REVISED COMPUTER PROGRAMS FOR TREE-RING RESEARCH

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ABSTRACT

Three computer programs that are basic to the processing and development of tree-ring chronologies are now available. They were designed to refine and replace older programs that were previously furnished by the laboratory. Program RWLIST replaces program RWLST and is used for data inspection. Programs INDEX and SUMAC replace INDXA. INDEX is used for curve fitting procedures while SUMAC does summaries of series of indices, analysis of variance and cross-correlation. The new programs represent an increase in efficiency and flexibility in use. They are written in current ANSI Fortran IV and will be readily adaptable to most computing environments.

Trois programmes pour ordinateur qui constituent la base du traitement des données et de l'élaboration de séries dendrochronologiques sont disponibles. Ils ont été travaillés pour affiner et remplacer des programmes plus anciens, autrefois fournis par le Laboratoire de Tucson. Le programme RWLIST remplace le programme RWLST, utilisé pour vérifier les données. Les programmes INDEX et SUMAC remplacent INDXA. INDEX est utilisé pour la recherche des courbes de lissage, tandis que SUMAC fait les résumés de séries d'indice, analyse de la variance et les calculs des corrélations. Ces nouveaux programmes sont plus efficaces et plus souples à l'usage. Ecrits en ANSI Fortran IV normal, ils sont facilement adaptables à la plupart des ordinateurs.

Für die Bearbeitung und Entwicklung von Jahrringchronologien stehen jetzt drei Computerprogramme zur Verfügung. Sie sollen die älteren Programme, die bisher vom Laboratory of Tree-Ring Research angeboten wurden, verbessern und ersetzen. Das Programm RWLIST ersetzt das Programm RWLST und dient der Datensichtung. Die Programme INDEX und SUMAC ersetzen das Programm INDXA. Mit dem Programm INDEX werden Ausgleichslinien an die Jahrringkurven angepaßt, das Programm SUMAC summiert Indexreihen und führt Varianzanalysen und Kreuzkorrelationen durch. Die neuen Programme haben ene höhere Effizienz und Flexibilität zur Folge. Sie sind in ANSI Fortran IV geschrieben und können an die meisten Computer-systeme angepaßt werden.

One of the continuing goals of the Laboratory of Tree-Ring Research is to maintain or develop computer software that is current by international scientific standards and to make this available to the scientific community in order that replicable research efforts are possible. Most recently this has resulted in new or revised programs that are basic to the development of tree-ring chronologies and to the understanding of their statistical characteristics. The main features of each of these programs is described in the following sections.

PROGRAM RWLIST

The purpose of this program is to provide output of raw ring-width measurements and to plot their 20 year means. This permits examination of the data for the purpose of proofreading and for decision making about the type of curve fitting procedure that might be used in the subsequent development of indices. The primary differences in this program and the older RWLST concern the upgraded Fortran and a new series of error checking procedures. RWLIST will detect a variety of maladies that are notoriously common to the batch-oriented user. These involve decadal sequences that

are reversed, missing, or duplicated and decadal sequences from two or more series that have been mixed. Input to the program may be from any standard peripheral device. A sample of the output is shown in Figure 1.

PROGRAM INDEX

Program Index uses curve fitting procedures to transform ring-width measurements into indices that have a mean value per series of about 1.0. The curve fitting options are the same as those found in the older INDXA program. They include a negative exponential curve, a straight line with positive, negative or zero slope, and a least squares polynomial. The computational formulae for the indices and the several statistics that describe each series are given by Fritts (1976). Figure 2 illustrates the printed output from the program operations.

