Beta-Count and AMS Radiocarbon Dates of Woodland and Fort Ancient Period Occupations in Ohio 1350 B.C. - A. D. 1650

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Abstract

Thirty-five new Beta-count and Accelerator Mass Spectrometry (AMS) radiocarbon dates from 17 Woodland and Fort Ancient period archeological sites in the Scioto and upper Muskingham-Licking drainages in southern Ohio are reported and evaluated in the context of all other 52 extant dates from these sites. The assayed samples were selected, in part, to fill in chronological gaps in this region over this time range. Results are used to refine the chronometric definition of archeological periods, clarify occupational histories of certain sites, and shed light on some prehistoric mobility patterns. All of the dates come from contained archeological deposits bearing ceramics, which will allow the fine, chronometric study of ceramic technological change. Twenty-one of the dates are derived from nut shells or food residues on pottery, which helped to secure dating precision and/or the contextual relevance of deposition of the samples. New methods for rigorously cleaning specimens, for removing carbonized food residues from pottery, and for preparing the residues for AMS dating after pretreatment, were developed and allowed focus on the desirable sample materials.

Introduction

This article reports, evaluates, and interprets 35 new Beta-count and Accelerator Mass Spectrometry (AMS) radiocarbon dates from 17 Woodland and Fort Ancient period archeological sites in southern Ohio. Most of the dated proveniences fall within the Scioto and Muskingham-Licking drainages. The calibrated dates range from ca. 1350 B.C. to A.D. 1650. The assays were targetted at very specific proveniences and sites, and are useful in a number of ways. First, they buttress and add to a growing corpus of radiocarbon dates on Ohio Woodland and Fort Ancient sites (e.g., Maslowski et al 1995; Shott 1992). In selecting the proveniences to be dated, specific attention was given to filling in regional chronological gaps -- particularly the lack of well-dated Early and Middle Woodland age and Cole affiliated habitation or mound sites in the Scioto drainage, and Early and Middle Woodland habitations in the upper Muskingham-Licking drainage. Effort was directed at sites that are well-known for their rich archeological records, but that had not yet been dated or were dated with only one or a few assays.

Second, the assays allow a refinement of the beginning and ending dates of the Early and Middle Woodland Periods in the Scioto drainage and the upper Muskingham-Licking drainages.

Third, the new dates help to clarify the occupational histories of certain specific archeological sites. The dates are particularly helpful in establishing the histories of two Middle Woodland habitations, McGraw and Murphy, which have been debated for some time, and the Late Woodland villages of Scioto Trails and Waterplant.

Fourth, each date was derived from a carbon sample that was closely associated with a relatively rich deposit of sherds, or larger sections, of utilitarian ceramic vessels used for cooking and/or storage. These associations, along with select others cited here, offer the possibility of modeling systematic changes in utilitarian ceramic technological traits through time in southern Ohio, and using such a model to predictively date other collections of sherds lacking datable materials (Braun 1985; Carr 1985). When coupled with ceramic compositional and/or microstylistic data, the associations also improve opportunities for estimating rates of local exchange of utilitarian

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vessels, and changes in exchange rates through time (Carr 1988; Carr and Komorowski 1995).

The project reported here hinged on the use of the AMS dating technique and, consequently, the development of some new laboratory methods. These include procedures for rigorous cleaning of specimens, for removing carbonized food residues from pottery, and for preparing the residues for AMS dating after pretreatment. Using the AMS technique and these innovations allowed the selection of particular dating materials (nut shells, food residues) that are desirable for enhancing dating precision and/or the contextual relevance of deposition of the sample.

Goals and Sampling Strategy

The impetus for this work was Braun's (1983, 1985) chronometric study in west-central Illinois. For that region, Braun selected well-dated archeological proveniences bearing sherds from cooking-storage pottery vessels, and statistically modeled changes in vessel wall thickness through time, from the Middle through Early Late Woodland. The regression that he derived between time and vessel wall thickness allows one to determine the absolute, calendar-year dates of ceramic-bearing proveniences that lack datable carbon.

The dating project described here for southern Ohio was begun with an analogous chronometric goal (Carr 1985, 1986), but considers a much longer period of time. Many substantial and important Ohio Woodland assemblages, and particularly ones of Early and Middle Woodland age, were excavated prior to the advent of radiocarbon dating and paleoethnobotanical studies. Carbonized wood, nuts, seeds, and other materials that would be useful for dating these assemblages were not often recovered in the field or saved in museums. By dating key sherd-rich archaeological deposits where carbon was fortitously or intentionally saved, and by modeling ceramic technological change through time, it was hoped that some proveniences within important sites, previously undatable on an absolute scale, might become datable by their quantitative ceramic characteristics.

This goal, as well as the availability of carbon materials, determined the selection of archeological proveniences that were dated and are reported here. Each provenience has four fundametal characteristics.

(1) Each included relatively rich deposits of sherds, or large sections, of ceramic cooking vessels. Cooking vessels, rather than ceramics of other functions, were sought because they are a complex solution to contradictory performance demands (Braun 1982, 1983; Steponaitis 1982), and were thought more likely to vary technologically over time.

(2) Most of the selected proveniences included carbon that was unusually closely associated with ceramics, in order to encourage the accurate dating of the ceramics. Also preferred were proveniences where the carbon was of a form likely to provide precise dates. Specifically, (a) proveniences having vessels with carbonized food residues on their interiors, or food residue drippings (not soot) on their upper exteriors, were selected when available. Such carbon deposits were almost certainly associated with the vessels, facilitating their accurate dating. Also, the carbon probably was derived from plant and animal foods dating to a few consecutive years, and probably accumulated on the vessels over the course of a few months or years, affording dating precision. Six of the dates reported here were derived from carbonized food residues on vessels. (b) Some proveniences were chosen because they demonstrated close associations with carbonized nuts or carbonized seeds of annual plants, rather than wood charcoal. The annual nature of these carbon samples encouraged dating precision. It also minimized the chance of dating inaccuracy by not introducing the potential problems of dating irrelevant, old heartwood or recycled wood. Thirteen of the dates discussed here were derived from carbonized nut shells and meats. (c) Wood charcoal samples were dated as a last resort, in order to fill in gaps in the temporal distribution of dates. Although an available wood sample from a provenience was sometimes larger in weight than an available nut sample, sample relevance was usually given priority over sample size and dating precision, and the nut sample was usually selected. When available, wood charcoal samples derived from smaller-diameter twigs were preferred over larger-diameter specimens, to avoid old wood. Sixteen of the reported dates were derived from wood charcoal.

Focusing on carbon deposits on pottery vessel walls, and on nuts and seeds, allowed the dating of key proveniences and sites where carbon had been saved only fortitously, and which previously had been thought undatable on an absolute scale. For example, in several cases, carbonized nut fragments or seeds were found within the ceramic, lithic, or bone collections from sites thought to lack any carbonized materials.

(3) Most of the selected proveniences occurred within habitation sites rather than mortuary sites, and smaller sites rather than larger ones, where possible. Habitation sites offered samples of utilitarian cooking ceramics that were likely to have had fairly short use-lives, in contrast to ceremonial vessels that might have been curated. Stronger associations between ceramic technology and ceramic date were thereby encouraged. Also, smaller habitation sites were sometimes occupied shorter periods of time and possibly experienced less churning of archeological deposits through their uselives than larger sites, reducing the chance of irrelevant associations between carbon samples and ceramics.

(4) Proveniences were selected so as to create as continuous a time sequence of ceramic-date associations as possible. This situation is essential to developing reliable ceramic-date regression models.

Notice that the above sampling strategy focuses on dating specific, localized deposits within archeological sites, rather than whole components or sites. This approach accords with the goal of defining a temporal continuum of ceramic technological change rather than discrete phase definitions.

The Samples

Figure 1 shows the sites in southern Ohio from which radiocarbon materials were dated. Table 1 lists the intrasite contexts of deposition of these materials, usually in as much detail as is known. Also reported are the project "association numbers" assigned to the depositional contexts. Each number refers to both the ceramic collection and carbon samples found in association in that context, and has been used to label the studied ceramics and unexpended radiocarbon samples in museum storage, so that these can be revisited. Table 2 gives the bibliographic references to published site reports, or the institutional location of primary site records, for the sites under consideration. Table 3 describes the kinds of materials that were dated, and the species of plants, where applicable. Four kinds of sample materials were used to establish the radiocarbon chronology: (1) shells and meat of nuts, mostly hickory; (2) wood charcoal, identified by species and/or growth age; (3) wood charcoal unidentified to species; and (4) carbonized food residues on pottery sherds. Species identifications were determined under a binocular zoomscope by paleoethnobotonist Dee Anne Wymer.

The dated samples represent only a fraction of the fortitiously and intentionally saved carbon materials that are associated with ceramic deposits and that are curated at the Ohio Historical Center. Carr has located and stored 59 additional Early Woodland through Late Woodland carbon samples associated with ceramics that could be assayed.

Laboratory Methods

The laboratory methods used for this project are a combination of currently prefered practices and certain innovations. Both are summarized here. The innovations include: (1) a very rigorous cleaning process, which was made acceptable by using AMS dating methods to compensate for substantial carbon losses from some samples during cleaning; (2) a method for securely removing datable, carbonized food residues from pottery sherds without introducing possible carbon contaminants from the pottery; (3) a method for pyrolizing weakly charred or carbonized food residues after pretreatment, in order to obtain better AMS targets; and (4) laboratory quality controls that were enhanced by the participation of the Southern Methodist University (SMU) laboratory in the international comparison study, T.I.R.I. (Scott et al. 1997).

Prior to sending nut and wood samples to the radiocarbon laboratory at the Institute for the Study of Earth and Man, Southern Methodist University, each sample was freed of any obvious contaminants (e.g., roots, soil) visible with a zoomscope. The specimens were also examined to ensure that undesirable organic preservatives had not been applied to them. Alvar in acetone, and paraphin in tolulene, were commonly applied to carbonized wood and corn, very occasionally to hickory nuts and seeds, and probably never to acorns, between 1920 and 1960, according to paleoethnobotanist R. I. Ford (personal communication 1986). Similarly, sherds with carbonized residues were selected for dating only if they were free of glues, which sometimes were used to mend breaks.

None of the sherds bearing carbonized deposits and dated here were previously x-radiographed to document their technology (Carr 1990; Carr and Riddick 1990) or to identify their membership with other sherds as parts of a single vessel (Carr 1993). However, to do so would not have caused ^{14}C decay and inflated the age of the sherds, in contradistinction to previously expressed concerns about this (Carr and Riddick 1990:61-62).

The selection criteria noted above, which focus on carbon deposits on vessel walls, and on nuts and seeds, led to our work with many carbon samples that were smaller in weight than that required by conventional beta-decay counting techniques. Nut and wood charcoal samples varied from .1 to 16 grams, and food residue samples weighed in the milligram range. Pretreated samples weighing half a gram or more were dated with beta-decay counting methods at the SMU Radiocarbon Laboratory. Smaller samples were dated with the AMS method at ETH in Zurich. Special sample preparation techniques had to be developed in order to date some of these AMS samples. AMS dating methods have previously been applied to date carbonized deposits on ceramic vessels (e.g., Bill et al 1984; Lovis 1990) and organic temper within vessels (Long et al 1983) only occasionally.

All of the samples were pretreated chemically at the SMU Radiocarbon Laboratory.

Pretreatment of wood charcoal and nut shells

Before the carbon content of a radiocarbon sample is extracted and analyzed, the sample must be purified of carbon-bearing contaminants which can penetrate it in its burial environment. Charcoal is particularly likely to absorb inorganic carbonates and organic humic acids from the soil, for the same reason it acts as an ideal purification filter for water and air. Pretreatment methods for purifying charcoal are designed to dissolve or extract these contaminants.

For this study, carbonates were removed with warm hydrochloric acid solutions of 1.3 N concentration. The progress of the reaction was monitored with the release of small CO_2 bubbles and with the pH of the solution. This solution was replaced when its pH rose above 1, to sustain the reaction. The charcoal samples were left in the solution until the forming of CO_2 bubbles ceased and the pH of the solution stayed below 1.0. This process usually lasted from three days to a full week. The sample was then neutralized in distilled water until the rinsing solution stayed at a pH of 5 or above.

Humic acids are removed with base solutions; here NaOH was used throughout the project. There is a risk that a

strong base solution may dissolve a sample that originally was only lightly or partially charred. This concern applies mostly to wood charcoal; nutshells appear inert to strong base solutions. Thus, for this project, the strength of the solution was adapted to the robustness of the sample, and ranged from 0.05 to 0.5 percent (about 0.01 to 0.1 N). When base-soluble humic acids were present in the sample, the solution turned brown to black, and the pH, initially 11 to 13, dropped to neutral. Fresh solutions were applied to the sample until their color barely changed to a weak tea tint and the pH level remained unchanged. Neutralization of the sample in distilled water followed the removal of humic acids.

Samples should be stored in a slightly acidic condition to prevent the absorbance of CO_2 from the air, which might occur if the sample has a residual base content from the previous procedure. Accordingly, a treatment in a 2% HCl solution, followed by a final rinse in distilled water, completed the pretreatment of the nutshell and charcoal samples.

All samples loose weight during pretreatment. This loss ranges from 20 to 80% of the initial raw sample weight. The loss cannot be avoided, and can be caused by one or several factors. Secondary carbonate and soluble organic compounds can form a substantial part of a sample's mass, which when removed, contribute to weight loss. Highly porous samples often are impregnated with silt and clays that are removed during pretreatment. In contrast, well-charred nut shell samples consist mainly of carbon, are chemically almost inert, and undergo the smallest amount of weight loss. Another, common cause of substantial weight loss is the only partial charring of a wood sample; the remaining organic compounds can break down during base treatments and become soluble and removed. This loss is acceptable, and even recommended when AMS dating is available, for it allows a very thorough cleaning process. In this project, nine samples with a raw weight of more than 1 gram had to be dated with AMS because the rigorous cleaning procedure reduced their weights below about 200 milligrams. Seven wood charcoal samples and one nut shell sample passed the cleaning process with sufficient sample weight for conventional dating.

Pretreatment of food residues on pottery

Dating the time of use of pottery sherds is not feasible in most circumstances. Pots fired at a low temperature may still contain some organic material in the core of their walls, but its origin is usually uncertain. It may have been added to the paste as a temper, or it may be a natural component of the clay, which dates to the deposition of the clay bed.

There is one situation that offers a reasonable chance to accurately date the time of use of pottery: cooking vessels with burnt food residues on their interior or rim area. The source materials for these residues are vegetables or meats, both short-lived products closely related to the human activity to be dated. However, the risk of post-burial contamination to food residues is substantial. Such samples usually have a large surface area and very little depth, which encourages the penetration of contaminants.

Removal of the baked-on, charred coating must be selective. Because the sample is usually very small -- in this project a few tenths of a millimeter thick and a few milligrams in weight -- a small amount of foreign carbon can have a large effect on the sample's date. Fragments of the paste of a pot with organic inclusions are one potential source of such contamination. Because such fragments are easily introduced from the uneven surface of a pot when physically scraping carbon residues off it, this procedure is not recommended.

