[RADIOCARBON, VOL. 35, No. 1, 1993, P. 67–72]

A NOTE ON SINGLE-YEAR CALIBRATION OF THE RADIOCARBON TIME SCALE, AD 1510–1954

MINZE STUIVER

Department of Geological Sciences and Quaternary Research Center, University of Washington, Seattle, Washington 98195 USA

INTRODUCTION

Most data in this Calibration Issue are based on radiocarbon age determinations of tree-ring samples with dendrochronologically determined calibrated (cal) ages. For high-precision measurements, substantial sample amounts are needed, and the processed wood usually spans 10 or 20 tree rings. Thus, the calibration curve data points usually have decadal, or bidecadal, spacing. These curves, to be used for the calibration of samples formed over 1 or 2 decades, may not be fully applicable to samples (leaves, twigs, *etc.*) formed in a single growing season.

The determination of a calibration curve with single-year spacing over many thousands of years requires an order of magnitude larger calibration effort than made so far. For instance, the counting time for producing the 440-yr single-year series reported here is identical to that needed for a 8800-yr bidecadal chronology. Fortunately, the production of a single-year calibration curve for the Holocene is not urgent, as the gains from such an effort are limited.

^{14}C determinations of either the cellulose or de Vries component of Douglas and Noble fir wood from the US Pacific Northwest (Table 1) form the basis for the Figures 1 and 2 calibration curves. All measurements are for single-year samples, except for AD 1890.5–1910.5 (2-yr data) and AD 1913–1916 (3-yr data). The average laboratory standard deviation in the measurements is 12.8 ^{14}C yr. The AD 1510–1625 and AD 1820–1950 data, published previously (Stuiver 1982; Stuiver & Quay 1981), have been corrected for minor amounts of radon in the counting process (Stuiver & Becker 1993).

The time span over which a sample is formed is important in limiting the cal age uncertainty introduced by wiggles in the calibration curve. The wiggles in a curve produced, for instance, by a 100-yr moving average of decadal calibration data are smoothed relative to those of the original decadal calibration curve. In areas of major cal age uncertainty (the horizontal portions of the curve), the ^{14}C age conversion for a sample formed over 100 yr, using the 100-yr moving-average curve, yields a cal age range smaller than the range obtained from the decadal (or single-year) calibration curve. The cal age range derived for the 100-yr sample, of course, represents the midpoint of the 100-yr time span. This approach is valid only when the growth rate of the specimen is reasonably constant, as the amount of material formed during the first 50 yr must approximate that of the second 50 yr.

Figures 1 and 2 detail the calibration curves for, respectively, single-year samples and 3-, 5-, and 10-yr moving averages. With an average standard deviation (for 1.0 error multiplier) in the single-year calibration curve of 12.8 ^{14}C yr, the uncertainties in the 3-, 5- and 10-yr moving averages are, respectively, 7.2, 5.6 and 4.1 yr.

In Figure 3, we compare the cal ages and ranges derived for three high-precision ^{14}C dates (120 ± 15, 180 ± 15 and 260 ± 15 ^{14}C yr BP). The calibration curves used are the Figure 1 single-year curve, its derivatives obtained through moving averages (3-, 5- and 10-yr), and the decadal (Stuiver

& Becker 1993) and bidecadal (Stuiver & Pearson 1993) curves. The 10-yr curves differ slightly, as a 10-yr moving average produces a continuous curve, whereas the decadal Stuiver and Becker calibration curve connects decadal midpoints by a straight line.

For regions of major cal-age uncertainty (^{14}C ages of 120 and 180 yr BP), the number of intercepts (Fig. 3) increases by an order of magnitude when moving from the decadal to the single-year curve. The cal age ranges around most intercepts derived from the single-year curve overlap, however, and do not improve time separation within the larger cal age ranges. Two-sigma cal age ranges (Fig. 3) usually increase for single-year-curve calibration, and additional segments appear. The calibration of a single-year sample against a single-year calibration curve leads to larger cal-age uncertainty than the calibration of a 10-yr sample against a decadal curve.