RUN TITLE CHETRO KETL (ARCHAEOLOGICAL BEAM)
DATE 10/08/79

IDENT.
101201

T R E E - R I N G W I D T H S

20 YR. MEAN	YEAR	0	1	2	3	4	5	6	7	8	9
0.000	646							2.020	4.790	4.080	5.480
3.741	650	4.600	3.560	3.720	4.610	3.210	3.950	3.560	4.070	3.080	1.730
2.640	660	.850	.980	1.750	1.320	.890	2.090	2.130	2.390	2.350	1.960
1.600	670	2.440	2.080	1.620	1.270	1.880	1.140	1.340	.890	1.320	1.310
1.473	680	1.050	1.350	1.710	1.200	1.750	1.420	1.140	1.520	1.610	1.420
1.210	690	.960	.870	1.030	.990	.940	1.400	.900	1.100	.950	.980
.844	700	.340	1.270	.820	1.200	.080	.860	.360	.310	.980	.460
.672	710	.990	.610	.500	.830	.550	.760	1.010	.200	.300	.830
.586	720	.770	.450	.420	.160	.080	.510	.800	.480	.700	.740
.829	730	.970	1.160	1.340	1.610	1.290	.980	2.100	1.220	.240	.540
.993	740	1.010	.360	.370	.810	.770	1.080	1.250	1.320	.390	1.060
.694	750	.470	.270	.240	.860	.520	.480	.660	.080	1.020	.860
.764	760	.780	1.080	1.070	1.140	.430	.980	1.080	.880	1.420	1.180
.959	770	.680	.880	1.390	1.020	.570	1.130	1.390	1.200	.850	.250
.945	780	1.070	.960	.380	.720	1.010	.960	.760	1.600	.960	1.130
.915	790	1.500	.620	1.160	.800	1.090	.700	.630	0.000	1.130	1.130
.965	800	1.390	1.320	1.530	1.230	.950	1.260	1.460	.740	.490	.220
.970	810	.830	.900	1.050	1.330	1.220	1.500	1.020	.320	.010	.770
1.163	820	1.310	1.350	2.040	1.590	1.080	.940	1.560	1.330	1.660	1.550
1.387	830	1.070	1.800	1.830	1.760	2.080	1.800	.860	.380	1.110	.640
1.234	840	.940	1.190	1.160	1.500	1.710	1.310	.970	.990	1.350	.870
1.052	850	.940	.580	1.030	1.170	1.060	.520	1.080	.830	1.410	1.070
.851	860	.880	.850	1.070	.780	.840	.500	.700	.200	.680	.830
.652	870	.480	.600	.740	.660	.780	.490	.870	.620	.080	.440
.545	880	.380	.650	.550	.320	.210	.940	.510	.690	.350	.600
.719	890	.700	.740	.640	.950	.500	.630	1.020	.890	1.410	1.710
.686	900	1.120	.460	.610	.160	.090	.570	0.000	.010	.580	.330
.514	910	.630	.580	.780	.600	.750	.340	.280	.810	.690	.940
.684	920	.970	.680	.240	.270	.050	1.200	1.180	.440	1.140	1.160
.738	930	.450	1.000	1.140	1.010	.820	.270	1.020	.240	.830	.650
.753	940	.910	.830	.600	.290	.630	.470	.790	1.050	.870	1.190
.795	950	1.140	.370	1.330	.930	.520					

LISTING FOR SPECIMEN 101201 FROM 646 TO 954. 309 YEARS. MEAN RING WIDTH 1.044 STANDARD DEVIATION .766
MEAN SENSITIVITY .477 FIRST ORDER AUTOCORRELATION .800

RUN TITLE CHETRO KETL (ARCHAEOLOGICAL BEAM)
DATE 10/08/79

PLOT OF 20 YEAR MEANS OF RING WIDTHS BY DECADE FOR SPECIMEN 101201

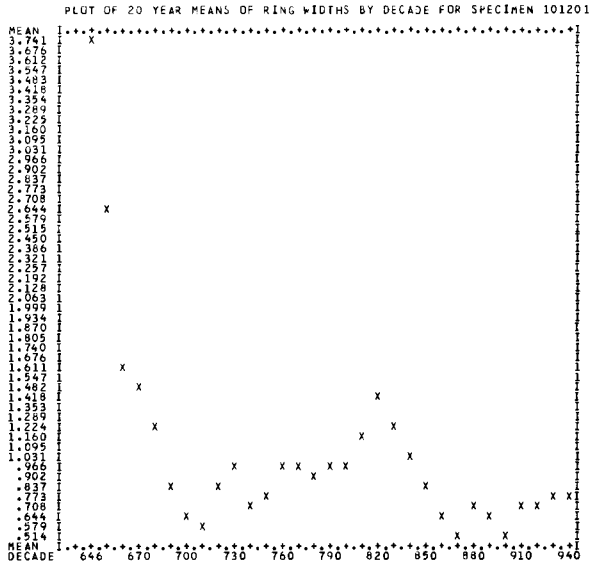

Figure 1. Output from program RWLIST.

