Andrew E Douglass: Father of Dendrochronology

Dendrochronology, the basis for the research described in this article, was developed 100 years ago by a Vermonter who migrated to Arizona Territory in the late 19th century, and it is worth a brief description of his career, the development of this science and, its somewhat belated application in New England, before proceeding with the body of the article.

A. E. Douglass ca 1915

Reverend Malcolm Douglass ca. 1880

On July 5th 1867 a boy named Andrew Ellicott was born to the Reverend Malcolm and Ann (Hale) Douglass in Windsor Vermont. The boy's father was rector of St. Paul's Episcopal Church in Windsor during the 1860s and was president of Norwich University from 1871 to 1874. His maternal grandfather, the Reverend Benjamin Hale, had been president of Hobart College in Geneva N.Y. and Douglass himself would later serve briefly as president of the University of Arizona. Undoubtedly the boy received a good education, both at home and in school and was possessed with a wide curiosity. As a chronicler of the Ellicott family observed in 1881 " Andrew E. Douglass, son of Malcolm, though only fourteen, is well versed in astronomy. In this respect he is like his ancestor, Andrew Ellicott[1], of West Point N.Y., showing how mental qualities descend from generation to generation.[2]" The family was devoted to the 'liberal education philosophy' of the times which encouraged students to become versed in a wide array of topics.

Windsor of the 1870s was a center for manufacturing and machine tool innovation and perhaps the streak of inherited inventiveness was nourished during Douglass' boyhood years in the town.

Douglass attended Trinity College in Hartford Connecticut, as had his father, and graduated with honors in astronomy, mathematics, and physics in 1889 at the age of 22. His passion for astronomy led him to employment with the Harvard College Observatory and a year later he accompanied an expedition to Arequipa Peru to establish the college's Southern Hemisphere Observatory. Spending three years there, he learned the ins and outs of establishing an astronomical observatory in a remote location and found time to measure and describe the movement of crescentic sand dunes in the surrounding desert, publishing a paper on the subject (check).

With his acquired knowledge and ambition he came to the attention of Percival Lowell who wished to establish an observatory in Arizona Territory for studying the planet Mars. Lowell hired Douglass who traveled to Arizona in 1894 in order to choose a suitable site. They settled on Mars Hill outside of Flagstaff and Douglass set to work designing the telescope and observatory structure and supervising their construction.

Douglass worked with Lowell for seven years, acting as director when Lowell was absent, making and cataloging observations of the Martian surface. However friction developed over Lowell's obsession with what he believed were canals constructed by a Martian civilization, and this conflict led to Douglass' dismissal in 1901. Douglass stayed on in Flagstaff until 1906 when he accepted a faculty position at the University of Arizona in Tucson teaching astronomy and physics.

While his employer was obsessed with Martians, Douglass' own scientific interest was solar variability and its potential effects on Earth's climate. The cycle of sunspots was known at the time and it was believed that this fluctuation must affect the Earth's weather, perhaps causing cycles of drought in arid regions. During the dozen years he spent in Flagstaff, Douglass had pursued this interest, but his research was hampered by the shortness of weather data available to him (perhaps a dozen years at that time). It is this vein of inquiry that led to a great insight: perhaps the long-lived pines that grew in the area preserved, in their pattern of annual growth layers, a record past droughts and wet periods stretching back centuries, and this record could be substituted for the absent weather records. Study of trees in the region confirmed that a common pattern of wide and narrow growth layers could be observed and related to the available records of precipitation. In fact, the pattern was so precise and consistent that Douglass could determine the felling date of trees cut in logging operations without reference to other records, simply by noting the relationship of wide and narrow layers to a standard he had developed.

The general notion that the age of trees could be determined by counting the 'rings' on a cut stump was well known, and indeed the idea that the growth of plants was determined in some part by environmental factors was not novel, A. E. Douglass' systematic application of these ideas in service of scientific inquiry was particularly insightful and had far-reaching influence. It is likely that Douglass was familiar with fellow Vermonter George Perkins Marsh's seminal work *Man and Nature* published in 1864[3] and his observations on forest growth and tree longevity may have informed the astronomer's studies.[4] Many scientists of the time (and previous two centuries) were widely read and studied, and possessed of wide-ranging and diverse interests. The geographer Ellsworth Huntington's interest in the rise and fall of the Mayan civilization led to collaboration with Douglass in the development of a 3,000 year-long growth curve from giant sequoia stumps in California which he combined with records of the fluctuating level of the Caspian Sea in an attempt understand and document climatic changes in Central America and their effect on peoples of the region.[5]

