EARLY HISTORY OF CROSSDATING

R. A. STUDHALTER

The early history of crossdating has recently been summarized by the author.[1] The salient features of this review, in so far as they apply to crossdating and the historical events leading up to the concept, are here briefly stated, since many readers of the *Tree-Ring Bulletin* may not have easy access to the publication in which it appeared. For the sake of brevity, documentation is omitted in the present paper; such dates as are included are for the purpose of helping the reader to keep his perspective in historic time.

In its historic development, the fundamental idea of crossdating arose from the subject of internal markers, and it may be considered to be a part of this broader field. An internal marker is any anatomical feature whereby an individual growth ring in a tree can be identified and often dated; included are ring thickness, partial rings, and the presence of abnormal or unusual cells in the ring. Most of the markers have been placed into the wood as a result of insect defoliation, drought, lightning, fire, frost, or hail, each of which factor is capable of producing a characteristic growth ring.

Once it had been shown that a distinctive ring was commonly produced in a given year, the tables could be reversed and a similar ring found in a similar position in another tree could logically be used to date such local occurrences as fire, frost, drought, hail, lightning, and insect defoliation. Such natural internal markers have been extensively used in dating individual rings, especially in Europe and America.

As long ago as 1882, Hough expressed the belief that it should be possible to date accurately certain insect injuries a century or more back from characteristic rings to be found in the discs of tree trunks stored in the museums of forestry and other schools. The dating of hail, frost, and insect injury was actually done by R. Hartig (1892), Rubner (1910), I. W. Bailey (1924, 1925), and many others. Such are the applications of tree-ring studies to climate — or rather, to the weather.

An outstanding early study involving naturally placed internal markers is a paper reprinted several times by Enos Mills (1904, 1908, 1909).

At an earlier time, when it was still thought that the earth is only 6000 years old, it was suggested by Agardh (1829, 1830) that tree rings might tell us the age of coal measures, of limestone strata, and other geological formations. And Candolle (1827, 1831, 1833) suggested applying age counts from tree rings to the age of talus slopes, to changes in dunes and river beds, to the origin of volcanic and madreporic (coral) islands, and even to the "last revolutions of the globe" (cataclysms).

Proposed applications of tree-ring dating to archaeology are also not new. As early as 1811, Waterhouse said: "Who knows, but we may hence form a probable conjecture of the age of those surprising antiquities (Indian mounds), discovered in this new world on the banks of the Ohio and Muskingum?" And in 1884, Baldwin reported that Professor Jeffries Wyman had thought that he could date Indian mounds in Florida by counting the rings of trees growing upon them; Baldwin seems to have prevented this work from being attempted by calling Wyman's attention to possible grave errors because of the many multiple rings present in the native trees of Florida.

The use of tree rings in dating "monuments" was frequently referred to in the European literature, but it is not clear what type of monuments was

[1]Studhalter, R. A. 1955. Tree growth: some historical chapters. *Botanical Review* 21:1-72.

being considered. Possibly they included initials and dates which successful hunters carved on trees as mementos.

Perhaps of greater human interest than natural markers are various internal markers which are intentionally placed into a tree by man. His purpose in so doing may have been quite hazy, or he may have been trying to solve some problem of diameter growth, or he may have been dating some individual growth layer, or again, he may simply have wanted to carve his initials into the bark of a tree. The method has been called internal tagging when it is done for the purpose of dating growth lawyers. Here, too, we find an extensive literature, going back to the Greeks, namely to Theophrastus, the student and successor of Aristotle. Although this early scientist of more than two millenia ago did not know that the growth rings of trees are supposed to be annual, he nevertheless knew in what region the new wood of trees is added to the old, and he saw the relation of a time concept to the diameter growth of trees. His own statement is as follows:

> ". . . and if one forces a stone or some similar object into a tree, it becomes hidden, since the new growth surrounds it, as was the case with the wild olive tree which stood in the market place at Megara."

The French botanist and forester Duhamel du Monceau (1751), in an effort to discover where and how new wood is formed, placed small strips of tin foil at definite depths in the cut bark and wood, treated the wound with an antiseptic, tied the parts together, and examined again at the end of the growing season. In other experiments, he (1758) forced fine wires through the bark and wood at approximately known depths for later examination. In these ways he was able to delimit the radial growth of a single season, thereby dating a growth ring accurately.

Artificial defoliation has been used as a tool in dating, as has also artificial freezing.

Although not originally intended as internal markers, the axe blazes of surveyors have very often served this purpose. As long ago as 1787, Burgsdorf used an axe mark made in 1767 on an oak tree at a boundary line as proof that only one ring is formed in a year; in 1785 the blaze had been grown over by 18 rings. A large number of boundary disputes have been settled in court by dating a surveyor's blaze from the number of growth rings which have grown over the wound in a known number of years. In general, courts in this country and elsewhere have recognized the accuracy of this method; only one instance has come to our attention in which a court ruled that one ring does not always represent the diameter growth of a single year, and that therefore a blaze cannot always be accurately dated.

