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In recent years there has been a marked resurgence of interest in dendrochronology, the science which permits the derivation of absolute and relative tree-ring dates and which leads to the reconstruction of past climatic variables. Today in many different parts of the world tree-ring research projects are being conducted with these objectives in mind. It is the purpose of this paper to report three new dendrochronological developments carried out by the Laboratory of Tree-Ring Research at the University of Arizona in Tucson. Although the work to be reported may be of particular interest to Southwestern archaeologists, it is believed that the results achieved will eventually have broader application to prehistoric studies in general and, consequently, be important to all New World anthropologists.

The initial development to be described concerns the establishment of the first absolutely dated prehistoric tree-ring chronology in Mexico (Scott 1963). At the Mexico City meeting of the XXXV International Congress of Americanists in 1962 it was announced that a 490-year floating tree-ring chronology had been derived from timbers recovered at the Casas Grandes site in northwestern Chihuahua (Bannister and Scott 1964). These spectacular ruins, excavated under the direction of Dr. Charles C. DiPeso for the Amerind Foundation, Inc., of Dragoon, Arizona, and the Instituto Nacional de Antropología e Historia of Mexico City, have yielded a rich archaeological assemblage of knowledge that promises to add greatly to our understanding of prehistoric cultural interrelationships between northern Mexico, the Southwest, and Mesoamerica.

Two years ago it was stated that the status of dendrochronology in northern Mexico was comparable to the situation as it existed in the American Southwest prior to 1929, that is, there was a centuries-long, precisely dated, modern ring record separated by an unknown interval of time from an earlier floating archaeological chronology based on prehistoric tree-ring samples. Furthermore, it was postulated that an extensive research program of many years duration would be required before the Casas Grandes relative sequence could be converted into an absolute ring series. However, through application of electronic computer technology it has been possible to circumvent the time-consuming field research anticipated and to date precisely the Casas Grandes sequence directly in the laboratory (Fritts 1963). By sliding the undated Casas Grandes sequence along the well established absolute dendrochronologies of northern Arizona and New Mexico, it was possible to determine statistically the one point in time where the Casas Grandes record showed a highly significant correlation. All other match points on either side of the true synchronization yielded non-significant correlation coefficients, as would be expected when comparing two physically unrelated time series. Our conclusion, substantiated by additional tests as well, was that the Casas Grandes ring record could be accurately dated at A.D. 848-1338.

The Casas Grandes dating project has yielded three major results. First, it has demonstrated the feasibility of utilizing electronic computers in establishing correlations between archaeological tree-ring series separated by geographic distances of up to 400 miles. Second, it has provided more than 50 absolute tree-ring dates for individual beams used in the construction of Casas Grandes. While the archaeological interpretation of these dates is a matter for the excavators, it must be mentioned that, unfortunately, none of the dates are cutting dates and that there is evidence pointing to considerable reuse of timbers throughout the ruin. Third, and most important, there now exists a modern tree-ring chronology in northern Mexico extending from the present time back to A.D. 1524, followed by a gap of 186 years, and then an archaeological ring record back to the middle of the ninth century. A long standing goal of dendrochronologists has been that of extending the tree-ring dating method into Mexico. A beginning has now been made and already tree-ring samples from several smaller sites in Chihuahua and Sonora have been tentatively crossdated into the Casas Grandes series. It is hoped that future studies will permit the dating of samples south of Chihuahua and thus directly contribute to the solution of chronological problems associated with central Mexico.

The second new development to be discussed concerns another long standing objective in the field of tree-ring investigations, that is, to gain a better understanding of tree growth-environmental relationships so that more accurate interpretations of paleoclimatic variables can be inferred from prehistoric ring records (Schulman 1956). To this end, Dr. Harold C. Fritts of the Laboratory of Tree-Ring Research staff has been conducting an intensive research program over the past several years (Fritts, Smith, and Stokes *in press*). By means of physiological and dendroclimatic studies, a model expressing the relationship between tree-growth and climate has been developed relative to certain coniferous species widely used in Southwestern dendrochronological analysis. This model is primarily a relationship in which precipitation, and, to a lesser extent, temperature influence the accumulation of food through photosynthesis, and thereby govern the quantity of cell parts that may be incorporated in the annual ring.