RUN TITLE HIDDEN FOREST, NEV. (BRISTLECONE PINE)
DATE 10/08/79

IDENT.
737321

T R E E - R I N G   I N D I C E S

EXPEC. GROWTH	YEAR	0	1	2	3	4	5	6	7	8	9
1.382	1550	.716	1.115	.867	1.170	1.104	1.413	1.311	.893	.569	.612
1.280	1560	.797	.708	.872	.512	.709	.844	.458	.898	1.129	1.121
1.186	1570	.851	1.121	1.575	.966	.947	1.112	.812	1.102	.744	1.047
1.099	1580	.982	1.301	1.154	.986	.244	.274	1.075	1.093	1.005	1.460
1.020	1590	.765	.682	.916	1.033	1.041	1.079	1.252	1.116	.989	1.081
.946	1600	.761	.895	1.266	.638	1.688	1.942	1.128	1.292	1.391	1.616
.878	1610	1.731	.906	1.052	.699	1.243	1.962	1.512	1.715	2.090	1.814
.816	1620	1.496	1.507	1.282	1.291	.202	1.005	.410	.917	.858	1.179
.758	1630	.409	.572	.241	.742	.965	.862	2.206	1.152	1.105	1.113
.705	1640	1.490	.772	1.468	.928	.920	1.118	1.363	1.134	.421	1.378
.656	1650	.854	1.367	.634	.249	.063	.806	1.098	1.202	1.082	.732
.611	1660	.950	.957	.947	.736	1.028	.390	1.025	.826	.260	.524
.569	1670	.035	1.381	.856	1.239	1.428	.564	1.081	1.790	1.710	1.198
.531	1680	1.621	1.480	1.300	1.693	.562	1.015	.039	1.484	1.295	1.123
.495	1690	1.434	1.179	1.187	1.216	1.079	1.379	1.031	1.292	.448	.966
.463	1700	1.405	1.567	1.753	.529	1.443	2.124	1.215	.340	.251	.758
.433	1710	1.063	.931	1.476	.424	1.353	.932	.144	.848	1.341	.932
.405	1720	1.507	1.044	.075	1.133	1.166	1.123	1.413	1.086	.885	.210
.379	1730	.422	.637	.721	.296	.730	.109	.384	.662	.832	.056
.356	1740	.731	.877	.057	1.604	.548	.348	1.022	.910	.887	1.100
.334	1750	1.017	.452	.061	.701	.982	.154	.870	.062	1.132	.759
.314	1760	1.178	.673	.741	.292	.652	.230	1.551	.996	.100	1.479
.296	1770	.845	.782	.958	1.308	1.212	1.776	1.542	.846	1.489	1.498
.279	1780	1.112	.794	.073	1.168	1.175	.074	.409	.785	.338	1.096
.263	1790	.076	.650	.884	.889	.894	.274	.511	.554	.557	.600
.249	1800	.442	.849	.732	1.267	.740	.455	1.164	.794	.168	.465
.235	1810	1.444	.641	1.202	.086	.912	1.178	.834	1.103	.576	.847
.223	1820	.941	1.171	.362	.592	.412	.322	.740	.511	.607	.704
.212	1830	.850	1.139	1.812	1.438	.096	1.356	.097	2.201	.688	.988
.201	1840	.894	1.397	1.153	1.915	1.266	.712	.971	.206	1.084	1.089
.192	1850	1.095	1.205	1.158	1.428	1.222	1.388	.644	.108	1.787	.816
.183	1860	1.202	.769	1.213	.111	.390	.168	.899	.734	.567	.911
.175	1870	.286	.862	.115	.580	1.164	1.053	1.116	1.062	.770	.536
.167	1880	.120	.480	.543	.121	.973	1.160	.674	1.847	2.040	1.056
.160	1890	1.372	1.941	1.006	.821	.887	1.846	.639	1.540	1.610	1.552
.154	1900	.649	.652	.393	.986	.132	1.457	.798	1.869	1.072	1.480
.148	1910	1.215	1.830	1.361	1.639	2.879	2.339	1.381	2.079	1.670	2.025
.143	1920	2.032	2.814	1.906	1.346	1.422	1.427	2.005	1.150	2.524	.362
.138	1930	1.816	1.968	2.267	.954	.147	2.438	.593	2.529	.896	2.022
.133	1940	1.653	2.036	1.815	2.049	1.523	1.146	1.609	1.691	1.465	1.780
.129	1950	.155	.311	1.797	.157	1.258	1.262	.158	1.587	1.114	.160
.125	1960	2.001	1.686	1.530	.404	1.458	1.381	1.059	.490	1.475	1.726
.121	1970	.989	1.653	.829	1.330	.584	2.090				