In a serendipitous confluence of interests, archaeologists attending a lecture by Douglass took note of his claim that he could determine the felling date of a tree from its pattern of growth rings, and following Douglass' talk asked him about the possibility of attempting to date the construction of prehistoric ruins that abounded in the region. An intense debate had developed among scholars over the age of the ruins, and estimates ranged from a few centuries to thousands of years. Douglass was intrigued, as the possibility extending his record of regional aridity with material from the ruins was attractive, and a collaboration was begun. The archaeologists would provide Douglass with sections of beams from a number of the best preserved ruins and he would attempt to match the growth patterns of the timbers with those he had developed from pines in the region. At the time this record developed from living trees extended back nearly 600 years. Initially, it was impossible to match the timbers in the ruins to the living tree chronology as a temporal gap of unknown length existed between them. A series of field expeditions funded by the National Geographic Society were undertaken to collect material that might bridge this gap, targeting specific ruins thought to contain timbers of the appropriate age. While this effort took nearly two decades of dedicated work it eventually succeeded in assigning calendar dates of construction to many important archaeological sites in the Southwest and the construction of a 2,000 year record climate for the region.[6] This accomplishment brought to Douglass significant scientific acclaim, something that eluded him in his chosen field of astronomy and climate cycles, and resulted in the establishment of the Laboratory of Tree Ring Research at the University of Arizona in 1937.

Throughout his long academic career at the University of Arizona Douglass pursued his interest in astronomy and solar influences on climate, founding the Steward Observatory in 1916 and developing and constructing a series of 'cycloscopes'. These were optical analytical devices designed to survey tree ring time-series for periodicities of variable length and character that could be compared with sunspot cycles in a search for causative relationships. The final version of this device was built in 1936 by Stanford University and is still housed at the University of Arizona in the Arizona State Museum, while the design, operation, and research conducted was described by Douglass in a series of articles and books.[7] It is only recently that modern computers and software have been developed that can emulate the type of analysis developed by Dr. Douglass with his cycloscopes.

The tree ring dating techniques Douglass developed[8] have been widely applied in the scientific world over the past century in a great variety of research fields including ecology, climatology, geology, and archaeology. Calibration of the radiocarbon time scale with tree ring dated samples for the past 12,000 years has led to increased accuracy in published radiocarbon dates for all fields that use this method for dating organic materials.

Given its broad application and wide acceptance in the scientific community it is interesting to note that it was not until the late 1970s that dendrochronology was systematically applied in the Eastern United States. While Douglass' student, researcher Edmund Schulman, and Douglass himself made collections in New England in the 1930s and 40s, little sustained interest resulted from these early efforts. Perhaps, in part, the relative youth of New England forests, a consequence of 200 years of settlement, cutting and clearing and harvest, combined with their relatively dense and mesic character dampened enthusiasm for its use in the region. Attempts to apply dendrochronology to archaeology in the eastern United States, most notably by Florence Hawley Ellis (student of Douglass) and her student, Robert Bell of the University of Chicago, in the 1940s and 50s met with limited success[9].

Beginning with Hal Fritts effort to reconstruct climate on a continental scale in the 1970s[10], and expanded by Edward Cook of Lamont-Doherty Earth Observatory at Columbia University N. Y. assisted by Paul Krusic and others, a network of tree ring chronologies in the New England region was developed. Largely based on samples from relict old-growth stands of red spruce and eastern hemlock, this network has provided a basis for further tree-ring work in the region.

Attention was first focused on historic structures of the region as a potential source of tree ring material in the 1990s. However a significant problem remained, because buildings constructed in the 18th and 19th centuries used timbers procured from the surrounding virgin forests composed of oak, beech, maple, chestnut, hickory, birch, pines, and a variety of other species. Spruce and hemlock, while utilized when conveniently located near settlements, were not sought out or widely used for construction until well into the 19th century. It is nearly impossible today to find stands of oak and pine, or many of the other species, with trees more than 100 years old. The forests of tall, straight pines and oaks, where trees of 250 to 400 years of age were not uncommon, as described by early settlers, had largely disappeared by the 1820s in southern Vermont and even earlier to the south in Connecticut, Massachusetts, eastern New York, and Pennsylvania[11]. Cycles of settlement, clearing, and harvest long ago eliminated such trees from today's landscape, and constructing 'bridge' chronologies from living trees to match growth patterns in timbers from historic structures represents a significant difficulty. While spruce and hemlock share some of the same ecological requirements and respond similarly to fluctuations in local climate, these characteristics are not necessarily shared with deciduous hardwoods and pines that prefer entirely different habitats. A harsh summer drought does not have precisely the same effect on hardwood forests growing in lowland valleys as on coniferous trees growing on mountain slopes.

