unsaturated C_{16} dicarboxylic acid of molecular weight 312.)

The C_7 to C_{12} normal fatty acids were also isolated and identified, but there was no indication of the higher homolog previously reported (*2–4*). Nor was there any evidence of the larger isoprenoid acids reported by Eglinton (*5*) or the iso- and anteiso-compounds reported by Leo and Parker (*4*). It is interesting to note that the C_{10} isoprenoid acid was not found in California petroleum by Cason and Khodair (*12*), even though their study included the search for this isomer. Although the absence of dicarboxylic acids in the naphthenic acid fraction of petroleum has been noted by Lochte (*13*), Douglas *et al.* (*7*) have recently reported the identification of C_8 to $C_{22}\alpha,\omega$-dicarboxylic acids from Carboniferous Scottish torbanite.

In this connection it is interesting to note that the C_{13}-diacid occurs as the major diacid component, determined by gas-liquid chromatography, in these studies, as is the case in torbanite (*7*). Long-chain dicarboxylic acids are rare in nature. Hilditch (*14*) noted the presence of C_{20} and C_{21} dibasic acids in the fruit coat fat, commonly known as Japan wax, of sumach berries; apparently, the dicarboxylic acids are rarely found in leaf waxes (*15*). Since microbial oxidation can lead to dicarboxylic acids (*16*), it has been suggested that the presence of these acids in sediments might be due to such transformations (*7*).

Reports of our detailed study of the acid composition of the Green River shale are in preparation [aromatic and cycloaromatic components (*17*), keto acids (*18*), saturated cyclic acids (*19*), and kerogen acids (*20*)].

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21. Supported by NASA grant NsG 101. We thank B. R. Simoneit for collecting the shale specimens and G. Zellweger for measuring the mass spectra.
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20 July 1967

Tree Ring Indices: A Circumpolar Comparison

Abstract. *A graphic and statistical comparison of major trends in tree ring indices representative of interior Alaska, northern Urals, northern Scandinavia, and Labrador indicates a highly significant correlation for most 50-year intervals between 1650 and the present. This is suggestive of similarities in trends of summer temperature on a circumpolar scale.*

Climatic changes, some of a rather large magnitude, have taken place in the past few hundred years on a worldwide scale. Although the most dramatic of these changes has been in the northern latitudes (*1, 2*) it is difficult to obtain a comprehensive view of the regional variation of climatic change, simply because instrumental records are short and stations are widely separated. Tree ring indices have provided supplementary information on some aspects of climatic change, for example, the occurrence of drought in the southwestern United States (*3, 4*), or relative summer temperatures in the north (*5–10*). In this paper, major fluctuations of tree ring indices representative of the northern timberline are compared and analyzed as indicators of climatic change.

The most important requirement for the construction of a climatically sensitive tree ring chronology is that the trees utilized be growing under some sort of climatic stress. The evidence for such a stress is the concomitant occurrence of similar patterns of wide and narrow rings in trees over local and regional areas. The systematic comparison of the sequence of patterns between trees and among groups of trees is termed cross dating, and permits the establishment of absolute dating for each ring. Chronologies developed in this manner may provide a reliable first approximation of the year-to-year variation of the stress-producing climatic parameter or parameters.

Tree ring indices are composed of a number of chronologies of individual or groups of trees and are representative of a regional area of uniformity with respect to the stress-producing climatic element. The direct comparison of chronologies by cross dating is limited to such regional areas. Other techniques must be employed for comparisons over greater distances, as between index groups. Hustich (*6*) compared minimal growth years only among tree ring indices representative of Alaska, Labrador, and Scandinavia, but with essentially negative results. Fritts (*4*) compared a large number of chronologies from the western United States in terms of relative 10-year departures from mean growth and was able to effectively show the historical and spatial pattern of drought in this large area from the year 1500 to the present. Adamenko (*9*) graphically compared indices representative of Scandinavia and the polar Urals which had been converted to 30-year running means, suggesting a strong resemblance of major tree growth trends between the two areas.

