A 7104-YEAR ANNUAL TREE-RING CHRONOLOGY FOR BRISTLECONE PINE, *PINUS ARISTATA*, FROM THE WHITE MOUNTAINS, CALIFORNIA

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ABSTRACT

A 7104-year tree-ring chronology has been developed for bristlecone pine, *Pinus aristata* Englem., in the White Mountains of east-central California, U.S.A. The chronology was extended backward in time by incorporating tree-ring series from living trees up to 4600 years old, as well as from standing snags, fallen trees, large remnants, and eroded fragments. The availability of datable wood in the 9000-year range has been indicated by radiocarbon analysis. Aspects of chronology development are described. Substantiating evidence, for both age and chronology, is derived from the bristlecone pine of east-central Nevada, where a 5000-year series has been developed. Dated bristlecone pine has been used in radiocarbon studies; approximately 500 samples of dated wood have been sent to various laboratories.

This article deals with the development of a 7104-year tree-ring chronology for bristlecone pine, *Pinus aristata* Engelm., from the White Mountains of east-central California.

Interest was drawn to the bristlecone pine in 1953 when Edmund Schulman began tree-ring studies of species of the upper timberline in a search for evidence of climatic change. He and his colleagues at the Laboratory of Tree-Ring Research, University of Arizona, had for many years studied conifers of the lower forest zones. Then they learned that some upper-forest species, especially trees growing under conditions of stress, also showed a record of sensitivity to drought in their growth-ring sequences. Greater emphasis was placed on this aspect of the study after a limber pine, *Pinus flexilis* James, discovered in Trail Canyon, near Sun Valley, Idaho, was found to have a drought-sensitive record of almost 1700 years (Schulman 1954).

In 1954 and 1955, a widespread search through the western United States resulted in the discovery of three bristlecone pines more than 4000 years old and six others more than 3000 years old (Schulman and Ferguson 1956). One, a 3100-year-old specimen, was in the Schell Creek Range, east of Ely, Nevada. All the others were in the White Mountains of east-central California, and this fact caused Schulman to focus his attention on that district of the Inyo National Forest.

Collections by Schulman and Ferguson in 1956 and by Schulman and Cooley in 1957 were reported in *National Geographic* (Schulman 1958), in an issue that went to press just before Schulman's death on 8 January, 1958. That article brought the trees worldwide attention, and the U.S. Forest Service, in the course of developing the Ancient Bristlecone Pine Forest, designated one area the Edmund Schulman Memorial Grove as a tribute to the scientist whose life work culminated in the knowledge that the bristlecone pine is the world's oldest known living tree.

With Schulman's death, however, study of the bristlecone pine lapsed until 1961, when the Laboratory of Tree-Ring Research gained support for further research.

Fritts (1969), also of the Laboratory of Tree-Ring Research, reported the highly instrumented growth studies that were carried on in the White Mountains for three summers (1962-1964) and, as a corollary, the analysis of replicated tree-ring samples from 20 different sites in the same range.

The lure of the bristlecone pines has beckoned the traveler-photographer-writer; two reports are noteworthy for their pictorial coverage and text descriptive of the area (Feininger 1968; Lindsay 1969).

Bristlecone pines grow in six states of the Southwest (Critchfield and Little 1966: 10, 52-53; Critchfield and Allenbaugh 1969), but we confined our research primarily to the White Mountains because we knew old trees were there and such factors as accessibility, research facilities, and climate were favorable. As Pacific storms move inland, moisture falls on the Sierra Nevada, leaving the White Mountains and the intervening Owens Valley in a rain shadow (Fig. 1). Thus, even though conifers in the White Mountains grow at elevations of 3000 to 3350 meters (10,000 to 11,000 feet) above sea level, they are in a relatively arid environment with an average annual rainfall of 305 to 330 millimeters (12 to 13 inches) (D'Ooge 1955; Wright and Mooney 1965). This combination of aridity, a predominantly dolomitic soil, and a huge mountain mass results in old, slow growing trees which have a tree-ring record that reflects climatic variation. Other factors favor the persistence of both the trees and the wood. The sparse ground cover and the scarcity of litter result in relative safety from ground fire. Tree trunks and large pieces of wood resist fire through the exclusion of oxygen due to a high ratio of volume to surface. The highly resinous nature of the compact wood provides resistance to moisture and decay. And the retention of needles for 20 to 30 years insures a somewhat stable photosynthetic capacity that can carry a tree over several years of stress (Fritts 1969). These age-producing features, combined in varying degrees, occur throughout the range of bristlecone pine.

The focus of the present study has been the extension of the tree-ring chronology beyond the limits of the living tree, hence old trees, *per se,* have not been intensely searched for and sampled. While other areas have only been lightly surveyed, workers both outside and within the Laboratory have added to the knowledge of old trees and their distribution. A 4900-year-old bristlecone pine, reported in the Snake Range of east-central Nevada (Currey 1965), provided the impetus for a current study by The University of Arizona in cooperation with the Humboldt National Forest involving an inventory and ecological study by the Department of Watershed Management, and a dendrochronological survey by the Laboratory of Tree-Ring Research. Collections made during the past three summer field seasons in the Snake, Mount Moriah, Ward Mountain, and Schell Creek Divisions of the Humboldt National Forest have included trees over 3000 years old, but none over 4000. Data from long-dead trees have been studied, but no serious attempt has been made to extend the chronology beyond 5000 years. LaMarche (1969), in relating environment to age of bristlecone pine, reports a tree in the White Mountains as 4000 years old at the time of its death in A.D. 1500. His sampling in the Snake Range and in nearby ranges has yielded other bristlecone pines from 2900 to 3700 years old. In the High Plateau region of southern Utah, he reports ages of over 1500 years; at the edge of the Table Cliffs at the southern end of the Aquarius Plateau in southern Utah, nearly 3000 years; and in southwestern Utah, at Bryce Canyon National Park, 1560 years, and at Cedar Breaks National Monument, 1650 years. Eardley and

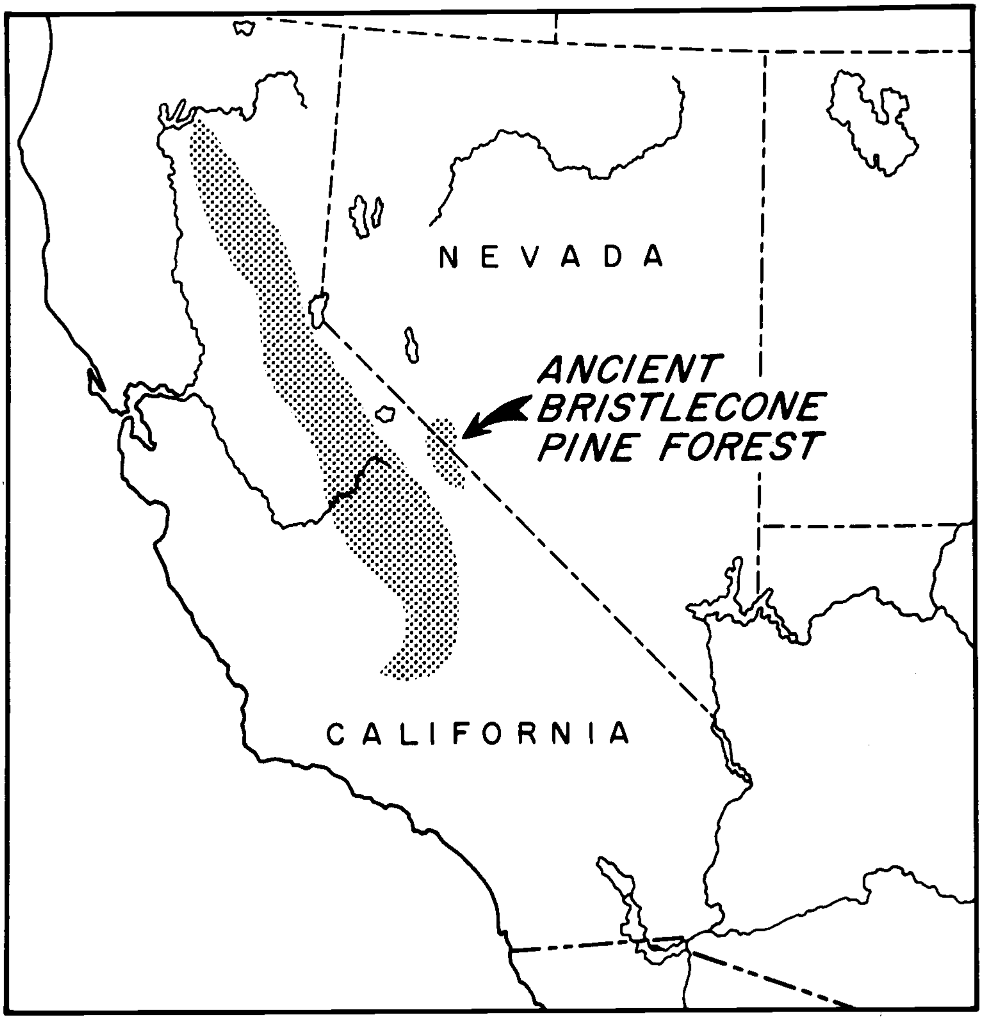

Fig. 1. Location of the White Mountains (arrow) in relation to the Sierra Nevada (larger shaded area).

Viavant (1967) reported a tree approximately 2480 years old in the Dixie National Forest, Cedar Breaks. Also in the Cedar Breaks area, Schulman and Ferguson (1956) had one tree with 1400 rings on an incomplete core and another tree about 1630 years of age.

Specimen Collection

Radial growth-ring sequences in core samples extracted with a Swedish increment borer are the primary source of chronologic data. In older bristlecone pines, the center of the tree often becomes exposed, due to partial cambial dieback, unilateral growth, and erosion or decay of the dead and exposed wood. In this case, it is practical to extract a core from the original center of growth (pith area) with a standard 40 centimeter (16 inch) increment borer.

To secure additional specimens and improve the quality of the chronology in the earlier periods, especially beyond the maximum age of living trees, we began, in 1963, to collect material of two types: (i) cores extracted either from the original central portion of standing or fallen snags or from large, eroded remnants of trees, and (ii) entire smaller remnants having the appearance of age and without specific known origin in relation to any tree, living or dead.

Cores obtained from near the original center of the stem (pith area coring) indicate the general characteristics of the ring record for a given tree and provide the earliest possible date for the specimen. Even though such a core, usually less than 40 centimeters long, may contain many hundreds of growth rings useful in chronology building, pith area coring is considered only a rapid survey technique. In contrast, more time is required to obtain the multicore sample that is often necessary to reconstruct the entire curvilinear radius characteristic of the unilateral growth of older trees, a technique developed by Schulman (1956) and illustrated by Bowers (1965, Fig. 5).

