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TREE RINGS—THE ARCHAEOLOGIST'S TIME-PIECE[21]

EMIL W. HAURY

SINCE 1929 Southwestern archaeology has stood on a much surer footing than at any other time in the history of its development. This stabilization is due to the research of Dr. A. E. Douglass of Tucson, Arizona, whose inquiries into the reaction of trees to weather, from an astronomic standpoint, led, as a ramification, to the use of the annual growth rings in trees in dating the pre-Spanish remains of man in the Southwest. From the standpoint of the archaeologist, the most significant progress date in Dr. Douglass' study was June 22, 1929. On that day ended a long search for a particular sequence of rings needed to complete the ring record. This sequence was found in a log in the Showlow ruin, and united two chronologies then extant, the one a floating series of five hundred and eighty years, the other an historic series extending from 1929 to about 1280 A.D. The great value of the joining of these two series lay in the fact that it became possible, for the first time, to speak of the age of the Southwest's foremost ruins in terms of the Christian calendar. By this one step, forty old villages, occupied by the Pueblo Indians before the arrival of Europeans, were placed historically. That this achievement was possible where written records were not kept seemed unbelievable; that the discovery was made by an astronomer who utilized material thought worthless by the archaeologist seemed still more incredible. But, in the brief six years which have elapsed since the Showlow log was found, the Southwestern student has come to take dendrochronology, or "tree time," as a matter of course, giving data gained through this medium precedence over knowledge gleaned in any other way. In fact, it may be stated without equivocation that the tree-ring approach has been the greatest single contribution ever made to American archaeology. In the regimentation of facts it has taken priority over typological and associational studies, even over stratigraphy which heretofore had proven itself the most valuable control. Tree rings and stratigraphy have shown themselves to be complementary and have combined to build a chronology which shall endure. The whole-hearted acceptance and the continued use of

[21] This paper is one of three read before a symposium on "Trees: Recorders of History and Climate," held at Santa Fe, New Mexico, on May 1, 1935, in connection with the Southwestern Division Meeting of the American Association for the Advancement of Science.

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the tree-ring approach by the Southwesternist will be an undying tribute to Dr. A. E. Douglass, the inventor of the system.

Since the finding of the first date ever to be derived from a pre-Spanish ruin, Kawiakuh in the Jeddito Valley, in 1928, many ruins, large and small, aggregating well over two hundred, have been dated by Dr. Douglass and his students. Impressive as this figure is, it is nevertheless admittedly small and forms but a very meager percentage of the ruins for which a potential date is possible.

The locality now affected by tree-ring dating in the Southwest may be limited by Mesa Verde on the north, Prescott on the west, Globe on the south, and Pecos on the east; thus including practically all of the plateau and mountain area. In the main, this area includes the sections where Basket Maker and Pueblo remains are the most dense. It is not too much to hope that extensions will be made from this region to include other cultures whose position in time can now be determined only by less satisfactory means. Especially bright are the prospects of carrying the system to other archaeological areas, as, for example, the Mississippi Valley.

Through painstaking research and the application of a rigorous procedure in the study of tree rings, Dr. Douglass has been able to establish a chronology for the Southwest extending in an unbroken line from the present almost to the time of Christ. Quoting from the Annual Report of the Chairman of the Division of Plant Biology of the Carnegie Institution,[22] Dr. Douglass writes:

"The long southwestern tree-ring records . . . have given a rainfall history, back to about 650 A.D. Two earlier sequences of 'Basket Maker' age, secured by Earl H. Morris, were joined together in March 1933, making a total length of about 800 years. Since January 1932, a definite relationship of the more recent of these to modern chronology has been under consideration. This connection was found in a superb specimen from Chetro Ketl collected and dated by Miss Florence M. Hawley in December 1931. This has been supported by many others, and has enabled us to carry a well-established chronology back to about 200 A.D. and a somewhat complacent record to 11 A.D. A few excellent charcoal sections of prehistoric beams collected in 1927 by Mr. Morris have been identified as dating near 350 A.D."

This chronology has a two-fold value for the archaeologist. First, it holds the key for dating countless other ruins that fall within its span,

[22] Year Book No. 33, for the year 1933–34.