The present comparison is based on (i) a 300-year index composed of four groups totaling 32 trees (*Picea glauca*) representative of the Yukon-Tanana

Table 1. Approximate distances (in kilometers) between collection sites.

Interior Alaska	– Northern Urals	4800
Interior Alaska	– Northern Scandinavia	5300
Interior Alaska	– Labrador	4400
Northern Urals	– Northern Scandinavia	1600
Northern Urals	– Labrador	6000
Labrador	– Northern Scandinavia	4400

Uplands of interior Alaska (*10, 11*), (ii) a 146-year index of 46 trees (*Picea mariana* and *P. glauca*) from the east coast of Hudson Bay and central Labrador [Hustich (*6*), series a and d] which will be referred to simply as the Labrador series, (iii) a 300-year index composed of four groups of trees (*Pinus silvestris* and *Picea abies*) from northern Norway and Sweden and compiled from several sources by Schove (*8*) with an unstated (but large) number of trees, and (iv) the 250-year northern Urals index (*Larix siberica*) published by Adamenko (*9*), also with an unstated (and apparently small) number of trees. Approximate great circle distances between collection sites are given in Table 1.

The graphic comparison of the four tree ring indices in Fig. 1 is the original comparison of Adamenko (*9*) between the polar Urals and Scandinavia, to which I have added the interior Alaska and Labrador indices. A 25-year time lag of the Scandinavian series behind the Urals series indicated by Adamenko (*9*) is retained here and is further applied to Hustich's Labrador series. The Urals series has been published only as a 30-year running mean, so I have converted the other series to the same form from the original index values.

Correlation coefficients (*r*) based on annual 30-year running mean values among the four indices are shown in Table 2. The correlations are for 50-year periods, except the last, which is 31 years. The 25-year time lag of the Scandinavian and Labrador indices is taken into account. Since the influence of the year-to-year variations in the original chronologies is virtually eliminated by the much greater amplitude of the oscillations generated by the 30-year running means, the correlation coefficients reflect primarily the degree of covariance among the major trends.

Table 2. Correlations (*r*) among indices (30-year running means).* Each date shown in a time interval refers to the first year of a 30-year period on which the running means are based.

	Urals	Scandinavia	Labrador
	1650 to 1699		
Alaska		−.09	
	1700 to 1749		
Alaska	.81	.81	
Urals		.73	
	1750 to 1799		
Alaska	−.06	.34	.80
Scandinavia			.74
	1800 to 1849		
Alaska	.70	.94	.73
Urals		.71	.12
Scandinavia			.74
	1850 to 1899		
Alaska	.73	.69	.82
Urals		.87	.92
Scandinavia			.77
	1900 to 1930		
Alaska	.97		

*Coefficients over .45 are significant at the .001 level ($N = 50$).

Of the 23 correlations, all but four are significant at much better than the .001 level. In the 1650–1699 interval, there is clearly no similarity between the Alaska and Scandinavia indices, but the other instances of low correlation (Alaska versus Urals and Scandinavia in the 1750–1799 interval and Urals versus Labrador in the 1800–1849 interval) appear to be attributable to phase differences rather than trend differences.

There is a group of factors which may detract from the comparative qualities of the tree ring indices. These include differences in basic collecting and measuring procedures, in numbers and species of trees comprising the indices, and methods of correcting tree ring measurements for age trend (the tendency of ring widths to become narrower as the tree becomes older). In an international comparison such as this, some differences of this sort are unavoidable but were minimized as much as possible for the present study.