A study (Wright 1963) of the relationship between the ring pattern along a single radius and the ring pattern of the cross section of which the radius is a part clearly shows that a cross section is of greater value than a core. While a single radius may contain only 95 percent of the annual rings (that is, 5 percent are "missing"), at least half of the missing rings may be found in their anticipated position through careful search of as little as 10 centimeters of circuit. Therefore, remnants are highly valuable in that they provide more surface area for detailed study of the very narrow and often locally absent rings that are critical in chronology building. In addition, remnants constitute the principal source of tree-ring material for radiocarbon analyses. And finally, the availability of such remnants makes it unnecessary to cut down a living tree for dendrochronological purposes. In the field, each potential specimen is critically examined to make sure it (i) has an average ring width noticeably greater than 0.10 millimeter (this maximum was established both to lessen the probability of missing rings, which present problems in dating, and to provide a greater volume of wood per year for radiocarbon analysis); (ii) is a pith area specimen; and (iii) is not too large to be conveniently carried – no small factor at elevations of 3000 meters.

Chronology Building

Basic to a tree-ring chronology is the fact that each consecutive annual growth ring is assigned to the calendar year in which it was formed. Thus, cores taken through living tissue have the chronology control provided by an outermost ring with a precisely known date. Inward from this so-called "bark" ring, successive annual growth layers are assigned to sequentially earlier years. A pattern of wide and narrow rings which is common to all radii and to different specimens forms the basis for crossdating among specimens. The master chronology for all specimens involved is unique in its year-by-year pattern; nowhere throughout time is precisely the same long-term sequence of wide and narrow rings repeated, because year-to-year variations in climate are never exactly the same.

In certain species of conifers, especially those at lower elevation or in southern latitudes, one season's growth increment may be composed of two or more flushes of growth, each of which may strongly resemble an annual ring (Glock, *et al.* 1960; Glock, *et al.* 1963; Fritts, *et al.* 1965). Such multiple growth rings are extremely rare in bristlecone pine, however, and they are especially infrequent at the elevation and latitude (37°23′N) of the sites being studied. In the growth-ring analyses of approximately 1000 trees in the White Mountains, we have, in fact, found no more than three or four specimens with even incipient multiple growth layers.

In bristlecone pine, problems of crossdating are caused by so-called "missing" rings associated with the extremely slow growth rate of this species on arid sites. One specimen, for example, contains more than 1100 annual rings in 12.7 centimeters of radius. Such slow-growing wood, with an average ring width of only a few hundredths of a millimeter, frequently lacks evidence of growth in a large portion of the circuit during a year of environmental stress. In some instances, 5 percent or more of the annual rings may be missing along a given radius that spans many centuries. The location of such "missing" rings in a specimen is verified by crossdating its ring pattern with the ring pattern of other trees in which the "missing" ring is present, or by checking against the ring record of the occasional specimen that contains every ring in a span of over 2000 years.

In developing the bristlecone pine chronology for the White Mountains, other chronologies were used for comparison and verification. Schulman's primary crossdating control was the tree-ring record back to 1250 B.C. for the Sierra Nevada giant sequoia, *Sequoia gigantea* (Lindl.) Decne. (Douglass 1919, 1928). Since that was the longest chronology then available, he had been increasingly concerned because the bristlecone pine chronology that he had developed back to 780 B.C. was fast approaching the limits of the sequoia record.

In more recent, computer-based research, Fritts (1963) demonstrated that the bristlecone pine chronology correlates with chronologies from trees as far away as 1600 kilometers to the east and south and about 480 kilometers to the north. This provides a basis for comparing portions of the White Mountain chronology for recent centuries with the preliminary bristlecone pine chronologies in the Spring Mountains, near Las Vegas, Nevada; in the Panamint Mountains, Death Valley National Monument (Schulman 1956; Schulman and Ferguson 1956); and in the Inyo Mountains, the southern extension of the White Mountain range. Other correlated chronologies include those of limber pine in the White Mountains and of the oldest known limber pine (in central Nevada), with an innermost ring at A.D. 25 (Schulman 1956); the integrated modern-archaeological chronology for the Southwest, which goes back to 59 B.C. (Schulman 1952, 1956); the chronology for single-leaf pinyon, *Pinus monophylla* Torr., in the White Mountains (Ferguson 1964) and Panamint Mountains, California (Ferguson and Wright 1962) and in the Snake Range, Nevada (Ferguson, unpublished); for limber pine, Douglas-fir, and bristlecone pine from the Snake Range (Ferguson, unpublished); and for sagebrush, *Artemisia tridentata* Nutt., a shrub species that reaches ages of more than 200 years, from both the White and Panamint mountains (Ferguson 1964).

Beyond the age limit of each of these controls, however, crossdating among bristlecone pine themselves becomes increasingly important. As the number of trees decreases with each successively older age class, therefore, the location and dating of remnants, especially those with more open ring records, becomes of greater concern.

Statistical Analysis

We have developed routine computer programs for calculating certain statistical measurements from tree-ring series (Fritts 1963). The entire set of rings from the lower trunk of a mature tree can be related to yearly climatic variation by removing, statistically, the gradual changes associated with the age of the tree (Fritts, *et al.* 1969).

An exponential curve is fitted to each series of ring-width values, and measured ring widths are divided by yearly values of the fitted curve. This process transforms the ring-width values to tree-ring indices which exhibit a mean of 1.00 and a variance that is independent of tree-age, position within the trunk, and mean growth of the tree. Additional programs include: (i) correlation coefficients, which give a measure of common relative variability of indices for pairs of cores from one tree or for different trees; (ii) mean sensitivity, which expresses the relative year-to-year variation in the ring index values; (iii) first-order serial correlation, which measures the degree of dependence of a single growth-ring index upon the index of the preceding ring; and (iv) standard deviation, which measures the variation about the sample mean.

From application of these statistical measurements to a particular site, one can infer how certain ecological conditions have limited ring growth (Fritts 1966, Fig. 2, Schulman Grove crest). An understanding of these relationships facilitates the search for sites and trees that contain sensitive records.

To evaluate the statistical qualities of trees in a representative site used for chronology building, I took paired cores from opposite sides of 18 trees in the valley known as Methuselah Walk. Most of the trees had trunks completely enclosed in live bark; in some older specimens, however, the cores were taken from live portions of partially dead trunks. The data summary for the period A.D. 1600-1964 (Table 1) shows that the specimens, listed in order of increasing number of missing rings, represent a gradient in site responses. In the same sequence, the mean sensitivity increases and the serial correlation decreases. Hence, the gradient in statistical parameters – increasing number of missing rings, increasing mean sensitivity, and decreasing serial correlation – fit the generalized scheme (illustrated by Fritts, *et al.* 1965, Fig. 4).

The gradient in tree-ring characteristics indicates very clearly that the logical approach in chronology building should be in the selection of specimens with the desirable features of datability uncomplicated by the problem posed by locally absent and missing rings. This study brought out what was very early realized: that in working with a new dendrochronological species, in a new area, and (increasingly) in a new time period, we would be much more secure in chronology building to work with material of a proven, but safe quality. Much of the data collected in the early stage of investigation was of an extremely difficult quality, with a very low average ring width (many specimens had more than 100 rings per radial inch), a high mean sensitivity, and many locally absent and missing rings. Realizing this, we focused our attention upon a search for trees with less critical qualities, but still with the desired age and usable ring series. This search, prompted to a large degree by those involved with radiocarbon analysis who were eager for dated wood of the earliest possible age, soon was centered in Methuselah Walk. We began to rely upon a new ring-growth characteristic, that of a skewed ring-width distribution (Ferguson 1968). In this, we found the desired feature for relatively rapid chronology building in ring series with a large dependable ring width, but only a few very diagnostic rings per century. A chi-square test for goodness of fit may be used to describe and illustrate this unusual distribution of ring widths (This program, part of a project supported by NASA grant NGR 03-002-101, was developed by Charles Huzar and Harold C. Fritts of the Laboratory of Tree-Ring Research). In Figure 2 the observed frequencies of ring-width index values in the most sensitive nine specimens of the statistical analysis group (Table 1) are plotted relative to the normal curve of distribution. The observed distribution is significantly nonnormal (P = .01), as indicated by a larger-than-normal observed frequency of small rings below two standard deviations, the remaining values

Table 1. Statistical data for paired cores in 18 bristlecone pine trees in Methuselah Walk, A.D. 1600-1964.

RADIUS					TREE		
Specimen Number	Mean Sens.	Serial Correl.	Mean Ring Width, mm	Absent Rings		Mean Sens.	Serial Correl.
64-F38A	.20	.58	.23	0	0	.19	.48
1-F38C	.23	.44	.25	0			
i-F10A	.32	.39	.38	1	1	.28	.33
64-F10B	.30	.33	.41	0			
63-14A	.33	.40	.42	0	0	.32	.35
63-14B	.35	.44	.33	0			
63-20A	.28	.47	.26	0	5	.27	.30
63-20B	.35	.14	.25	5			
63-42A	.34	.28	.33	3	8	.13	.19
63-42B	.34	.33	.29	5			
63-41B	.34	.45	.28	0	6	.14	.32
63-41A	.41	.31	.30	6			
63-15A	.34	.62	.30	2	7	.32	.53
63-15B	.38	.54	.27	5			
64-F14B	.37	.29	.19	4	12	.36	.42
64-F14A	.42	.54	.15	8			
64-F17A	.32	.46	.27	5	13	.32	.39
64-F17B	.41	.34	.23	8			
64-F6B	.44	.48	.21	13	14	.34	.41
64-F6A	.33	.34	.19	1			
63-93A	.35	.34	.26	7	14	.35	.33
63-93B	.37	.38	.28	7			
63-28A	.42	.25	.29	7	15	.39	.25
63-28B	.40	.31	.27	8			
64-F12A	.41	.16	.23	6	16	.39	.14
64-F12B	.45	.25	.17	10			
64-F20A	.45	.37	.18	11	16	.37	.50
64-F20B	.36	.60	.38	5			
64-F2A	.42	.24	.16	12	19	.37	.17
64-F2B	.40	.09	.21	7			
64-F18A	.45	.26	.23	11	19	.41	.21
64-F18B	.42	.17	.20	8			
64-F13A	.54	.28	.17	16	26	.49	.28
64-F13B	.51	.43	.20	10			
64-F16D	.45	.37	.36	10	35	.48	.29
64-F16A	.56	.27	.19	25			

being displaced toward the upper range. In a chronology with these characteristics, only the small rings represent the limiting effects of climate; the remainder vary about the mean and serve primarily to indicate the passage of time. The ridge site (Fig. 2B), reported by Fritts (1969), exhibits a stronger climatic relationship, in which all or nearly all of the rings are more or less limited in growth by climate. Such a sensitive site has a chronology in which the observed distribution of index values does not differ significantly from the theoretical normal curve (Fig. 2B). Two standard deviations encompass a greater range of index values.

