SAMPLING FOR MACROREMAINS

It is often impractical to recover all size classes of botanical macroremains from every cubic meter of soil removed from a site. Even if all soil is bulk sieved through a water separator system, choice of mesh to allow efficient processing (generally 1.0 mm or $\frac{1}{16}$") may lead to loss of small remains. If poppy seed testing is used to determine extent of loss, and an acceptable recovery level is achieved, bulk sieving is still time consuming and may produce more material than can ever be analyzed.

Collecting samples of excavated soil for flotation or fine sieving is a practical alternative to bulk sieving for all size grades of macroremains. Sampling produces fewer samples for analysis and speeds processing, since small soil volumes (rather than entire contexts) may be used. In the remainder of this section, I discuss sampling strategies for flotation and fine sieving, outline basics of taking samples, and cover special recommendations for successful sampling. Good sampling strategies and processing techniques are the bases of a successful paleoethnobotanical analysis; even the best specialist cannot make up for erratic sampling or sloppy flotation. As M. Jones stresses, paleoethnobotanists must take "a conscious and active part in deciding which . . . plant remains will end up under microscopes rather than on . . . spoil-tips" (1991:53).

Strategies for Sampling

I recommend a "blanket sampling" strategy for flotation: collect soil for flotation from all excavation contexts. There are practical reasons for choosing this strategy, but it also has advantages for later analysis of materials.

During the course of excavation, it is often impossible to predict which contexts (i.e., site areas, feature classes, soil types, cultural components) contain macroremains. This is especially true if only charred remains are preserved, since these are difficult to see during excavation. Because charring occurs through deliberate or accidental burning, collecting flotation samples only from contexts with evidence of burning may seem a viable strategy. In practice, however, sampling only in hearths or obvious ashy deposits does not always lead to recovery of a representative sample of macroremains. Hearth samples often contain little more than charred wood, since repeated use of a hearth may result in ashing of fragile remains such as seeds or tubers. Such material may be more abundant on the floor around the hearth or in a pit filled with garbage. Hearths may be periodically cleaned of wood, ash, and spilled foods, further limiting their usefulness. Once charred material is spread around (i.e., moved from primary to secondary depositional contexts), it is difficult to see and therefore difficult to sample. Routinely sampling all contexts avoids the problem of predicting where remains will occur.

Another practical advantage of blanket sampling is that it is an easy strategy to carry out in the field. Excavation crews are simply instructed to take float samples from every level in each unit and from all features. Taking float samples becomes

part of the routine of excavation; variation in sample taking among individuals is minimized.

From the perspective of later analysis of materials, blanket sampling gives the analyst maximum flexibility. If, for example, a site turns out to have several discrete temporal components, a subsample of flotation can be chosen for analysis to maximize temporal contrasts. One might compare assemblages from all hearth features or floor samples through time (e.g., Pearsall 1988a). For single-component sites, samples might be chosen to give greatest information on differential use of space. In such a case, one might group samples by activity area and observe patterning in the data. It is much easier to choose a subsample for analysis from a large population of flotation samples (perhaps analyzing 25% or fewer of total samples) than to predict what sorts of samples will be needed while excavation is proceeding.

Blanket sampling, specifically sampling around and above and below features, also provides the analyst with the means of evaluating the contents of features, since "[w]ithout these contrasts of adjacent loci, the functional or symbolic interpretations based on archaeobotanical materials from specific proveniences are weakened and perhaps suspect," (Lennstrom and Hastorf 1995:716). In other words, how can one argue that the contents of a pit reflect activities involving food specific to that context, if one has not examined samples from floor deposits into which the pit was dug, or the deposits overlying it? As Lennstrom and Hastorf (1995) illustrated through systematic sampling of deposits at the Pancán site, Peru, contrasting feature fill with "companion" deposits is an easy way of determining whether feature deposits are independent (i.e., primary). Note in Figure 2.31, for example, how the botanical assemblage from a hearth in Structure 7 closely resembled the deposits above and below it (compare the pie chart for the hearth, center, to those from the deposits above and below it), while a hearth from Structure 16 was apparently independent of the surrounding deposits. Significantly, Lennstrom and Hastorf (1995) found that few pits contained botanical remains independent of the surrounding deposits.