A fundamental breakthrough in the quantitative evaluation of past climatic conditions has been achieved as an outgrowth of Fritts' work. Carefully controlled field studies on trees growing under varying conditions yielded detailed records of radial and other growth changes over a period of several years. Furthermore, by establishing individual weather stations at the sites of the instrumented trees, simultaneous records of external environmental variables were also obtained. These data were then statistically analyzed by means of stepwise multiple regression techniques—a method which takes complex interactions into account—and equations were derived expressing the relationship between tree growth and significantly related environmental parameters. These equations provide predictability of ring widths in terms of precipitation and temperature of 80 to 88% (correla-

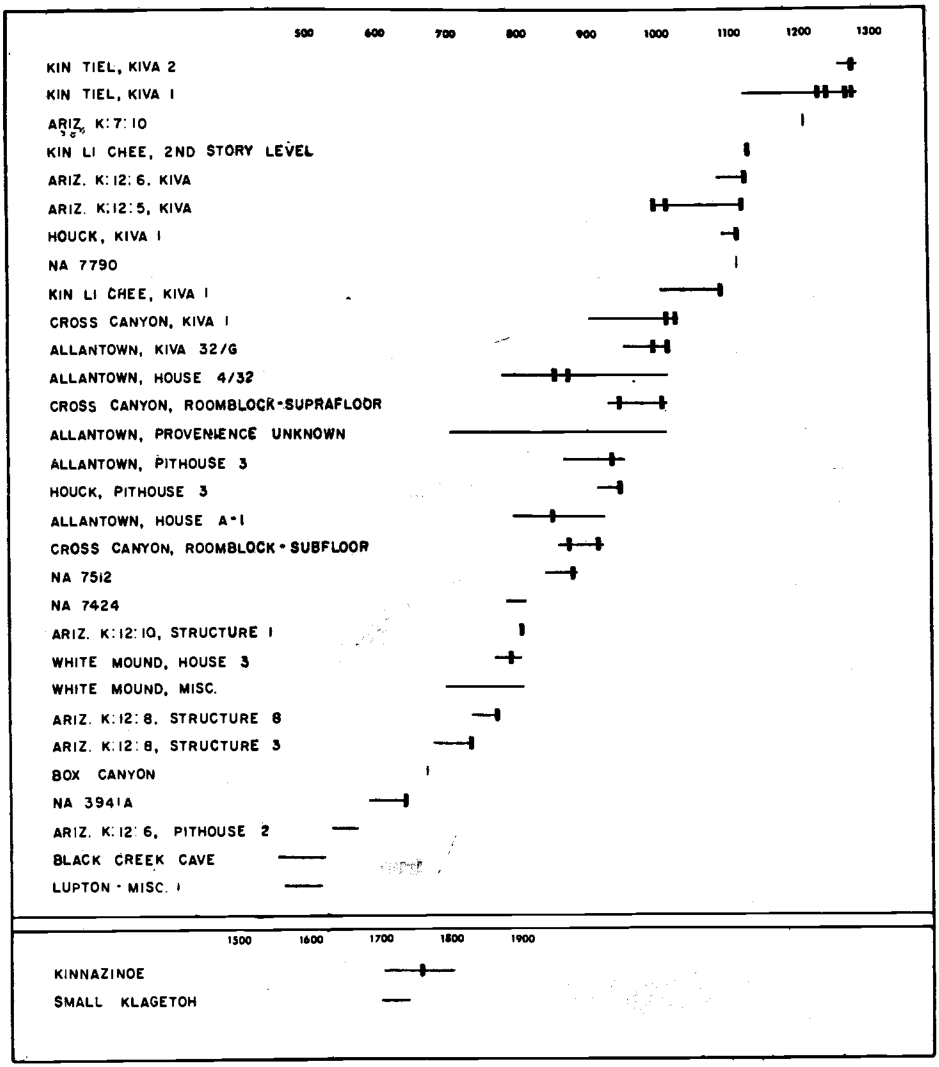

Figure 1. A schematic representation of the dated sites in Arizona quadrangle K arranged in chronological order as determined by tree-ring dating (see text).