The indices representative of Alaska, Labrador, and Scandinavia are based on measurements in hundredths of a millimeter (*6, 8, 10*); the Urals series was measured in tenths of a millimeter

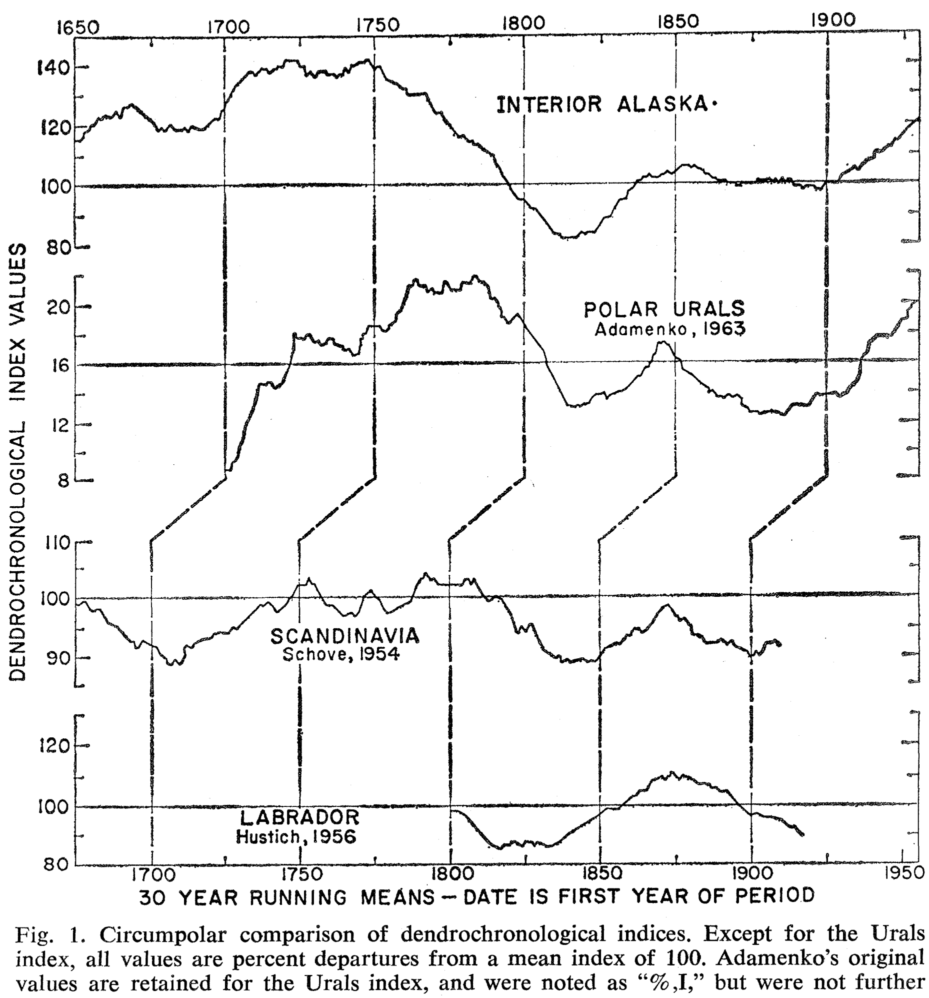

Fig. 1. Circumpolar comparison of dendrochronological indices. Except for the Urals index, all values are percent departures from a mean index of 100. Adamenko's original values are retained for the Urals index, and were noted as "%,I," but were not further defined (*12*).

(*12*). Some method of age trend correction was employed for all indices, except the Alaska, which is developed from trees having no or negligible age trend, a characteristic of some growth in this area previously noted by Giddings (*5*). I have corrected the two groups comprising the Labrador index by plotting Hustich's uncorrected values (*6*) and converting them to percent departures from an eye-fitted age trend curve as described by Schulman (*3*). Schove (*8*) noted that the chronologies comprising the Scandinavia index were corrected, but by differing methods which he did not specify. Adamenko (*12*) stated that his measurements were corrected "according to the method of Rudakov."

The climatic significance of these indices is similar in that they are believed to reflect temporal variations of growing season temperature, but the details of this relationship appear to vary somewhat according to the species and the geographical location. The indices used here are regarded as reflecting primarily June (*10*) or July (*6, 13*) temperatures.