A more appropriate procedure is to soften the food residue and free it from the pottery vessel's surface using hydrofluouric acid of about 15% concentration. This will penetrate the food residue without altering it, and dissolve the underlying silicate clay minerals that form the pot's surface. The layer of food residue can then be removed from the pot easily and almost completely. This acid treatment also removes all carbonate contamination. The samples can then be given a base treatment, as previously described for wood charcoal and nut shell samples, and a final acid wash. This procedure was used on the food residue samples studied here.

Dating large samples

As a first step, the procedure of benzene synthesis (Noakes 1967, Polach et al 1972) was used to extract each sample's carbon content and to covert it to a compound that reliably permits the detection of the radioactive decay of ^{14}C atoms. The major conversion steps and the products are combustion to CO_2, lithium carbide, hydrolization to acetylene, and catalytic trimerization to benzene. Next used was the beta decay counting procedure commonly referred to as liquid scintillation counting. "Liquid" refers to the liquid, benzene form of the sample carbon, and "scintillation" to the light emission from the sample benzene caused by radioactive decay events. The benzene samples were prepared for counting with the addition of about one weight percent of butyl PBD scintillator. This substance causes light emission upon the beta decay of ^{14}C atoms. Calculating the age of samples requires three types of measurements from the scintillation counters: the rate of decay of the carbon sample, the rate of decay measured from a standard, and the background signal registered by the counter when a sample of infinite age (i.e., zero decay rate) is measured. The background test was made with benzene synthesized from anthracite of Pennsylvanian age (250 Mio years).

The standard represents the rate of ^{14}C decay of a modern sample of zero age. This standard was prepared in the SMU laboratory by synthesizing benzene from the oxalic acid radiocarbon standard issued by NIST (the successor organization of the National Bureau of Standards). The standard simulates the radiocarbon activity of the atmosphere in 1950,

the reference date to which all "Before Present" (BP) ages are related.

Counting measurements lasted between two and three days for each sample. The values for the background and modern standards were averaged from measurements made during approximately six months, three before and three after the measurement of the sample. These counting procedures are detailed in Haas (1979) and Devine and Haas (1987).

Dating small samples

The pretreated wood charcoal, charred nut shells, and charred food residues that were less than .5 g were submitted to the Accelerator Lab of the ETH in Zurich, Switzerland, for AMS dating. During the period of 1986 to 1989, when most of the samples were dated, ETH prepared targets by pressing the ground sample charcoal powder into copper disks. Weakly charred samples had to undergo additional charring in order to produce a measurable ion beam current in the accelerator. The same was true for the charred food residues from pottery, which had not been exposed prehistorically to the direct, intense heat of fire. Additional charring was performed under a vacuum in a quartz tube, which was heated from the outside by a gas-oxygen flame. Additional details on the AMS dating procedure at ETH are given by Bonani et al (1987).

Calculation and reporting of ages

Age calculations were made according to the recommended standard method of Stuiver and Polach (1977) and with internally developed statistical error calculations (Haas et al 1978; Meeks 1979). All ages reported here were corrected for fractionation, based on $\delta^{13}/_{12}C$ measurements (Table 4), which were made on a 2 cm^3 aliquot of the CO_2 gas collected after sample combustion. These measurements were made at the SMU stable isotope laboratory.

The Dates

Tables 4 and 5 list the 35 new radiocarbon dates reported here for 17 sites, placed in the context of all extant, previously determined radiocarbon assays from the same sites. Only the new dates are corrected for $^{13}/_{12}C$ fractionation. Bidecadal calibrations of the dates to real time were calculated using Stuiver and Reimer's (1993) extended and revised calibration program, CALIB 3.0., which uses the bidecadal data of Stuiver and Pearson (1993) and Pearson and Stuiver (1993). For the age-range of concern here, there are no differences in these data from those used in the newer program, CALIB 3.03. The uncalibrated and calibrated new dates reported here supercede all previous, differing reportings of them by others (Dancey and Pacheco 1997:30-32; Maslowski et al 1995; Pacheco 1991:5), who did not have the benefit of all the information available to us. The dates in Tables 4 and 5 are arranged according to their corrected and calibrated ages, rather than their uncorrected, uncalibrated ages.

Two bidecadal calibrations, using laboratory multipliers of 1.0 and 1.8, have been calculated and are reported in Table 5. Using a multiplier of 1.0 implies that no laboratory error contributes to the radiocarbon date's precision, which is unrealistic, or that a very good estimate of laboratory error is already included in the radiocarbon date's measure of precision. When laboratory errors are not fully accomodated within a date's precision, reported standard errors must be multiplied by a factor larger than 1.0 when a date is calibrated.

P. Reimer (personal communication 1996) recommends using a multiplier of 1.8 for most work. Her recommendation is based on several recent studies (International Study Group 1982; Kazimierz et al 1992; Scott et al 1992; Stuiver 1982:14-23; Stuiver and Pearson 1993:3-4) of intralaboratory and interlaboratory error levels. This multiplier factor has consequently been applied in Table 5 to all dates not determined by SMU and ETH.

In contrast, the radiocarbon dates determined by ETH and SMU are calibrated with a laboratory multiplier of only 1.0, because laboratory error is already accomodated in the reported precision of these dates, using the calculation methods of Haas et al (1978). The final report of the Third International Radiocarbon Intercomparison (TIRI), which was organized and analyzed by the Department of Statistics, University of Glasgow (Scott 1997), lists SMU among the laboratories that report dating results consistent with an error multiplier of 1.0.

Decadal calibrations of a select subset of the radiocarbon dates are also shown in Table 5. Like the bidecadal calibrations, the decadal calibrations were calculated with CALIB 3.0, which uses the decadal data of Stuiver and Becker (1993). Again, there are no differences in these data from those used in the newer CALIB 3.03, for the age-range of interest.

Decadal calibration is relevant to only short-lived samples encompassing 10 years of growth or less, such as small twigs, coherent sections of larger trees represented by a few growth rings, nuts, and seeds. The decadal calibrations listed in Table 5 are limited to those assays meeting this criterion. They include most of the AMS radiocarbon samples assayed by ETH and the University of Arizona, and two beta-count samples processed by Southern Methodist University.

Note that the decadal calibrations, although more appropriate than the bidecadal calibrations for the short-lived samples, yield slightly less precise dates and often more intercepts on the radiocarbon-real time curve. This is so because the decadal curve involves less averaging and smoothing than the bidecadal curve, and because the decadal curve is less well defined, being based on less data than the decadal curve.

When integrating assays from both short-lived and long-lived samples, it is possible to argue that assays should be calibrated with one radiocarbon-real time curve -- the bidecadal curve -- for consistency (P. Reimer, personal communication, 1996). The bidecadal calibrations of dates from all samples are reported here for this purpose, and used in the analyses described below.

Stratigraphic and Stylistic Evaluations of the Dates' Accuracy

In order to detect age-biased radiocarbon dates, and to gain insight into the history, temporal continuity, and longevity of occupation of the archaeological components studied here, each component for which a suite of radiocarbon dates is available was examined graphically for modalities and outliers in its dates. The whole suite of dates, each potential mode, and various possible group of modes were then tested statistically for their "consistency," i.e., whether the dates in a suite or mode or group of modes could represent an instant in time, or a duration of time significantly long compared to the precision of the analysis (Long and Rippeteau 1974:210).

Statistics for these analyses were calculated using Stuiver and Reimer's (1993) computer program, CALIB 3.0. The standard Chi-square test (Ward and Wilson 1978), with a .05 significance level, was used to detect statistically significant differences among dates in a set. The test evaluates the null hypothesis that all dates of a set represent a single sample population from an instant in time. The T' statistic generated by the test expresses, nonlinearly, the magnitude of the differences. The analyses were made on dates all calibrated in CALIB 3.0 with Stuiver and Pearson's (1993) bidecadal time curve, regardless of whether the dates were derived from short-lived or longer-lived carbon samples. A laboratory multiplier of 1.0 was assumed. Using both the bidecadal time curve and a laboratory multiplier of 1.0 minimized the number of date-intercepts relevant to each sample and decreased the standard deviation/range of the date. These parameters were used because (1) a lab multiplier of 1 is relevant to the dates produced by SMU and ETH (see above); and (2) no cases of systematic interlaboratory bias could be found for components dated multiple times by more than one laboratory. Using these parameters had the effect of increasing the probability of finding subsets of dates from a site that might represent more than a single sample population from a moment in time.

Table 6 lists the relevant statistics for each site having multiple radiocarbon dates, along with any modes or outliers that were found. The laboratory numbers of the samples falling in each mode, and the range of mean dates defining each mode, are given.

The intrasite radiocarbon date inconsistencies revealed in Table 6 (column 3, "different") can be thought of as significantly large temporal variation attributable to any of several factors: (1) contaminating factors or stratigraphic disturbances that produced outlying dates, (2) the presence of two or more modes/occupations, or (3) continuous occupation over a long time. Any of these factors might be responsible for the improbability of a suite of carbon samples having been drawn from the same sample population from one moment in time.

The particular cause(s) of inconsistency inferred for each site are summarized in Table 6, column 5, and are discussed here. We begin with an assessment of outlier dates that should dismissed or seriously questioned, and proceed to the issues of multicomponency and long-term continuity in occupation.

Questionable dates

Several of the new dates reported here, and certain previously published dates for the sites studied here, can be dismissed or seriously questioned for their accuracy, based on provenience, stratigraphic, ceramic stylistic, and/or general cultural-historical time-phase criteria. All dates reported in this section are calibrated, unless otherwise specified.

ETH 3072, from Dominion Land Company, calibrates between 808 and 522 B.C., with a mean of 780 B.C. The date is a statistical outlier (T' = 13.26, Table 6) relative to the other three dates from the site, which cluster between 510/430 and 170 B.C., and which statistically represent a single sample population from a potentially brief period of time. The mean of ETH 3072 is 270 to 350 years earlier than that of the next oldest date from the site, ETH 3071, although they are statistically the same at the .05 significance level (T' = .65). ETH 3072 is 590 years earlier than the youngest date from the site, ETH 4241.

The peripheral age of ETH 3072 does not accord with contextual information from Dominion Land Company, which instead suggests that all four dates should be similar. The four dates come from four, morphologically similar refuse pits that were dug within the same interior ditch of this circular earthwork-mound site. Moreover, all of the refuse pits contained thick sherds from ceramic vessels that are very similar in their large size, subconoidal-flat bottomed form, and technology, and probably in their age. Thus, on both statistical and contextual grounds, ETH 3072 can be dismissed.

C 942, from the Toephner mound, calibrates to 910 B.C. It is ca. 500 years earlier than all seven other dates from the site. Also, its error level is double those of the other seven dates. Both of these factors suggest that this date may have been derived from a contaminated sample, and that it should be dismissed. This conclusion seems appropriate, even though the imprecision of the date leads to it being statistically assessed as similar to the other seven dates (T' = 2.04, Table 6), and to the next youngest date, SMU 2163 (T' = .60).

The remaining seven dates from the Toephner Mound cannot be rigorously examined for their order relative to their stratigraphic position, because their standard deviations are

high enough to be statistically considered the same moment in time, and their means are very close. However, Table 7 shows that the order of the calibrated dates roughly parallels the stratigraphic order of the features to which they pertain. Features in the upper versus lower halves of the mound are readily ordered by their calibrated dates.

C 874, from the Florence mound, calibrates to 640 A.D. The date is 840 to 990 years later than SMU 1919 (350/320/200 B.C.) from the same site, and the two dates are statistically different (T' = 9.15, Table 6). C 874 is significantly later than the accepted date for the end of Adena culture and the beginning of Hopewell culture within the Scioto drainage, i.e., approximately 40 B.C. (100 B.C. radiocarbon time, Greber 1991) or A.D. 12 (50 B.C. radiocarbon time, Seeman 1988:565). The date is also later than the accepted date for the end of Adena culture in areas peripheral to the Scioto, where Adena culture may have persisted until somewhere between *ca.* A.D. 72 and 260/289/324 (A.D. 1 or 200 radiocarbon time; Black 1979; Greber 1991; Murphy 1975:124; Otto 1979; see below, also). The date is out of line with the accepted age-range for the Adena Plain ceramic type, several vessels of which were found in the central fire place of the mound. In contrast, SMU 1919 falls near the center of the time range for Adena culture. On these bases, C 874 can be rejected, and SMU 1919 can be retained as a reasonable date for the mound floor at Florence.

Murphy (1975:125) also concluded that C 874 should be rejected as too late, and made a circumstantial argument for the possible contamination of the sample. We would note that the same possibility would have existed for SMU 1919, which was collected and curated under similar conditions, but which was apparently and fortunately not so affected.

ETH 3069, from Harness-28, calibrates between 1880 and 1790 B.C. This date is between 1740 and 2260 years earlier than ETH 3068 and ETH 4242,which calibrate to 50 B.C. and A.D. 380, respectively, and is a strong statistical outlier in comparison to them (T' = 224.34, Table 6). ETH 3069 is also a strong statistical outlier relative to only the next youngest date from Harness-28, ETH 3068, on a pairwise comparison (T' = 121.09). However, contextually, all three samples come from the same large refuse-filled trough, and should be roughly similar in age. The trough contained diagnostic artifacts of the Middle Woodland Period, which date elsewhere between ca. 40 B.C. or A.D. 12 until A.D. 439 or 541 (50 or 100 B.C until A.D. 350 or 400 on the radiocarbon time scale; Greber 1991:1; Seeman 1988:565). ETH 4242 and ETH 3068 align with this age range, but ETH 3069 does not. Moreover, the site of Harness-28 at large has a Middle Woodland and an Early Late Woodland component, but no earlier component that might account for ETH 3069. Thus, on contextual and statistical grounds, ETH 3069 can be dismissed.

ETH 3074 and SMU 2438, both from Newark Campus, calibrate to 20 A.D. and 540 A.D., respectively. The two dates differ by 520 years and are statistically different (T' = 9.69, Table 6), yet come from the same refuse pit. The dates are out of sequence regarding the vertical positions of the samples, although the pit was shallow and lacked internal stratigraphy, making the significance of the reversal unclear. Both dates fall within the Middle Woodland period as defined in calibrated time (40 B.C. or A.D. 12 until A.D. 439 or 541), and agree with the general Middle Woodland style of the ceramics and the blades found within the pit. However, details of the ceramics suggest that the earlier, 20 A.D. date may be preferable. Most of the ceramics from the pit are much thinner-walled than typical McGraw cordmarked Middle Woodland vessels, and have thin, parallel, closely space cordmarking. These ceramic characteristics resemble those of the ceremonial, quadrapedal vessels from the Mound City site, which dates early in the Middle Woodland Period. The pit also contained mica, a raw material that was emphasized at Mound City.

The fact that ETH 3074 was derived from a nutshell sample, whereas SMU 2438 is based on a wood charcoal sample, does not help sort out the accuracy of the two dates, given the younger, not older age of SMU 2438.

The previously published date, UCLA 685, from the McGraw site, can be dismissed. The McGraw ceramic assemblage is fully Middle Woodland (Prufer 1965). The calibrated date of 200 B.C. is ca. 200 years too early relative to the conventionally held beginning date of the Ohio Middle Woodland (40 B.C. or A.D. 12; Greber 1991; Seeman 1988:565). It is also too early relative to other calibrated dates for Ohio Middle Woodland records summarized by Greber (1983:90). It is separated by at least 230 years from the means of other, more coherent, calibrated dates from McGraw, although it is statistically the same as ETH 2885 (T' = 2.41), the next oldest date from the site. Finally, UCLA 685 was derived from a bone sample at a time early in the development of radiocarbon dating, and may be biased for this reason. Prufer (1965:104-105) also dismisses the date.