The established 7104-year chronology is now being strengthened by incorporating data having a greater sensitivity. As specimens are dated, measured, and standardized, they are evaluated in terms of measures of sensitivity, correlation, and the chi-square test

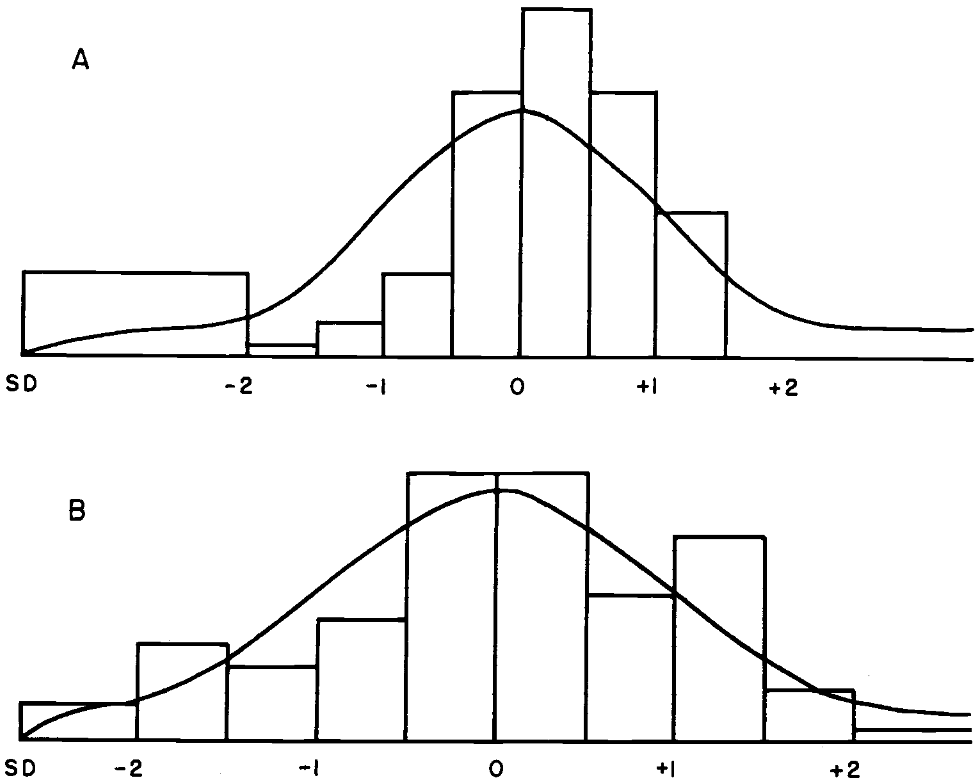

Fig. 2. The frequency distribution of bristlecone pine ring-width indices for (A) a significantly nonnormal and (B) a normal pattern. The curve represents the theoretical frequency and the histogram the observed frequency. The longitudinal axis represents the index values, but the histogram units equal half the standard deviation.

for goodness of fit, and thus are described in terms of variability and distribution of ring width. On the basis of this evaluation, we are selecting specimens that will provide maximum information about climate for incorporation into the master chronology.

The present Laboratory study of bristlecone pine in Nevada, combined with previous studies of this species in the Spring Mountains near Las Vegas, Nevada, and the current work in the White Mountains, has made it possible to further substantiate the individual chronologies. Correlation coefficients for a 114-year period, 1850-1963, were derived relating the initial bristlecone pine master chronology (16 cores from 13 trees) for east-central Nevada to the master chronologies for bristlecone pine in the White Mountains, 210 miles to the southwest, and in the Spring Mountains, 180 miles to the south-south-west, and the White Mountains to the Spring Mountains, 140 miles apart. The correlation coefficients .55, .48, and .50, respectively, are all highly significant at the 99% confidence level.

Master Chronology

The present master chronology (Fig. 3 and Appendix A) consists of two existant chronology units and 17 individual specimens. Upon extension of the chronology in

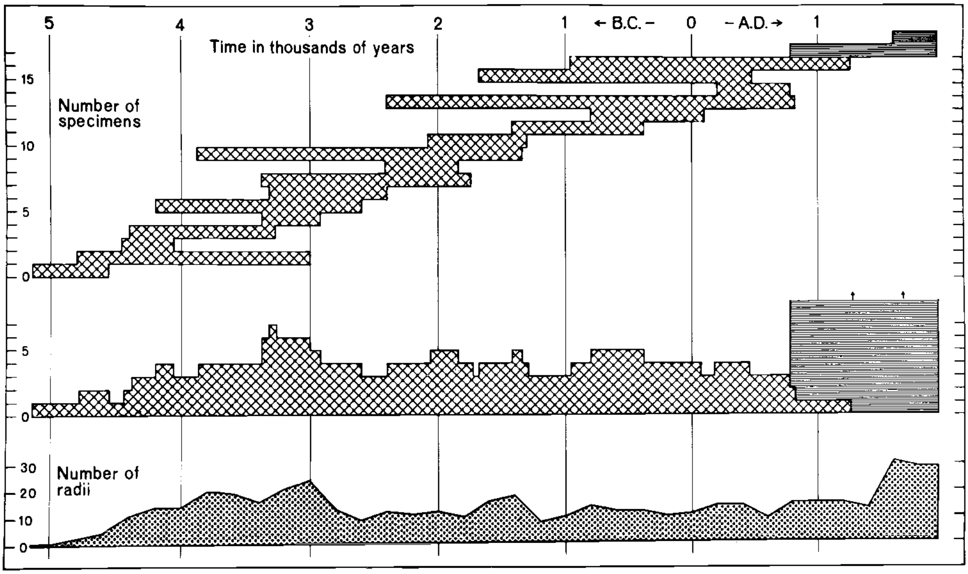

Fig. 3. Components of the master chronology: (upper) the time interval contained in each tree-specimen; (middle) specimen depth throughout the total chronology, expressed as a histogram-compaction of the upper bar-intervals; and (lower) a summary of measured radii, at 200-year intervals.

either direction, the first six and the last six values are subject to change; hence, these 12 figures are in parentheses.

The first chronology unit is made up of paired cores from nine trees in Methuselah Walk. These specimens comprise the second half (those with the most missing rings, and generally higher mean sensitivity and lower serial correlation) of the data in Table 1 (Ferguson 1968, Table 1). The second unit is the Schulman Master, composed of 14 trees, which extends from A.D. 800 to 1954. It incorporates specimens from four sites in the White Mountains:

White Mountains, south; now the Schulman Grove area: WHT-s 4759-A (Pine Alpha), 4760-A, 4761, 4767-A, and 4769-B,

White Mountains, west; what we now call the Silver Canyon site: WHT-w 4771, 4773, 4775, and 4778.

White Mountains, relay station; this site is the west ridge adjoining the study area reported by Fritts (1969): WHT-rs 4786 and 4788.

White Mountains, north; the specimen is from a site southeast of the Natural Area, now the part of the Ancient Bristlecone Pine Forest known as the Partiarch area: WHT-n 4843-A.

The units comprising the present master chronology are tabulated (Table 2) under the Laboratory of Tree-Ring Research (TRL) specimen number. For the 17 individual specimens, the first two digits designate the year of initial collection; the remaining portion is the sequential collection number for tree-specimens. The interval utilized is tabulated in the computer time scale. Two or more measured radii (from either a core or a cross section) often were incorporated into a specimen mean. The resultant measured radii depth of the master chronology is represented (Figure 3) by the broken line

Table 2. Components of the 7104-year bristlecone pine chronology with the related interval in years, mean sensitivity, and serial correlation.

Component	Interval, years	Mean Sensitivity	Serial Correlation
Chronology:			
Methuselah Walk	9600-9962	.33	.27
Schulman Master	8800-9954	.40	.24
TRL specimen number:			
63-88	7044-9285	.24	.54
63-48	8200-8800	.29	.56
63-43	6000-7200	.26	.52
	7200-8850	.24	.65
	5600-6200	.30	.77
61-1	6330-8473	.39	.38
63-55	7200-8100	.48	.52
67-23	6584-7626	.49	.33
68-102	5930-6713	.39	.31
63-89	4140-5394	.26	.46
	5395-6649	.20	.57
64-F19	5600-6170	.51	.38
64-F22	4623-6269	.51	.43
66-405	4680-5606	.26	.38
65-F131	3796-4899	.33	.28
	4900-5409	.23	.39
68-106	4622-5085	.58	.16
65-F117	3600-4730	.28	.53
63-92	3539-3978	.26	.58
63-34	3540-5101	.41	.29
	3205-3600	.52	.32
63-92E	2859-3440	.35	.45

determined by the radii depth at 200-year intervals. The specimen depth throughout the 7104-year series is presented in the histogram at the bottom (Figure 3). Substantiating evidence exists in the form of many dated ring series which, through the shortness of the sequence, lack of time, or other considerations are not yet part of the computer analysis.

The present master chronology is intended primarily for use in dating other wood specimens, both for chronology extension and for material used in the calibration of radiocarbon ages. Therefore, the analysis was carried one step further. The final operation was the conversion of the index chronology to a time series of annual growth departures with a "high-pass" digital filter (Julian and Fritts 1968). The values are the same as those which could be obtained by first smoothing the series by means of a 13-year weighted moving average, and then subtracting the smoothed values from the original values. The net effect is to remove any long-term oscillations or trends which may have been present in the original series. The filter used in this work removes half of the variation over periods of greater than 7 years, and about 90% of the variation over periods of more than 16 years. However, the year-to-year differences in index values, which forms the basis for crossdating, are retained in the filtered chronology (See Note).

Restrictions of computer programming necessitated two modifications in the handling of the A.D. and B.C. time scales. First, to avoid changing from positive to negative values in the middle of the sequence and to provide a working base of nearly 10,000 years, we arbitrarily set the year A.D. 1 equal to 8001. Second, because the

Judeo-Christian calendar system, with no zero year, incorporates one 19-year bidecade at the B.C.-A.D. transition, we have added a zero year in order to keep the decade system constant on the computer scale.

Schulman (1956) had the latter problem; in his tabular presentation of index values extending into the B.C. period, he said (p. 103) "A zero year has been introduced for continuity; thus the first value in the table is at -55 A.D. (or 56 B.C.)."

In the summary of the component specimens (Table 2) and in the master chronology (Appendix A), the chronologic data may be converted to the B.C.-A.D. time scale by a simple subtraction. Values for given years in the A.D. time period may be derived by subtracting 8000 from computer time-scale values of 8001 and greater; B.C. years by subtracting computer values of 8000 and less from 8001.