1. Andrew Ellicott was a noted surveyor who worked for Gen. George Washington following the

Revolutionary War. During a long career he surveyed lands in New York, Pennsylvania, and Florida for the new nation, laid out the boundaries of the District of Columbia and revised the street plan for the capitol city, provided the first accurate measurements of Niagara Falls, served as a teacher and mentor to Meriwether Lewis, was an avid astronomer, and professor of mathematics at West Point military academy. He designed surveying instruments that were widely used and made measurements and observations on the Gulf Stream and astronomical phenomena while on surveying expeditions.

2. Biographical and historical accounts of the Fox, Ellicott, and Evans families, and the different families connected with them (1882) by Charles W. Evans. Buffalo, Press of Baker, Jones & co. (215)

3. Man and Nature; or Physical Geography as Modified by Human Action. George Perkins Marsh New York: Charles Scribner, 124 Grand Street. 1864

4. Along with many other insightful comments Marsh observed "*Great luxuriance of animal or vegetable production is not commonly accompanied by long duration of the individual. The oldest men are not found in the crowded city; and in the tropics, where life is prolific and precocious, it is also short. The most ancient forest trees of which we have accounts have not been growing in thick woods, but isolated specimens, with no taller neighbor to intercept the light heat and air, and no rival to share the nutriment afforded by the soil*" (ibid. 276 - 277, footnotes). Douglass, and his student Edmund Schulman, later refined this sentiment into the principal of 'longevity under adversity' as their studies had led them to search out the oldest individual trees in their efforts to extend records of the earth's climate back in time. Their search led to the discovery of bristlecone pines in the White Mountains of California up to 5,000 years in age growing under extremely cold and arid conditions.

5. The Climatic Factor as Illustrated in Arid America, by Ellsworth Huntington. With contributions by Charles Schuchert, Andrew E. Douglass, and Charles J. Kullmer. Washington D.C. Published by the Carnegie Institution of Washington. 1914.

6. See Tree Rings and Telescopes: the Scientific Career of A. E. Douglass by George Ernest Webb. University of Arizona Press, Tucson Arizona. 1983, and The Secret of the Southwest Solved by Talkative Tree Rings by A. E. Douglass. National Geographic Magazine 56(6): 736 - 770, 1929.

7. See for example Climatic Cycles and Tree Growth: A Study of the Annual Rings of Trees in Relation to Climate and Solar Activity by A. E. Douglass. Published by the Carnegie Institute of Washington, Washington D. C. 1919.

8.The article "Crossdating in Dendrochronology" by A. E. Douglass, Journal of Forestry 39: 825 - 831, 1941 summarizes the basic process of pattern matching that is key in all applications of dendrochronology.

9.See Tree Ring Dating and Analysis in the Mississippi Drainage by Florence Hawley Ellis 1941 and Dendrochronology in the Mississippi Valley. In: Archaeology in the Eastern United States.

Robert E. Bell 1953. Edited by James B. Griffin, University of Chicago Press. Chicago. 345–351.

10.

11. Marsh, writing in the mid 19th century in Man and Nature, states "*The remaining forests of the Northern States and of Canada no longer boast the mighty pines which almost rivaled the gigantic Sequoia of California; and the growth of the larger forest trees is so slow, after they have attained to a certain size, that if every pine and oak were spared for two centuries, the largest now standing would not reach the stature of hundreds recorded to have been cut within two or three generations.*" (274) In a subsequent table copied from Dr. Samuel Williams 'The Natural and Civil History of Vermont', volume I, second edition 1809, page 87 (first edition published in 1794), oak, birch, ash, basswood, hemlock, buttonwood (sycamore), and maple, four to five feet in diameter and 100 to 200 feet tall, and a white pine six feet in diameter and 274 feet tall are listed as the largest of their respective species commonly found in the region (specifically Vermont).