The previously reported date, BETA 15267, and the new date, ETH 4243, from the Murphy site, calibrate to 40 B.C. and A.D. 450, respectively. Both are modest outliers, separated by ca. 160 years and 120 years, respectively, from the cluster of four dates inbetween them. When all six dates are tested statistically for their consistency, they are found to represent different instances in time (T' = 19.18, Table 6). When either one or the other of the two outliers is removed from the date-series, the remaining five dates are found to be the same moment, statistically, implying that the outlying date that is held out is statistically different. At the same time, a pairwise consistency test between BETA 15267 and its adjacent date BETA 16619 show them to be statistically the same (T' = 1.20). This is also the case for ETH 4243 and its adjacent date BETA 16621 (T' = 2.55).

Although the relevance of BETA 15267 and ETH 4243 is questionable, they are retained here for several reasons. First, both dates fall within the conventional definition of the Middle Woodland Period, 40 B.C. or A.D. 12 until A.D. 439 or 541 (100 or 50 B.C. until A.D. 350 or 400 radiocarbon time; Greber 1991:1; Seeman 1988:565). Second, the consistency

test of all six dates from Murphy, which would see either BETA 15267 or ETH 4243 as signficantly different from the remaining five, assumes that Murphy was a single, short term occupation. This assumption is reasonably debatable (see below; also Wymer 1997:161). Contextual data can be used to argue that Murphy was occupied a short total duration, and in probably two or more episodes (see below). These occupations could have been separated by signficant periods of time. Third, BETA 15267 and its adjacent date, BETA 16619, come from the same stratified Feature 14. They are not only statistically the same by a pairwise consistency test (see above), but also are ordered correctly stratigraphically. BETA 15267 was derived from a sample within the ashes of a fire at the bottom of Feature 15 (Stratum III). BETA 16616 was obtained from a sample from a layer of fill (Stratum II) directly above it. Fourth, the pottery associated with BETA 15267 and BETA 16619, which fall early in the Middle Woodland Period, are technologically and stylistically transitional between classic Early Woodland and Middle Woodland ceramics, as would be expected. Partial remains of four vessels were found at the discontinuity between Stratum III and Stratum II of Feature 14. The vessels are plain like Early Woodland ceramics in southern Ohio, rather than cordmarked, like some Middle Woodland wares. The vessels also have walls that are transitional in their thickness between thick, Early Woodland ceramics and thinner, Middle Woodland ceramics. Finally, it is notable that the excavator of the Murphy site, Dancey (1991:50-51), concluded that BETA 15267 is a credible date, although without the benefit of date ETH 4243.

BETA 4347, from Scioto Trails, calibrates to 1041 or 1150 A.D. It can be rejected on quantitative and contextual grounds. It is removed by at least 155 years from the latest mode of dates for Scioto Trails (BETA 4349, 4350), which cluster between A.D. 870 and 886. A pairwise consistency test shows that it is statistically different from the next youngest date, BETA 4350 (T' = 9.31). BETA 4347 falls well outside of the accepted dates for Newtown-like Early Late Woodland ceramics, which predominate at Scioto Trails and within the general intrasite area from which the carbon sample was taken. Newton-like ceramics are estimated to date between A.D. 400 or 450 and 800 uncorrected radiocarbon time in southern Ohio (Stott 1992; , Seeman 1980:5; Seeman and Dancey, personal communication 1998).

SMU 1964, BETA 4348, and BETA 4349, from Scioto Trails, calibrate to A.D. 636, 680, and 870, respectively. They are all from the same refuse pit, Feature 5, but are fully stratigraphically reversed. The three dates, taken together, are statistically different at a .05 significance level (T' = 10.46), primarily as a result of the outlying value of BETA 4349. However, when tested pairwise, the chronologically/stratigraphically adjacent dates of SMU 1964/BETA 4348, and BETA 4348/BETA 4349 are statistically the same at the 95% level (T' = 2.06, 3.84, respectively), defining a cline of overlapping dates.

The preferred interpretation, here, is that all three dates are accurate and should be accepted, for three reasons. First, the precision of each of the three dates is narrow and does not indicate contamination. Second, SMU 1964 and BETA 4348 closely agree with each other and with one other date (ETH 3067) from the same locale within the site. Third, Feature 5 is a large, deep, midden-filled refuse pit without differentiated strata. The fill in the feature could easily represent a single fill event in which stratified midden deposits were reversed in their order. The long occupational history of Scioto Trails, and the thick midden accumulations in the general area of Feature 5, would accomodate such a scenario.

It is suggested that all three dates questioned here be retained for other analyses, and that the ceramics associated with each of the various levels of Feature 5 be dated by the radiocarbon date of that level, or by the date(s) of adjacent levels, if there is no radiocarbon date for a given level.

ETH 2886 and ETH 4502, both from the Greencamp site, calibrate to A.D. 530 and A.D. 1300. Both dates are derived from food residue removed from several sherds that belong to the same vessel, yet the dates are separated by ca. 770 years and are statistically different (T' = 54.03, Table 6). Nothing unusual about either samples or their pretreatment process was noted at the time of dating the samples.

On ceramic stylistic grounds, the earlier date of AD. 530, ETH 2886, can be dismissed. The vessel bearing the carbon has a flattened lip and an everted rim with an exteriorly folded over collar. Not enough of the rim is present to determine if castellations occurred on it, but a second, similar vessel from the site does have castellations. These stylistic traits would assign the vessel to the late Late Woodland Period and the Cole complex, dating after ca. A.D. 1100 (Barkes 1981; Morton 1984; Seeman 1980; see also Potter 1966).

Ambiguity in Fort Ancient dates

The two suites of dates from the early Fort Ancient villages of Blain and O.C. Voss continue to be difficult to decifer. The significant patterns and contradictions that remain to be explained are the following.

(1) Multiple authors (Barkes 1981; Murphy 1975:235; Prufer and Shane 1970:232-247) find the ceramic assemblages at Blain and O.C. Voss to be homogeneous, and place these sites in the (early) Fort Ancient tradition, based on ceramic and other criteria (e.g., the paucity of shell tempering in pottery). Prufer and Shane (1970:233, 247) holds that Blain was occupied continuously for no greater than a hundred years, somewhere between ca. A.D. 1030 and A.D. 1285 calibrated time (A.D. 970 and A.D. 1225 uncalibrated). However, the radiocarbon dates from both sites have the same two statistically significant modes (Table 6), one between ca. A.D. 1000 and A.D. 1300, and a second after A.D. 1400, calibrated time. Both sites show a 100+ year gap in dates after *ca.* A.D. 1300, despite the large number of dates determined for both.

(2) At neither site do dates from the two modes segre-

gate spatially.

(3) At O.C. Voss, an odd but strong pattern occurs, whereby six features that were each dated twice each yielded one date in the earlier mode and one date in the latter. The pattern cannot be explained by differences between the two laboratories that made the determinations, the University of Michigan and Ohio Wesleyan University.

(4) Prufer and Shane (1970:233) rejected the two dates from the later mode at Blain that he determined (M 1910, OWU 247a), based on two possible sources of error: rootlet contamination and fractionation for a maize sample. However, the credibility of these later dates must remain open to investigation, at least as part of the statistical distribution of dates for the site, given the new date, ETH 4501, which also is "late". It was rigorously cleaned and corrected for fractionation.

(5) The large number of late dates at Blain and O.C. Voss that fall in the range of later, Anderson and Feurt phase Fort Ancient sites, which bear high percentages of shell tempered ceramics, must be reconciled with the very low incidence of shell tempered ceramics at Blain and O.C. Voss (3.3%, very rare; Prufer and Shane 1970:234-235).

Comments on certain acceptable dates

Dates ETH 3481, ETH 3311, and ETH 3410, from Phillip Smith Mound, have stratigraphic positions allowing them to be assessed. These dates calibrate to 400, 400, and 380 B.C., respectively, and are correctly ordered. ETH 3481 and ETH 3311 date premound features on the floor below the mound, while ETH 3410 postdates the building of the primary mound but predates the building of the secondary mound. All three dates can be accepted.

Dates ETH 3487, ETH 3070, and SMU 1868, from the Locust Site, calibrate to A.D. 80, 220, and 230. All three are statistically the same (T' = ..69, Table 6). They come from three pits with plain, moderately thick ceramics that best correspond to the Early Woodland type, Adena Plain, but that have some traits relating them to later, Middle Woodland ceramics of the Scioto valley. Seeman (1985:55) would date the rim sherds between 40 B.C and A.D. 146/190 (radiocarbon time 150 B.C. and A.D. 100), based on their being everted as strongly as many examples from the Middle Woodland, Scioto valley site of McGraw. Carr noted 11 body sherds in Feature 19 that were burnished -- a trait that also suggests the Middle Woodland. Thus, the radiocarbon and stylistic data concur. They imply a late Adena occupation in the Muskingham valley, which overlapped in time with Hopewell occupations in the Scioto (see below and Greber 1991). The dated proveniences do not show evidence of admixture of deposits from the Early Late Woodland and Fort Ancient age components at the site.

The three dates from the Cole site (ETH 3926, DIC 2284, SMU 2083) and the three dates from the Howard Baum site (ETH 4244, DIC 1928, SMU 1930), are very consistent and statistically the same within each site (T' = .18, 1.64, respectively). Both sites were small, lack evidence of houses, and revealed few pits (15 or less) or other subsurface features. All contextual data point to their short occupation, which is borne out by the dates.

Modality of the Dates and Some Inferences about Site Histories and Culture History

In this section, the dates in Tables 4 and 5 are used to assess the occupational histories of several sites, as well as some broader, regional chronological and culture historical issues. The following discussion progresses through time, beginning with the Early Woodland.

The Origins of pottery making

The beginning of pottery making is not as well dated in the upper Ohio valley (Murphy 1975:123) as it is in the Midwest U.S. (Farnsworth and Emerson 1986) and New England (Petersen and Hamilton1984; Petersen and Sanger 1994). The practice of pottery making appears to have spread from its origins in the South Atlantic Seaboard, at ca. 2500 - 2000 B.C. radiocarbon time, up the Atlantic Coast. It eventually reached the Northeast by ca. 1200 - 1400 B.C. radiocarbon time, where it is found in the form of Vinette I and related ceramics (Brown 1986:600; Petersen and Hamilton 1984:418; Petersen and Sanger 1994:126; Tuck 1978). From there, pottery making appears to have spread into Pennsylvania (Kinsey 1958) and the upper Ohio valley (Clay 1980), where Fayette Thick pots were produced. At Rais Rockshelter, in Jackson Co., Ohio, Fayette Thick pottery is bracketed by two dated strata, between 1560 +/- 135 and 1020 +/- 220 B.C. radiocarbon time (Swartz 1971). From the Appalachian Plateau, via either the upper Ohio River, other streams in Kentucky draining into the Ohio, or less likely the Tennessee river, pottery-making spread west into Indiana, Illinois, Michigan, Wisconsin, and Iowa, where it is evidenced in Marion Thick pots (Helmen 1951). This form was not common in the lower Ohio valley until ca 600 - 500 B.C. radiocarbon time (Emerson 1986:623; Butler and Jeffries 1986:532).

The acceptable, earliest dates from Dominion Land Company and Toephner (Tables 4and 5), which are well-dated sites that held samples of very thick pottery, are 605 B.C. and 464 B.C. corrected radiocarbon time (780, 410 B.C. calibrated time). They do not help to resolve the history of the spread of pottery over the East, being comparable to the earliest dates of Marion pottery in the Midwest.

In contrast, the single date of 1150 B.C. corrected radiocarbon time (1390/1330 B.C. calibrated time), from the Continental Construction site, supports the early date from

Rais Rock Shelter. These two dates imply the possible spread of pottery into the Midwest from the Appalachian Plateau via the upper Ohio valley, instead of the Tennessee. This conclusion reaffirms the position of Butler and Jeffries (1986:531-532).

The pottery sample from Continental Construction, Feature 15, which yielded the 1150 B.C. date, is comprised of four plain, grit-tempered, orange-brown colored body sherds. The sherds range from 10 to 13 mm in thickness. They look quite similar in their tempering and surface treatment to the flower-pot-shaped Fayette thick sherds from Dominion Land Company, 500 years later.

The temporal duration of Adena culture

One common interpretation of upper Ohio valley culture history is that Hopewell ceremonial life and material culture in the central Scioto valley, the Miami drainages, and the Licking were unique, localized developments out of a previous, relatively uniform, more broadly spread set of Adena ceremonial practices in Ohio, Indiana, Kentucky, and West Virginia. Thus, in some areas, societies with Adena ceremonial culture may have persisted and been contemporaneous with societies in other areas that went on to develop ceremonial practices called Hopewell (Murphy 1975:219). Webb and Snow's (1945:Map I) comparison of the geographic distribution of Adena and Hopewell mortuary sites, with a concentration of sites from both cultures around Chillicothe, Ohio, but with a more restricted distribution for Hopewell sites, can be used to support this position. So can Black's (1979:21) study of settlement patterns in the Hocking valley, which documented a great number of Adena mounds and base camps, there, and a lack of Hopewell mounds, earthworks, and base camps. Greber (1991:20-22), agreeing with this position, has given further support to it by noting that three mounds on the Plains of the lower Hocking (Connet 3, Connet 4, and Armitage) each have uncalibrated radiocarbon dates with means in the first and second centuries A.D., which fall within the time frame of central Scioto Hopewell sites. Several other mound sites on the Plains are noted by Greber to have small numbers of bladelets, which strongly correlate with the Middle Woodland period. Finally, Murphy (1975:125) has summarized the acceptability of certain other A.D. dates for Adena mounds in Kentucky (Wright, Hambelton) and Ohio (Sayler Park).

This view of Adena persistence is futher supported for another area, the upper Muskingham drainage, by three new dates from the Locust site. The Locust site had a small Adena component that possibly was the remains of a homestead (Seeman 1985:99). Dates ETH 3487, ETH 3070, and SMU 1868 each come from pits with thick pottery similar to Adena Plain, and help to define the component. The dates, which are statistically the same, fall within the first and second centuries A.D., corrected radiocarbon time: A.D. 20, 115, and 151 (calibrated A.D. 80, 220, 240). The dates point to the continuation of Adena lifeways in areas not far removed from Hopewell peoples. The Locust site is about 16 miles down river from the Newark earthworks, a major Hopewell ceremonial center.

It is also significant that none of the newly dated sites that yielded Adena pottery and that are in the Scioto drainage, i.e., Continental Construction, Dominion Land Co., Toephner, Phillip Smith, and Florence, have acceptable dates extending beyond ca. 150 B.C. radiocarbon time. None continue into the period of development of Hopewellian ceremonialism in the Scioto valley.

Occupational histories of middle Woodland sites

The small, Middle Woodland habitations of McGraw and Murphy, and the more ephemeral and functionally uninterpreted site of Harness-28, each have multiple acceptable radiocarbon dates. A comparison of these date-series reveals an interesting pattern: all three sites have a wide disperson of dates (Table 4) with two or more definable modes (Table 6), despite the supposed short-term, single occupation of the sites. This pattern contrasts with the similarly small and apparently short-occupation Late Late Woodland habitations of W.S. Cole and Howard Baum, which each exhibit one, tight cluster of dates.