Materials grown over decades will provide better cal-age control than single-year samples. Of course, single-year samples may be the only ones available for a specific site. As the current single-year calibration curve is only for the post-AD 1510 interval, the calibration of these samples (against a decadal or bidecadal curve) will, in most instances, lead to underestimated cal-age uncertainty.

Single-year ^{14}C age records may differ between regions. Pacific Northwest Δ^{14}C values (derived from the Fig. 1 ^{14}C ages) contain an 11-yr cycle with an average amplitude of 1.40 ± 0.16 ‰ (*ca.* 11 ± 1 ^{14}C yr). This amplitude differs significantly from the 11-yr cycle amplitude of 4.8 ± 0.6 ‰ (*ca.* 39 ± 5 ^{14}C yr) found in Russian trees (Kocharov 1992) between AD 1600 and AD 1950. Confirmation of the Russian data set would imply Pacific Northwest-Russia ^{14}C age differences of at least 20 ^{14}C yr for parts of the single-year record. ^{14}C age differences of about 10 ^{14}C yr appear to be an upper limit for regional offsets in decadal or bidecadal calibration curves (Stuiver & Pearson 1992).

Acknowledgments

This work was supported by National Science Foundation grant BNS-9004492. P. J. Reimer and P. J. Wilkinson provided crucial technical and analytical support.

References

Kocharev, G. E. 1992 Radiocarbon and astrophysical-geophysical phenomena. *In* Taylor, R. E., Long, A. and Kra, R. S., eds., *Radiocarbon After Four Decades: An Interdisciplinary Perspective*. New York, Springer Verlag: 130–145.

Stuiver, M. 1982 A high-precision calibration of the AD radiocarbon time scale, *Radiocarbon* 24(1): 1–26.

Stuiver, M. and Becker, B. 1993 High-precision decadal calibration of the radiocarbon time scale AD 1950-6000 BC. *Radiocarbon*, this issue.

Stuiver, M. and Pearson, G. W. 1992 Calibration of the radiocarbon time scale 2500–5000 BC. *In* Taylor, R. E., Long, A. and Kra, R. S., eds., *Radiocarbon After Four Decades: An Interdisciplinary Perspective*. New York, Springer Verlag: 19–33.

_____1993 High-precision calibration of the radiocarbon time scale, AD 1950–500 BC and 2500–6000 BC. *Radiocarbon*, this issue.

Stuiver, M. and Quay, P. D. 1981 Atmospheric ^{14}C changes resulting from fossil fuel CO_2 release and cosmic ray flux variability. *Earth and Planetary Science Letters* 53: 349–362.