* * * S T A T I S T I C S   F O R   I N D I C E S * * *

NUMBER OF YEARS	426	MEAN RING WIDTH	.444
FIRST ORDER AUTOCORRELATION	.258	MEAN INDEX VALUE	1.021
STANDARD DEVIATION	.532	SUM OF INDICES	435.098
MEAN SENSITIVITY	.585	SUM OF SQ. OF INDICES	564.870
NUMBER OF ABSENT RINGS	0	PERCENT OF ABSENT RINGS	0.0

CURVE FIT OPTION 0
NEGATIVE EXPONENTIAL CURVE (Y = AEXP(-BX)+D)
16 ITERATIONS WERE REQUIRED
COEFFICIENTS OF THE EQUATION ARE - -
A = 1.314
B = .008
D = .079

Figure 2. Output from program INDEX.

RUN TITLE HIDDEN FOREST, NEV. (BRISTLECONE PINE)
DATE 10/08/79
PLOT OF OBSERVED 20 YEAR MEANS / EXPECTED GROWTH BY DECADE FOR SPECIMEN 737321
(O=OBSERVED, X=EXPECTED, S=BOTH VALUES VERY SIMILAR)

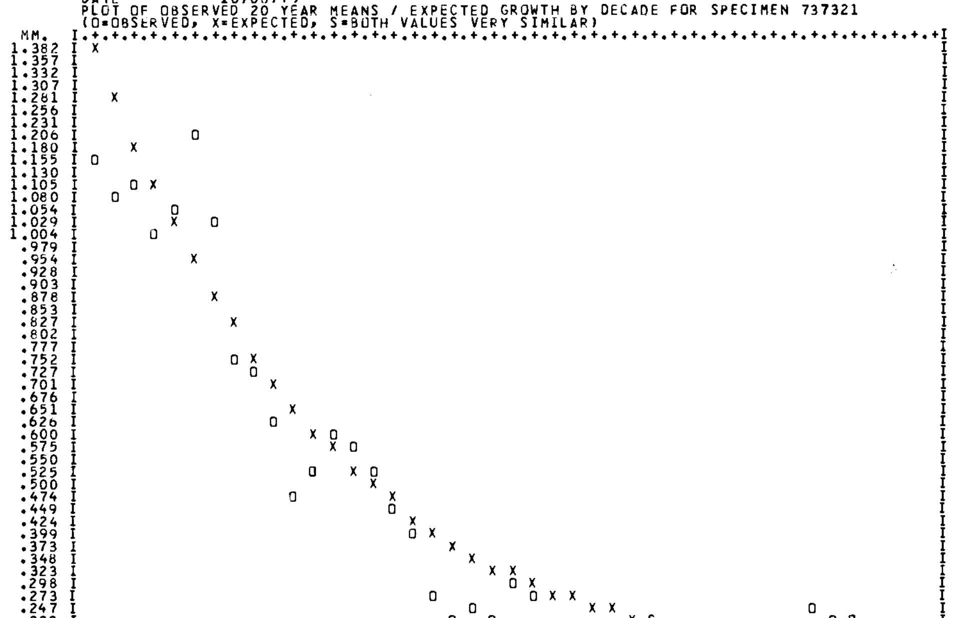

Figure 3. Printer plot from program INDEX.