The dispersion and multimodality of dates from McGraw, Murphy, and Harness-28 suggest a different occupational history for them than the excavators. Prufer (1965) and Dancey (1991), have respectively concluded for McGraw and Murphy. Evidence is now reviewed for each site.

The McGraw site was comprised of a ca. 7 inch refuse midden on the slope of a levee of the Scioto river. The midden presumably derived from domestic activities, although no remains of a building was found at McGraw. It is possible that one or more homesteads lay upslope from the midden, on the top of the levee (Dancey 1991:38), although Prufer (1965:13) thought not, based on his test excavations there.

There is no unequivocal contextual evidence for the number of times that McGraw was occupied, but several kinds of data do point to multiple occupations, each separated by significant amounts of time. (1) Prufer did not record the McGraw midden to have been stratified. However, J.A. Brown has mentioned (pers. comm. 1985) that, on his visit to the site during excavation, he saw stratigraphic profiles with layers of mussel shells, suggesting several episodes of deposition. (2) The utilitarian ceramics from McGraw are much more diverse in thickness and decorative style than those at each of Murphy, Newark Campus, Harness-28, Mound City Feature 35 below the embankment, and Seip Locality 20. This could indicate that McGraw was occupied more than once, with significant time between occupations. (3) Electron microprobe analyses of the clay chemistry of 59 coarse and fine-ware ceramic sherds from McGraw (Yeatts 1990), and petrographic analysis of the temper of 33 coarse and fine-ware sherds (Carr and Komorowski 1995:741, 744), indicate that a substantial percentage of the McGraw ceramics were made from raw materials found at a

distance of more than 25 km from the site and occurring in several different drainage systems. The results suggest that residents at McGraw participated in several different exchange networks, which logically could have pertained to different time periods and different occupations of the site.

(4) The radiocarbon record from McGraw (Tables 4, 5, 6) is consistent with the above three kinds of evidence for multiple occupations. Acceptable radiocarbon dates range widely, from 30 B.C. - A.D. 481 (calibrated A.D. 30 - 610). Statistical consistency tests show that all acceptable radiocarbon dates cannot be attributed to one moment in time. Statistical consistency can be obtained only with a minimum of two suites of dates (i.e., possibly two occupations), with means ranging between 30 B.C. and A.D. 280, and between A.D. 435 and 481 radiocarbon time (calibrated A.D. 30 - 410, and A.D. 560 - 610). In the earlier suite, two modes are definable from the frequency distribution of the mean dates: 30 B.C., and A.D. 120 - 280 radiocarbon time (calibrated A.D. 30 - 50, and A.D. 220 - 410). Thus, the radiocarbon record suggests two or three episodes of occupation. Each episode could have been relatively brief, providing the brief total length of occupation of the site (ca. 1 generation) concluded by Prufer (1965:137).

The Murphy site is a small homestead concluded by Dancey (1991) to be similar to the McGraw site in its function and occupational history. Dancey models Murphy as having had a well maintained internal structure composed of a food processing zone, a refuse zone, and a zone within which one or more houses may have stood. No clear post patterns were definable. Dancey (1991:66-67; see also Pacheco 1996:21) has argued that the clear internal structure he sees for the site, the presence of stock-piled tool blanks, and the heavy recycling of the lithic assemblage all imply a permanent residence. He goes on to suggest (pp. 50, 66-67) that the site was occupied one time, about one century, somewhere between 100 B.C. and A.D. 225, and probably in the second century A.D., radiocarbon time. It should be noted that Dancey's conclusions were drawn without the benefit of the date ETH 4243. Also, his interpretation of Murphy differs from that of Yerkes (1988, 1990), who sees the site as a short-term seasonal occupation.

We have not evaluated whether Murphy was occupied permanently the year-round or seasonally, but do suggest that the site was occupied two or perhaps three different times, with the primary (or at least most frequently dated) occupation being somewhere between A.D. 60 and 210 radiocarbon time (calibrated A.D. 120 - 330). Three pieces of evidence suggest the multiple occupations. (1) A frequency distribution of all available dates from Murphy forms a central cluster of four dates, from A.D. 60 - 210 radiocarbon time (calibrated A.D. 120 - A.D. 330), and two outlying dates of 90 B.C. and A.D. 360 (calibrated 40 B.C. and A.D. 450). The outlying dates are both separated from the main cluster by 150 years (calibrated 160 and 120 years, respectively), and one or both could represent separate occupations -- an idea that Dancey (1991:67) entertained but did not conclude.

(2) A statistical consistency test of all available dates (see above) shows that they include one significant outlier, either BETA 15267 (90 B.C. radiocarbon time; calibrated 40 B.C.) and/or ETH 4243 (A.D. 360 radiocarbon time; calibrated A.D. 450). The inbetween dates that range over A.D. 60 - 210 radiocarbon time (calibrated A.D. 120 - 330), along with one of the two outliers but not both, can be considered, statistically, one moment in time. The inbetween dates could have been produced by a short term occupation of a year to the much longer occupation of a century, which Dancey prefers.

Our suggestion is that this well-dated occupation, somewhere between ca. A.D. 120 and A.D. 330 calibrated time, and the other possible one or two occupations of Murphy, were each brief, on the order of years. The number of pits found at Murphy is small: 20 basins, earth ovens, cylindrical pits, and hearths, and 17 post molds. Ceramics are scant: 858 sherds. The sherd inventory from Murphy is only 8.5% of the number of sherds found at McGraw, and could reasonably be the product of 10 to 20 broken vessels. If two or three vessels were in use at Murphy at one time, and if their average uselife were six months to one year, as is found ethnographically (Rice 1987:297, Fig. 9.4), this would imply a length of occupation of only 1.7 to 10 years.

(3) The internal structure of Murphy can be interpreted as the product of multiple occupations as easily as it can be interpreted the result of one occupation. Specifically, the site has six or seven spatially segregated clusters of features that could logically be attributed to several different periods of occupation of the site. Most of these clusters are functionally equivalent, containing one or more basins and earth ovens, with post molds nearby. These clusters are: (a) Features 138, 139, 147; (b) 130, 131, 135; (c) 120, 121, 123; (d) 14, 23, 33, 100A in a line; (e) 16, 20, 21, 31, 110ABD; and (f) 167. A unique cluster of two hearths and posts is comprised by features 17, 48, 55, 68, 72, 74, and 81. Each of these clusters could represent processing features with supplemental pole-supported racks of a kind. The location of these several clusters of features in the same area need not be attributed to their functional interrelationship and contemporaneity, and to Murphy having been occupied once, as Dancey has concluded. Instead, the total distribution could reflect simply the repeated location of very small, year-round habitations (or more temporary, seasonal or multiseasonal special-purpose camps) within the same general area, within the constraints of the topographic high on which Murphy sits.

Thus. there are multiple lines of evidence supporting that Murphy was the location of two or more short occupations, either year-round or seasonal, at different periods of time. In this way, Murphy does not differ from McGraw.

The Middle Woodland component of Harness-28 also may be the product of more than one period of use, and would fall into the possible multi-occupation pattern posed by McGraw and Murphy. Consistency tests show that the two dates, ETH 3068 (125 B.C. radiocarbon time; calibrated 50 B.C.) and ETH 4242 (A.D. 250 radiocarbon time; calibrated A.D. 380) are statistically different and are not representative of the same

moment in time. Both dates comes from hickory nutshell carbon samples, which do not produce old heartwood problems. The dates come from the same, very large refuse trough or midden remnant, which conceivably could have been filled with mixed debris from different occupations of the site.

In sum, the radiocarbon date series from McGraw, Murphy, and Harness-28 each have a wide dispersion and multiple modes, which suggest their each having been occupied more than one time. The dispersion of the dates in each series cannot be attributed to solely the stochastic process of carbon-14 decay and other errors (Shott 1992), as shown by the statistical tests of consistency that were made. The dispersion of the dates cannot be attributed to one to several centuries of occupation of these sites, because the dates of each series are divided into modes, and because the archeological inventory from each site is too small to be the product of an extended occupation.

The conclusion that McGraw, Murphy, and possibly Harness-28 were each occupied two or more different times for short periods, either year-round or seasonally. in no way conflicts with the Vacant Center - Dispersed Agricultural Hamlet hypothesis of Middle Woodland settlement proposed by Prufer (1964a, 1964b) and admirably tested by Dancey and Pacheco (1997; Pacheco 1996). It also accords with the contemporary view that Ohio Hopewell peoples relied considerably, for their subsistence, upon a garden plot or more intensive farming system (Dancey 1991:67; Ford 1979; Smith 1989; Wymer 1996:41-42, 47; 1997:158-161) that involved periodic shifting of plots (Dancey 1991:66; Wymer 1996:47) and, by implication, a periodic shifting of residences, with the potential and predisposition for garden plot reuse and homestead reoccupation. Wymer (1997:161) specifically concludes from her paleoethnobotanical studies of four Licking valley Middle Woodland homesteads, including Murphy, that Middle Woodland habitation sites may have been periodically reused, after abandonment for perhaps several generations, to exploit previously cleared, renewed garden areas, which would have been easier to clear than virgin oak forests (for analogous arguments, see Binford 1972; Shott 1992). What is questioned here and by Wymer is the number and lengths of occupation of Murphy and similar sites, and rates of residence shifts (residential mobility), not the functions and seasons of occupation of the sites, which must be evaluated with other kinds of data.

The dispersed, statistically heterogeneous, multimodal radiocarbon records from McGraw, Murphy, and Harness-28 contrast with the statistically consistent radiocarbon dates from both of the Late Late Woodland sites of W.S. Cole and Howard Baum. Although all five sites are small and probably had short total lengths of occupation, the Middle Woodland and Late Woodland sites differ in their occupational histories: repeated reoccupation concluded for the Middle Woodland sites is not evident for the Late Late Woodland sites. It is possible that this difference, between the Middle Woodland and Late Late Woodland sites, reflects the different patterns of farmstead relocation during these two periods, in response to the growing of Eastern Agricultural Complex cultigens during the Middle Woodland versus the growing of maize during the Late Late Woodland. Because maize readily depletes a soil of essential nutrients (Heidenreich 1971), probably moreso than do Eastern Agricultural Complex cultigens, Late Woodland maize growers may have been less inclined to reuse previously cleared and occupied areas, despite the ease with which those cleared areas might have been resettled. Middle Woodland gardeners may not have been as constrained by previous impacts of cropping on soils, allowing for the resettlement of previously cleared and occupied areas. This scenario assumes that McGraw, Murphy, W.S. Cole, and Howard Baum all functioned primarily as homesteads for gardening or farming, which remains to be firmly demonstrated.

The ending of Hopewell mortuary ceremonialism, and the shift from dispersed-homestead to aggregated-village life in the central Scioto valley

Convention holds that the flamboyant mortuary-ceremonial practices that define Hopewell culture and the Middle Woodland Period throughout southern Ohio ended somewhere around A.D. 350 (Seeman 1988) or A.D. 400 (Greber 1991:1; Griffin 1967:183) uncorrected radiocarbon time. The Early Late Woodland Period, defined on the basis of ceramic and projectile point styles, and correlated with the development of aggregated village life, is thought to have begun around A.D. 450 (Seeman 1980:5), or A.D. 400 (Seeman and Dancey, personal communication 1998), based specifically on sequences of culture change in the Cincinnati area of Ohio. Potentially, there is a 50 to 100 year gap between the end of the Middle Woodland and the beginning of the Early Late Woodland as now defined..

This chronological scenario is problematic in four ways. (1) The Middle Woodland and Early Late Woodland are traditionally defined to a large degree by cultural subsystems that are different: mortuary practices, ideas, and remains, on the one hand, and subsistence-settlement practices and their material correlates on the other. During the in situ alteration of culture from the Middle Woodland into Late Woodland, it is possible that these two subsystems changed at somewhat different points in time. In particular, the dispersed settlement system of the Middle Woodland could have continued some time after the collapse of most Hopewell mortuary practices and ceremonialism, and only later been transformed into aggregated village life (see also Dancey 1996:400). This possible scenario, and the archaeological use of shifting criteria to define the Middle and Early Late Woodland Periods, could be the cause of the above-noted, potential gap between the end of the Middle Woodland and the beginning of the Early Late Woodland. (2) The chronological sequence, and the initial date of the Early Late Woodland, in southwestern Ohio

are extended—perhaps overly so—to the central Scioto valley, for the lack of stratified Middle Woodland - Early Late Woodland sites there. (3) New and previous radiocarbon dates suggest that Middle Woodland dispersed settlements, and perhaps mortuary ceremonialism, extended later in time than A.D. 350 or 400 in the central Scioto. (4) New and previous radiocarbon dates suggest that aggregated communities developed somewhat later than A.D. 450 in the central Scioto, in contrast to southwestern Ohio.

To explore the Middle Woodland - Early Late Woodland transition effectively, it is necessary to track and date change in different cultural subsystems separately, and to date such changes in different locales with information respectively relevant to those specific locales. Focusing on data from the central Scioto, we begin with the better dated of cultural changes — the shift from dispersed homesteads to aggregated village life — and then consider the end of Hopewell mortuary ceremonialism.

Based on the radiocarbon assays in Tables 4 and 5, a more relevant date for the beginning of aggregated village life in the central Scioto is probably ca. A.D. 500 radiocarbon time (calibrated A.D. 630). This is apparent from the two sequences of dates from the Waterplant and Scioto Trails-Zencor sites. Both sites have yielded four dates between A.D. 500 and 525 radiocarbon time (calibrated A.D. 630 - 640), but none earlier. Waterplant and Scioto Trails offer the most detailed radiocarbon record of Early Late Woodland sites in the central Scioto, and provide the best data currently for estimating the beginning of aggregated village life there. Dancey (1996:396) agrees.[1]

A date of ca. A.D. 500 radiocarbon time (calibrated A.D. 630) for the beginning of aggregated village life in the central Scioto fits well with the record of terminal dates for the dispersed settlement pattern of Hopewell peoples there. The three dates that define the second, last apparent occupation of the McGraw site (see above) fall between A.D. 435 and 481 radiocarbon time (calibrated A.D. 560 - 610). Dancey (1996:400) notes that many candidates for Middle Woodland homesteads of which he is aware also contain artifacts of post-Hopewellian styles, affirming the continuity of a dispersed settlement pattern and homestead reuse beyond A.D. 400.