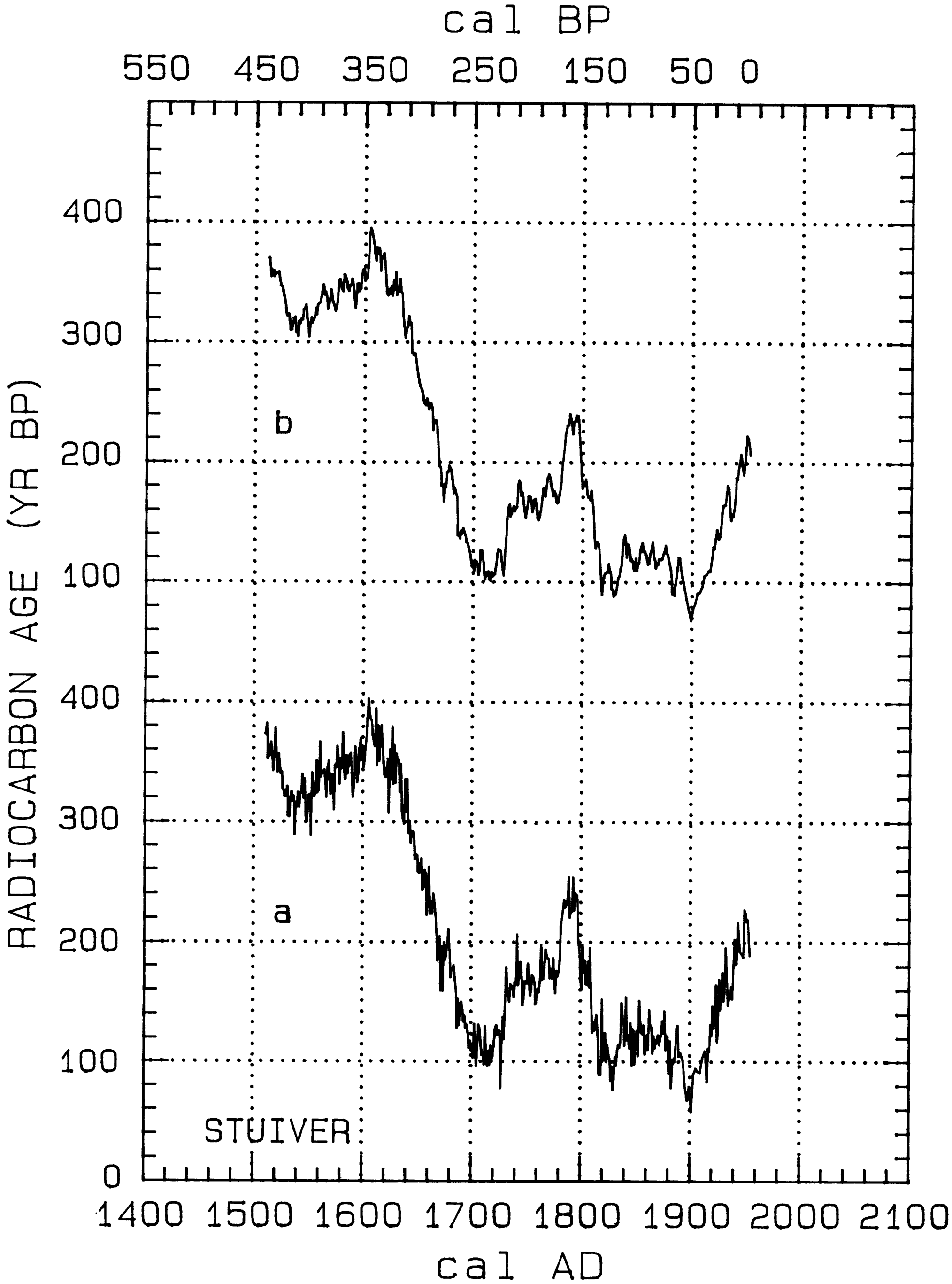


Fig. 1. ^{14}C age *vs.* cal age for single-year samples (a) and 3-yr moving averages (b)

https://doi.org/10.1017/S0033822200013813 Published online by Cambridge University Press