In implementing blanket sampling, it is important that defined contexts be sampled discretely; hearths must be sampled separately from surrounding house floor, pits from midden, floor from wall trenches, and so on. Although I describe this strategy as sampling of all excavated contexts, there are contexts where sampling is of little value. Areas of clear disturbance, such as rodent burrows, plow zones, or redeposition from looters pits (or backfill of old excavations), need not be sampled. In a multistage project, preliminary analysis from one season may reveal that certain contexts lack useful paleoethnobotanical data. Wall trench samples or post molds, for instance, might prove unproductive. It is valid to reduce sampling in such contexts to a minimum for spot-checking.

Blanket sampling is not the only macroremain sampling strategy in use today. M. Jones (1991) discusses five approaches to selecting contexts for sampling macroremains: total sampling (i.e., blanket sampling), interval sampling, probabilistic sampling, purposive or judgmental sampling, and no sampling at all (an approach still all

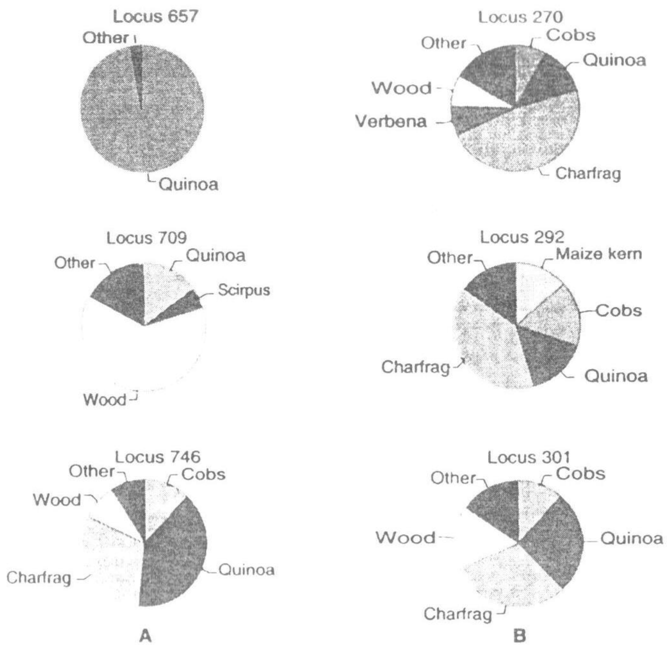

FIGURE 2.31 A comparison of botanical materials recovered from hearths to materials recovered from deposits above and below the features: (a) hearth from Structure 16 with companion deposits; (b) hearth from Structure 7 with companion deposits. Hearths are the middle circles in each group (from Lennstrom and Hastorf 1995:706).

too common around the world). Arguing that total sampling is more commonly advocated than achieved and judgmental sampling too dependent on previous knowledge of the population being sampled, M. Jones (1991) advocates a probabilistic approach to sampling for plant remains. In his view, as long as the sample fraction is large enough to reflect population hetereogeneity adequately, probabilistic sampling best generates data sets that can be statistically manipulated and compared among sites. van der Veen (1992), in a study of crop husbandry regimes in northern England between 1000 BC and AD 500, for example, was able to compare using multivariate statistics assemblages of charred plant remains among sites at which samples were collected either from all excavated features (well-defined, sealed contexts) or from a random selection of excavated contexts. The latter strategy was employed at sites where excavations were of too large a scale to process samples from all contexts.