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for wood which has not yet been excavated may be compared with this ring record at any time in the future; second, it offers a weather record, a story of years of drought and of plenty, which opens a large field for study along ecological lines. Owing to local variations in the ring patterns, the master plot or chart of the rings which we now possess does not operate over the entire Southwest. Rapid strides are being made annually to remedy this by the construction of new chronologies. The net result of these studies will bring an even wider area into the picture where dates may be obtained from ruins. In that section where the chronology has functioned with the most success, we find that ruins have yielded dates which fall into a span of more than thirteen centuries, beginning with about the year 1700 for the latest, and extending to about 350 A.D. for the earliest. It may be fairly stated that the lower limit has not yet been reached. The significance of this naturally is that, where so great a span of time is involved, a new means is supplied for arranging antiquities into stages without the need of cumbersome and often inexact nomenclatures. But more than this, the span of years into which we now know that Basketmaker III and Pueblo IV ruins fall has been an eye-opener as to the rate of culture growth. The ages estimated for some of the major and late ruins on purely empirical grounds were shown to be somewhat too high by the actual dates, but the discrepancy was not inordinately large. Further, the order of periods was unchanged, which in itself is an excellent commentary on the reliability of the methods developed in local research prior to the addition of dendrochronology. For the earlier stages in Basketmaker-Pueblo growth, however, the estimates were considerably in excess of the actual dates. To be specific, dates for those Basketmakers who possessed pottery, which were generally placed before Christ, can now be carried forward to at least 700 A.D. As a consequence, the periods following Basketmaker III are later than heretofore supposed, Pueblo I, for example, dating from the late 700's to approximately 900, and Pueblo III at its zenith dates about 1100. The evident fact is that the development from primitive beginnings to the peak of achievement was a swift one, and did not require the centuries of laborious evolution generally imagined. In this point, then, dendrochronology has brought about perhaps the most revolutionary single element in archaeological thought. We have also learned that the development did not progress equally over a wide area; in marginal areas a Pueblo II stage had been reached when at other points Pueblo III was already in full flower.

Reviewing the distribution of dated ruins within the present time

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scale, we find that sites placed culturally in Pueblo III and IV, dating from 1000 to 1350, are most numerous, thus giving us the fullest data on those stages. With the exception of the Flagstaff area, Pueblo II is practically undated and, for Pueblo I, dates are available for both the eastern and western variants. From this point back, the information is very sketchy.

As I see it, there are three angles in the tree-ring-archaeological relationship which must be considered. These are: the field angle, covering the collecting of the beam material; the laboratory angle, embracing the dating of the wood or charcoal samples; and the interpretative angle, in which the facts discovered in the preceding step are integrated and fitted into the background.

For the first of these, it is unnecessary to go into detail, as the field man is already acquainted with the general methods and requirements.[23] Sampling in standing ruins requires specialized equipment, and should be done with due regard for the antiquities involved. The recovery of charcoal and decayed wood from open sites is also beset with special problems which must be met as they arise. Success or failure in getting satisfactory dates, i.e., the final growth layer of the tree, may depend upon the method of handling the beam material in the field by the field technician, for neglect or improper treatment may cause a partial loss of outer rings on fragile specimens.

Looking at the problem from the angle of one who dates the wood, I believe it cannot be too strongly urged that the excavator himself should have a fundamental knowledge of woods, and the utility of ring types. With such knowledge, laboratory work could be reduced to a minimum. However, a wise policy to pursue at all times, whether conversant with the subject or not, is to save all material about which there may be any doubt. The excavator's task does not stop with the selection and care of the material, for, if improperly recorded, certain desired information will assuredly be lost. Wood should receive the same careful attention that is accorded to all other types of specimens. The fullness of the results will depend to a degree upon the thoroughness and wideness of the sampling. The more rooms giving beam material, the better the growth changes of the structure and the history of the culture will be understood.

The second phase, the dating of the wood, is beyond a doubt the most important and crucial step of the three, for inaccuracies will in-

[23] McGregor, J. C., Tree Ring Dating; Museum Notes, Museum of Northern Arizona, Vol. 3, No. 4, 1930.

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evitably lead to chaos in the third step, the interpretation. This is to say that to express the cutting date of a log as 1100 A.D. definitely places it; the quantity is unchanging; it is either right or wrong. The weight of the decision naturally rests upon the individual who undertakes the dating, and his responsibility is therefore very great. This dictates that he should proceed with sound and discerning judgment based upon substantial facts. By common consent, it was decided at the tree-ring conference at Flagstaff in 1934 that at least two competent individuals should agree on any date before such a date is published, thus verifying its accuracy.

Some misunderstanding has been created in the past by the failure to specify whether a published date was the bark date[24] or that of the innermost ring of the log. For the archaeologist, the bark date only has real or primary value. On the other hand, the innermost ring and those intervening are of interest to the student concerned with chronology-building and cycle studies. It is therefore the further duty of the examiner of the wood to state the true condition of the date, whether derived from the final ring or from the last ring on a specimen with an indeterminate number missing. All these points must be seriously considered in the interpretative angle.