With the establishment of a master chronology, the dating of heretofore difficult specimens is greatly facilitated. To illustrate the procedure of crossdating an unknown with the master chronology, we chose for the "unknown" a segment of a 293-year series from Pine Alpha (WHT-s 4759), the first tree authenticated as over 4000 years in age – the first of the *ancient* bristlecone pines (Schulman and Ferguson 1956; Schulman 1958). The total tree-ring record for pine Alpha (frontispiece) has not yet been worked out because of a compressed interval between 1700 and 1250 B.C. However, four cores within the earliest interval readily crossdated with each other. These were measured, individually standardized, and incorporated into a specimen mean with an arbitrary "floating" chronology. Visual crossdating for the 200-year interval from 5971 to 6170 (2030 to 1831 B.C.) is shown (Fig. 4) in the plots of the filtered data; the master chronology contains five specimens through this period. The crossdating is especially evident in the minimum ring-years.

A core from the approximate level of the root-stem transition extended the chronology for Pine Alpha to an innermost ring at 5807 (2194 B.C.). Including the 1968 growth ring, this tree contains a continuous span of 4161 years. For total age, a few years would have to be added to the actual pith of the earliest core date and for height growth to the level of sampling.

Since the computer data for the earliest period of the master chronology was derived, four ring-years have been added following a detailed examination of newly surfaced sections of TRL 63-92E. These years occur between the following year-pairs in Appendix A: 3170-3171, 3228-3229, 3302-3303, 3433-3434. It is because this type of refinement is relatively common in the spearhead of chronology building, often with a

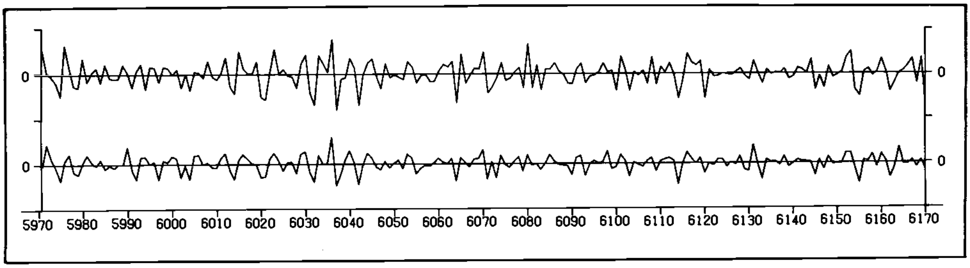

Fig. 4. The innermost ring sequence from Pine Alpha (upper plot), as an example of the establishment of crossdating by comparison of plotted series of filtered data, shown in comparison with a 200-year segment, 5971 to 6170 (2030 to 1831 B.C.), of the filtered master chronology (lower plot).

single specimen and that not always of optimum quality, that I have retained the computer-based chronology control, rather then using the conventional A.D.-B.C. time scale.

RADIOCARBON ANALYSIS

Studies made in cooperation with radiocarbon laboratories at the universities of Arizona, California (San Diego), and Pennsylvania are a major aspect of the present project. These related radiocarbon studies have been summarized by Damon, Long, and Grey (1966), Ralph and Michael (1967), Rainey and Ralph (1966), Stuiver and Suess (1966), and Suess (1965, 1967).

The Laboratory of Tree-Ring Research provides precisely dated wood, in 10-year samples throughout the total range of the established chronology, for the calibration of dates derived by radiocarbon analysis in terms of cycles and trends. As of 15 May 1969, 471 tree-ring-dated samples of wood, representing the broad time intervals listed in Table 3, had been sent to the various laboratories engaged in this work.

Initially, dated wood in bulk form was distributed upon request, and the preparation of the unit samples was done by the receiving C-14 laboratory. This procedure led to lack of standardization, possible misinterpretation, and occasional redistribution. The primary reason for shifting from this procedure to the present form of distribution was so that the basic statement regarding the tree-ring dating of units submitted to C-14 analysis could be made by the Laboratory of Tree-Ring Research.

With the present master chronology as a guide to dating, the constantly increasing supply of bulk wood throughout the known time range, the slow but steady improvement in the quality of the collected wood, and the hundreds of full (20 grams) and partial decade units now on hand, we are in an ever-increasingly better position to supply dated wood for radiocarbon analysis. And, added to this, we have supplied wood for other studies, such as of remnant magnetism, trace elements, and for other isotopic methods.

Radiocarbon analysis of a single, small remnant that contains a 498-year ring series indicates that the specimen is approximately 9000 years old. The average ring width is 0.33 mm, mean sensitivity is .33, and the serial correlation is .46. These statistical parameters, coupled with a span of nearly 500 years, describe a specimen of above average quality that holds great promise for the ultimate extension of the tree-ring chronology farther back in time.

Table 3. Dated Samples Submitted for Radiocarbon Analysis.

INTERVAL	NUMBER OF SAMPLES
A.D. 1501 - 1966	23
1001 - 1500	11
501 - 1000	27
1 - 500	3
1 - 500 B.C.	18
501 - 1000 B.C.	43
1001 - 1500 B.C.	49
1501 - 2000 B.C.	60
2001 - 2500 B.C.	49
2501 - 3000 B.C.	40
3001 - 3500 B.C.	58
3501 - 4000 B.C.	17
4001 - 4500 B.C.	37
4501 - 5000 B.C.	18
5001 - 5500 B.C.	18

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NOTE

A plot, on a vertical scale spanning 4 cm. and with a horizontal scale of one year = 0.2 cm., by the CALCOMP plotter (California Computer Products off-line tape-plotter system) on a 12-inch bond scroll, of the 7104-year master chronology (filtered series) is available for $15.00 from the Tree-Ring Society, Mrs. Helen McQuay, Secretary, Laboratory of Tree-Ring Research, University of Arizona, Tucson, Arizona, 85721, U.S.A.

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Appendix A. Filtered values for the tree-ring chronology, 5142 B.C. to A.D. 1962, for bristlecone pine, *Pinus aristata,* from the White Mountains, California.

Values for given years in the A.D. time period may be derived by subtracting 8000 from computer time-scale values of 8001 and greater; B.C. years by subtracting computer values of 8000 and less from 8001.

	0	1	2	3	4	5	6	7	8	9
2850										(39)
2860	(14)	(-37)	(58)	(7)	(-43)	-17	3	17	9	-5
2870	-29	12	13	-19	2	5	-9	2	4	-22
2880	59	-32	-1	-30	-6	38	15	34	-12	-61
2890	-25	20	7	27	26	-19	-17	-16	40	-45
2900	-17	21	42	2	-5	-7	41	-63	4	-16
2910	2	3	33	10	-13	-29	-5	-7	41	6
2920	-6	-39	18	10	-19	5	2	14	1	6
2930	-13	3	-9	16	-21	18	18	10	1	-41
2940	-6	-10	8	13	7	7	-28	4	-6	20
2950	-13	17	19	-20	-8	-5	-6	4	-27	7
2960	28	22	20	-21	-20	-5	12	35	-50	3
2970	-2	-3	31	15	0	-22	-24	4	19	11
2980	-21	14	-23	2	0	-6	-2	33	-6	-2
2990	0	-10	-11	10	0	-5	0	-2	-37	31
3000	19	24	6	-36	-37	11	47	31	-23	-9
3010	-14	-34	9	5	18	4	-10	29	-24	42
3020	-47	-27	37	17	-29	0	-2	18	8	4
3030	-45	-3	27	-47	52	1	-3	7	34	-49
3040	-19	9	14	32	-18	-22	-16	10	46	15
3050	-74	19	-6	2	6	-2	6	-1	-2	9
3060	-7	30	2	17	-42	-40	25	10	-3	-6
3070	-18	-17	7	73	24	-24	-38	30	10	-50
3080	8	-7	10	-4	-9	22	-14	1	16	0
3090	-24	23	4	-30	0	-4	50	-27	28	14
3100	-5	-29	2	-15	-34	48	6	0	10	0
3110	-11	-15	-5	9	6	3	-43	-13	19	26
3120	31	3	-49	7	-12	-6	27	23	8	2
3130	-15	-43	15	11	-26	3	20	28	-14	-10
3140	-5	30	-22	9	-53	-1	5	63	-11	-54
3150	0	41	-12	39	-8	-6	-18	-33	24	37
3160	-4	18	-40	15	1	0	-28	29	0	-13
3170	-3	-7	-8	15	-10	4	0	1	-8	21
3180	-1	-2	-39	-12	47	39	-10	-49	-7	14
3190	36	-56	47	-13	-12	-6	4	51	0	-25
3200	-16	9	-12	-5	-1	24	26	-20	-28	10
3210	-6	-31	48	4	-12	-23	46	-12	-19	-8
3220	21	12	-6	-13	-14	47	34	-72	-27	29
3230	10	0	12	19	-72	0	29	-22	-2	83
3240	-33	0	36	-49	1	-18	14	-8	1	9
3250	-4	-5	1	52	-22	-38	-21	5	50	20
3260	-4	-24	-4	-50	9	47	-11	1	24	8
3270	-23	-41	54	-14	-8	-20	38	-20	12	0
3280	-18	4	-29	23	34	5	-5	-37	-12	30
3290	7	2	3	15	-47	31	-5	2	-10	6
3300	-4	-27	32	-2	3	-19	16	-10	-14	17
3310	-11	11	6	3	-2	0	0	-10	8	10
3320	-6	-14	0	-22	18	8	6	-9	5	13
3330	7	-69	33	27	-7	8	-29	-24	30	20
3340	8	0	10	-14	-40	28	-9	2	-13	45
3350	-13	-26	-11	-20	10	49	-2	23	-10	-41
3360	11	-4	43	-8	-7	-46	-22	28	50	-2
3370	-12	48	-63	32	19	-52	-14	-60	49	41
3380	30	-27	-29	7	62	-82	3	50	10	-31
3390	-56	74	-10	-12	0	12	-45	26	39	3