Dating the end of flamboyant Hopewellian mortuary practices is more difficult, for lack of multiple, corroborating radiocarbon sequences. All three dates from Russell Brown Mound 3 within the Liberty earthwork fall after A.D. 400, two significantly later. They are UCLA 246C, UCLA 246B, and UCLA 246A, which respectively are A.D. 430 +/- 90, A.D. 590 +/- 70, and A.D. 615 +/- 70 radiocarbon time (calibrated A.D. 550, 670, 670; Shane 1975:361). Three of ten acceptable dates from the Edwin Harness mound within the Liberty earthwork fall between A.D. 400 and 500. They are DIC 664, DIC 860, DIC 661, which are: A.D. 450 +/- 60, A.D. 450 +/- 50, and A.D. 460 +/- 65 radiocarbon time (calibrated A.D. 600, 596, 600; Greber 1983:91). The first and third are associated with the Big House or the heavy clay floor extending beyond the Big House; the second comes from an activity area north and outside of the Big House. An additional four dates associated with the Big House or the clay floor fall before A.D. 400. The Edwin Harness series also includes three dates in the A.D. 750 - 840 range. All pertain to events on the outer stratum of the mound rather than the mound floor. From the Seip earthwork, three of nine radiocarbon assays postdate A.D. 400. They are DIC 1724, DIC 289, and DAL 281, which are A.D. 470 +/- 55, A.D. 590 +/- 105, and A.D. 590 +/- 105 (calibrated A.D. 600, 670, 670; Greber 1983:91). The first of these dates comes from charcoal in a pit in Locality 20, just west (outside) of the earthwork wall. The last two dates derive from buildings within the earthwork and that have been inferred to be the locations of crafting activities--perhaps the making of textiles or basketry--in preparation for mortuary or other ceremonies (Baby and Langlois 1977).

All told, these dates appear to indicate that mortuary activities of the kind associated with Big Houses, like those at Edwin Harness, Seip Mounds 1 and 2, and Hopewell 25, came to an end in the central Scioto by ca. A.D. 400, whereas other Hopewellian ceremonial activities and the building of small mounds within some earthworks continued on later, to at least A.D. 500, uncorrected radiocarbon time. Whereas the dates for the Big House or the heavy clay floor at Edwin Harness define a mode centering around A.D. 318 uncorrected radiocarbon time, peripheral activity areas such as the northern activity area at Edwin Harness, Locality 20 at Seip, and the craft buildings at Seip post-date A.D. 400. So too does the construction of Russell Brown Mound 3.

It is important to understand that the previously posited date of A.D. 400 radiocarbon time for the end of Ohio Hopewell mortuary ceremonialsm was initially estimated during the early phases of radiocarbon dating, in part by comparison to dates from Hopewellian burial mounds and habitations in other areas of the Midwest and Northeast U.S. (Griffin 1967:181). This approach was reasonable at the time, but has become less appropriate as the number of local radiocarbon dates from the central Scioto valley has increased over the past decade.

Coming full circle, by focusing on local, Scioto valley dates, and by tracking separately the ending of Hopewell mortuary ceremonialism and the shift from dispersed homesteads to aggregated village life, a transformational sequence is revealed that makes sense theoretically. As community social integration and regulation through ritual within ceremonial centers waned from elaborate mortuary practices within Big Houses to simpler and/or smaller mortuary ceremonies or nonburial ceremonies, social integration and regulation through coresidence increased. The above dates suggest that this change was at least stepped if not gradual, over more than a century. Dancey (1992) discusses other possible aspects of this transition.

Early Late Woodland settlement mobility

The two Early Late Woodland sites of Waterplant (Dancey 1988) and Scioto Trails-Zencor (Potter 1966) are

similar enough in their content, layout, and proximity to suggest a close tie between them. Both sites are very large relative to preceding Middle Woodland habitations. Both have dense concentrations of debris within them, which apparently reflect the locations of houses or house clusters. Waterplant was surrounded by a C-shaped ditch and possible embankment. Scioto Trails-Zencor has been thought to have had a ditch (Potter 1966), and this appears to be the case from aerial photographs (Dancey, pers. comm. 1996). The two sites are only four miles apart.

Dancey (1988:233) posited, based on what dates were available, that inhabitants of the Water Plant site may have depleted their local resources and moved northward to a new location, creating the Scioto Trails-Zencor site. This is an attractive hypothesis, in line with current understanding of the nature of settlement and mobility of Monongahela, Shenks Ferry, Owasco, Onondaga and other Late Prehistoric villages to the east of the Scioto valley (e.g., Bradley 1987:49-50, 116). The idea also takes into account the lack of evidence for large-scale maize agriculture by the inhabitants of Waterplant and Scioto Trails-Zencor, and the ease with which the catchments of these well-populated sites might have been overused.

This hypothesis does not seem so viable, now. The contemporaneity of Waterplant and Scioto Trails-Zencor between ca. A.D. 500 and 620 radiocarbon time (calibrated A.D. 630, 680) is clear from four dates from Waterplant and three dates from Scioto Trails-Zencor that fall within this time range (Tables 4, 5). After that time, Waterplant appears to have been abandonned and Scioto Trails-Zencor evidences later occupation.

The suites of dates from Waterplant and Scioto Trails-Zencor raise at least three alternative hypotheses about their relationships. First is that the inhabitants of the two sites had a competitive relationship, and Waterplant was abandonned after continued tensions. The ditches that surround Waterplant and apparently Scioto Trails-Zencor would support this idea. A second hypothesis is that Waterplant was abandonned for some other reason, and its inhabitants subsequently aggregated with those of Scioto Trails-Zencor at that site, which continued onward in time for another ca. 200 years. This idea seems less likely at this time, for Scioto Trails-Zencor is considerably smaller than Waterplant. Scioto-Trails-Zencor encompassed ca. 1 - 2 ha. (Dancey, pers. comm.), whereas Waterplant covered ca. 3.15 ha (Dancey 1988:226). A third possibility exists if Scioto Trails-Zencor was instead occupied twice (Table 6), somewhere between A.D. 502 to 620 radiocarbon time (calibrated A.D. 636 - 680) and again around A.D. 750 or 780 radiocarbon time (calibrated A.D. 870 -886). Both Waterplant and Scioto Trails-Zencor might have been occupied at similar times, between A.D. 500 and 620 radiocarbon time, and then abandonned. Scioto Trails then may have been reoccupied around A.D. 750 or 780 radiocarbon time, perhaps upon an amelioration of whatever had earlier caused abandonment of the two sites. Physical anthropological studies would be welcome in sorting out the interrelationships between the two sites and the cause(s) of their abandonment.

Future Directions

The array of new dates reported in this paper, and their evaluation along with previously reported dates, have helped to both clarify and broaden the range of possible chronological and culture-historical reconstructions for the Scioto and upper Muskingham-Licking drainages. Some of the events dated here, and/or the interpretations drawn from them, remain very much open to further inquiry. Tight archaeological associations between radiocarbon samples and ceramics that were found by one of us (Carr), that remain to be dated, and that could further understanding of the Scioto and upper Muskingham culture-historical sequence include the following. Two additional samples from Feature 5 at Florence Mound could help to verify the one acceptable date for this site. Two samples from the Middle Woodland Feature 8 at Harness-28 might help to clarify whether there were two Middle Woodland occupations of this site. Four samples from Features 21 and 76 at Waterplant could clarify if a possible second, later component occurred there. One sample from Continental Construction Feature 5 might be used to help verify the one date from the Early Late Woodland component there. Fifty samples from other undated or dated proveniences are available for Dominion Land Company, Toephner, Phillip Smith, Locust, Scioto Trails, W. S. Cole, Howard Baum, and Blain. However, their assay does not seem necessary at this time, given the consistency of dates for the intrasite proveniences or sites to which they pertain. Persons interested in making further radiocarbon assays of any of these remaining samples should feel free to consult with the senior author.

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Endnote

It is interesting, although of debatable relevance, that away from southwestern Ohio, the beginning dates for Waterplant and Scioto Trails-Zencor correspond to those of the Childers site, a similar, well dated Early Late Woodland village site further east on the Ohio River (Shott 1992). The two oldest dates from Childers that Shott accepts (SMU 2270, 2254) are A.D. 480 and 510 (calibrated A.D. 610, 630). Based on a number of quantitative and contextual analyses, Shott (1992:Table 6) estimates that Childers was occupied from A.D. 510 or 525 to A.D. 646 or 657 (calibrated A.D. 630 or 634 to A.D. 680 or 684).

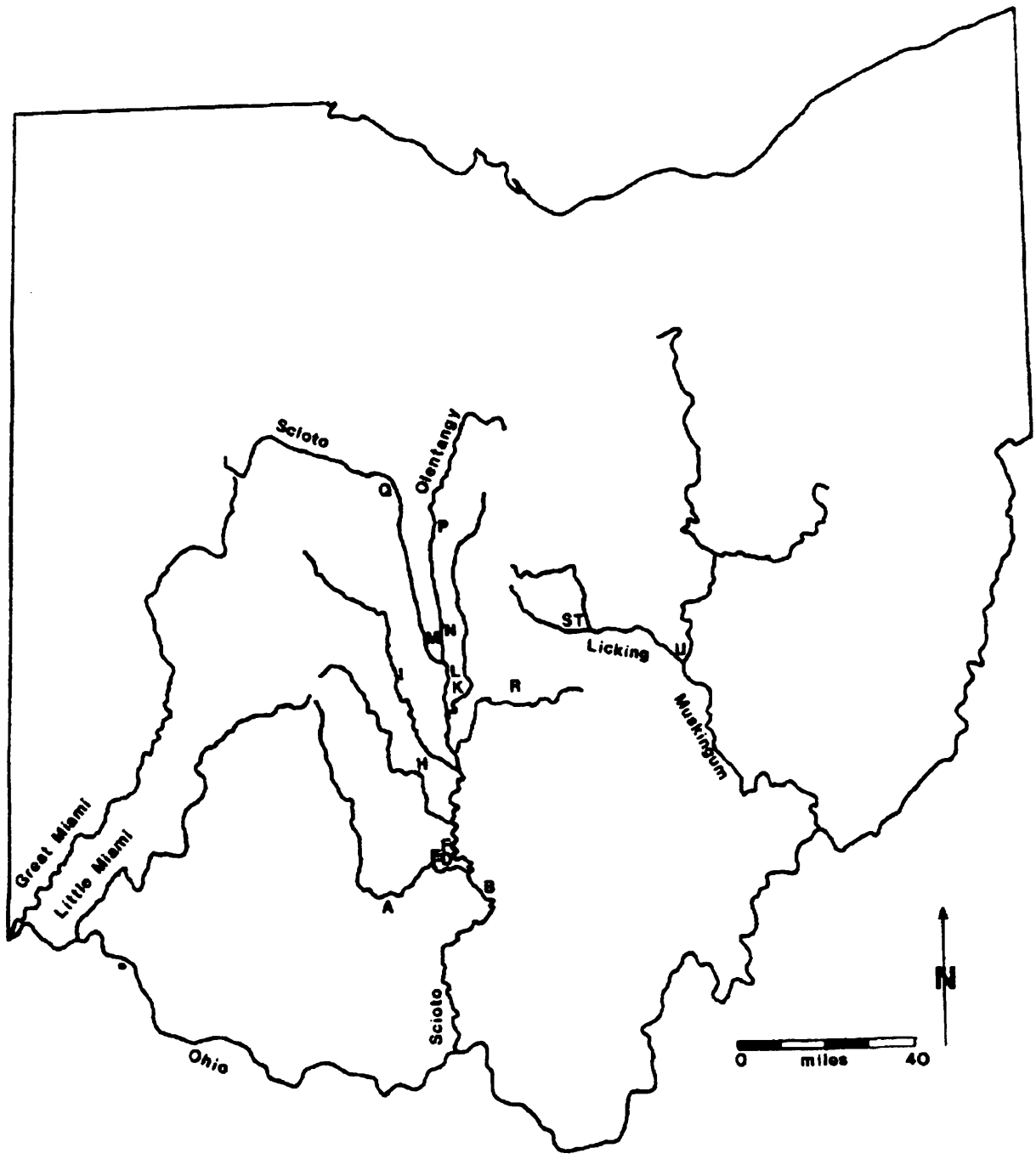

Figure 1. Geographic distribution of archaeological sites in Ohio from which carbon samples and ceramic collections were analzed. (A) Howard Baum. (B) Harness-28. (D) McGraw. (E) Blain. (F) Continental Construction. (H) Florence. (I) O.C. Voss. (K) Waterplant. (L) Scioto Trails. (M) Toephner. (N) Dominion Land Company. (P) W.S. Cole. (Q) Greencamp. (R) Phillip Smith. (S) Murphy. (T) Newark Campus. (U) Locust.

Table 1. Carbon Samples and Their Contexts of Deposition

	Sample No.	Carr's+ Assoc. No.	Site	Intrasite Provenience
Sites and Features with Early Woodland Ceramics				
*	ETH 3312	40	Continental Construction, Ross Co.	Feature 15, large shallow pit; sample scattered throughout pit
*	ETH 3072	55	Dominion Land Co., Franklin Co.	Feature 3, pit, east end; within the enclosure trench
*	ETH 3071	56B	Dominion Land Co., Franklin Co.	Feature 8, pit, bottom; within the enclosure trench
*	ETH 3073	54	Dominion Land Co., Franklin Co.	Feature 1, pit, one location within it; within enclosure trench
*	ETH 4241	57	Dominion Land Co., Franklin Co.	Feature 7, refuse pit
	C 942		Toephner Mound, Franklin Co.	Feature 7, log tomb
*	SMU 2163	46B	Toephner Mound, Franklin Co.	Feature 6, Burial 24, accession no. 3369/156
	M 521		Toephner Mound, Franklin Co.	Feature 9, log tomb
	C 923		Toephner Mound, Franklin Co.	Feature 2, log tomb
	M 520		Toephner Mound, Franklin Co.	Feature 5, log tomb
	M 517		Toephner Mound, Franklin Co.	Feature 2, log tomb
	M 518		Toephner Mound, Franklin Co.	Feature 3, log tomb
	M 519		Toephner Mound, Franklin Co.	Feature 4, log tomb
*	ETH 3481	48A	Phillip Smith Mound, Fairfield Co.	Feature 7, storage pit in premound floor
*	ETH 3310	49A+B	Phillip Smith Mound, Fairfield Co.	Post hole 40 of structure on premound floor
*	ETH 3311	52	Phillip Smith Mound, Fairfild Co.	Burial 2, dug into primary mound and overlain by secondary mound
*	SMU 1919	47B	Florence Mound, Pickaway Co.	Feature 5, central fire place on mound floor
	C 874		Florence Mound, Pickaway Co.	
*	ETH 3487	67D	Locust, Muskingham Co.	Feature 19, shallow basin, flotation sample from fill throughout
*	ETH 3070	69A	Locust, Muskingham Co.	Feature 13, shallow basin, flotation sample from fill throughout
*	SMU 1868	68B	Locust, Muskingham Co.	Feature 7, shallow pit, flotation sample from fill throughout
Sites and Features with Middle Woodland Ceramics				
*	ETH 3069	26A	Harness-28, Ross Co.	Large refuse trough, 35S, 0E, 30-35" level
*	ETH 3068	27A	Harness-28, Ross Co.	Large refuse trough, 35S, 5E, 25-35" level
*	ETH 4242	28	Harness-28, Ross Co.	Large refuse trough, 40S, 5E, SW 1/4, 33"+ level
*	ETH 3074	53B	Newark Campus, Licking Co.	Feature 4, SW quarter, bottom to 15 cm. above
*	SMU 2438	53A	Newark Campus, Licking Co.	Feature 4, refuse pit, NE and SW quadrats, 10-20 cm level
	UCLA 685		McGraw, Ross Co.	Square B1, midden
*	ETH 2885	31	McGraw, Ross Co.	Square D1, midden
*	ETH 2884	33	McGraw, Ross Co.	Square C1, midden
	UCLA 679A		McGraw, Ross Co.	Square D1, midden
*	ETH 2883	32	McGraw, Ross Co.	Square D1, midden
	UCLA 679B		McGraw, Ross Co.	Square D1, midden

Table 1. continued on next page.