In addition to the updated Fortran and the revised output print format, program INDEX differs from INDXA in several ways. Extensive error checking procedures have been added that are similar to those described for program RWLIST. When errors in the input stream or in other facets of processing are encountered, messages that attempt to specify the problem are printed on the output file before the program is stopped. Also included now is an option that permits a line printer plot of 20 year means of the expected and observed values of the indices for each series. An example of this is shown in Figure 3.

Program INDEX may be used as a single unit or in sequential job processing with program SUMAC described below. The input stream is basically composed of control records and measurement records. The user has extensive control over the devices used for data origination and destination. The output stream is minimally composed of printed output. Indices may also be punched or stored on peripheral devices.

PROGRAM SUMAC

SUMAC is a program designed to accomplish three different procedures: (1) develop summaries of series of indices, (2) do analysis of variance of series of indices, and (3) do cross-correlation of series of indices. All three types of analysis may be performed in any particular job execution or each may be done separately depending

RUN TITLE SATAN PASS, N.M. (DOUGLAS FIR)
DATE 10/09/79

IDENT. 161540

S U M M A R Y O F T R E E - R I N G I N D I C E S

SEQUENCE NUMBERS INCLUDED ARE 31 32

YEAR	INDICES 0	1	2	3	4	5	6	7	8	9	NUMBER OF CORES 0	1	2	3	4	5	6	7	8	9
1381		4.348	1.664	3.118	2.850	1.786	2.099	2.159	1.558	.994		1.	1.	1.	1.	1.	1.	1.	1.	1.
1390	.410	.606	.998	.509	.725	.805	.629	.275	.256	.118	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1400	.355	.356	.435	.436	.674	.437	.358	.152	.244	1.084	1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
1410	1.595	1.628	2.961	.838	2.143	1.061	1.942	2.382	1.031	.392	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1420	1.189	.556	.987	.627	.955	1.104	1.689	2.158	2.552	1.180	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1430	1.035	2.329	2.163	2.419	1.675	1.172	.565	.740	.320	.687	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1440	.757	1.010	.464	.620	.472	.241	.180	.744	.273	.393	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1450	.189	.782	.888	1.038	.517	.042	.741	.113	1.295	.833	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1460	.606	.486	.569	.073	.191	.119	.720	1.046	.840	1.013	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1470	.943	.319	.390	.487	.129	.377	.449	.656	.164	.104	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1480	.147	.481	.489	.556	.833	.935	.509	.289	.817	1.107	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1490	.842	1.757	1.261	.907	.824	.067	.281	.592	1.134	1.085	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1500	.216	.335	.493	.649	.608	.895	.211	.760	.321	.690	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1510	.510	1.330	1.384	1.331	1.937	1.777	.985	.191	1.054	1.491	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1520	1.721	.870	.421	.641	.473	.571	.961	.787	.945	.887	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1530	1.346	1.525	1.087	.890	.682	.853	.764	1.297	.310	1.035	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1540	1.351	1.169	.182	1.320	.535	1.141	.588	.807	.560	1.222	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1550	1.287	.454	.580	.981	.384	.852	1.279	1.646	1.150	.872	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1560	.564	.315	.344	.517	.701	1.148	.881	.798	1.036	1.657	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
1570	1.460	.936	.967	.398	.581	.593	.434	1.010	.584	.409	2.	2.	2.	3.	3.	3.	3.	3.	3.	3.
1580	.194	.566	.574	.209	.198	.263	.680	.746	1.405	.919	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
1590	.415	1.362	.345	.278	1.776	1.547	1.367	1.340	.755	1.131	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