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
3400	-41	-6	3	-28	32	67	-7	-54	-34	14
3410	-4	-3	2	23	70	-27	-9	-23	-28	27
3420	3	-7	14	-6	-11	19	-10	22	-57	-8
3430	47	-4	-16	2	20	16	-11	0	-17	-21
3440	29	32	-15	-27	-24	9	36	-18	-10	3
3450	9	-9	22	14	-26	-25	12	0	17	26
3460	-42	-21	22	-5	0	21	-65	24	28	49
3470	-46	-2	61	-65	-44	47	-5	31	0	-30
3480	46	-6	2	-36	4	25	-37	-17	30	9
3490	-32	4	37	-16	-3	33	-50	-11	18	39
3500	-1	5	-14	-39	45	-55	40	17	-11	9
3510	-25	-37	45	27	-45	-4	12	-2	9	-32
3520	38	-1	-23	32	-20	-16	45	0	-44	32
3530	-84	45	76	-9	-71	33	-48	49	-6	27
3540	-5	-7	-14	-7	20	4	-27	0	20	-14
3550	13	-8	-25	28	30	-10	-27	23	-35	22
3560	22	-17	-18	-1	-2	9	14	15	-6	39
3570	-45	-25	15	-33	-7	26	36	-20	-27	27
3580	18	-33	35	3	-19	-7	8	-6	-5	1
3590	44	-2	-62	-22	13	10	-17	5	23	33
3600	-49	39	7	4	-10	-14	23	6	-14	-1
3610	-13	5	19	-13	22	-54	3	41	-23	25
3620	-28	4	-6	16	23	-42	3	-27	29	-6
3630	8	-1	3	55	-58	-2	3	-20	10	0
3640	40	-30	-10	9	44	2	-53	-27	14	23
3650	-7	20	-6	-21	19	17	-29	10	-39	18
3660	38	-5	-4	10	-2	15	-54	3	0	8
3670	-3	6	26	17	-48	16	-27	17	2	5
3680	11	-19	6	-8	0	21	-20	5	16	-5
3690	-11	6	-14	-18	48	-21	-4	11	-12	19
3700	-8	-16	-8	16	-15	0	-10	37	17	4
3710	-2	2	-54	-12	16	17	-4	21	29	-27
3720	-29	4	1	4	0	5	0	18	-15	4
3730	-8	3	6	-8	3	7	2	-53	7	28
3740	19	17	21	-80	23	-12	1	13	-2	-10
3750	6	48	-33	14	-22	1	-10	-8	-4	3
3760	20	8	-17	23	-6	-12	13	-7	-31	9
3770	5	19	22	-16	2	-2	-25	14	2	-6
3780	-10	8	-5	15	7	-20	2	3	-5	-5
3790	19	2	-10	34	-17	-10	3	4	-5	2
3800	-29	20	-11	-7	26	22	-18	-31	-11	25
3810	-2	9	15	-25	18	-13	-14	4	19	7
3820	-3	41	-37	-8	-10	-3	5	24	8	0
3830	-36	28	-30	-32	18	7	33	-2	1	20
3840	-47	2	11	18	-15	11	-10	-17	-6	14
3850	6	1	7	-8	0	-3	-14	7	14	2
3860	8	6	3	-41	-13	12	1	16	34	-11
3870	0	-36	1	2	-5	12	21	-1	-36	10
3880	10	-5	8	0	8	-7	-17	-9	30	4
3890	-12	-5	4	-5	14	9	10	-64	28	20
3900	-17	-7	28	-15	-20	0	16	31	-13	-6
3910	-3	9	-8	3	-30	33	-7	-9	-7	16
3920	0	1	-15	-4	21	2	21	-51	-4	0
3930	10	16	31	-12	-4	-2	19	-56	35	1
3940	-2	13	-47	28	-17	22	7	-17	-3	11
3950	-1	-29	-6	20	27	12	6	-40	2	7
3960	-1	-17	5	6	6	21	-15	0	1	13
3970	-35	7	7	11	-6	-17	- 3	23	-5	-19
3980	8	13	-3	-1	-17	-6	5	37	21	-23
3990	-27	22	0	-23	-16	29	18	-14	-34	39

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
4000	16	-30	-15	12	28	10	0	-2	-66	48
4010	7	-29	10	8	-17	-16	13	21	20	-42
4020	0	-3	4	0	27	-13	6	22	-30	-3
4030	26	-31	-5	0	27	4	-1	1	-2	-10
4040	-9	-7	6	0	35	-5	-21	-9	37	-2
4050	-51	3	17	13	-3	-16	-9	20	12	-12
4060	-8	12	4	3	4	-33	21	-11	35	-3
4070	-23	-10	0	37	-27	-28	-4	22	18	10
4080	-1	28	-84	37	7	9	4	-22	8	-9
4090	7	-24	17	-7	14	5	3	-12	23	-32
4100	-1	-9	15	12	17	-14	5	-28	21	-11
4110	2	-21	10	11	10	-15	4	14	-23	-10
4120	34	45	-72	-6	24	-29	22	5	11	-27
4130	19	-1	0	11	-22	-13	11	7	5	16
4140	3	-25	-26	11	7	-4	16	14	0	-29
4150	5	-7	5	14	29	-29	-3	-25	1	37
4160	3	-16	7	-6	18	-54	9	10	3	9
4170	44	-46	-10	8	15	-25	-7	-4	33	-37
4180	29	-20	1	16	68	-69	9	2	13	-70
4190	24	20	12	-1	16	14	-52	9	-11	-6
4200	30	-36	23	14	-35	11	-8	27	-5	0
4210	15	-3	-5	-3	-11	-3	15	-5	19	14
4220	-43	8	3	-16	14	5	6	-55	30	12
4230	-2	0	19	-2	-32	-6	15	10	-8	4
4240	11	0	16	-17	-5	7	-27	6	9	17
4250	9	-50	24	8	-11	0	-4	10	21	-42
4260	3	16	-1	4	8	-26	8	0	7	20
4270	-8	-7	-6	-9	26	-1	-9	15	-17	-56
4280	25	18	3	-5	-4	15	28	-14	-6	0
4290	-25	5	25	-3	-17	9	-17	4	-8	22
4300	69	-41	-45	5	-19	12	27	11	-14	-14
4310	-33	40	20	-12	-4	-17	6	19	10	-12
4320	23	-76	21	17	-2	-13	41	-2	-17	20
4330	5	-7	-40	6	5	3	-12	15	37	0
4340	-70	17	9	15	-9	21	-3	-5	2	-15
4350	16	-30	23	8	-21	-20	9	38	0	-20
4360	5	10	16	-27	-17	16	29	-36	18	-9
4370	-23	8	11	2	20	5	0	-32	1	27
4380	-68	26	19	4	-23	35	-6	23	-43	-2
4390	19	14	-5	9	-67	40	10	-3	0	16
4400	-11	-16	-6	-6	10	18	-5	-19	12	6
4410	32	-9	-1	-28	9	1	-14	-1	45	-36
4420	-1	15	-8	-44	5	33	11	-20	17	-5
4430	40	-19	-29	-9	28	8	-13	23	-14	-42
4440	37	-40	5	22	22	-1	-6	2	22	-33
4450	-9	-4	22	1	-20	37	16	-26	-22	-22
4460	11	6	13	0	-4	17	9	-47	9	27
4470	0	-21	7	-8	9	-5	-2	11	30	-28
4480	13	-12	-5	-33	9	13	30	-13	10	7
4490	-12	1	-71	45	16	10	-23	-17	28	-3
4500	12	46	-42	-19	-3	-7	14	32	-11	-33
4510	22	-4	0	13	-27	-12	17	11	-12	0
4520	-4	21	27	-47	13	22	-32	-32	12	26
4530	0	0	23	-23	-8	-2	15	37	1	-69
4540	-4	30	34	-37	-4	-4	27	5	9	-80
4550	34	40	-39	14	2	-17	26	2	3	13
4560	-12	-19	-21	-3	29	3	7	-3	3	-27
4570	0	6	31	-35	-11	14	11	0	1	-8
4580	4	13	9	-15	-34	32	21	-21	-28	5
4590	20	11	-2	-1	-12	5	-14	3	22	-16
4600	6	-3	6	-10	-8	6	17	-21	23	26

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
4610	-42	-5	-19	14	24	-9	-8	-13	11	18
4620	-7	15	-26	14	-16	8	12	-18	31	-2
4630	-20	8	-9	-15	-4	2	12	58	-47	-16
4640	-3	12	36	-7	-64	50	-13	12	-15	12
4650	5	-12	6	3	9	-25	-33	32	24	-14
4660	3	1	-28	14	33	-14	-4	-21	7	-8
4670	-1	30	13	-27	-35	26	11	11	-12	-19
4680	16	6	-1	28	-5	-1	-43	-9	17	20
4690	2	2	-9	-27	5	14	-8	-10	28	0
4700	14	-5	-21	-3	4	30	-22	1	15	-4
4710	-6	1	-1	-15	-12	15	7	23	-9	-25
4720	8	-22	16	-2	-2	7	-8	17	25	-41
4730	11	-4	14	-4	-29	22	18	-4	-14	12
4740	7	-17	4	19	-29	4	17	18	-31	-28
4750	9	25	-13	13	14	-43	9	6	0	4
4760	-2	12	-12	-6	-9	23	-3	19	-19	-6
4770	9	4	8	9	-28	9	13	-62	37	-8
4780	11	9	-3	10	-16	12	-16	4	1	-8
4790	18	-3	2	-10	11	-37	27	8	-1	7
4800	-7	2	23	-10	-27	8	-15	12	0	2
4810	22	-10	-4	0	-4	-3	-22	0	14	7
4820	1	-7	6	15	-9	-8	17	-14	-1	16
4830	-5	-9	-1	1	-2	12	-7	6	14	-2
4840	-11	-8	-6	-4	7	12	15	-20	0	0
4850	-4	17	-31	10	-5	32	-1	-15	-4	-3
4860	-7	0	9	12	-15	12	-1	25	5	-37
4870	22	-7	-18	-15	15	6	-11	17	24	-18
4880	3	-8	-16	12	16	-8	-31	21	12	3
4890	-8	-25	5	5	16	-13	-1	4	9	9
4900	7	-30	9	0	-1	-16	14	-6	-10	0
4910	1	20	13	13	15	-66	9	1	-2	33
4920	9	-37	-20	17	12	4	-12	-18	15	22
4930	22	-40	1	-7	-2	16	-14	-2	28	22
4940	-17	-38	18	-5	7	-5	15	9	9	-29
4950	-32	13	17	0	-19	18	-2	0	4	6
4960	-7	-6	26	-17	20	-8	-17	11	2	-9
4970	-9	0	24	-36	35	-6	-4	-11	18	-14
4980	13	3	-25	-5	16	15	-4	-1	7	-1
4990	-37	-5	7	18	10	-1	11	-13	-26	0
5000	24	20	0	-18	-20	21	15	6	-57	31
5010	14	-10	-11	43	-16	5	-28	6	-14	15
5020	-18	6	18	20	15	-65	23	-43	25	31
5030	14	-45	-2	20	12	-12	-7	11	12	-24
5040	31	-14	9	-32	16	-15	4	30	-28	2
5050	0	15	-23	-6	19	0	-1	5	8	5
5060	-4	6	-35	-14	26	24	39	-37	-68	39
5070	6	-17	20	8	-6	-10	21	-2	0	-28
5080	14	9	1	-3	-7	13	-11	8	-17	-3
5090	6	6	2	-7	4	2	4	-8	6	-2
5100	9	-25	22	0	-15	10	14	-4	-35	12
5110	34	-18	10	-8	-29	11	31	-10	-29	21
5120	-23	2	0	26	13	-3	6	-27	-9	6
5130	18	6	-7	-2	5	-13	24	-62	15	36
5140	33	-44	-7	4	5	3	-25	13	21	2
5150	-39	8	0	19	-3	-12	26	19	-46	-9
5160	-2	39	-9	-31	14	18	-5	16	-2	-27
5170	-1	-3	20	32	-38	10	-22	19	-23	8
5180	-6	11	4	8	-6	-16	7	26	-9	-27
5190	10	23	-34	42	16	-38	9	-11	-10	-17
5200	3	14	11	3	2	-23	17	17	-37	6
5210	12	13	5	-18	-16	3	9	-6	4	15