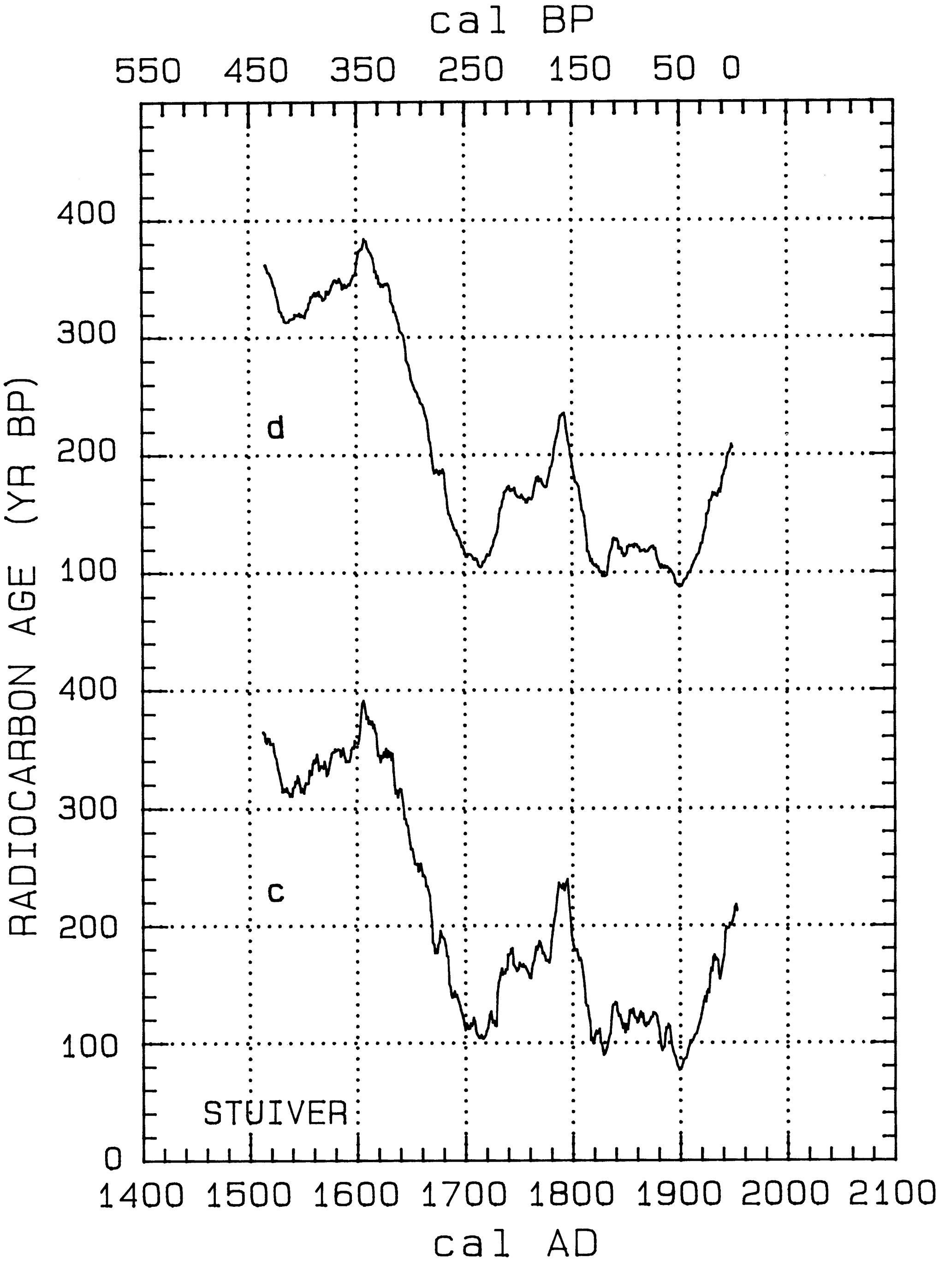


Fig. 2. ^{14}C age *vs.* cal age for 5-yr (c) and 10-yr (d) moving averages of single-year results depicted in Figure 1

https://doi.org/10.1017/S0033822200013813 Published online by Cambridge University Press