The approach to sampling presented in the handbook on archaeobotany prepared for the European Science Foundation (ESF 1989) emphasizes cost-effectiveness and obtaining a representative selection of plant remains. For sampling for charred remains, for example, researchers are advised to consider the number of samples that can be processed by the archaeobotanist and the relative importance of the data (i.e., rare Neolithic remains or seeds from a Roman site?). The strategy I call blanket sampling is considered unrealistic: "in most cases this would represent far too much work for the manpower. It would not be very cost-effective either, in terms of results obtained for the time spent" (ESF 1989:21). Situations in which random sampling and judgmental sampling would be appropriate are discussed—an example of the latter would be to select features that are going to be dateable and productive—with an emphasis on involving the archaeobotanist in fitting the sampling strategy to the situation. While I do not advocate judgmental sampling as a general approach, for the reasons discussed earlier, I agree that there are situations where this is an appropriate strategy. Encountering a waterlogged feature, such as a latrine, or excavating down to a waterlogged stratum in a site otherwise characterized by charred preservation, is one such situation: the opportunity to learn about past people–plant interrelationships that extraordinary preservation presents justifies increased sampling in such an area. Waterlogged and desiccated sites present unusual challenges for sampling and processing; these are considered further in the next section.

Sampling Techniques

There are three commonly used techniques for taking flotation or fine-sieve samples: "pinch" or composite sampling, column sampling, and point sampling.

Composite, or pinch, sampling is appropriate for many common sampling situations. A composite sample (referred to as a scatter sample by Lennstrom and Hastorf 1992) is made up of small amounts of soil gathered from all over a context combined in one sample bag. In the excavation illustrated in Figure 2.32, for example, a house floor has been exposed in eight excavation units (a–h). A number of features have been defined (1–5). Each section of floor (unit) and each feature can be considered a separate context for sampling. To collect composite flotation samples for one level of such a house floor, label flotation bags with provenience information for each context. Fill each bag with small scoops of soil from all around the appropriate areas. Soil may be taken toward the bottom of a level, in the upper part of the level, or little by little throughout. The important point is that soil be collected widely over each context so that the sample represents the area as a whole. Cultural levels in middens, sublevels in large features, and arbitrary fill levels are other appropriate contexts for composite sampling. Composite samples should always be taken from the area around features, so that feature fill may be compared to general unit fill. A standard soil volume should be collected whenever possible.

Flotation samples for a sequence of fill layers, midden material, or floors in an excavation can also be taken from one area selected at random for sampling