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
5220	-8	-7	-9	16	18	-19	-31	6	33	-12
5230	-8	14	15	-13	-24	13	-3	15	-4	0
5240	0	36	-67	28	12	-10	2	-9	-2	18
5250	33	-34	-9	-16	8	-2	4	1	0	7
5260	7	3	-19	-3	1	39	5	-58	19	-11
5270	7	17	27	-47	4	-4	-17	5	18	11
5280	15	-10	-15	-11	8	14	-8	15	5	-12
5290	-17	-6	12	-4	2	29	-12	-16	-1	7
5300	-24	27	-4	34	10	-43	-12	2	14	7
5310	-16	4	5	6	-7	-10	31	7	-12	-11
5320	-43	10	19	-8	16	5	4	6	0	-18
5330	-15	5	5	3	-13	21	-3	28	-16	-21
5340	7	2	3	3	-8	-2	13	-6	-14	-4
5350	20	7	-13	0	10	22	-7	-38	2	23
5360	-17	-10	10	16	-2	-2	-9	2	3	-2
5370	11	-17	0	6	1	-2	5	-4	1	1
5380	13	-13	3	-3	-8	-6	18	3	-10	6
5390	-8	-4	2	-6	7	0	23	-16	-1	6
5400	4	14	-20	-7	1	6	-10	5	16	-4
5410	-20	31	-5	-25	-7	19	-1	1	3	1
5420	12	-14	-5	-5	-7	7	22	-3	-8	-19
5430	-2	20	2	23	-33	15	1	-28	12	10
5440	2	-5	-6	2	8	0	4	-3	-9	5
5450	-8	-7	17	7	0	-6	-4	-9	-14	35
5460	10	-20	-9	-1	20	-9	5	6	-14	1
5470	0	-7	12	-9	5	2	2	-16	-6	1
5480	23	18	-18	-10	-20	11	24	-11	5	-4
5490	-5	-4	2	10	17	-4	-1	-19	-10	1
5500	11	-8	16	15	-1	-5	-22	-27	21	4
5510	31	7	-28	-3	0	3	0	0	25	-8
5520	-20	-2	3	-10	11	29	-9	-15	-7	-2
5530	22	-22	4	-3	15	-8	-12	16	19	-4
5540	-15	13	-7	-42	11	30	9	-17	-2	3
5550	1	4	0	-26	10	11	20	-18	0	-2
5560	-13	8	10	14	-16	-9	15	-21	-1	4
5570	10	2	8	-2	10	-22	1	2	10	-2
5580	-3	-3	-11	10	-8	9	-1	-17	-6	0
5590	33	6	-16	-9	-3	32	-13	-3	0	-4
5600	6	38	-55	7	14	4	16	-1	-43	-8
5610	10	11	9	-9	-9	16	21	4	-48	20
5620	3	-15	6	27	-16	-16	3	-5	28	14
5630	-21	-37	30	-7	10	1	-21	-6	12	-1
5640	-1	14	-3	-2	-17	32	1	10	0	-20
5650	-33	30	8	-1	-19	12	-5	5	4	31
5660	-47	-17	34	-30	41	-12	0	4	9	-20
5670	-24	34	-5	0	22	-3	-25	-12	37	-6
5680	-20	-3	7	-5	22	21	-7	-48	14	-8
5690	1	10	15	-2	-16	14	14	-3	-30	6
5700	-3	27	8	-27	11	8	-49	26	2	24
5710	-4	-12	20	-28	-14	0	8	2	16	-4
5720	-3	-10	-10	29	7	-2	-12	6	-3	-27
5730	14	0	5	-5	-12	10	28	3	-24	12
5740	-16	-9	11	21	-12	-11	0	-22	17	0
5750	28	3	-44	0	28	6	-23	12	32	-48
5760	54	-44	4	28	-37	-43	24	44	26	-23
5770	-32	6	-4	0	8	-19	18	-2	-2	30
5780	17	-17	-17	-49	56	3	-50	31	17	11
5790	12	-44	5	-13	4	21	8	-16	3	30
5800	-36	1	2	13	-31	25	-6	6	-26	20
5810	23	-24	-14	10	-6	15	8	-16	-8	2

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
5820	43	-3	-42	9	22	-57	35	-4	-10	29
5830	-19	0	-3	4	-10	0	24	-3	25	-20
5840	-20	0	25	-12	20	-10	-50	13	0	12
5850	4	20	-40	16	18	-13	9	10	2	-59
5860	-3	30	-7	19	8	5	6	-8	-22	47
5870	-44	31	-12	0	-29	18	-21	5	4	20
5880	-1	-19	16	26	-19	-45	25	34	-17	-6
5890	-7	6	-7	-14	21	-14	4	27	6	-23
5900	21	15	-36	-7	-3	3	38	-71	22	11
5910	29	-38	-3	22	1	-33	25	11	25	-45
5920	14	4	-2	23	-51	14	39	-47	3	7
5930	25	7	-27	-1	-15	22	4	-15	-2	2
5940	10	10	-2	-14	-10	1	-7	23	0	-12
5950	18	3	-2	-14	5	14	19	-26	-28	29
5960	-40	9	12	-l	12	-7	23	-11	12	-7
5970	-33	-2	44	12	-9	-37	7	23	-17	-23
5980	3	21	5	-3	10	-11	-2	-8	0	-2
5990	38	-13	-34	15	17	0	6	-35	9	4
6000	18	14	-30	-3	-34	19	21	-1	3	-7
6010	-8	13	24	-13	-34	8	22	12	1	0
6020	-30	-28	12	25	8	-15	4	5	-21	22
6030	28	-17	-40	20	-1	2	60	-48	-22	8
6040	30	3	-46	-3	24	14	-7	-13	6	-9
6050	2	8	-11	22	13	-22	-10	-3	-5	2
6060	13	4	0	12	-39	14	3	-7	10	12
6070	31	-35	5	-32	19	-2	-8	5	15	-17
6080	20	-4	0	-14	0	20	6	-2	-4	-5
6090	-25	13	18	-28	-2	7	0	4	28	-12
6100	-8	20	6	-29	3	-3	-7	6	13	-18
6110	6	9	12	6	-47	-2	25	10	-1	12
6120	-22	0	-5	8	9	-9	3	-4	15	-15
6130	-18	40	-1	-36	8	2	3	-5	15	-8
6140	-1	7	4	3	1	-27	7	-14	14	-3
6150	-1	-1	22	22	-11	-46	6	4	19	-10
6160	20	4	-33	-10	34	-3	-4	6	-10	6
6170	-17	12	24	-23	-9	0	16	9	-2	-6
61[illegible]	-24	3	31	-6	0	-2	-21	-4	16	1
6[illegible]	-12	15	2	-3	10	-9	-11	15	-1	-11
62[illegible]	-7	19	4	6	-3	0	-17	-16	26	11
6210	-30	12	22	-21	-2	-17	13	-5	17	10
6220	-2	-10	14	-10	-38	18	16	8	-13	25
6230	0	-20	-27	2	15	9	-2	-11	19	0
6240	7	-41	20	-6	-11	18	17	-17	3	-8
6250	2	-1	14	-13	19	5	-15	-4	5	-1
6260	-3	35	-56	16	-1	-4	20	-3	0	15
6270	0	-46	6	-6	40	7	-27	-9	12	0
6280	14	-17	5	-3	3	13	-3	-11	-6	13
6290	27	-49	26	-24	15	17	-41	14	13	-15
6300	30	7	-34	-7	16	-5	-3	22	16	-43
6310	-9	5	17	7	3	-33	10	-2	28	-2
6320	1	16	-58	29	23	11	-22	-40	12	-6
6330	26	10	-15	9	11	-36	7	15	-4	-21
6340	9	16	-16	1	23	-17	5	26	-34	5
6350	4	-10	6	27	-40	-6	31	7	-26	17
6360	-33	9	9	10	1	-33	17	7	-5	4
6370	-2	25	-17	-11	10	13	-18	9	18	-19
6380	0	-3	7	-35	11	8	6	-6	0	3
6390	0	11	-32	18	1	-6	18	9	0	-22
6400	20	-21	7	13	-24	19	-15	-8	10	-1
6410	-9	1	18	17	-25	-2	5	-2	6	-10

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
6420	5	-3	-1	1	-5	14	4	11	0	8
6430	-73	23	35	12	-19	-14	7	8	-26	10
6440	0	10	23	-48	23	-11	11	-1	6	4
6450	15	-45	15	2	0	2	5	-14	-1	-3
6460	5	9	4	-19	13	-8	-4	14	9	-19
6470	0	7	8	-19	22	-24	10	-11	12	8
6480	8	-21	6	20	-12	-43	30	4	0	-6
6490	0	13	-17	0	13	10	6	-28	-6	28
6500	2	5	-67	26	21	2	0	-9	5	0
6510	-2	11	-8	-2	-2	-9	0	21	-25	7
6520	7	-10	3	5	10	-6	-7	0	21	-3
6530	6	-5	-10	-10	15	-9	9	12	8	-5
6540	-26	-12	8	1	-8	11	4	10	17	-35
6550	8	0	-16	8	0	13	-12	-12	14	7
6560	-8	1	0	0	28	-12	-11	-17	7	1
6570	10	19	9	-66	21	32	-22	5	-8	5
6580	6	-21	7	-15	13	11	12	-5	3	-9
6590	-8	-6	12	-10	3	6	40	-56	7	24
6600	-14	0	-8	2	7	5	14	-42	6	-5
6610	0	9	21	-1	23	-23	-39	21	19	-30
6620	30	-39	29	-6	-3	15	15	-5	-27	9
6630	8	-6	-18	3	12	4	14	-6	-4	-9
6640	-1	0	-6	17	-11	1	4	15	24	-56
6650	6	13	37	-68	17	0	22	10	-16	-12
6660	-1	25	-29	-1	-2	14	4	-5	0	-19
6670	8	32	-34	5	2	8	-11	10	16	-36
6680	23	-14	15	12	9	-61	26	-11	14	-6
6690	27	19	-4	-58	4	4	17	11	-4	-2
6700	-14	4	21	-2	-11	14	12	-4	-58	4
6710	19	7	7	3	-19	6	10	0	36	-26
6720	-4	-32	26	-26	8	15	17	-28	22	16
6730	-7	-44	31	-6	-14	2	6	1	-10	33
6740	4	-11	-34	8	4	43	-64	49	-4	1
6750	-33	10	-5	14	-3	-4	5	-9	20	-23
6760	19	-26	21	-4	-19	12	4	17	6	-30
6770	15	-2	7	6	-15	0	11	-1	-2	-9
6780	13	-21	3	3	6	14	-27	8	4	-24
6790	10	20	2	-18	9	2	21	-1	-35	-6
6800	30	-33	-5	20	5	15	-16	-17	9	14
10	15	-19	-16	4	7	-17	-3	19	9	18
20	2	-10	-22	5	30	-20	-19	10	34	-57
6830	31	-7	5	-17	9	-5	16	24	-30	1
6840	-2	-20	14	1	1	16	6	-33	11	-4
6850	3	2	0	17	6	-42	43	-45	15	26
6860	-18	-9	-13	26	-3	6	-6	-21	5	10
6870	4	3	14	-16	-1	18	-5	-11	17	-32
6880	34	-65	41	16	-1	-10	0	5	12	-45
6890	20	5	4	10	9	-2	-43	27	-11	0
6900	13	-3	16	11	-52	20	10	-9	21	18
6910	-50	-10	15	4	15	9	-22	-1	-6	19
6920	7	14	-51	38	-42	-4	12	30	18	0
6930	-68	30	8	20	-57	42	6	-15	11	13
6940	-67	29	14	16	15	25	-29	-34	-26	15
6950	-14	30	5	10	-4	-23	12	6	8	8
6960	-40	9	7	-6	25	-11	-29	11	3	17
6970	47	-50	22	-44	9	4	1	15	-20	-17
6980	22	0	29	-48	24	13	-12	-39	3	45
6990	24	1	-18	-25	12	-31	20	0	6	0
7000	13	-23	-1	15	-11	12	23	7	-62	8
7010	9	-18	16	6	-5	0	-4	28	-12	24