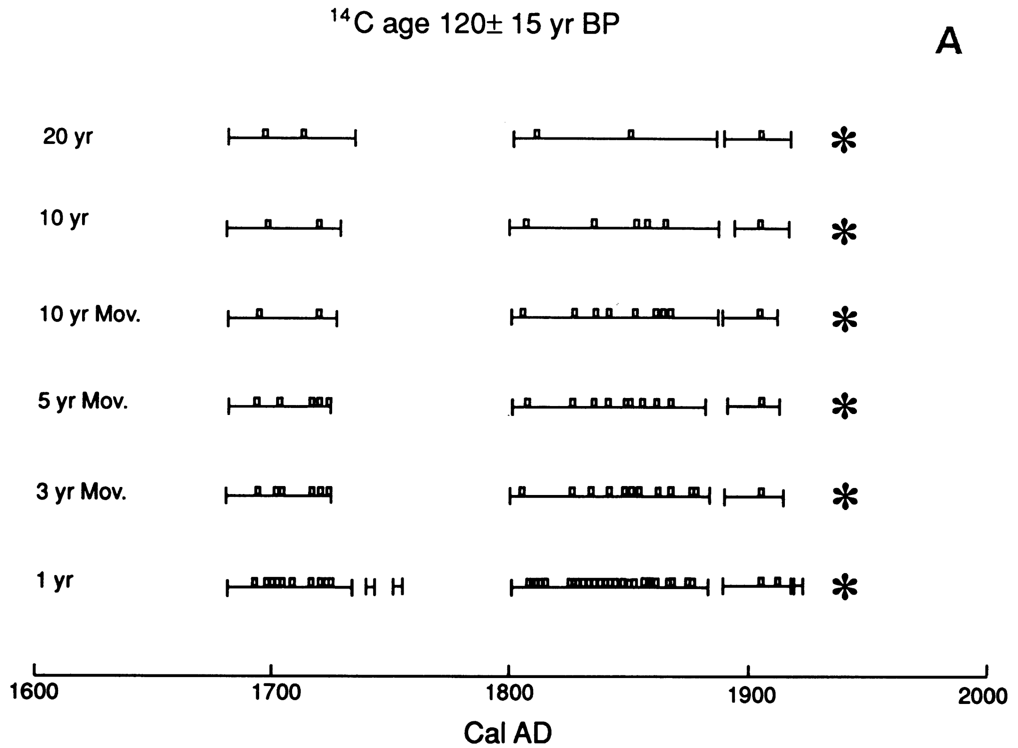
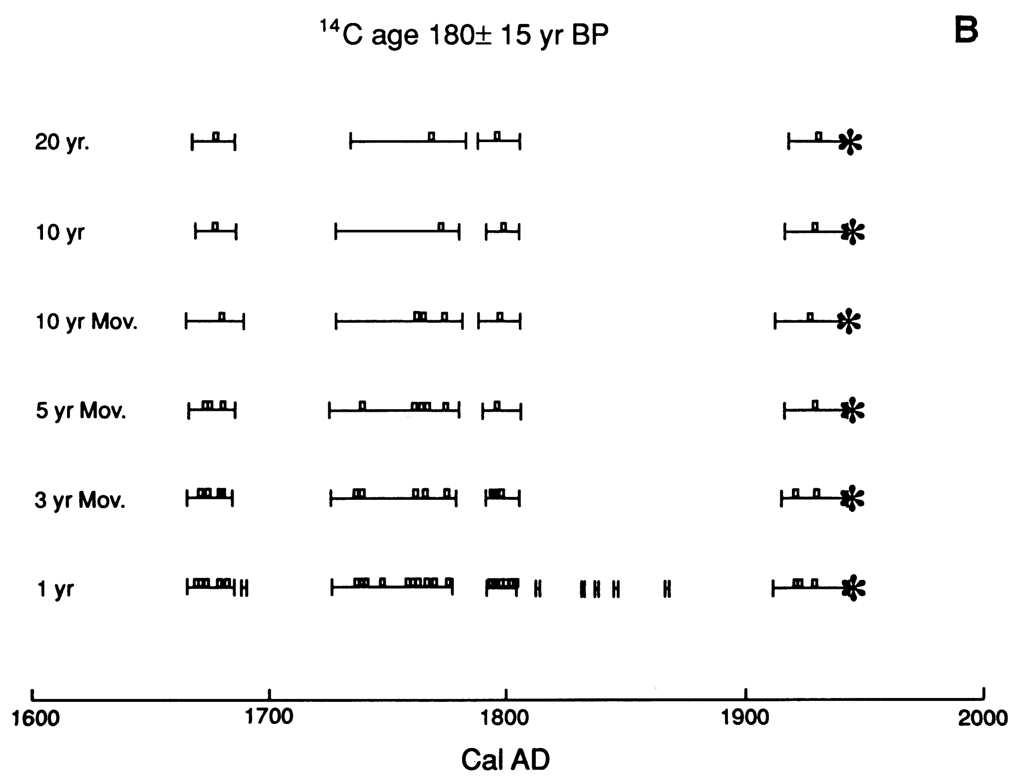


Fig. 3A–C. Cal age results for three ^{14}C ages (120 ± 15, 180 ± 15, and 260 ± 15 ^{14}C yr BP). Cal age intercepts (□) were derived from the Figure 1 single-year calibration curve, the 3-, 5- and 10-yr moving averages, the Stuiver and Becker (1993) decadal curve, and the Stuiver and Pearson (1993) bidecadal curve. | = 2 σ cal age ranges. * = nuclear bomb intercepts near AD 1954–1955.