Table 1 continued. Carbon Samples and Their Contexts of Deposition

	Sample No.	Carr's* Assoc. No.	Site	Intrasite Provenience
	MI 1558		McGraw, Ross Co.	?
	UCLA 705		McGraw, Ross Co.	Square B1, midden
	UCLA 688		McGraw, Ross Co.	?
	OWU 62		McGraw, Ross Co.	Square D2, midden
	UCLA 679C		McGraw, Ross Co.	Square C1, midden
	OWU 61		McGraw, Ross Co..	Square C1, midden
	BETA 15267		Murphy, Licking Co.	Feature 14, stratum III
	BETA 16619		Murphy, Licking Co.	Feature 14, stratum II
*	AA 2823	12	Murphy, Licking Co.	Feature 81, bottom of post mold or small refuse pit
	BETA 16620		Murphy, Licking Co.	Feature 100A, stratum I
	BETA 16621		Murphy, Licking Co.	Feature 130, stratum I
*	ETH 4243	13	Murphy, Licking Co.	Feature 68, earth oven, center and bottom
Sites and Features with Early Late Woodland Ceramics				
	BETA 15506		Waterplant, Franklin Co.	Feature 12, east and west quarters
	BETA 15508		Waterplant, Franklin Co.	Feature 76, 12.5-24.5 cm. level
	BETA 15507		Waterplant, Franklin Co.	Feature 21, 39-49 cm. level
*	SMU 1973	19	Waterplant, Franklin Co.	Feature 90, pit, 40-59 cm. level
*	SMU 1964	8B	Scioto Trails, Franklin Co.	Square 3L3, Feature 5, refuse pit, 35-40 cm. level
*	ETH 3067	9B	Scioto Trails, Franklin Co.	Pit, east half, in square 12or9R3, 70-80 cm. level
	BETA 4348		Scioto Trails, Franklin Co.	Square 3L3, Feature 5, refuse pit, 40-45 cm. level
	BETA 4349		Scioto Trails, Franklin Co.	Square 3L3, Feature 5, refuse pit, 50-55 cm. level
	BETA 4350		Scioto Trails, Franklin Co.	Square 6R0, Feature 6, SE corner, burnt earth and ash layer, 25-30 cm level
	BETA 4347		Scioto Trails, Franklin Co.	Square 0, Feature 2, refuse pit, 30-35 cm level
*	ETH 3309	41BX	Continental Construction, Ross Co.	Feature 5, basin in upper half used as refuse pit
Sites and Features with Late Late Woodland, Cole Ceramics				
*	ETH 2886	44A+B	Greencamp, Marion Co.	pit
*	ETH 4502	44C+D	Greencamp, Marion Co.	pit
*	ETH 3926	72A	W. S. Cole, Delaware Co.	Feature 3, refuse pit, below level 2
*	SMU 2083	71A	W. S. Cole, Delaware Co.	Feature 1, refuse pit, level 3
	DIC 2284		W. S. Cole, Delaware Co.	Scattered sample from midden
*	ETH 4244	38A	Howard Baum, Ross Co.	Feature 12, scattered locations in fill
	DIC 1928		Howard Baum, Ross Co.	Feature 4, north half, refuse pit, 40-80 cm.
*	SMU 1930	39	Howard Baum, Ross Co.	Feature 3, storage pit, scattered locations in fill

Table 1. continued on next page.

Table 1 continued. Carbon Samples and Their Contexts of Deposition

	Sample No.	Carr's[+] Assoc. No.	Site	Intrasite Provenience
Sites and Features with Fort Ancient Ceramics				
	OWU 229b		O. C. Voss Village, Franklin Co.	190L12
	M 1875		O. C. Voss Village, Franklin Co.	Feature 7
	M 1882		O. C. Voss Village, Franklin Co.	Feature 20
	M 1881		O. C. Voss Village, Franklin Co.	Feature 19
	OWU 243b		O. C. Voss Village, Franklin Co.	Feature 9
	M 1873		O. C. Voss Village, Franklin Co.	Feature 4
	M 1870		O. C. Voss Village, Franklin Co.	Feature 2
	OUW 244		O. C. Voss Village, Franklin Co.	Feature 11
	M 1872		O. C. Voss Village, Franklin Co.	Feature 3
	M 1871		O. C. Voss Village, Franklin Co.	Feature 2
	M 1879		O. C. Voss Village, Franklin Co.	Feature 14
	M 1877		O. C. Voss Village, Franklin Co.	Feature 9
	OWU 245		O. C. Voss Village, Franklin Co.	Feature 19
*	ETH 4500	85A	O. C. Voss Village, Franklin Co.	Feature 21, refuse pit, 2.65 feet below plowzone
	M 1883		O. C. Voss Village, Franklin Co.	Feature 11
	M 1884		O. C. Voss Village, Franklin Co.	190L12
	M 1876		O. C. Voss Village, Franklin Co.	Feature 8
	OWU 246		O. C. Voss Village, Franklin Co.	Feature 20
	OWU 248		Blain Village, Ross Co.	Feature 2, large, cylindrical, unstratified refuse pit
	OWU 247b		Blain Village, Ross Co.	Feature 4b. large, cylindrical, stratified, ceremonial (?) pit
	M 1911		Blain Village, Ross Co.	Feature 1, large, basin-shaped, stratified refuse pit
	M 1910		Blain Village, Ross Co.	Feature 6, charred logs of a possible house
	OWU 247a		Blain Village, Ross Co.	Feature 4a, large, bell-shaped, unstratified refuse pit
*	ETH 4501	76A	Blain Village, Ross Co.	Feature 18, refuse pit, probably near bottom, between 1.6 and 2.3 feet below plowzone

[+] The association number used by Carr to refer to, label, and store all ceramic collections from features and all carbon samples associated with them, at the Ohio Historical Center, Columbus, and Kent State University, Kent, OH. The ceramic and carbon samples from the McGraw site at the University of Michigan, and those from the Newark Campus site at the Licking County Landmarks and Historical Society may not have been stored separate from the remainder of the collections and by association number.

* Indicates a new date.

Table 2. Bibliographic References for Sites and Radiocarbon Dates Analyzed Here

Sample No.	Site	Bibliographic Reference**
Sites and Features with Early Woodland Ceramics		
* ETH 3312	Continental Construction	field notes, Licking Co. Archaeological and Landmarks Society
* ETH 3072	Dominion Land Co.	this report, field notes, Ohio Historical Center, Columbus
* ETH 3071	Dominion Land Co.	this report; field notes, Ohio Historical Center, Columbus
* ETH 3073	Dominion Land Co.	this report; field notes, Ohio Historical Center, Columbus
* ETH 4241	Dominion Land Co.	this report; field notes, Ohio Historical Center, Columbus
C942	Toephner Mound	Web, and Baby1957:110; Norris 1985:135
* SMU 2163	Toephner Mound	this report; Norris 1985
M 521	Toephner Mound	Ford 1969:25; Norris 1985:135
C 923	Toephner Mound	Webb and Baby 1957:110; Norris 1985:135
M 520	Toephner Mound	Ford 1969:25; Norris 1985:135
M 517	Toephner Mound	Ford 1969:25; Norris 1985:135
M 518	Toephner Mound	Ford 1969:25; Norris 1985:135
M 519	Toephner Mound	Ford 1969:25; Norris 1985:135
* ETH 3481	Phillip Smith Mound	this report; field notes, Ohio Historical Center, Columbus
* ETH 3311	Phillip Smith Mound	this report; field notes, Ohio Historical Center, Columbus
* ETH 3310	Phillip Smith Mound	this report; field notes, Ohio Historical Center, Columbus
* SMU 1919	Florence Mound	this report; field notes, Ohio Historical Center, Columbus
C 874	Florence Mound	Webb and Baby 1957:110
* ETH 3487	Locust	this report; Seeman 1985
* ETH 3070	Locust	this report; Seeman 1985
* SMU 1868	Locust	this report; Seeman 1985
Sites and Features with Middle Woodland Ceramics		
* ETH 3069	Harness-28	this report; field notes, Kent State University
* ETH 3068	Harness-28	this report; field notes, Kent State University
* ETH 4242	Harness-28	this report; field notes, Kent State University
* ETH 3074	Newark Campus	this report, field notes, Ohio State University
* SMU 2438	Newark Campus	this report; field notes, Ohio State University
UCLA 685	McGraw	Prufer 1965:104
* ETH 2885	McGraw	this report; Prufer 1965
* ETH 2884	McGraw	this report; Prufer 1965
UCLA 679A	McGraw	Prufer 1965:104
* ETH 2883	McGraw	this report; Prufer 1965
UCLA 679B	McGraw	Prufer 1965:104
MI 1558	McGraw	Prufer 1965:104
UCLA 705	McGraw	Prufer 1965:104
UCLA 688	McGraw	Prufer 1965:104
OWU 62	McGraw	Prufer 1965:104
UCLA 679C	McGraw	Prufer 1965:104
OWU 61	McGraw	Prufer 1965:104
BETA 15267	Murphy	Dancey 1991:50
BETA 16619	Murphy	Dancey 1991:50
* AA 2823	Murphy	this report; Dancey 1991
BETA 16620	Murphy	Dancey 1991:50
BETA 16621	Murphy	Dancey 1991:50
* ETH 4243	Murphy	this report; Dancey 1991

Table 2 continued on next page.

Table 2. Bibliographic References for Sites and Radiocarbon Dates Analyzed Here

Sample No.	Site	Bibliographic Reference**
Sites and Features with Early Late Woodland Ceramics		
BETA 15506	Waterplant	Dancey 1988:252
BETA 15508	Waterplant	Dancey 1988:252
BETA 15507	Waterplant	Dancey 1988:252
* SMU 1973	Waterplant	this report; Dancey 1988
* SMU 1964	Scioto Trails	this report; field notes, Ohio Historical Center, Columbus
* ETH 3067	Scioto Trails	this report; field notes, Ohio Historical Center, Columbus
BETA 4348	Scioto Trails	M. Otto, pers. comm. 1996; field notes, Ohio Historical Center, Columbus
BETA 4349	Scioto Trails	M. Otto, pers. comm. 1996; field notes, Ohio Historical Center, Columbus
BETA 4350	Scioto Trails	M. Otto, pers. comm. 1996; field notes, Ohio Historical Center, Columbus
BETA 4347	Scioto Trails	M. Otto, pers. comm. 1996; field notes, Ohio Historical Center, Columbus
* ETH 3309	Continental Constr.	this report; field notes, Licking Co. Arch. and Landmarks Society
Sites and Features with Late Late Woodland, Cole Ceramics		
* ETH 2886	Greencamp	this report; site records, Ohio Historical Center, Columbus
* ETH 4502	Greencamp	this report; site records, Ohio Historical Center, Columbus
* ETH 3926	W. S. Cole	this report; field notes, Ohio Historical Center, Columbus
* SMU 2083	W. S. Cole	this report; field notes, Ohio Historical Center, Columbus
DIC 2284	W. S. Cole	field notes, Ohio Historical Center, Columbus
* ETH 4244	Howard Baum	this report; field notes, Ohio Historical Center, Columbus
DIC 1928	Howard Baum	field notes, Ohio Historical Center, Columbus
* SMU 1930	Howard Baum	this report; field notes, Ohio Historical Center, Columbus
Sites and Features with Fort Ancient Ceramics		
OWU 229b	O. C. Voss Village	Ogden and Hay 1960
M 1875	O. C. Voss Village	Shane 1975:363
M 1882	O. C. Voss Village	Shane 1975:363
M 1881	O. C. Voss Village	Shane 1975:363
OWU 243b	O. C. Voss Village	Ogden and Hay 1960
M 1873	O. C. Voss Village	Shane 1975:363
M 1870	O. C. Voss Village	Shane 1975:363
OWU 244	O. C. Voss Village	Shane 1975:363
M 1872	O. C. Voss Village	Shane 1975:363
M 1871	O. C. Voss Village	Shane 1975:363
M 1879	O. C. Voss Village	Shane 1975:363
M 1877	O. C. Voss Village	Shane 1975:363
OWU 245	O. C. Voss Village	Ogden and Hay 1960
M 1884	O. C. Voss Village	Shane 1975:363
M 1883	O. C. Voss Village	Shane 1975:363
M 1876	O. C. Voss Village	Shane 1975:363
OWU 246	O. C. Voss Village	Ogden and Hay 1960
* ETH 4500	O. C. Voss Village	this report
OWU 248	Blain Village	Prufer and Shane 1970:232
OWU 247b	Blain Village	Prufer and Shane 1970:232
M 1911	Blain Village	Prufer and Shane 1970:232
M 1910	Blain Village	Prufer and Shane 1970:232
OWU 247a	Blain Village	Prufer and Shane 1970:232
* ETH 4501	Blain Village	this report; Prufer and Shane 1970

* Indicates a new date.

** References with page numbers list the radiocarbon assay. References without page numbers provide general information on the archaeology of the site.

Table 3. Carbon Samples and Their Nature*

Sample No.	Site	Description of Sample	Derived by Flotation?
Sites and Features with Early Woodland Ceramics			
ETH 3312	Continental Construction	2.43 g. hickory and sycamore wood charcoal	N
ETH 3072	Dominion Land Co.	.45 g. of one hickory (pignut?) nutshell and nut meat	N
ETH 3071	Dominion Land Co.	.6 g. hickory nutshell and a little nut meat	N
ETH 3073	Dominion Land Co.	.12 g. probably hickory, or less probably walnut, wood charcoal; all of the same species	N
ETH 4241	Dominion Land Co.	1.55 g. shagbark hickory nutshell with some meat	N
SMU 2163	Toephner Mound	1.1 g. charred wood stick, 10 rings	N
ETH 3481	Phillip Smith Mound	1 g. hickory nutshell	N
ETH 3310	Phillip Smith Mound	.8 g. hickory nutshell and unidentifiable nut meat	N
ETH 3311	Phillip Smith Mound	1.05 g. wood and bark charcoal, unidentified species	N
SMU 1919	Florence Mound	5.1 g. shagbark hickory nutshell	N
ETH 3487	Locust	.14 g. hickory nutshell	Y
ETH 3070	Locust	.91 g. wood charcoal, unidentified	Y
SMU 1868	Locust	2.23 g. wood charcoal, unidentified sp.	Y
Sites and Features with Middle Woodland Ceramics			
ETH 3069	Harness-28	.54 g. hickory nutshell; .07 g. *Juglandaceae* nutshell; .19 g. walnut shell	Y
ETH 3068	Harness-28	1.08 g. hickory nutshell	Y
ETH 4242	Harness-28	1.04 g. hickory nutshell	Y
ETH 3074	Newark Campus	.36 g. hickory nut, hazelnut, acorn shell	N
SMU 2438	Newark Campus	5.23 g. nearly all white (?) oak wood charcoal	N
ETH 2885	McGraw	carbonized food remains on interior of 1 pottery sherd	N
ETH 2884	McGraw	carbonized food remains on interior of 1 pottery sherd	N
ETH 2883	McGraw	carbonized food remains on interior of 1 pottery sherd	N
AA 2823	Murphy	carbonized food remains on interior of 2 pottery sherds	N
ETH 4243	Murphy	1.035 g. wood charcoal, unidentified sp.	N
Sites and Features with Early Late Woodland Ceramics			
SMU 1973	Waterplant	3.34 g. maple, hickory, ash, elm wood charcoal	N
SMU 1964	Scioto Trails	1.307 g. walnut, .210 g. white oak, .057 g. honey locust, unidentified wood charcoal	N
ETH 3067	Scioto Trails	1 shagbark hickory nutshell	N
ETH 3309	Continental Construction	.878 g. butternut and hickory shell; .568 g. wood charcoal	Y
Sites and Features with Late Late Woodland, Cole Ceramics			
ETH 2886	Greencamp	carbonized food remains on interior of 1 pottery sherd	N
ETH 4502	Greencamp	carbonized food remains on interior of 8 sherds from one pot	N
ETH 3926	W. S. Cole	.41 g. white oak wood charcoal, 5 rings of a developed tree; preservative possibly used on this sample	N
SMU 2083	W. S. Cole	1.52 g. honey locust, .88 g. sugar maple, .05 g. hophornbeem; preservative possibly used on this sample	N
ETH 4244	Howard Baum	wood charcoal, unidentified	N
SMU 1930	Howard Baum	16.1 g. elm, walnut, possibly mulberry wood charcoal in large chunks	N
Sites and Features with Fort Ancient Ceramics			
ETH 4500	O. C. Voss Village	2.1 g. hickory wood charcoal	N
ETH 4501	Blain Village	.93 g. hickory sp., .71 g butternut, .22 g. black walnut	N

* Wood and nut species were identified by Dee Ann Wymer.