The significance of the woody overgrowth covering dates, initials, and other markings cut through the bark is discussed by many writers, such as Goeppert (1868), who begins his citations with Bartolinus (1654).

The work of Enos Mills, referred to above, also contains a number of instances of internal markers deliberately placed by man, although the original purpose of the marker was not one of dating a given ring. Mills' painstaking study is still one of the best examples of interpreting the events which had befallen a single large tree during its long life.

While the applications cited above do not usually involve true crossdating, they at least represent a close approach to its methods.

It is a relatively short step from the dating of individual growth rings to the method which we now know as crossdating, for this method makes use of the same internal markers discussed above. Crossdating involves the use of identifiable characteristics of rings in two or more trees, with a view of assigning dates to the individual rings. The first direct approach to this method appears in three countries of Europe in the eighteenth century. The Frenchmen Duhamel and Buffon (1737) counted back to the wood ring of 1708-1709, in which they found a severe frost injury, called false sapwood by them. There is more than abundant historical proof that the winter of 1708-09 was a very severe one in Europe. The false sapwood was believed to be the result of severely cold weather, it being a common belief at that time that wood continues to be formed in a tree throughout the winter. Such a backward count assumed, no doubt correctly for most trees in central and northern Europe, that a single prominent growth ring is laid down in one year. Just a few years later, Linnaeus (1745, 1751) in Sweden also counted back to the winter of 1708-09, for which he found a thin ring. Still later, Burgsdorf (1783) in Germany again counted back to the same winter, the ring for which contained a severe freezing injury. Candolle (1839-1840) in France also succeeded in counting back to the same severe winter on a juniper tree. None of the first three men, at least, seems to have known of the work of the others. If these data are combined into one, we have here, in a sense, the beginning of crossdating, for the growth ring of 1708-09 was identified in several trees — trees of different ages, of different species, and growing in different localities and habitats. I believe that we would be justified in stating that crossdating had its birth in the year 1737.

If, however, one is not willing to accept that date, he will be forced to accept the year 1783 as the first date of crossdating and the German botanist and forester Burgsdorf as the father of crossdating. For on that date, Burgsdorf tells us that (1) frost damages the bark and may also injure the wood; (2) sometimes one finds dead and decayed areas enclosed within the normal healthy wood, which has grown over them; and (3) according to ring counts, this condition occurred in the winter of 1708-09 *in beech and in most other trees.* The italics are mine. In thus comparing several trees of different species he fulfilled all of the criteria of crossdating. It is of considerable interest that, in all of this early work, the factor responsible for the recognition of the telltale rings was not drought, but frost. With temperature in mind, Linnaeus called tree rings the chronicles of winters. In the course of time, this terminology gave way to others which are based on the factor of drought rather than temperature. Twining (1833) spoke of tree rings as meteorological tables and records of the seasons, and Pokorny (1865-66) referred to them as meteorological yearbooks, which go back hundreds and even thousands of years. Baldwin (1884) considered them true records of the weather and L. H. Bailey (1885) used the term meteorological records of the years.

Two of the five methods suggested by Candolle (1833) for estimating or determining the age of trees involve simplified crossdating. He recorded ring thicknesses in groups of ten for as many trees as possible of a given species, taking into account the fact that growth rates differ in young and in older trees. Having thus established the average annual diameter increment for each species in different periods of growth, one would be able, he says, to determine the age of a given standing tree of that species with reasonable accuracy from its diameter. Or else, by making a cut in the side of a trunk one could measure the ring thicknesses for a given period of time and arrive at an estimate of the total growth and age from the diameter of the trunk. This method, he says, was used long ago by Adanson in estimating the age of a large monkey bread tree (*Adansonia digitata*) on Magdalena Island. These methods of Candolle came to my attention too late to be included in the paper printed in *Botanical Review*.

The suggestions of Candolle were apparently quite fruitful for, forty years later, Elias Lewis (1873) stated that it had long been customary to make estimates of the age of standing trees from the number of rings on another tree of the same species in which rings could be counted.

Next we come to a completely forgotten letter to the *American Journal of Science* by Twining (1833), who once more discovered the very essence of crossdating. Working in New Haven, Connecticut, he stated in part:

> "In the year 1827, a large lot of hemlock timber was cut from the north eastern slope of East Rock, near New Haven, for the purpose of forming a foundation for the wharf which bounds the basin of the Farmington Canal on the East. While inspecting and measuring that timber, at the time of its delivery, I took particular notice of the successive layers, each of which constitutes a year's growth of the tree; and which, in that kind of wood, are very distinct. These layers were of various breadth, indicating a growth five or six times as full in some years as in others, preceding or following. Thus, every tree had preserved a record of the seasons, for the whole period of its growth, whether thirty years or two hundred,—and what is worthy of observation, *every tree told the same story*. Thus, if you began at the outer layer of the two trees, one young and the other old, and counted back twenty years, if the young tree indicated, by a full layer, a growing season for that kind of timber, the other tree indicated the same."