https://doi.org/10.1017/S0033822200013813 Published online by Cambridge University Press

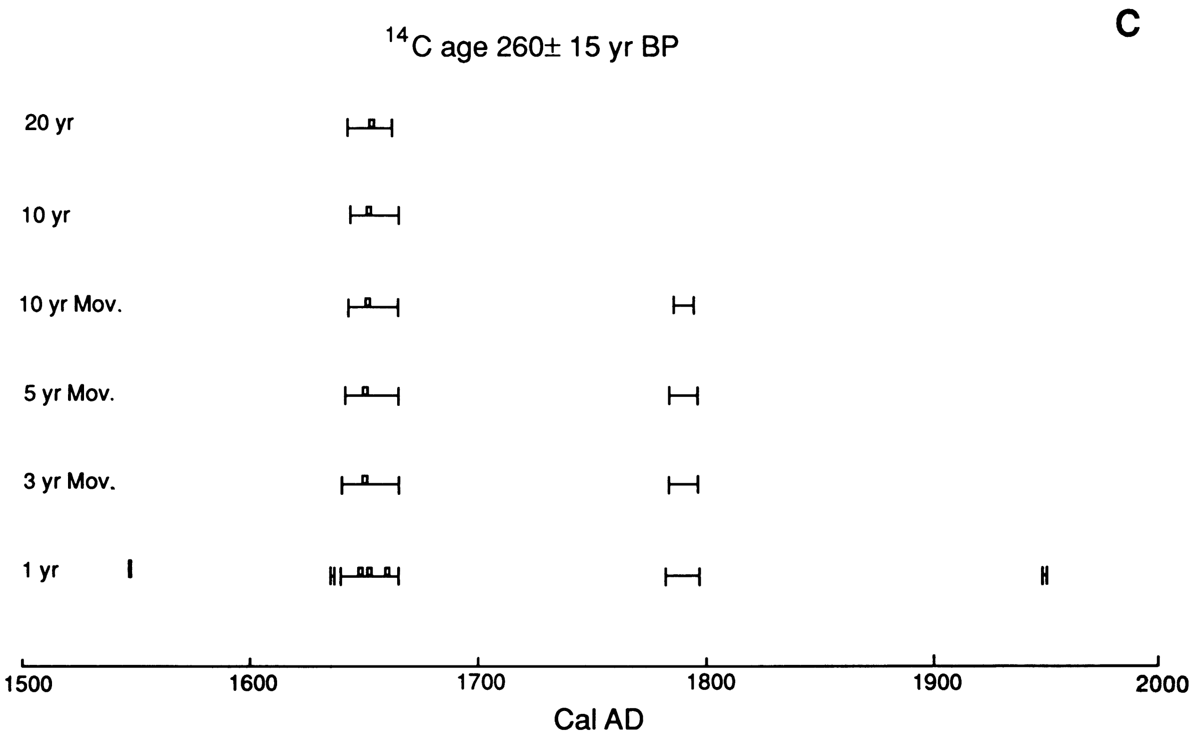


TABLE 1. ^{14}C determinations of either the cellulose or de Vries component of Douglas and Noble fir wood from the US Pacific Northwest

Year AD	Tree	Location	Species	Wood Treatment
1916–1954	C	Olympic Peninsula (47°46′N, 124°06′W)	Douglas fir	CL*
1820–1919	A	Olympic Penninsula (47°46′N, 124°06′W)	Douglas fir	DV**
1690–1725 1755–1759 1784–1822	B	Mt. Rainier, Washington (46°45′N, 121°45′W)	Douglas fir	DV
1686–1781	DW	Cougar, Washington (46°4′N, 122°17′W)	Noble fir	CL
1510–1700	F	Coos Bay, Oregon (43°7′N, 123°40′W)	Douglas fir	CL

*CL = cellulose
**DV = de Vries-treated wood