Table 4. Beta-Count and AMS Radiocarbon Dates and Corrections

Sample No.	Site	C-14 Date B.P. Uncorrected	Calendar Date	$\delta^{13}/_{12}C$**	C-14 Date B.P. Corrected	Calendar Date, Corrected
Sites and Features with Early Woodland Ceramics						
* ETH 3312	Continental Construction	3140 +/- 100	1190 B.C.	-27.4	3100 +/- 100	1150 B.C.
* ETH 3072	Dominion Land Co.	2515 +/- 95	565 B.C.	-22.7	2555 +/- 100	605 B.C.
* ETH 3071	Dominion Land Co.	2470 +/- 95	520 B.C.	-26.9	2440 +/- 100	490 B.C.
* ETH 3073	Dominion Land Co.	2235 +/- 95	285 B.C.	-26.4	2210 +/- 100	260 B.C.
* ETH 4241	Dominion Land Co.	2190 +/- 75	240 B.C	-28.3	2135 +/- 80	185 B.C.
C 942	Toephner Mound	2780 +/ 410	830 B.C.			
* SMU 2163	Toephner Mound	2431 +/- 235	481 B.C	.-26.1	2414 +/- 235	464 B.C.
M 521	Toephner Mound	2410 +/- 200	460 B.C.			
C 923	Toephner Mound	2377 +/- 150	427 B.C.			
M 520	Toephner Mound	2350 +/- 200	400 B.C.			
M 517	Toephner Mound	2300 +/- 200	350 B.C.			
M 518	Toephner Mound	2280 +/- 200	330 B.C.			
M 519	Toephner Mound	2200 +/- 200	250 B.C.			
* ETH 3481	Phillip Smith Mound	2360 +/- 80	410 B.C.	-24.9	2360 +/- 90	410 B.C.
* ETH 3311	Phillip Smith Mound	2350 +/- 105	400 B.C.	-24.9	2350 +/- 110	400 B.C.
* ETH 3310	Phillip Smith Mound	2300 +/- 85	350 B.C.	-25.7	2285 +/- 100	335 B.C.
* SMU 1919	Florence Mound	2210 +/- 66	260 B.C.	-25.1	2209 +/- 66	230 B.C.
C 874	Florence Mound	1425 +/- 250	525 A.D.			
* ETH 3487	Locust	1905 +/- 90	45 A.D.	-23.5	1930 +/- 100	20 A.D.
* ETH 3070	Locust	1870 +/- 75	80 A.D.	-27.2	1835 +/- 80	115 A.D.
* SMU 1868	Locust	1832 +/- 146	118 A.D.	-26.3	1811 +/- 146	151 A.D.
Sites and Features with Middle Woodland Ceramics						
* ETH 3069	Harness-28	3545 +/- 90	1595 B.C.	-26.1	3525 +/- 95	1575 B.C.
* ETH 3068	Harness-28	2020 +/- 85	70 B.C.	-21.6	2075 +/- 90	125 B.C.
* ETH 4242	Harness-28	1725 +/- 75	225 A.D.	-26.7	1700 +/- 80	250 A.D.
* ETH 3074	Newark Campus	2000 +/- 95	50 B.C.	-25.6	1990 +/- 100	40 B.C.
* SMU 2438	Newark Campus	1557 +/- 100	393 A.D.	-25.6	1547 +/- 100	403 A.D.
UCLA 685	McGraw	2180 +/- 80	230 B.C.			
* ETH 2885	McGraw	1985 +/- 90	35 A.D.	-25.2	1980 +/- 100	30 B.C.*
ETH 2884	McGraw	1700 +/- 125	250 A.D.	-16.7	1830 +/- 135	120 A.D.
UCLA 679A	McGraw	1810 +/- 80	140 A.D.			
ETH 2883	McGraw	1790 +/- 115	160 A.D.	-22.7	1810 +/- 80	140 A.D.
UCLA 679B	McGraw	1760 +/- 80	190 A.D.			
MI 1558	McGraw	1720 +/- 140	230 A.D.			
UCLA 705	McGraw	1670 +/- 80	280 A.D.			
UCLA 688	McGraw	1670 +/- 80	280 A.D.			
OWU 62	McGraw	1515 +/- 166	435 A.D.			
UCLA 679C	McGraw	1510 +/- 80	440 A.D.			
OWU 61	McGraw	1469 +/- 65	481 A.D.			
BETA 15267	Murphy	2040 +/- 80	90 B.C.			
BETA 16619	Murphy	1890 +/- 110	60 A.D.			
* AA 2823	Murphy	1823 +/- 80	127 A.D.	-25.94	1807 +/- 85	130 A.D.
BETA 16620	Murphy	1760 +/- 60	190 A.D.			
BETA 16621	Murphy	1740 +/- 60	210 A.D.			
* ETH 4243	Murphy	1700 +/- 65	250 A.D.	-31.9**	1590 +/- 70	360 A.D.

Table 4 continued on next page.

Table 4 continued. Beta-Count and AMSRadiocarbon Dates and Corrections

Sample No.	Site	C-14 Date B.P. Uncorrected	Calendar Date	$\delta^{13}/_{12}C$**	C-14 Date B.P. Corrected	Calendar Date, Corrected
Sites and Features with Early Late Woodland Ceramics						
BETA 15506	Waterplant	1450 +/- 80	500 A.D.			
BETA 15508	Waterplant	1450 +/- 70	500 A.D.			
BETA 15507	Waterplant	1330 +/- 70	620 A.D.			
* SMU 1973	Waterplant	1280 +/- 102	670 A.D.	-25.8	1267 +/- 102	616 A.D.
* SMU 1964	Scioto Trails	1448 +/- 40	502 A.D.	-25.7	1437 +/- 40	515 A.D.
* ETH 3067	Scioto Trails	1435 +/- 80	515 A.D.	-25.6	1425 +/- 90	525 A.D.
BETA 4348	Scioto Trails	1330 +/- 60	620 A.D.			
BETA 4349	Scioto Trails	1200 +/- 60	750 A.D.			
BETA 4350	Scioto Trails	1170 +/- 50	780 A.D.			
BETA 4347	Scioto Trails	950 +/- 50	1000 A.D.			
* ETH 3309	Continental Construction	1205 +/- 90	745 A.D.	-27.7	1160 +/- 100	790 A.D.
Sites and Features with Late Late Woodland, Cole Ceramics						
* ETH 2886	Greencamp	1500 +/- 105	450 A.D.	-20.3	1575 +/- 100	375 A.D.
* ETH 4502	Greencamp	715 +/- 65	1235 A.D.	-27.9	670 +/- 70	1280 A.D.
* ETH 3926	W. S. Cole	745 +/- 70	1205 A.D.	-26.8	715 +/- 75	1235 A.D.
* SMU 2083	W. S. Cole	743 +/- 154	1207 A.D.	-25.9	728 +/- 154	1294 A.D.
DIC 2284	W. S. Cole	680 +/- 55	1270 A.D.			
* ETH 4244	Howard Baum	745 +/- 70	1205 A.D.	-25.0	745 +/- 75	1205 A.D.
DIC 1928	Howard Baum	710 +/- 55	1240 A.D.			
* SMU 1930	Howard Baum	640 +/- 41	1310 A.D.	-24.6	646 +/- 41	1298 A.D.
Sites and Features with Fort Ancient Ceramics						
OWU 229b	O. C. Voss Village	1040 +/- 215	910 A.D.			
M 1875	O. C. Voss Village	1030 +/- 120	920 A.D.			
M 1882	O. C. Voss Village	880 +/- 100	1070 A.D.			
M 1881	O. C. Voss Village	830 +/- 100	1120 A.D.			
OWU 243b	O. C. Voss Village	815 +/- 220	1135 A.D.			
M 1873	O. C. Voss Village	780 +/- 100	1170 A.D.			
M 1870	O. C. Voss Village	720 +/- 100	1230 A.D.			
OWU 244	O. C. Voss Village	675 +/- 90	1275 A.D.			
M 1872	O. C. Voss Village	575 +/- 100	1375 A.D.			
M 1871	O. C. Voss Village	550 +/- 100	1400 A.D.			
M 1879	O. C. Voss Village	540 +/- 100	1410 A.D.			
M 1877	O. C. Voss Village	520 +/- 100	1430 A.D.			
OWU 245	O. C. Voss Village	517 +/- 110	1433 A.D.			
M 1884	O. C. Voss Village	470 +/- 150	1480 A.D.			
M 1883	O. C. Voss Village	470 +/- 100	1480 A.D.			
M 1876	O. C. Voss Village	450 +/- 100	1500 A.D.			
* ETH 4500	O. C. Voss Village	425 +/- 75	1525 A.D.	-27.6	380 +/- 80	1570 A.D.
OWU 246	O. C. Voss Village	387 +/- 158	1563 A.D.			
OWU 248	Blain Village	1035 +/- 55	915 A.D.			
OWU 247b	Blain Village	970 +/- 220	980 A.D.			
M 1911	Blain Village	760 +/- 100	1190 A.D.			
M 1910	Blain Village	490 +/- 100	1460 A.D.			
OWU 247a	Blain Village	405 +/- 150	1545 A.D.			
* ETH 4501	Blain Village	365 +/- 70	1585 A.D.	-30.8**	270 +/- 75	1680 A.D.

* Indicates new date.

** Indicates $\delta\ ^{13}/_{12}C$ is out of line; thus the corrected date may be inaccurate.

Table 5. Beta-Count and AMS Radiocarbon Calibrations

Sample No.	Site	Calibrated, All Samples** Bidecadal; Lab Mult. = 1 min (cal. date) max	Calibrated, All Samples** Bidecadal; Lab Mult. = 1.8 min ( ) max	Calibrated, Only AMS Samples; Decadal; Lab Mult. = 1
Sites and Features with Early Woodland Ceramics				
* ETH 3312	Continental Constr.	1446 (1390, 1330) 1216 B.C.	n/a	
* ETH 3072	Dominion Land Co.	808 (780) 522 B.C.	n/a	805 (770) 429 B.C.
* ETH 3071	Dominion Land Co.	772 (510, 430) 395 B.C.	n/a	767 (500, 490, 480, 470, 430, 420, 410) 394 B.C.
* ETH 3073	Dominion Land Co.	389 (350, 320, 200) 113 B.C.	n/a	
* ETH 4241	Dominion Land Co.	351 (170) 43 B.C.	n/a	349 (170) 4 B.C.
C 942	Toephner Mound	1435 (910) 401 B.C.	1874 () 37 B.C.	
* SMU 2163	Toephner Mound	807 (410) 195 B.C.	n/a	803 (410) 175 B.C.
M 521	Toephner Mound	779 (410) 205 B.C.	906 () 40 B.C.	
C 923	Toephner Mound	767 (400) 210 B.C.	806 () 110 B.C.	
M 520	Toephner Mound	778 (400) 181 B.C.	831 B.C. () 19 A.D.	
M517	Toephner Mound	760 (380) 102 B.C.	809 B.C. () 76 A.D.	
M 518	Toephner Mound	755 (380) 58 B.C.	805 B.C. () 84 A.D.	
M 519	Toephner Mound	406 (340, 320, 200 B.C.) 12 A.D.	784 B.C. () 215 A.D.	
* ETH 3481	Phillip Smith Mound	518 (400) 372 B.C.	n/a	678 (400) 262 B.C.
* ETH 3311	Phillip Smith Mound	750 (400) 257 B.C.	n/a	
* ETH 3310	Phillip Smith Mound	404 (380) 197 B.C	n/a	404 (380) 202 B.C.
* SMU 1919	Florence Mound	374 (350, 320, 200) 175 B.C.	n/a	363 (350, 320, 230, 220, 210) 169 B.C.
C 874	Florence Mound	400 (640) 885 A.D.	132 () 1030 A.D.	
* ETH 3487	Locust	31 B.C. (80 A.D.) 223 A.D.	n/a	38 B.C. (80 A.D.) 227 A.D.
* ETH 3070	Locust	85 (220) 322 A.D.	n/a	
* SMU 1868	Locust	67 (230) 410 A.D.	n/a	
Sites and Features with Middle Woodland Ceramics				
* ETH 3069	Harness-28	1959 (1880, 1830, 1820, 1800, 1790) 1699 B.C.	n/a	2007 (1880, 1840, 1830, 1790, 1780) 1692 B.C.
ETH 3068	Harness-28	191 B.C. (50 B.C.) 23 A.D.	n/a	199 B.C. (50 B.C.) 50 A.D.
* ETH 4242	Harness-28	248 (380) 428 A.D.	n/a	255 (360, 370, 380) 426 A.D
* ETH 3074	Newark Campus	90 B.C. (20 A.D.) 125 A.D.	n/a	89 B.C. (50 B.C.) 50 A.D.
* SMU 2438	Newark Campus	416 (540) 631 A.D.	n/a	

Table 5 continued on next page.