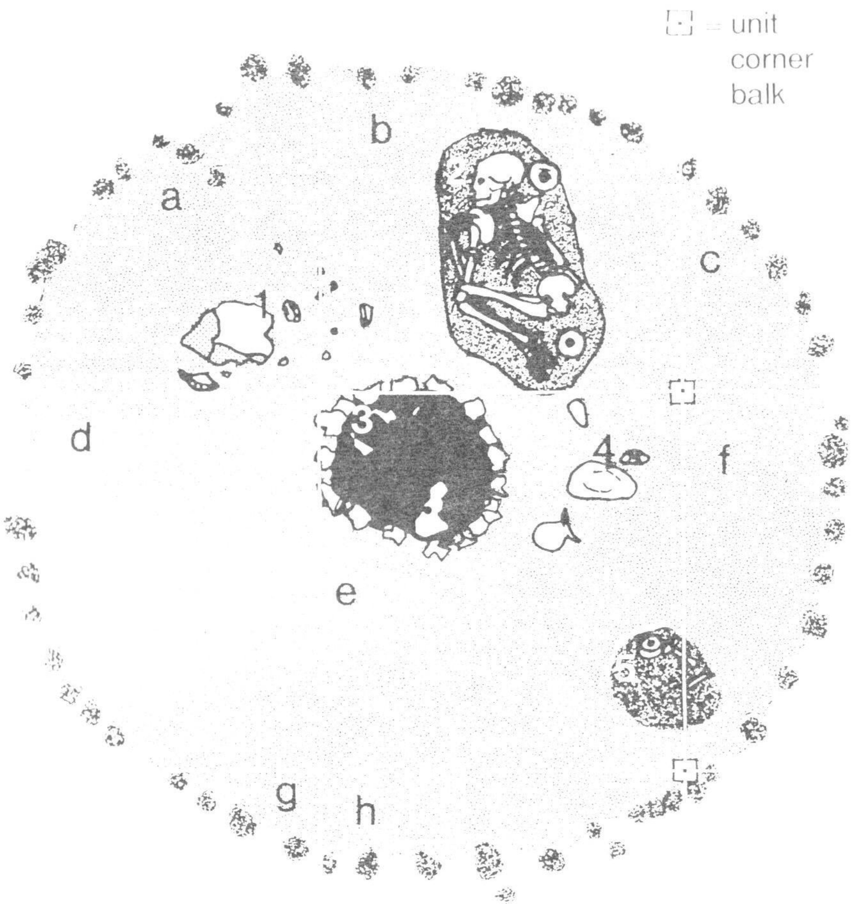

FIGURE 2.32 During excavation of this hypothetical Neolithic house floor, flotation samples will be taken from each discrete archaeological context. First composite samples will be taken from each excavation square (a–h), then each feature will be sampled: (1) stone tool manufacturing area; (2) burial pit; (3) hearth; (4) milling area; (5) trash pit.

purposes. This is column sampling. In Figure 2.33, a sampling column has been left in one unit until excavation is completed. Each natural level of floor (1–5) is to be sampled separately. More than one balk can be left for sampling purposes. The advantages of column sampling are that samples can be left in place until the unit is finished, each level is clearly visible in profile for precise sampling, and all bagging, labeling, and note taking can be done at once. The major disadvantage is that samples represent only remains present in part of the excavation. This is a valid subsample, but of a different sort than a composite sample. When using the column sampling approach, be sure to take separate feature samples and to collect soil from any horizontal strata that do not occur in the column.

There are a number of situations in which sampling small, precisely located areas provides very useful information. I refer to this as point sampling; Lennstrom and Hastorf (1992) use the term bulk sample. Figure 2.34 illustrates sampling one unit of floor in a 50 × 50-cm grid to obtain detailed information on activity areas. Sampling small features or the soil inside or under ceramic vessels are other examples of point sampling. Soil volume should always be taken.

Lennstrom and Hastorf (1992) compared bulk (point) and scatter (pinch or composite) sampling schemes during research at the Pancán site in Peru. Both sampling strategies were used simultaneously in excavation; that is, pairs of samples were taken from each excavated locus for which enough soil was available for two 6-l samples. In all, 327 loci, from all excavated phases and cultural contexts at this Andean village site, yielded paired samples. In general, the two sampling approaches produced fairly similar results—usually the same kinds of plant remains, in about the same frequencies (e.g., note the similarities between Fig. 2.35a and b)—but also exhibited a number of interesting differences.

Scatter samples, for example, tended to recover higher densities of charred material than did bulk (point) samples (as measured in fragment count/liter of soil; see Chapter 3 for discussion of quantitative approaches). Overall, scatter samples showed a smaller range of variability in density, lending support to the assumption that sampling in pinches produces a sample that is the average for the locus. Bulk samples varied more widely in density. Scatter samples also tended to produce a higher diversity of charred remains than did bulk samples, again reflecting that the former sampling strategy captures more actions and places within a locus. However, as suggested by Asch and Asch (1975), Lennstrom and Hastorf (1992) found that calculating the mean occurrence of charred remains in a locus from several bulk samples produced a "better" average than a single scatter sample, in the sense that high numbers of different taxa were recovered. Finally, bulk sampling did produce a more detailed picture of spatial patterning of botanical remains than did scatter sampling, as can be seen by comparing Figure 2.35a and b.

Lennstrom and Hastorf's (1992) study demonstrated that some assumptions about the results of bulk and scatter sampling strategies discussed above are correct. However, since all types of contexts at Pancán showed similar results from both bulk and scatter samples, these authors conclude that context does not dictate which strategy to use. An important exception is sampling for detailed spatial comparisons.