A further relationship involving atmospheric pressure has been suggested. Schove (*14*) stated that his Scandinavia index is indicative of "probable (atmospheric) pressure patterns of individual summers" on the basis that summer temperature is closely related to wind and atmospheric pressure conditions. Adamenko (*9*) tentatively attributed the 25-year lag previously mentioned between the Scandinavia and Urals indices to "the same delay observed in frequency trends of the anticyclonic situations in western and central Europe, compared with those in eastern Europe." During my investigation of Alaskan timberline tree growth, however, I have not found a statistically significant relationship to any climatic parameter other than temperature.

The inference of similarities of major temperature trends based on tree ring indices can be supported by other evidence. Bray (*15*) found that periods of minimal forest growth in British Columbia during 1655–1723, 1799–1833, and, to a lesser extent, 1873–1913, corresponded to similar depressions in Adamenko's polar Urals index as well as to glacial maxima in northwestern North America. It appears that Bray's minimal forest growth periods correspond generally to the Alaskan as well as to the Urals indices. The interior Alaska index also correlates with glacial maxima in the nearby Alaska range, dated by Reger (*16*) as occurring in 1650, 1830, and 1875.

The intent of this paper has been to show that there is a significant degree of similarity in the major oscillations of tree ring indices representative of the circumpolar area. This is suggestive of similarities in long term trends of summer temperatures on a hemispheric basis.

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21 August 1967

Sea-Floor Spreading near the Galapagos

Abstract. *Seismicity, volcanism, and a linear pattern of very large magnetic anomalies that show symmetry about a broad negative anomaly suggest that a type of sea-floor spreading occurs near the Galapagos Islands in the east-equatorial Pacific. This spreading results from the tensile stresses generated by different spreading directions of two adjacent segments of the East Pacific Rise, and it is suggested that the area be called the Galapagos Rift Zone.*

The hypothesis of spreading of the sea floor, advanced by Hess (*1*) and Dietz (*2*), proposes that the ocean basins have grown with the continued formation of new crustal material at the crest of the mid-oceanic ridge. Dramatic evidence to support this thesis has been presented by Pitman and Heirtzler (*3*) and by Vine (*4*) from analysis of the pattern of the magnetic anomaly observed over the axial zones of different portions of the mid-oceanic

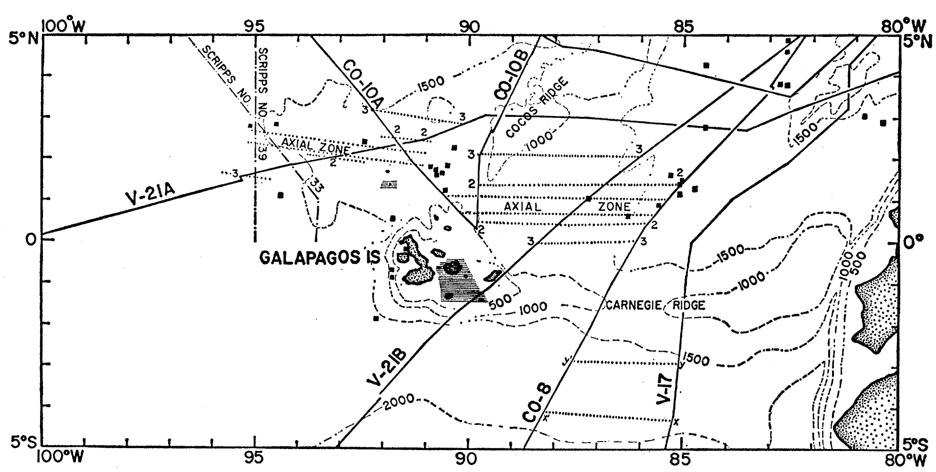

Fig. 1. Location map. Depth contours in fathoms are dashed. Epicenters as determined by Acharya (*7*) are indicated by solid squares. Hachured area indicates region in which Cox and Dalrymple (*8*) found reversely magnetized rocks. Dotted lines correlate magnetic anomalies shown in Figs. 2 and 4. Dot-dashed lines are approximate tracks for the Scripps Institution profiles shown in Fig. 2 (*11*). The west coast of South America appears on the extreme right.