That Twining fully appreciated the significance of his discovery is indicated by his own italics, as given above.

In addition to his clear statement of crossdating, Twining spoke of having, in these logs, two or three hundred potential meteorological tables, each of which is a natural, unerring, graphical record of past seasons. While he does not mention rainfall and drought specifically, these factors are implied as being responsible for the unusually thick and thin growth rings. And his prophetic insight into the future is shown by his last paragraph, which reads as follows:

> "If you should think fit to make such a suggestion (the collecting, labelling, and preserving of discs of tree trunks in all parts of the country), it might lead, in fact, to the preservation of sections from aged trees in different parts of the country, and a comparison of their lines of growth with the history of the weather as far back as our knowledge extends. If the observations just related, with respect to a particular lot of timber, should be found to hold true of trees, in general, drawings of these sections, on a reduced scale, would soon find their way to the pages of scientific journals. It would be interesting, then, to make comparisons of one with another, — to compare the sections of one kind of tree with that of another kind from the same locality, — or to compare sections of the same kind of tree from different parts of the country. Such a comparison would elicit a mass of facts, both with respect to the progress of the seasons, and their relation to the growth of timber, and might prove, hereafter, the means of carrying back our knowledge of the seasons, through a period coeval with the age of the oldest forest trees, and in regions of the country where scientific observation has never yet penetrated, nor a civilized population dwelt."

Here, indeed, do we have not only the truest type of crossdating, but a clear statement of some problems not undertaken until a century later.

Pokorny (1865-66, 1867, 1869) discussed accurately both the background and some of the problems of crossdating. In eastern Europe, he studied a large number of Christmas trees (firs) and found a characteristic thick ring for 1861, regardless of the greatly varying ages of the trees and of their presumably variable former habitats. Again, in a study of discs of pine trees collected by Professor Simony, Pokorny found the ring for 1808 extraordinarily thin, whereas those of 1806, 1807, 1809, and 1810 were quite thick. He placed considerable emphasis on relative thicknesses as opposed to actual thicknesses.

In Germany, Ratzeburg (1866) compared the ring of a certain year, which was the result of caterpillar injury, in a number of different trees, in this manner assigning definite dates to these rings and hence to the injuries.

A modification of crossdating, in which however its exact principles were used, was reported by Robert Hartig (1897). In some trees which had been killed by smoke and fumes, he found it impossible to make actual ring counts at the base of the trunk because of the frequent omission of rings at that level. First he studied the ring patterns in the upper part of the bole, where he assumed all rings to be present for the age represented there, recording the especially thick and thin rings and the number of more nearly average rings between them. Then, by locating the distinctive rings in the lower bole at DBH and interpolating for the missing rings, he was able to determine rather accurately the age of the tree. This method, as stated by Andrew and Gill (1939), is almost exactly the method in use by the dendrochronologists; it differs only in that the work was limited to different parts of a single tree.

The article of the Dutch astronomer Kapteyn (1914), reporting on work done in 1880 and 1881 in Holland and Germany, has been previously reviewed in the *Tree-Ring Bulletin.*

It is quite probable that there have been many other cases of crossdating previous to 1900 which have not been sufficiently described in the literature to indicate with certainty that the methods of crossdating were used, and not merely those of dating. If, for example, an old insect injury or a frost injury is dated from tree rings, it proves to be a matter of simple dating if only a single tree is used, but it becomes a clear-cut instance of crossdating if the same injury is dated from more than one tree. And it is equally probable that in some of the court cases involving boundary disputes blazes from more than one tree were used as evidence. This might prove to be a fruitful field of historic investigation for one who has a legal turn of mind.

To summarize: It is clear that a lot of work had been done by botanists, foresters, and astronomers on crossdating between 1737 and 1900, and that the methods of this dating tool were often used consciously. It is the present writer's belief that scarcely any of these men knew anything about the work of any of the others; that each one had arrived at the concept independently. With the single exception of Candolle's books, each of the writings mentioned in this paper seems to have been forgotten shortly after publication. A few, such as Kuechler, Pokorny, R. Hartig, and Kapteyn, had been resurrected by others within the past few years; others, such as Burgsdorf, Twining, Vonhausen, and Ratzeburg, appear to have been rediscovered only now and reviewed for the first time in the issue of the *Botanical Review* mentioned above.

Preceding 1900, not one of the papers in which crossdating was used, except those of Candolle, made much impression on the scientific world and apparently none on popular thought. It remained for Dr. A. E. Douglass to rediscover the method in the American Southwest after 1900, to use it persistently and extensively, and to apply it widely to astronomy and archaeology.

Texas Technological College,
Lubbock, Texas