tions from .897 to .940) of the total variance for selected species growing under certain site conditions in the American Southwest. Only 9 to 13% of the chronology variance remains unexplained. When these equations are applied to prehistoric ring records, paleoclimatic reconstructions can be made with a precision previously unobtainable.

It was also found that the three species studied, Douglas fir, pinyon pine, and Utah juniper, exhibit different characteristics in their response to common climatic manifestations. Analyses based on chronology differences between species, therefore, can also lead to interpretations of a highly refined nature. While Fritts' recent work substantiates the findings of earlier researchers in dendroclimatology, the promise of truly quantitative estimates of past climatic factors should lead to a new plateau in the level of our understanding of prehistoric man's relation to his environment.

The final new development to be reported concerns an intensive review of the estimated 100,000 archaeological tree-ring samples now housed in the Laboratory of Tree-Ring Research. Utilizing modern techniques of sample preparation and analysis, specimens are being systematically studied on a site-by-site basis in order that previously published dates may be confirmed and new dates may be derived. Resultant data are being recorded in a uniform manner and special emphasis is being placed upon the determination of sample proveniences and the organization of pertinent site information. In addition, ring width measurements representing signficant species at each dated site are being encoded on IBM cards so that reconstructions of prehistoric climatic variables may someday be made in accordance with the dendroclimatic principles described above.

This National Science Foundation financed project has so far produced data far exceeding our early anticipations. Many of the specimens being reviewed have not been examined for over 30 years, and, of course, the techniques of dendrochronological analysis have been greatly improved since then. Furthermore, since all significant Southwestern tree-ring collections, originally gathered by several different institutions, are now located in the Laboratory in Tucson, it has been possible for the first time to study as a unit all of the samples from any given site, thereby giving us better control over local tree-ring chronology variations and vastly increasing the potential number of datable specimens. The result has been the establishment of exceptionally strong regional tree-ring chronologies which in turn have allowed in certain areas an increase of dates up to 600% over previously published information and an increase in the number of dated sites of well over 300%.

At this time project work has been concentrated in two localities of northern Arizona: the Tsegi Canyon and its environs (Arizona quadrangle D) and the region from the Rio Puerco north to Nazlini Creek (Arizona quadrangle K). As an example of the type of data being obtained, Figure 1 illustrates a simple schematic representation of the dated site and distinct site components in Arizona K arranged in chronological order as determined by tree-ring dating. Each horizontal line opposite the site name shows the range of outside dates while the vertical bars indicate distinct date clusters associated with definite building periods The dated units, all restricted to a relatively tight geographical area, progress from Basketmaker III structures, in the A.D. 500's, through Pueblo I and II pithouses, Pueblo III kivas and other features, and finally, two late architectural units in the A.D. 1700's. The total tree-ring chronology range for this small region extends from A.D. 345 to 1289, and from A.D. 1512 to 1804. A similar situation is found in the Arizona D quadrangle where the total tree-ring chronology extends from A.D. 384 to 1379 and also includes numerous dated sites.

As this dating project continues, it can be expected that comparable results will be achieved throughout large portions of the Southwest. With possibly several thousand accurately dated structures, more or less evenly distributed over at least a millenium of time, we eventually hope to provide archaeologists with the most precise regional chronologies yet available in the New World. The existence of strong temporal controls in depth should in turn stimulate additional change through time studies of such archaelogical manifestations as settlement patterns, architectural types, ceramics, and various artifact varieties. It has been said that the Southwest has the potentiality of contributing more to our knowledge of the manner in which cultures have developed through time than any other area in the Americas. Dendrochronology can help fulfill this promise.

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