Table 5 continued. Beta-Count and AMS Radiocarbon Calibrations

Sample No.	Site	Calibrated, All Samples** Bidecadal; Lab Mult. = 1 min (cal. date) max	Calibrated, All Samples** Bidecadal; Lab Mult. = 1.8 min ( ) max	Calibrated, Only AMS Samples; Decadal; Lab Mult. = 1
UCLA 685	McGraw	368 (200) 101 B.C.	392 () 34 B.C.	
* ETH 2885	McGraw	196 B.C. (30, 40, 50 A.D.) 249 A.D.	n/a	86 B.C. (30, 40, 50 A.D.) 130 A.D.
* ETH 2884	McGraw	62 (220) 386 A.D.	n/a	31 (180, 190, 220) 384 A.D.
UCLA 679A	McGraw	124 (230) 335 A.D.	69 () 409 A.D.	
* ETH 2883	McGraw	89 (240) 402 A.D.	n/a	84 (240, 310, 320) 408 A.D.
UCLA 679B	McGraw	213 (260, 300, 320) 398 A.D.	89 () 429 A.D.	
MI 1558	McGraw	140 (340) 531 A.D.	57 () 611 A.D.	
UCLA 705	McGraw	259 (410) 446 A.D.	232 () 549 A.D.	
UCLA 688	McGraw	259 (410) 592 A.D.	232 () 549 A.D.	
OWU 62	McGraw	396 (560) 668 A.D.	232 () 813 A.D.	
UCLA 679C	McGraw	444 (560, 590) 641 A.D.	413 () 664 A.D.	
OWU 61	McGraw	545 (610) 653 A.D.	447 () 668 A.D.	
BETA 15267	Murphy	157 B.C. (40 B.C.) 66 A.D.	196 B.C. () 122 A.D.	
BETA 16619	Murphy	11 (120) 249 A.D.	65 B.C. () 388 AD.	
* AA 2823	Murphy	123 (240) 340 A.D.	n/a	91 (240) 376 A.D.
BETA 16620	Murphy	228 (260, 280, 330) 398 A.D.	135 () 415 A.D.	
BETA 16621	Murphy	238 (260, 280, 330) 428 A.D.	146 () 423 A.D.	
* ETH 4243	Murphy	411 (450) 554 A.D.	n/a	
Sites and Features with Early Late Woodland Ceramics				
BETA 15506	Waterplant	547 (630) 663 A.D.	442 () 687 A.D.	
BETA 15508	Waterplant	551 (630) 660 A.D.	467 () 679 A.D.	
BETA 15507	Waterplant	653 (680) 776 A.D.	621 () 868 A.D.	
* SMU 1973	Waterplant	662 (730, 770) 887 A.D.	627 () 982 A.D.	
* SMU 1964	Scioto Trails	605 (636) 655 A.D.	562 (640) 664 A.D.	
* ETH 3067	Scioto Trails	557 (640) 674 A.D.	n/a	544 (640) 687 A.D.
BETA 4348	Scioto Trails	656 (680) 772 A.D.	635 () 789 A.D.	
BETA 4349	Scioto Trails	775 (870) 941 A.D.	685 () 977 A.D.	
BETA 4350	Scioto Trails	789 (886) 962 A.D.	775 (890, 984) A.D.	
BETA 4347	Scioto Trails	1022 (1041, 1150) A.D.	1010 (1040, 1150) 1214	
* ETH 3309	Continental Con.	775 (890) 997 A.D.	n/a	
Sites and Features with Late Late Woodland, Cole Ceramics				
* ETH 2886	Greencamp	400 (530) 608 A.D.	n/a	400 (530) 608 A.D.
* ETH 4502	Greencamp	1283 (1300) 1396 A.D.	n/a	1281 (1300) 1394 A.D.

Table 5 continued on next page.

Table 5 continued. Beta-Count and AMS Radiocarbon Calibrations

	Sample No.	Site	Calibrated, All Samples** Bidecadal; Lab Mult. = 1 min (cal. date) max	Calibrated, All Samples** Bidecadal; Lab Mult. = 1.8 min ( ) max	Calibrated, Only AMS Samples; Decadal; Lab Mult. = 1
*	ETH 3926	W. S. Cole	1261 (1290) 1379 A.D.	n/a	1261 (1290) 1379 A.D.
*	SMU 2083	W. S. Cole	1171 (1290) 1402 A.D.	1020 () 1443 A.D.	
	DIC 2284	W. S. Cole	1284 (1300) 1389 A.D.	1275 () 1400 A.D.	
*	ETH 4244	Howard Baum	1229 (1280) 1300 A.D.	n/a	
	DIC 1928	Howard Baum	1277 (1290) 1304 A.D.	1242 () 1393 A.D.	
*	SMU 1930	Howard Baum	1295 (1306, 1364, 1375) 1394	1287 (1310, 1360, 1380) 1402 A.D.	
Sites and Features with Fort Ancient Ceramics					
	OWU 229b	O. C. Voss Village	777 (1010) 1227 A.D.	642 () 1371 A.D.	
	M 1875	O. C. Voss Village	890 (1010) 1162 A.D.	780 () 1239 A.D.	
	M 1882	O. C. Voss Village	1028 (1180) 1276 A.D.	996 () 1293 A.D	
	M 1881	O. C. Voss Village	1051 (1230) 1286 A.D.	1019 () 1373 A.D.	
	OWU 243b	O. C. Voss Village	1012 (1240) 1485 A.D.	819 () 1454 A.D.	
	M 1873	O. C. Voss Village	1174 (1280) 1298 A.D.	1036 () 1395 A.D.	
	M 1870	O. C. Voss Village	1229 (1290) 1391 A.D.	1164 () 1410 A.D.	
	OWU 244	O. C. Voss Village	1278 (1300) 1399 A.D.	1222 () 1425 A.D.	
	M 1872	O. C. Voss Village	1298 (1400) 1437 A.D.	1280 () 1475 A.D.	
	M 1871	O. C. Voss Village	1304 (1410) 1444 A.D.	1285 () 1611 A.D.	
	M 1879	O. C. Voss Village	1307 (1410) 1446 A.D.	1287 () 1616 A.D.	
	M 1877	O. C. Voss Village	1315 (1420) 1454 A.D.	1292 () 1627 A.D.	
	OWU 245	O. C. Voss Village	1310 (1420) 1468 A.D.	1289 () 1635 A.D.	
	M 1884	O. C. Voss Village	1315 (1440) 1635 A.D.	1283 () 1953 A.D.	
	M 1883	O. C. Voss Village	1402 (1440) 1611 A.D.	1304 () 1644 A.D.	
	M 1876	O. C. Voss Village	1407 (1440) 1621 A.D.	1309 () 1651 A.D.	
	OWU 246	O. C. Voss Village	1408 (1480) 1663 A.D.	1299 () 1954 A.D.	
*	ETH 4500	O. C. Voss Village	1440 (1480) 1641 A.D.	n/a	
	OWU 248	Blain Village	977 (1010) 1029 A.D.	894 () 1154 A.D.	
	OWU 247b	Blain Village	880 (1030) 1282 A.D.	663 () 1402 A.D.	
	M 1911	Blain Village	1213 (1280) 1303 A.D.	1046 () 1400 A.D.	
	M 1910	Blain Village	1294 (1430) 1644 A.D.	1299 () 1638 A.D.	
	OWU 247a	Blain Village	1406 (1470) 1655 A.D.	1298 () 1954 A.D.	
*	ETH 4501	Blain Village	1517 (1650) 1954 A.D.	n/a	1521 (1650) 1953 A.D.

* Indicates a new date.

** Calibrations were determined by the computer program CALIB 3.0 (Stuiver and Reimer 1993), using the calibration data and methods described in the text.

() Indicates that the bidecadal calibrated date(s) calculated with a Lab Multiplier of 1.8 are the same as those calculated with a Lab Multiplier of 1.0.

Table 6. Tests of Consistency of Mutiple Radiocarbon Dates within Sites

Site	Samples Tested for Consistency; Modes Found*	Test Results, T' statistic** at .05 Signif. Level		Most Likely Inferred Causes of Inconsistencies
Dominion Land Co.	All: ETH 3072, ETH 3071, ETH 3073, ETH 4241	different	13.26	outlier ETH 3072
	Mode 1: ETH 3072	n/a		
	Mode 2: ETH 3071, ETH 3073, ETH 4241	same	5.73	
	Mode 1 mean: 780 B.C.			
	Mode 2 means: 510/430 - 170 B.C.			
Toephner Mound	All: C 942, SMU 2163, M 521, C 923, M 520, M 517, M 518, M 519	same	2.04	outlier C 942
	Mode 1: C 942			
	Mode 2: SMU 2163, M 521, C 923, M 520, M 517, M 518, M 519			
	Mode 1 mean: 910 B.C.			
	Mode 2 means: 410 - 340/320/200 B.C.			
Phillip Smith Mound	All: ETH 3481, ETH 3311, ETH 3310	same	.34	
	All means: 400 - 380 B.C.			
Florence Mound	All: SMU 1919, C 874	different	9.15	outlier C 874
	Mode 1: SMU 1919	n/a		
	Mode 2: C 874	n/a		
	Mode 1 mean: 350/320/200 B.C.			
	Mode 2 mean: 640 A.D.			
Locust	All: ETH 3487, ETH 3070, SMU 1868	same	.69	
	All means: 80 - 230 A.D.			
Harness-28	All: ETH 3069; ETH 3068; ETH 4242	different	224.34	outlier ETH 3069, 2 occupations
	Most: ETH 4242, ETH 3068	different	9.56	
	Mode 1: ETH 3069	n/a		
	Mode 2: ETH 3068	n/a		
	Mode 3: ETH 4242	n/a		
	Mode 1 mean: 1880/1830/1820/1800/1790 B.C.			
	Mode 2 mean: 50 B.C.			
	Mode 3 mean: 380 A.D.			
Newark Campus	All: ETH 3074, SMU 2438	different	9.69	outlier SMU 2438?
	Mode 1: ETH 3974	n/a		
	Mode 2: SMU 2438	n/a		
	Mode 1 mean: 20 A.D			
	Mode 2 mean: 540 A.D.			

Table 6 continued on next page.

Table 6. Tests of Consistency of Mutiple Radiocarbon Dates within Sites

Site	Samples Tested for Consistency; Modes Found*	Test Results, T' statistic** at .05 Signif. Level		Most Likely Inferred Causes of Inconsistencies
McGraw	All, excluding bone sample UCLA 685: ETH 2885, ETH 2884, UCLA 679a, ETH 2883, UCLA 679b, MI 1558, UCLA 705, UCLA 688, OWU 62, UCLA 679C, OWU 61	different	30.08	2 or 3 occupations
	Mode 1: ETH 2885, ETH 2884, UCLA 679a, ETH 2883, UCLA 679b, MI 1558, UCLA 705, UCLA 688	same	8.02	ETH 2885 may or may not be included in thismode
	Mode 1a: ETH 2885 (possibly distinct)	n/a		
	Mode 1b: ETH 2884, UCLA 679a, ETH 2883, UCLA 679b, MI 1558, UCLA 705, UCLA 688	same	2.95	
	Mode 2: OWU 62, UCLA 679C, OWU 61	same	.18	
	Mode 1 means: 30/40/50 - 410 A.D. Mode 1a mean: 30/40/50 A.D. Mode 1b means: 220 - 410 A.D. Mode 2 means: 560 - 610 A.D.			
Murphy	All: BETA 15267, BETA 16616, AA 2823 BETA 16620, BETA 16621, ETH 4243	different	19.18	2 or 3 occupations
	Mode 1: BETA 15267	n/a	n/a	
	Mode 2: BETA 16619, AA 2823, BETA 16620, BETA 16621, ETH 4243	same	6.97	
	Mode 1 mean: 40 B.C. Mode 2 means: 120 - 450 A.D.			
Waterplant	All: BETA 15506, BETA 15508, BETA 15507 SMU 1973	same	3.39	
	All means: 630 - 680 A.D.			
Scioto Trail	All: SMU 1964, ETH 3067, BETA 4348, BETA 4349, BETA 4350, BETA 4347	different	63.16	outlier BETA 4347, long, continuous occupation, or possibly 2 occupations
	Most: SMU 1964, ETH 3067, BETA 4348, BETA 4349, BETA 4350	different	21.62	
	Mode 1: SMU 1964, ETH 3067, BETA 4348	same	2.11	
	Mode 2: BETA 4349, BETA 4350	same	.14	
	Mode 3: BETA 4347			
	Mode 1 means: 636 - 680 A.D. Mode 2 means: 870 - 886 A.D. Mode 3 mean: 1041/1150 A.D.			

Table 6 continued on next page.

Table 6. Tests of Consistency of Mutiple Radiocarbon Dates within Sites

Site	Samples Tested for Consistency; Modes Found*	Test Results, T' statistic** at .05 Signif. Level		Most Likely Inferred Causes of Inconsistencies
Greencamp	All: ETH 2886, ETH 4502	different	54.03	outlier ETH 2886
	Mode 1: ETH 2886	n/a		
	Mode 2: ETH 4502	n/a		
	Mode 1 mean: 530 A.D.			
	Mode 2 mean: 1300 A.D.			
Cole	All: ETH 3926, SMU 2083, DIC 2284	same	.18	
	All means: 1290 - 1300 A.D.			
Howard Baum	All: ETH 4244, DIC 1928, SMU 1930	same	1.64	
	All means: 1280 - 1306/1364/1375 A.D.			
Voss	All: OWU 229B, M 1875, M 1882, M 1881, OWU 243b, M 1873, M 1870, OWU 244, M 1872, M 1871, M 1879, M 1877, OWU 245, M 1884, M 1883, M 1876, OWU 246, ETH 4500	different	51.20	long, continuous occupation, or possibly 2 or 3 occupations
	Most: M 1882, M 1881, OWU 243b M 1873, M 1870, OWU 244, M 1872, M 1871, M 1879, M 1877, OWU 245, M 1884, M 1883, M 1876, OWU 246, ETH 4500	different	34.74	
	Mode 1: OWU 229B, M 1875, M 1882, M 1881, OWU 243b , M 1873, M 1870, OWU 244	same	8.09	
	Mode 1a: OWU 229B, M 1875 (possibly distinct)	same	.00	
	Mode 1b: M 1882, M 1881, OWU 243b, M 1873, M 1870, OWU 244	same	2.93	
	Mode 2: M 1872, M 1871, M 1879, M 1877, OWU 245, M 1884, M 1883, M 1876, OWU 246, ETH 4500	same	3.94	
	Mode 1 means: 1010 - 1300 A.D.			
	Mode 1a means: 1010 A.D.			
	Mode 1b means: 1180 - 1300 A.D.			
	Mode 2 means: 1400 - 1480 A.D.			
Blain	All: OWU 248, OWU 247b, M 1911, M 1910, OWU 247a, ETH 4501	different	78.52	long, continuous occupation, or possibly 2 occupations
	Mode 1: OWU 248, OWU 247b, M 1911	same	5.61	
	Mode 2: M 1910, OWU 247a, ETH 4501	same	3.19	
	Mode 1 means: 1010 - 1280 A.D.			
	Mode 2 means: 1430 - 1650 A.D.			

* Means for the listed assays are calibrated using the bidecadal curve of Stuiver and Pearson (1993) and Pearson and Stuiver (1993).

** The tests of consistency were determined by computer program CALIB 3.0 (Stuiver and Reimer 1993) and are described in the text. Error levels for the listed assays assume a laboratory multiplier of 1.

Table 7. Stratigraphic Sequence and Order of Calibrated Radiocarbon Dates Compared for the Toephner Mound

Stratigraphic Sequence	Ordered, Calibrated Radiocarbon Dates*
Top of Mound	
Feature 1, no date	
Feature 3, M 518	
Feature 2, C 923, M 517	
Feature 4, M 519	Feature 4, M 519
Feature 5, M 520	Feature 2, M 517; Feature 3, M 518
Feature 7, C 942	Feature 5, M 520; Feature 2, C 923
Feature 6, SMU 2163	Feature 9, M 521; Feature 6, SMU 2163
Feature 9, M 521	Feature 7, C 942
Floor of Mound	

*After Norris (1985:129).