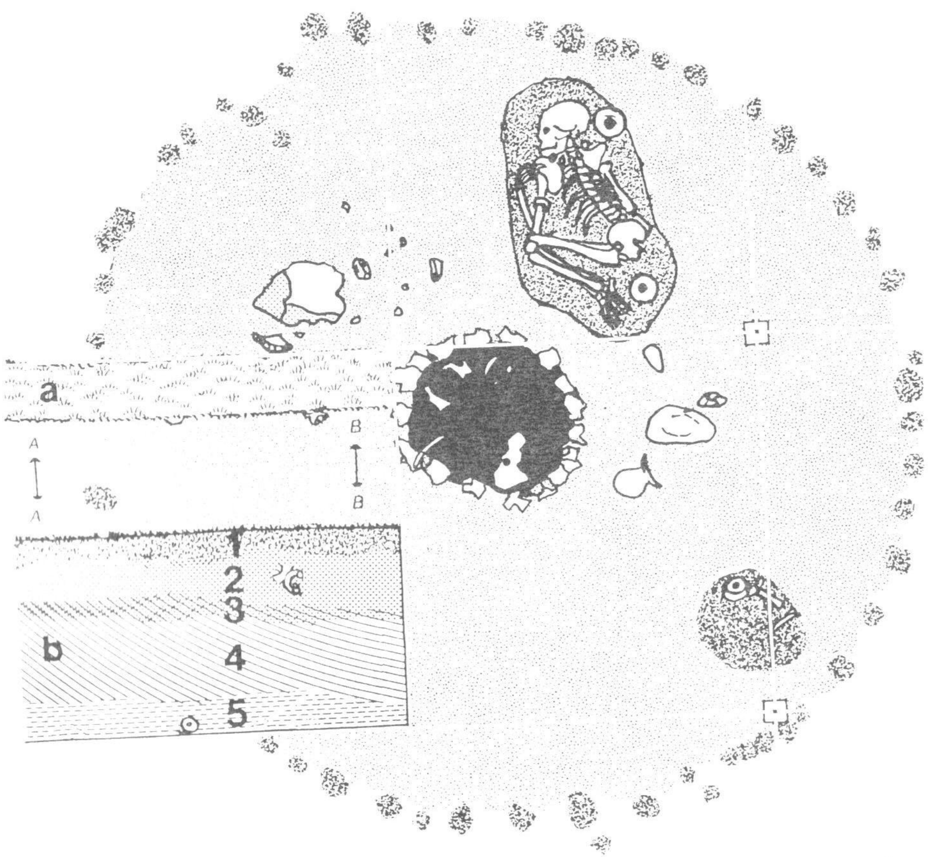

FIGURE 2.33 During the hypothetical house excavation, flotation samples could be taken from a soil column rather than by composite sampling near the bottom of each level. A narrow soil balk (a) is left in one excavation square; (b) shows the balk in profile. Column samples are taken from each stratigraphic level (1–5). Note that a number of important features are not represented in this soil column. These would be sampled separately, as shown in Figure 2.32.