A few words may be said at this point in connection with the release of tree-ring data. It is naturally desirable that dates be released as soon as possible after they have been determined. It is realized, however, that the reports in which they should properly be published may be years in preparation, and that their immediate publication through normal channels may not be feasible. To meet this contingency and others, the idea of issuing a tree-ring bulletin was conceived less than a year ago by those vitally interested in dendrochronology. It was felt that the long delay in the issuance of dates might retard the advancement of the study, especially in chronology building, and at the same time withhold vital information from the archaeologist. The publication of the dates in a small quarterly in no way detracts from their value in the final published form. To endow such information with maximum value, it is desirable that together with data as to the origin of the wood, the sap-heart date, bark date, etc., the culture affiliation should also be stated as clearly as possible. Without this the dates have little or no meaning to the archaeologist. If, in the tabular form of presentation, the lack of space demands the use of Pueblo I, Pueblo II, etc., the

[24] Denoting the final layer of woody tissue grown by the tree, occurring beneath the bark.

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variants of these periods should be explicitly stated. For the benefit of those concerned with the dating of wood, a combined chronology reproduced in a line cut would also be invaluable, for, by this means, information as to local differences in the ring records could be uniformly and inexpensively disseminated. I should like to emphasize the fact that, since the student's reliance on or rejection of, tree-ring data will depend largely upon its fullness and the form of publication, this step should be carefully planned.

We now come to the third consideration, namely the interpretation of tree-ring facts from the standpoint of archaeology. We may ask at once, are there any standards of correlation which may be offered for general acceptance? While to answer this question requires some discussion, it may be admitted from the start that each case in which tree-ring dates have contributed to our knowledge of ruins, special circumstances demanded special consideration in the interpretation, and that a formula or group of standards cannot be absolutely set down. To restate the query put a moment ago, to what extent can we rely upon wood from a room in order to date the masonry and the associated artifacts? An answer can be given only after a careful inspection of the related facts, as wholly different explanations may be controlled by these.

One of the first points to be considered is the question of cutting date, versus deadwood date. This is to say, does the bark date on a log represent the actual time of cutting by the people who built it into their dwelling, or does it represent the last year of the life of the tree which died through natural causes and stood or lay in the forest for a long period before being selected by man? It is generally believed that deadwood or wind-fallen trees were infrequently utilized, first, because this type of wood is much more resistant to the axe than green or live wood, and secondly, in the case of pine and most woods in the local forests, it soon decays and becomes unfit for use. If used, however, it must have been rarely, since the task of hunting out proper deadwood in the forest would probably exceed that of cutting fresh logs. An occasional piece thus incorporated into a structure in which the beams were dominantly live wood, would give an earlier date. It could be largely discounted since precedence, in most instances, must be given to the most recent dates. Exceptions to this would be cases of remodelling or replacements, i.e., fresh logs built into an existing building. Further support for the use of live wood is obtained in cases where a series of logs from a single room terminate with the same ring, representing the same year. In one instance with which I am acquainted, twenty-four

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logs from a pithouse gave the same terminal date. The probability of the occurrence of this condition, if deadwood has been selected for the structural beams, is extremely small. Repetitions of this case call for a generalization to the effect that live wood was generally used, and that the final ring can be accepted as representing the construction time. One condition that may introduce error is the possibility that beams once cut were not immediately used, but were allowed to season in order to avoid sagging. Although seasoning of logs is practised by the [Pueblos to some extent, it cannot be positively asserted that this procedure obtained in ancient times. A variation of a year or two in the dates of logs of a given house may suggest this. If seasoning prevailed, house-building was definitely planned a year or two in advance, a condition which was probably not general. Emergency situations must also have arisen which demanded immediate construction. Admitting that a year or two elapsed between cutting and construction time, the factor is so small as to be trivial, and the problem resolves itself into a very minor one.