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
7020	-10	-19	-15	6	12	2	-4	-10	-3	8
7030	14	4	3	-14	-5	10	-12	11	-3	-7
7040	3	24	-12	44	-64	-27	42	-26	3	7
7050	13	10	4	-7	3	-4	-12	-12	18	-8
7060	0	4	3	17	-21	11	-21	19	-6	25
7070	-18	3	0	-26	18	3	0	21	-37	19
7080	-2	-4	0	24	-5	-45	18	0	13	2
7090	-21	28	-7	-14	0	3	8	-12	10	-8
7100	0	2	23	-1	0	2	-48	29	2	16
7110	13	-50	-10	25	-2	3	21	-11	-9	-7
7120	3	21	-31	46	-1	-53	24	-22	32	-17
7130	6	12	-16	5	-15	13	17	-13	9	4
7140	-25	-8	25	-17	23	30	-53	13	19	-71
7150	17	3	24	33	-36	-12	16	-4	21	14
7160	-33	4	-17	13	-3	16	-17	5	0	3
7170	10	8	15	-64	24	25	-20	-11	22	4
7180	9	8	-6	-48	-6	42	-43	16	31	-7
7190	4	24	-28	-41	-3	38	2	-5	-4	4
7200	1	-3	-5	12	13	24	-33	-28	0	15
7210	-4	5	-1	9	-3	7	2	-10	-1	-6
7220	9	10	18	-3	-55	13	31	0	-22	0
7230	9	5	-14	0	2	0	3	-10	0	13
7240	-3	19	2	-33	34	-8	-25	1	9	7
7250	13	-4	-39	16	4	21	-10	-12	6	10
7260	11	1	-66	21	9	11	2	4	1	-6
7270	0	-15	22	35	-18	-64	30	15	-3	-9
7280	0	20	1	-39	18	-5	14	13	-40	8
7290	10	0	-11	2	29	-9	-1	-11	9	18
7300	19	-30	-51	-4	45	8	6	-9	-9	8
7310	22	-24	-10	-16	14	17	19	1	-35	-9
7320	19	11	2	10	-26	17	-11	-23	13	15
7330	-7	-3	27	-42	-1	8	-3	9	16	2
7340	14	-41	9	-6	-1	7	16	-13	13	-28
7350	-2	4	13	3	-5	7	2	4	-12	3
7360	8	22	-7	-9	-30	22	7	-34	-7	13
7370	4	6	0	-5	16	24	-32	-18	3	13
7380	11	-3	1	-38	14	16	0	13	-13	22
7390	-22	-8	-3	8	-3	2	7	14	-38	11
7400	-1	-2	18	-12	1	16	-13	-4	15	-5
7410	0	0	-28	17	12	-8	25	-40	-7	25
7420	-2	7	13	-4	6	-19	0	-25	16	20
7430	-9	-5	18	-9	-28	21	14	28	-47	15
7440	-29	32	-34	0	6	3	13	1	10	-29
7450	3	-14	12	5	3	22	-2	-21	0	12
7460	6	9	-7	-4	-22	16	-48	36	20	-9
7470	-10	7	-3	-9	-5	22	7	-1	8	-5
7480	1	-41	9	14	16	5	4	-20	-15	8
7490	1	23	-29	23	9	-23	-30	15	2	9
7500	12	-7	-2	6	7	-8	16	-1	-11	-29
7510	-9	20	19	23	-41	10	35	-23	-60	18
7520	20	8	-2	10	18	-49	23	9	0	1
7530	-20	8	-1	17	-10	-9	18	-12	-8	-6
7540	3	21	18	-4	-1	-48	-17	23	12	-3
7550	8	5	-12	16	10	-3	3	-24	21	-27
7560	-9	11	26	0	21	-57	8	0	9	10
7570	-7	-5	5	13	-12	11	0	2	-42	9
7580	25	-5	-4	4	13	-1	0	6	-6	3
7590	-44	10	5	16	18	-35	-2	24	5	0
7600	-4	17	-4	-28	24	-12	3	9	-44	22
7610	5	8	-5	4	8	-11	-7	0	-2	0

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
7620	27	1	-37	-8	12	10	-4	3	0	-11
7630	30	19	-47	15	1	11	-24	-6	0	2
7640	36	-23	-5	7	-2	-14	9	4	3	0
7650	-5	17	11	-6	-13	-45	36	0	-6	-12
7660	5	8	30	5	-51	11	0	6	3	-6
7670	17	21	3	-43	6	21	-21	-30	10	10
7680	1	16	8	24	-54	25	2	-50	16	30
7690	8	1	0	-9	-36	22	21	-3	-6	-18
7700	25	-27	18	1	-22	-1	25	-6	13	-12
7710	0	2	-30	10	15	16	8	-4	0	-24
7720	9	-4	-20	12	5	-5	19	-5	16	-19
7730	-7	11	10	6	-64	29	8	4	4	2
7740	12	-23	-1	8	9	-3	-29	15	9	14
7750	3	-35	1	3	6	11	-23	7	-7	23
7760	6	26	-52	7	-4	11	-15	14	9	5
7770	1	-20	-3	4	3	7	3	-19	5	12
7780	11	-39	8	8	-19	14	11	-15	8	6
7790	3	-27	-7	25	9	5	-13	31	-19	-42
7800	6	15	20	13	-1	-38	0	3	-12	21
7810	-9	2	9	-4	3	-12	12	9	2	-8
7820	-17	3	7	-1	2	6	-5	3	6	1
7830	-6	-16	7	-10	19	-9	25	-35	4	45
7840	25	-63	-30	21	-2	15	16	-22	21	12
7850	14	-47	-16	29	10	11	-29	16	0	11
7860	-15	-2	13	5	-35	20	1	21	-20	-3
7870	-22	1	14	12	-3	-11	-12	17	1	9
7880	-14	1	1	5	4	11	18	-25	-21	0
7890	15	17	-18	1	17	-36	12	2	-9	-3
7900	8	2	12	-4	-2	-17	19	1	25	-36
7910	7	-14	8	20	9	-26	20	-5	-5	14
7920	-56	16	16	-2	4	-4	10	0	-1	12
7930	-19	-13	7	4	10	-8	15	22	-53	8
7940	0	2	0	1	17	-7	-4	6	14	-12
7950	22	-55	24	8	-15	1	3	-1	0	-5
7960	3	12	-11	8	43	-12	-52	-24	32	3
7970	1	8	15	-18	-5	11	-29	3	22	6
7980	0	-15	3	24	-30	-10	5	25	6	1
7990	7	-53	22	15	-5	-24	0	0	1	18
8000	0	-4	0	2	9	-6	27	-38	2	8
8010	3	0	10	32	-6	-43	-31	1	29	22
8020	-29	6	-10	-8	9	0	13	15	11	-42
8030	33	-35	-5	9	2	19	33	-64	8	22
8040	-2	27	-33	3	-16	6	-1	1	-16	6
8050	14	24	10	-40	18	9	-35	1	13	5
8060	-3	4	11	-5	3	-34	32	-36	32	-9
8070	10	-34	20	-1	13	-21	8	5	2	0
8080	0	21	6	-44	16	0	0	-50	15	32
8090	-2	6	18	-18	-9	-6	20	3	0	17
8100	-42	-17	22	9	-2	5	8	4	15	-65
8110	8	30	-20	3	3	9	19	-14	-18	-1
8120	9	6	-1	-32	22	12	0	-10	11	0
8130	3	-21	3	0	19	-7	-6	-11	22	-3
8140	-8	5	8	-7	10	-7	-7	-30	31	37
8150	-24	-30	-4	13	12	-8	2	15	-15	14
8160	-10	7	-20	22	2	-14	10	10	-27	-3
8170	12	15	-22	21	-13	2	-9	16	-17	-5
8180	6	1	4	3	-3	2	3	2	-3	-11
8190	-3	10	-5	8	1	4	5	-23	2	22
8200	-17	-3	-8	0	12	1	13	-6	-22	11
8210	-5	3	6	18	-23	-21	10	8	7	0

Appendix A. (Cont'd)