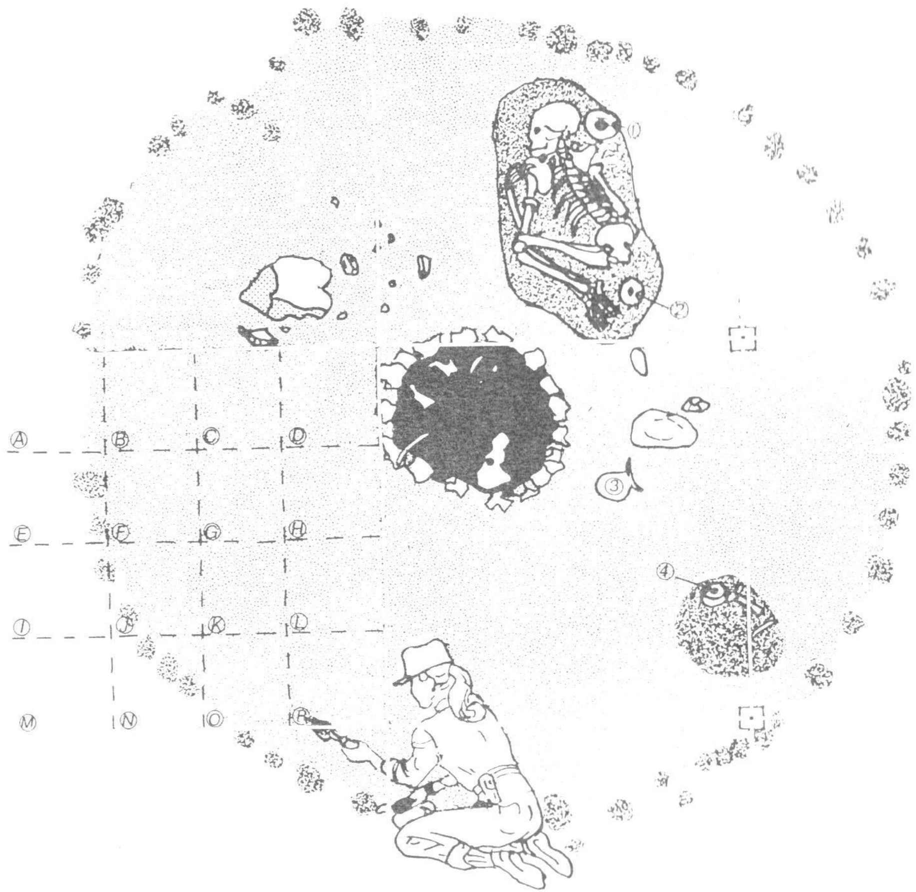

FIGURE 2.34 Point samples in a 50-cm grid: the archaeologist places a grid in each square to facilitate taking samples (A–P). The interiors of four ceramic vessels (1–4) will also be sampled.

in this situation, bulk (pinch) sampling is recommended (i.e., as illustrated in Fig. 2.34). Because density, diversity, and ubiquity were lower for bulk than for scatter samples at Pancán, bias may be introduced when contexts sampled in different ways are compared. Employing one strategy throughout, with duplicate samples taken when necessary, solves this problem (Lennstrom and Hastorf 1992).

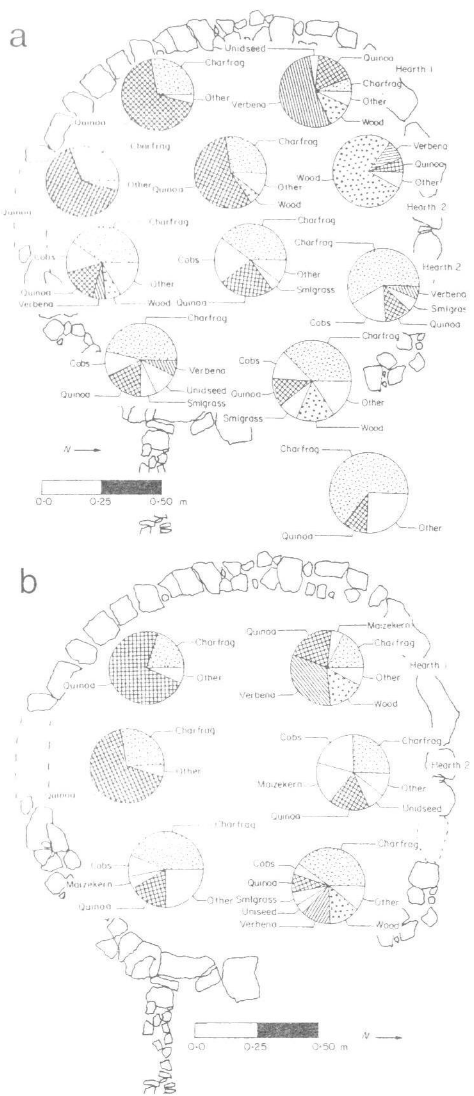

FIGURE 2.35 A comparison of botanical materials recovered by bulk and scatter sampling from structure ASD7: (a) relative percentages from bulk samples; (b) relative percentages from scatter samples (from Lennstrom and Hastorf 1992:224).