While wood found within a room is most apt to be related to it structurally, several other conditions may also prevail which might prove to be disturbing factors in the interpretation. For example, charcoal from the fireplace might conceivably give far more recent dates than the roof beams. Where the structure has been burned, it may not always be possible to segregate wood from the two sources. A further confusing situation might be created by the dumping of discarded wood into an abandoned room which was being filled with rubbish; however, here the nature of the wood and its position in the fill will usually give some clue as to its origin. Logs found as an integral part of the house, i.e., built into the walls or lying on the floor in such a position as to indicate clearly that they were once in the roof, are naturally the most convincing in offering construction dates. Let us take an ideal case to see what possibilities might arise where definite structural wood is being dealt with. Say that six major logs supporting a roof give, in each case, the same bark date of 1300. Little leeway is possible here in interpretation, for the odds overwhelmingly favor that date as the time of construction, or within a year or two in case of seasoning. Should one of the logs give a date of 1150, the obvious discrepancy of 150 years can best be explained by supposing that that particular log was salvaged from an older structure. This situation is known to have occurred in the past, as witness the log taken from a house in Oraibi a few years ago which was cut in the late 14th century.[25] Or we may find that one or more

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of the logs gives a reading of 1350, fifty years later than the remaining five. In this event, a repair or replacement may be indicated. It is further conceivable that each of the six logs will give different dates, probably indicating a heterogeneous collection of beams, in which event only the latest date will be of any particular value. Such a condition must be rated as highly unsatisfactory. It will be readily seen that the various situations thus outlined will, in one way or another, affect the interpretation. Each set of circumstances presents a particular problem, the solution of which cannot be reached by pre-arranged standards.

A similar set of conditions may be visualized in working out the relationship of the dates of a room to those of the artifacts contained within. To put this as a question: Are the artifacts within a house approximately the same age as the house itself? Generally speaking, they are; however, in some instances they may be more recent. This is said with full recognition of the possibility of finding old pottery and the like in recent rooms, and recent materials in rooms which have been occupied for a long time. In this case judgment must be influenced by the archaeological conditions. The best form of proof for dating artifacts in this manner lies in the consistent appearance of a trait or traits within rooms of the same general age. This is to say that group data became the decisive factor. For example, the Canyon Creek cliff ruin,[26] located on the Fort Apache Indian Reservation, offered eighteen datable rooms out of a total of about sixty. These rooms are scattered throughout the length and breadth of the structure in both the first and second stories. The artifacts from all rooms were uniformly of the same generic kind, reflecting no period changes, and the range of dates from the eighteen rooms was between 1326 and 1348. From this it may be concluded that the material culture is of comparable age, or perhaps a little later. It can be unerringly dated to the 14th century. This angle of tree rings and archaeology is one of the most vital, and, because of its admitted importance, a correlation should not be attempted without full comprehension of all related information.

Once material culture has been satisfactorily dated in a region, objects native to that place, but alien to another, become valuable time indicators. In such cases tree rings are directly responsible for ordering the data in the primary area, and indirectly in the adjoining area. The

[25] Douglass, A. E., The Secret of the Southwest Solved by Talkative Tree-Rings; National Geographic Magazine, December 1929, p. 754.

[26] Haury, E. W., The Canyon Creek Ruin and the Cliff Dwellings of the Sierra Ancha; Medallion Papers XIV, Gila Pueblo, Globe, Arizona, 1934.

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value of this approach is particularly high in such regions where, owing to physiographic and other conditions, tree rings may never be utilized. The time status of the Hohokam of the Gila Basin has been worked out chiefly by this method. The same principle will doubtless be brought into play in the study of Mexican and Mississippian cultures.

Exact as a date may be, it is not possible to value each one equally. Distinctions arise which are governed to a certain extent by conditions already outlined, and by others which will be mentioned presently. We need to consider the value of a single date versus many dates, first, from a one-type site, i.e., one in which the occupation was short and the material culture all of one phase, and second, from a site long occupied, in which growth changes are apparent. An individual date from a one-type ruin can be more rigidly interpreted than one from a large complex site, since, in the former, there was little opportunity for old beams to be re-used and for other disturbing factors to creep in. Single dates may be strengthened by dates from other sites of approximately the same age and cultural association. As an example, two dates from Gila Pueblo, a one-type ruin, are 1345 and 1385. While these are indicative of the age, there is of course room for error. However, with dates ranging from 1326 to 1348 in the Canyon Creek ruin, and with a terminal date of 1383 for the Showlow ruin, both of which manifest cultural ties with Gila Pueblo,the dates procured at Gila Pueblo may be admitted as valid.

In the case of a site giving several stages, group data only will give satisfactory results, for individual dates offer too great an opportunity for misinterpretation owing to the possibility of re-used beams. One important case of this character is now before us. The earliest date from a ruin in the Southwest is about 350 A.D. This was obtained from a log found by Mr. Earl H. Morris in Mummy Cave, Canyon del Muerto. Archaeologically, it is known that this cave was occupied from Basketmaker II times, but the conditions were so confused that the association of the beam in question could not be positively determined. No matter how strong the temptation may be to date the culture on the strength of this log, it cannot legitimately be done until further dates or relevant facts have been gathered.