1600	.533	.632	.510	.640	1.002	1.614	1.454	1.907	1.957	2.365	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
1610	3.689	3.399	2.456	2.616	1.230	2.054	2.023	2.177	2.727	1.663	4.	4.	5.	5.	5.	5.	5.	5.	5.	5.
1620	2.680	2.969	1.030	.780	.432	.603	.336	1.355	1.247	2.233	5.	5.	6.	6.	6.	6.	6.	6.	6.	6.
1630	1.868	.997	.753	1.644	1.929	1.252	1.100	.587	.825	1.549	7.	7.	7.	7.	7.	8.	8.	8.	8.	8.
1640	2.081	1.149	1.457	1.654	1.285	.930	1.905	1.588	1.082	1.283	9.	9.	9.	9.	9.	9.	10.	10.	10.	10.
1650	.932	1.648	1.452	1.442	.879	1.237	1.452	.698	.950	.367	13.	13.	14.	14.	14.	14.	14.	14.	14.	14.
1660	1.058	.755	.671	.775	.339	1.787	.893	.570	.281	.490	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
1670	.172	1.058	.353	1.061	.329	1.077	.337	.890	.793	.511	14.	14.	14.	14.	14.	14.	14.	15.	15.	15.
1680	1.506	1.381	1.630	1.792	.369	.087	1.217	1.078	.900	1.302	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.
1690	1.813	1.317	1.754	1.735	1.133	1.240	.456	.288	.679	1.307	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.
1700	.900	1.955	1.047	1.094	.716	.686	1.168	1.194	.917	.601	18.	18.	18.	18.	18.	18.	19.	19.	19.	19.
1710	1.781	1.417	1.662	1.248	1.031	.939	.164	1.020	.765	.938	19.	19.	20.	20.	20.	20.	20.	20.	20.	20.
1720	1.929	1.391	.552	1.393	.274	.855	1.296	1.399	.120	.040	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1730	.682	1.017	1.312	.450	.843	.109	.850	.613	.311	.735	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1740	.642	.645	.226	1.173	.352	1.414	1.859	2.736	.120	2.029	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1750	.899	.867	.298	.644	1.269	.632	.665	.612	1.224	1.849	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1760	1.298	.322	1.647	.240	1.301	.476	1.532	.854	1.758	1.619	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1770	1.355	1.532	1.225	.190	.886	.669	.967	.256	.816	.583	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1780	.330	.922	.216	1.424	1.756	1.221	.686	1.441	.451	1.084	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1790	.920	1.361	1.620	1.873	.975	1.757	.745	.880	1.005	.703	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1800	.404	.637	1.076	.560	1.190	.957	.129	1.415	.869	.811	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1810	.456	.434	.558	.510	.899	.919	2.095	1.910	.255	.137	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1820	.806	1.263	.007	.273	.625	.822	.351	.282	1.147	.323	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1830	1.007	.852	1.111	1.470	1.769	1.722	1.194	1.770	2.099	2.480	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1840	2.412	1.824	.848	.840	1.450	.641	.972	.015	1.446	1.371	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1850	1.163	.554	1.495	.892	.378	1.957	2.025	.656	1.293	.971	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1860	.855	.134	1.403	.634	.510	.861	1.002	1.640	1.303	2.098	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1870	1.032	1.212	.207	1.160	1.613	.515	.596	1.870	.738	1.048	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1880	.130	.429	1.287	1.217	1.604	1.336	.807	.853	1.638	1.171	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1890	.937	1.466	1.081	.577	.296	1.228	.580	1.024	.702	.348	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1900	.590	.679	.345	1.104	.040	1.604	.989	1.259	2.044	.438	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1910	1.255	1.077	1.387	.584	1.321	1.821	1.574	1.470	.425	1.493	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1920	2.032	.501	1.019	.775	1.722	.261	1.376	.782	1.301	.758	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1930	.747	1.185	1.472	.698	.528	2.117	1.242	1.645	1.162	1.128	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1940	.433	2.191	1.354	.607	1.119	1.111	.526	.880	1.508	1.043	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1950	.312	.127	1.138	.399	.270	.136	.334	.332	.929	.383	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1960	1.043	.664	.816	.840	.727	1.336	1.111	.196	1.659	1.314	20.	20.	20.	20.	20.	20.	20.	20.	20.	20.
1970	1.433	.342	1.017								20.	20.	20.							