The issues underlying this discussion of sampling techniques are both practical and of importance for interpretation. When excavating a 1 × 1-m test pit, for example, one usually collects a single flotation sample per level to provide basic information on plant occurrence. In that case, it is immaterial whether the sample is a shovelful from one spot (bulk or point sample), a series of trowelfuls from around the unit (pinch or scatter sample), or a piece of standing balk—each strategy will capture the commonly occurring plant remains. I prefer pinch samples because a single sample must represent the unit as a whole. However, taking smaller samples from each corner (i.e., four 2.5-l samples instead of one 10-l sample) and averaging the results would be statistically stronger (i.e., larger n and smaller standard error [Banning 2000]; see discussion in Chapter 3), assuming that the smaller samples contained adequate material for quantitative analysis. Unfortunately, this approach would also be more time consuming—and thus expensive—since there is a minimum handling time for a sample, regardless of its size. Further, density of charred material in the soil largely dictates minimum sample size, making it impossible, in practical terms, to reduce sample sizes substantially.

The important point to consider is whether the higher effort and cost of taking more samples per unit area—in essence, this is what point or bulk sampling means—overrides the ease of scatter sampling. In my view, the key is the importance of spatial data. In other words, once excavation moves to opening up horizontally complex areas, and context-specific botanical data become important, then samples should be taken at closer intervals and from more closely circumscribed areas. While I understand Lennstrom and Hastorf's concern about comparability of samples, it is also important that sampling be responsive to changes in excavation strategy or circumstances; if one starts with scatter sampling in the testing phase, one may well want to move to point sampling later, and simply keep in mind when looking at diversity that some differences may relate to sampling strategy. Finally, I would not recommend scatter sampling over more than a 1 × 1-m area; if units are larger, then they should be subdivided.

Hints for Good Sampling

Sampling for flotation or fine sieving can be improved in several ways:

1. Collect a standard-size sample of soil for processing from each sampled context. As is discussed further in Chapter 3, it is important not only that the analyst know how much soil was floated to produce an assemblage of macroremains but also that sample sizes do not fluctuate dramatically among contexts. Sample size fluctuation can affect comparability of rarer remains. Obviously, it may not be possible to take a standard sample from all contexts, especially for point sampling. This is why I recommend measuring sample volume or weight again before flotation. The only way to choose an appropriate sample size is by experimentation and prior experience. Start by floating several 10-l samples collected from different contexts and evaluate the quantity of material recovered. Although there are formulas for calculating

optimal sample sizes for assemblages of macroremains (see Chapter 5), a useful rule of thumb is a minimum of twenty pieces of wood. If enough soil is floated to concentrate wood to that extent, chances are that sufficient numbers of seeds are also present. If test samples consistently contain few seeds, however, sample size should be increased even if wood is abundant. Recovery efficiency of the flotation system should also be tested.

2. Treat soil collected for flotation gently. If you must collect samples for flotation from soil passed through bulk screens, take care that the soil is not mashed through the screen. Small seeds and charcoal fragments in friable soil generally pass easily through $\frac{1}{4}''$ screen (hence the reason for flotation in the first place). Note that larger botanical remains and faunal materials will be separated from the rest of the sample if soil is screened; this can bias results later in the analysis. Do not pack soil tightly into flotation bags, and be careful not to put heavy artifact bags on top of soil bags or stack too many soil bags on top of each other. Plastic tubs with snap-top lids and handles make sturdy, easily transported containers for flotation soil (Alan Hall, personal communication, 1997).

