinson's methodology is relatively straightforward. A set of transects was established along which a series of 10 m x 10 m squares were laid out. Sherds collected from the squares were used to date the settlement debris and measure its density (number of sherds per 100 m^2). Following this procedure, Wilkinson mapped zones of high sherd density along a 10 km stretch of the southern side of the Euphrates river valley near Kurban Höyük in southeastern Turkey. The highest densities were recorded around sites of the Late Roman-Early Byzantine period, a time of maximum population in the area. Scatters of Bronze Age sherds suggested that manuring with settlement debris occurred during the previous population peak as well. A study of phosphate concentrations around the sites provided only partial support for this interpretation of the sherd scatters.

In a subsequent study, carried out in northern Iraq, Wilkinson was able to extend the evidence for manuring in the fields around settlements to the third millennium B.C. (Early Bronze Age). He points out that a key assumption behind this work is that people fertilized fields with their own debris rather than that of abandoned settlements, so datable pottery would correspond both to the period of settlement and to the period of manuring (Wilkinson 1989:41). In the Iraq study, the scatters correlated with the age of the settlements, so, at least in this case, the assumption holds.

Further evidence for the practice of using settlement-derived debris as long ago as the second millennium B.C. in the Near East comes

from minimal textual as well as excavated evidence from fields. For example, A. Leo Oppenheim (1974) considers one of the subsidiary meanings of the word for dirt in Akkadian (*eperu*) to refer to the settlement debris dug up and carried out to the fields (by boat, according to the Chicago Assyrian Dictionary). Somewhat further afield, G.N. Lisitcyna (1976) reports sherds used to date ancient buried fields in Turkmenistan—most date to the medieval period, but Late Bronze Age and Early Iron Age sherds have also been found.

Fertilizer in the Ancient Mediterranean World

Passed down to us from antiquity, the Romans' extensive writings on farming practices, from farming manuals to short references in literary texts, suggest how we might view some of the items found in Roman gardens and fields. Ancient writers on agriculture and cultivation provide a wealth of technical information for the archaeologist: propagation techniques, nursery practices, manuring and fertilizing methods, harvesting times and equipment (see White 1970 for many references). Of course, caution must be exercised in drawing from these works, as their primary function was literary rather than utilitarian. As Seneca observed, Virgil, whose writings contain a variety of unlikely plant associations, "wished not to teach farmers but to delight readers." Nonetheless, these sources offer specific detail against which to compare archaeological remains.

Gardens and fields in the Roman world were commonly fertilized with domestic debris and manure (White 1970:125–145). Fertilizer was a valued commodity; manure piles and garbage were assets, even subject to litigation (Buck 1983:29–30). Columella (10.80–85) urges gardeners not to "hesitate to bring as food for newly ploughed fallow-ground whatever stuff the privy vomits from its filthy sewers," while other authors point to refuse pits, barn cleanings, and the remains of banquets as excellent sources of fertilizers.[3]

The sources, supported by recent archaeological evidence, describe the preparation of fertilizer. Cleanings from barns, charred kitchen refuse, broken pottery and other discarded objects, and human and animal manure were all thrown into a compost pit. The prepared compost was then used on fields and in gardens. This widespread practice produces a characteristic layer in the garden or field, one filled with carbonized remains, bone fragments, small potsherds, and even bits of metal. The material found by archaeologists is normally in poor condition, highly abraded from constant reworking as the garden or field was tilled. Furthermore, the random direction of the remains, which have never "settled" onto a surface, is a visible characteristic in baulk sections, and can be "felt" while troweling horizontal surfaces (Cunliffe, pers. comm. 1985). In the remains of the palace gardens of Herod the Great at Jericho (late first century B.C.), archaeologists have identified components that suggest refuse from a food preparation area: potsherds, charcoal from native trees and shrub species used as fuel, carbonized seeds and fruit pits from meal preparation, and butchered animal bones (Gleason 1987/88). The work of Ford et al. (this volume) on the Roman fields of the Berkshire Downs demonstrates the importance of sherd-filled fertilizer in the detection of agricultural sites through field surveys, and in the dating of those fields through a study of the pottery's stratigraphic location in test trenches. They note, too, the presence of worked flint rather than potsherds, as evidence for prehistoric manuring practices.

In short, the presence of manuring and refuse in the soil can be said to be characteristic of Roman period cultivated land and should be looked for during excavation and field surveys. Its composition must be recognized and communicated to the environmental specialists for the interpretation of environmental remains so that phytoliths, macrofossils, and other remains are distinguished from any evidence for garden plants.

3. Cato (5.5.8) recommends a large dung hill, from which foreign matter is cleaned before hauling it out in the autumn. Archaeological evidence suggests that such care was rarely taken. See also Cato 7.1.3, 36.1.1, 37.1.3. Varro is quite specific on the construction of such pits (*De Re Rustica* 1.13.4), and on the types and placement of manure (1.38.1–3). Virgil (*Georgics* 2.346) recommends covering young plantings with manure and a deep level of top soil, or a thick layer of porous stone or rough shells. Pliny the Elder devotes considerable discussion to the use of dung in *Natural History* 17.50–57.

Black Earth

For years, British archaeologists considered a type of compacted black soil found in urban sites to be flood deposits or cultivated soils. Micromorphological analysis has revealed that this "black" or "dark earth" is an accretion of rubbish, perhaps the enriched, disturbed soil of market gardens (Macphail 1981).

Plaggen Soils

Land reclamation, sometimes on a grand scale, has been carried out in many areas. In this volume Clark Erickson discusses how Andean peoples created fertile raised fields on the margins of Lake Titicaca.

In northern Europe, "plaggen" soils resulted when farmers built raised fields on sandy soils by applying "a mixture of animal manure and cut heather sods or other such absorbent, usually humic, material over the fields" (Heidinga 1988:21). Not only was fertility enhanced, but the structure created by the sods helped the soil retain moisture (ibid.). The agricultural system integrated plant and animal husbandry, because the soils needed continual replenishment. The anthropogenic origin of these soils is shown by inclusions of charcoal, coal, sherds, brick, and burned soil (van de Westeringh 1988:14).

Concluding Remarks

Working with the complexities of fertilizer on cultivated land can test the talents of the most interdisciplinary of researchers. Ideally, an archaeologist would have the skills of a soil scientist, chemist, archaeobotanist, paleobotanist, entomologist, and zooarchaeologist, along with superb traditional abilities in field survey, stratigraphic excavation, and artifact analysis. In practice, the excavation director can facilitate interpretation by involving specialists in the early phases of the project. Simply recognizing that potsherds, charcoal, and other items came from manure can lead to the important questions about ancient cultivation practices, land use, and labor at the site. These questions can then guide the appropriate sampling strategy for the different types of materials. In addition, soil samples of modern analogues as well as baseline samples of non-field soils can make the difference between meaningful results and guesswork. Such sampling is best undertaken during the excavation phase of the project.

Under long term cultivation, soil nutrients must be replenished, and ancient farmers developed a variety of ways to do this. Unfortunately for the archaeologist, the addition of all sorts of different materials makes an already difficult problem (Is this an ancient field? What was planted on it?) even more complex. And yet, these traces of ancient agriculture may give us the only evidence for the date a field was cultivated, or indeed, that the ground was cultivated at all. Ancient fertilizing practices may provide the clues that permit us to interpret land as the landscape of a past culture.

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