	0	1	2	3	4	5	6	7	8	9
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8230	-6	-2	25	3	1	-31	-43	33	2	1
8240	10	8	-5	-4	-5	3	-7	2	5	13
8250	-5	-8	0	13	13	-42	8	10	0	-4
8260	11	-15	-8	-5	14	4	0	1	15	5
8270	-24	0	6	11	-24	6	16	0	-22	-10
8280	10	20	-13	7	-8	-8	6	0	29	-11
8290	5	0	10	9	-80	20	19	0	0	1
8300	0	2	12	10	23	-38	-14	3	-16	6
8310	2	5	-11	14	5	0	-10	6	15	13
8320	9	-52	24	-12	-16	3	7	11	-5	-6
8330	11	2	4	-17	-2	20	-9	-7	24	-10
8340	-27	12	4	21	-20	3	0	-4	-7	2
8350	16	3	-12	-11	4	21	-16	0	5	-5
8360	33	-51	17	0	5	8	0	6	26	-63
8370	-8	24	22	-7	4	16	-16	-15	-19	16
8380	6	3	6	3	7	-3	-34	11	8	12
8390	-16	-12	4	2	6	12	-2	6	10	-1
8400	-8	-6	4	-14	-14	25	-10	2	17	-4
8410	0	-1	-1	-6	-6	13	-15	14	1	-18
8420	0	3	15	5	-3	-6	0	-2	0	-1
8430	4	-22	19	19	-18	0	4	-26	21	5
8440	30	-4	-58	3	25	36	-42	-12	18	-12
8450	6	-18	12	20	5	-22	15	5	-10	1
8460	4	-6	11	-10	-10	6	10	-20	11	-1
8470	2	2	3	8	-30	12	11	0	-3	4
8480	-10	2	4	-7	7	11	-8	3	-16	1
8490	3	-12	13	2	-3	13	4	-15	6	0
8500	-4	-24	9	18	9	-6	2	-22	-10	19
8510	15	28	-10	-27	3	0	14	-2	-32	3
8520	-20	29	21	0	-6	-25	21	3	-12	13
8530	4	-28	14	6	8	-9	-34	31	21	-7
8540	-3	2	-20	2	-2	-6	5	-12	16	-2
8550	4	5	13	33	-88	17	1	8	-9	12
8560	58	37	-67	-68	35	11	-4	40	5	-41
8570	-4	-11	1	5	13	0	-1	10	-4	2
8580	-27	3	20	7	-17	4	11	24	-11	-5
8590	-6	-32	17	16	-18	8	-26	19	7	0
8600	11	-5	-1	-14	5	4	-7	15	10	-4
8610	-5	-20	-1	15	7	-18	-7	10	13	3
8620	-18	11	-3	13	-7	-4	-1	-29	15	19
8630	-4	2	-6	0	-6	11	-6	12	6	-8
8640	-21	19	19	9	-32	-37	30	17	-10	-6
8650	11	-26	21	-2	-5	-3	28	-1	-10	-8
8660	-3	-14	12	27	-13	-14	11	-1	3	-5
8670	-15	9	28	-34	32	1	-3	-48	0	52
8680	7	-47	22	6	-9	-17	13	12	-10	10
8690	-2	6	-20	7	14	-5	9	5	-24	-44
8700	37	26	-21	-21	34	3	7	-28	15	-7
8710	17	-21	0	15	-10	10	10	-8	-12	11
8720	-35	18	8	12	-9	-4	0	-8	16	-14
8730	2	4	8	-1	-14	19	-1	0	25	-18
8740	-43	0	38	-14	-1	-16	4	23	12	-13
8750	8	-7	-15	4	3	-1	0	6	-5	24
8760	5	-2	-50	0	23	20	-12	-16	0	10
8770	5	-7	-1	-7	15	0	-1	-1	-9	19
8780	-9	-11	-15	15	18	7	4	-13	-3	-12
8790	0	6	18	5	-43	11	16	9	5	-49
8800	28	-6	-2	22	-27	10	21	13	5	-60
8810	-5	30	0	16	-40	24	44	-48	-36	5

Appendix A. (Cont'd)

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8830	-3	13	4	17	6	-2	-11	2	22	-14
8840	-24	-43	33	32	10	-20	16	-35	0	23
8850	-25	3	12	4	2	-15	-5	0	19	12
8860	-19	3	-6	34	17	-28	7	-50	-25	25
8870	27	-6	1	3	-1	0	22	-6	-36	11
8880	-1	7	36	-33	-19	33	-8	-28	17	-22
8890	1	14	29	-9	-5	-26	31	18	-1	-9
8900	-20	15	13	-5	-32	28	-9	-36	19	6
8910	8	1	5	-28	-1	17	-4	49	8	-39
8920	-28	28	21	-13	-65	21	24	4	12	9
8930	-21	0	-40	20	15	-9	13	27	-45	5
8940	6	30	-12	12	-36	-3	3	3	4	7
8950	7	-2	-8	0	20	-12	22	-60	12	21
8960	18	-62	23	-1	13	17	41	-69	29	-43
8970	35	1	-19	9	5	-20	8	38	24	-41
8980	-15	-36	52	4	-35	13	-9	7	-8	18
8990	-7	3	11	33	-12	-58	7	10	3	14
9000	12	-36	7	14	27	-51	-14	40	0	5
9010	-21	13	15	-5	-42	7	9	13	18	-27
9020	18	-9	-24	25	26	-5	-23	-19	8	4
9030	7	21	-5	-29	19	-20	8	-2	3	2
9040	-1	12	34	-36	-25	15	15	34	-67	-6
9050	28	16	18	-36	20	-32	8	9	6	-23
9060	-14	34	-13	11	-2	40	-3	-37	0	18
9070	-28	-2	14	-8	2	3	7	-10	-13	10
9080	-3	9	14	-15	-5	-6	3	27	9	-32
9090	13	-2	20	-60	21	5	20	22	-61	18
9100	27	-4	10	-77	21	24	19	-10	-5	6
9110	-8	-2	22	-11	0	0	0	1	7	5
9120	-11	-25	20	-13	0	51	-13	-58	21	15
9130	4	33	-5	-63	0	2	13	13	17	-8
9140	-10	7	-33	11	27	14	-3	-15	-17	24
9150	-13	-51	40	-6	1	5	25	-24	3	9
9160	14	-19	-33	16	-12	29	15	7	-42	34
9170	-21	7	-23	14	31	-21	1	-17	4	16
9180	-29	2	9	18	0	16	-29	-1	2	-15
9190	23	-16	1	17	-15	36	-47	17	0	-18
9200	6	-5	8	6	18	17	-33	7	-42	8
9210	11	13	0	10	27	-28	39	-44	-65	37
9220	37	-22	9	18	-6	-5	25	-78	17	26
9230	-5	17	9	0	-20	23	-47	8	17	-10
9240	-6	16	4	-1	-2	14	-37	0	13	27
9250	2	0	-11	26	-48	-3	-8	42	-63	24
9260	20	5	14	11	-74	9	31	24	13	-49
9270	5	17	30	-76	16	53	-29	-23	-7	34
9280	5	-3	-12	26	12	-56	7	36	-34	-2
9290	2	23	-9	5	16	-10	-14	14	-8	-24
9300	0	9	21	4	-16	12	21	-53	21	-25
9310	11	6	-21	21	42	-29	-2	6	0	-11
9320	-1	19	7	-47	-4	22	14	18	-35	-34
9330	31	15	10	8	-1	-3	-29	45	-50	-14
9340	7	17	10	0	-25	8	21	-1	7	13
9350	-5	-63	37	14	-22	-10	24	16	-8	18
9360	11	-22	-38	8	4	-26	4	23	26	-20
9370	17	-31	5	8	22	1	18	-59	35	-52
9380	18	10	-15	14	-7	21	22	-25	19	7
9390	-76	16	23	8	21	-2	-10	-4	-1	0
9400	-2	-22	19	0	-5	8	23	-26	13	0
9410	-27	7	18	3	-21	-12	1	15	-5	0

Appendix A. (Cont'd)

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9420	17	-13	-5	24	30	0	-61	-5	33	-1
9430	21	-27	3	5	-49	30	29	-3	-30	10
9440	11	14	-59	34	14	0	-20	26	-16	25
9450	-63	28	-1	12	19	5	-23	-36	19	11
9460	-7	-4	-9	26	9	-14	-2	30	-60	18
9470	35	3	15	-16	-11	-43	0	39	10	-24
9480	3	30	-48	-17	34	-2	-10	31	-19	34
9490	10	17	-88	11	62	11	-15	-59	1	37
9500	-64	19	42	16	-12	-22	-13	10	-23	12
9510	19	21	-8	-19	36	-81	36	19	-5	13
9520	48	-18	-27	-63	28	2	29	20	-33	-12
9530	24	1	3	-41	-4	26	6	5	-32	50
9540	39	-34	-61	46	-6	-16	15	-26	-21	22
9550	16	-9	-16	17	7	-2	27	6	-39	0
9560	1	12	5	-13	6	12	-44	29	14	-10
9570	41	-73	24	4	21	-2	-27	24	2	-19
9580	-44	27	11	20	-7	-26	0	27	5	30
9590	-68	40	-47	-3	39	0	-5	-7	19	25
9600	-62	14	3	-1	7	17	-7	-27	12	9
9610	18	10	-36	-21	0	11	8	21	0	-8
9620	4	12	-20	12	-39	48	-35	3	22	6
9630	1	-20	-41	12	23	13	9	-8	-29	18
9640	16	-9	-26	26	0	4	-2	-38	8	33
9650	-1	30	-29	9	-3	-46	9	23	-10	-14
9660	3	25	-3	6	4	-30	30	37	-54	8
9670	-55	37	9	1	19	-23	-6	-3	2	6
9680	16	-29	31	24	-20	4	-44	25	15	-1
9690	-38	9	3	0	7	13	3	-8	-8	-13
9700	28	-7	16	-31	-2	17	32	-36	-28	12
9710	14	1	9	0	0	1	-17	-14	9	5
9720	7	29	-27	-9	-3	0	14	20	18	-47
9730	12	-1	21	-17	23	-59	47	-26	2	-18
9740	-4	21	-8	14	1	-9	5	24	-19	5
9750	14	22	-15	-44	1	24	-8	-22	27	-39
9760	38	3	27	-46	5	-3	-8	15	-8	8
9770	9	9	-19	18	-4	12	16	-73	23	39
9780	7	-14	-46	-8	15	24	-9	3	15	-23
9790	-7	5	20	6	9	-64	13	23	-8	12
9800	0	-20	4	16	24	-7	-12	-24	6	16
9810	12	17	-14	-62	30	6	-16	11	25	0
9820	-20	33	-15	-11	-35	15	6	14	29	-43
9830	3	8	6	25	-11	-12	-34	-4	14	16
9840	21	13	-28	11	-10	-42	25	-5	6	7
9850	-1	-20	12	16	24	32	-53	-27	2	-5
9860	14	-1	19	-12	30	-45	-2	-3	15	9
9870	0	5	21	-17	1	-1	-7	-4	16	-4
9880	-11	-17	13	6	-17	12	2	4	4	0
9890	-14	16	8	0	-9	24	-38	14	26	-72
9900	16	26	4	5	-36	24	-4	0	17	14
9910	-36	14	-6	-2	11	12	-15	-7	-1	12
9920	-7	23	28	-57	-2	1	27	0	12	-73
9930	31	18	19	-3	-42	14	-21	12	12	6
9940	6	-4	-1	-7	0	-14	26	21	-17	5
9950	-64	39	2	17	-7	-23	0	(15)	(18)	(33)
9960	(-78)	(10)	(16)							