3. Double-tag soil bags. Paper tags placed inside soil sample bags disintegrate rapidly in moist soil. Provenience information written with an ink marking pen on the outside of plastic bags fades quickly in sunlight. String tags used to close bags come untied or are pulled off when bags are moved. Double-tagging all bags (one label inside the bag, one outside) maximizes chances that provenience information will stay with the sample until it is processed. For inside labels, use aluminum or plastic tags. Alternatively, double-bag samples, placing the internal tag between inner and outer bags, or write directly on the inner bag with indelible ink. Place the external tag so that it can be easily read. Avoid paper tags, which tear easily as bags are moved around. I recommend that all provenience data and sample numbers be written in full on both tags; be sure to include the date and excavator's initials; this may help identify a sample when all else fails. This takes a little longer, but it gives the flotation crew an original tag to put with each flotation fraction (light and heavy), two opportunities to decipher poor handwriting or smeared ink, and the chance to catch mislabeling or ambiguities before they are perpetuated.

4. Evaluate the condition of the soil. If flotation samples are wet, plastic bags should be left open for soil to dry while awaiting flotation. It may be necessary to spread out large wet samples, or to process those by water sieving. If cloth bags are used, those with moist soil should be placed in open air to dry. If samples are waterlogged and wet sieving is planned, be sure sample bags are tightly closed and check periodically to be sure soil is not drying out. It is also a good idea to close tightly samples containing desiccated remains, since dry soil may begin to pick up moisture from the air, which can lead to mold growth on materials.

5. Process soil samples with the goal of keeping pace with fieldwork. Although flotation invariably runs behind excavation, beginning soil processing early in the field season, rather than leaving it all for the end, allows feedback on recovery to guide sampling, both in size and in location of samples.

OF MACROREMAINS

In this section, I discuss a number of issues that may arise when one chooses and implements macroremain recovery strategies at an archaeological site. These include how to choose a recovery system that fits both the needs of the project and the nature of deposits, how to deal with problem soils, when to use chemical flotation, how to determine efficiency of flotation recovery, and how to use salt water for flotation.

Choosing a Recovery System

As was discussed earlier in this chapter, botanical macroremains can be recovered from archaeological sites in three ways: (1) by collection of material *in situ* during excavation, (2) through screening, and (3) by use of water recovery techniques (flotation). For recovering all size grades of macroremains from soil, flotation and fine sieving (dry or wet) are the only reliable alternatives. I begin by discussing how to choose among the options for flotation and then discuss fine sieving techniques.

Flotation Systems

The techniques of manual flotation, water separator and SMAP systems, and froth flotation each have drawbacks and advantages. Each flotation system was developed to fit the needs of a particular field situation, and attempts to adapt it to different situations meet with varying success. For example, when basic "tub" manual flotation was tried in Iran, lack of running water led to its abandonment and a return to small-scale flotation in the lab (Hole *et al.* 1969). A flotation system may end up costing a project unnecessary time, money, and headaches because it is not well suited to budget, field conditions, or soils. In deciding what system to use, it is wise to consider the initial cost of equipping the system, the cost of running it, the speed and soil capacity of the system, and its capacity to recover remains adequately from the soils of the site. Considering these factors should at the least minimize unpleasant surprises at the flotation station and at best give good, speedy recovery of remains that keeps pace with excavation.

The cost of equipping a system is the easiest factor to deal with in advance of excavation. Table 2.2 lists the estimated costs of building relatively inexpensive systems, an IDOT-style manual flotation system and a plastic SMAP machine in 1998. The total cost for a froth flotation device is approximately $2200; a purchased Flote-tech system around $5000. A steel SMAP machine has an estimated cost of $900–1200 (Hunter and Gassner 1998). Closely related to costs of equipping the system is local availability of components—an important consideration for projects operating in remote areas. An additional cost to consider is that of transporting the system to the excavation site.