While we have been concerned so far mainly with dates from structural wood, Dr. Florence M. Hawley has also demonstrated the utility of charcoal fragments from rubbish heaps in the case of Chetro Ketl.[27]

[27] The Significance of the Dated Prehistory of Chetro Ketl, Chaco Canyon, New Mexico. The University of New Mexico Bulletin, Vol. I, No. 1, 1934.

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The value of pottery sequences obtained from the study of daily sweepings of broken pottery and charcoal, as a check against information obtained in the building itself, needs hardly to be pointed out. This study also helps in solving the problem of the length of time involved in the accumulating of rubbish mounds.

So far, the climatic angle of tree rings and archaeology has only been mentioned. Yet here lies a very fertile field, for past weather and human activity are intimately related. In the present chronology, which just falls short of 2000 years, one extended drought and several short ones are recorded. We suspect that the most severe of these, the drought lasting from 1276 to 1299, profoundly affected certain of the Southwestern peoples, and was responsible in the main for shifts in the population at about that time. But so far we have done little more than look at the raw and isolated facts. Here the archaeologist must coöperate with the climatologist whose interpretation of the tree-ring calendar from the weather angle is needed before it is possible to carry the study forward along strictly archaeological lines.

We would do well to ask ourselves at this point whether or not the tree-ring data we now have conflicts with the archaeological evidence. It has already been intimated that, before the benefits of dendrochronology were available, the error of age estimates of culture stages increased progressively from recent to remote times. However, since this adjustment has been made in the minds of students of Southwestern archaeology, it can be said that no glaring conflicts, such as radically differing dates for the same cultural stage, have occurred. Indeed, should a violent disagreement occur, it would be well to look into the possibility of irregular conditions in the archaeological evidence. Improper release of dates and too rigid an interpretation, may tend to throw the facts out of alignment. On this last point, it is well to remember that, while a date may generally place a developmental stage, it does not delimit it. A problem relating to this part of the discussion has recently been raised by Mr. John C. McGregor, who, in dating wood from pit-houses excavated by the Museum of Northern Arizona, found a span of 150 years in bark dates from the wood of a single pit-house. Upon first consideration, one might say that the house was occupied for this period, and that towards the end of the occupancy, log replacements were made, thus accounting for the great difference in time. The improbability of a 150-year life for an underground house, and the lack of change in the material culture associated with it, in view of the more rapid changes general over the Southwest, tend to

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temper this idea. But the problem is not easily solved. A likely explanation is that, in the construction of the house, the builders robbed an old dwelling for useful beams, adding to them others cut currently, and consequently of much later date.

Much, very much indeed, has been accomplished in the few years that dendrochronology and archaeology have joined hands, but the work has literally only begun. Some ramifications of the subject have been almost entirely neglected. Along lines of basic research more work is necessary. For example, master plots covering zones or more restricted areas than we now possess, would be invaluable in hastening the dating in marginal areas, as in the Mimbres, where certain fundamentals shown in the Flagstaff chronology were apparently not repeated. Fortunately Dr. Douglass and Mr. H. S. Gladwin are now at work on this problem and results may soon be expected. Research on woods other than those now used should lead to worthwhile results.

Extension of tree-ring dating to other areas is a challenge which cannot be overlooked. First steps outside of the nuclear area in the Flagstaff-Chaco Canyon sector, were made to the east in the Rio Grande where Mr. W. S. Stallings, of the Laboratory of Anthropology, has succeeded in the difficult task of building up a basic chronology extending to 1100 A.D.[28] In the Tennessee Valley, Dr. Hawley has obtained significant results from wood found in Mound-builder remains. Northern Mexico and possibly parts of South America may similarly prove to be rich fields. For the tropics, the outlook is not bright, although not altogether hopeless. In my opinion, illuminating work might well be done in Egypt where an abundance of useful wood of dynastic times is available. While the Egyptian chronology has been worked out with reliability on astronomic and historic ground, I believe it is not unlikely that tree-rings might well substantiate and possibly amplify this.

The degree to which success will come in the relationship of American archaeology and dendrochronology will depend largely upon the degree of coöperation among those vitally concerned in the study. Due to its involved nature, the welfare of the subject depends upon coördinated efforts. Lacking this, the most unique check yet discovered on the changing quality of human culture cannot bear its richest fruit.

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[28] A Tree-Ring Chronology for the Rio Grande Drainage in Northern New Mexico; Proceedings of the National Academy of Sciences, Vol. 19, No. 9, pp. 803–806; 1933.

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