* * * S T A T I S T I C S F O R S U M M A R Y * * *

TIME RANGE IS	1381-1972	NUMBER OF YEARS	592	STANOARD OEVIATION	.616
FIRST ORDER AUTOCORRELATION	.450	MEAN SENSITIVITY	.576	MEAN INDEX VALUE	.995
STANDARD ERROR	.102	SUM OF INDICES	589.147	SUM OF SQ. OF INDICES	810.409
MEAN RING WIOTH	.442	NUMBER OF ABSENT RINGS	182	PERCENT OF ABSENT RINGS	15.71675
ANOVA PERIOO IS	1820-1969	NUMBER OF YEARS	150	MEAN INDEX VALUE	1.017
R OF MEAN WITH				SUM OF SQ. OF INOICES	199.389
STANOARD ERROR	.837	(INTERCEPT)	.024	(SLOPE)	.0393
MEAN RING WIOTH	.329	NUMBER OF ABSENT RINGS	103	PERCENT OF ABSENT RINGS	34.33333

Figure 4. Summing of series output from program SUMAC.

upon the problem at hand. The rationale for these procedures, the associated statistical formulae, and examples of their usage are given by Fritts (1976).

The major differences between SUMAC and the summary processing sectors of INDXA concern increased flexibility in the types of input stream that are possible, simplification of input directives, revised output print format and increased efficiency of operation. There are three types of summary processing that SUMAC does. The first of these is one of the most common types of analysis encountered, i.e., ring-width data from one site are available that represent replicated series of two or more samples per tree. In this case program INDEX is loaded, executed, and the resulting indices are written to intermediate disk storage. Program SUMAC is then loaded and executed. It reads the indices from intermediate storage and then develops a new data file that can be directly instead of sequentially accessed in search of any series. The program then develops tree summaries, matched specimen summaries and a site summary. Data sets that contain replicated series from several sites may also be processed as long as the number of samples per tree and the number of trees per site are constant. In this case additional summaries across samples for all sites and across trees for all sites would be produced. The printed output from a final site summary is shown in Figure 4. Options are present that permit any or all summaries to be punched or stored on other devices.

The second type of summary processing in SUMAC is designed to do the same tasks as those described above but the data being input are indices that have been produced by INDEX or INDXA that have been stored as physical card images. The third summary procedure is designed to do summaries of indices for single specimens and/or multiple specimen summaries. For example, site summaries and tree summaries developed at different times may be input to produce an areal or regional chronology.

The cross-correlation procedures and output do not vary substantially from those found in INDXA. The analysis of variance procedures remain constant but the output

RUN TITLE SATAN PASS, N.M. (DOUGLAS FIR)
DATE 10/09/79

A N A L Y S I S O F V A R I A N C E

SOURCE OF VARIATION		RAW SUM OF SQUARES	CORRECTED SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	VARIANCE COMPONENT	PERCENTAGE VARIANCE COMPONENT
GROUP MEANS	(G)	ONLY ONE GROUP IS BEING USED					
CORE CLASS MEANS	(C)	3101.201	.197	1.000	.197		
TREE MEANS IN GROUPS	(T X G)	3111.260	10.257	9.000	1.140		
CORE MEANS IN GROUPS	(C X G)	ONLY ONE GROUP IS BEING USED					
CORE MEANS WITH TREES IN GROUPS	(C X T/G)	3121.044	9.587	9.000	1.065		
SUBSAMPLE	(C X T/G)	SUBSAMPLING NOT USED					
MEAN INDICES IN TOTAL CHRONOLOGY	(Y)	3987.785	886.782	149.000	5.952	.291	76.622
CHRONOLOGIES OF GROUPS	(Y X G)	ONLY ONE GROUP IS BEING USED					
CHRONOLOGIES OF TREES IN GROUPS	(Y X T/G)	4174.441	176.399	1341.000	.132	.041	10.905
CHRONOLOGIES OF CORE CLASSES	(Y X C)	3993.243	5.261	149.000	.035	-.001	-.353
CHRONOLOGIES OF CORE CLASSES WITH GROUPS	(Y X C X G)	ONLY ONE GROUP IS BEING USED					
CHRONOLOGIES OF CORES WITH TREES IN GROUPS	(Y X C X T/G)	4254.807	65.322	1341.000	.049	.049	12.826
SUBSAMPLE	(Y X C X T/G)	SUBSAMPLING NOT USED					

TOTAL SUM = 3101.00 N OF ELEMENTS = 3000.
ERROR SQ. OF Y = .0059 ERROR OF Y = .0769

Figure 5. ANOVA output from program SUMAC.

print format has been extensively revised. It follows the tabular presentation of Fritts (1976: 288). An example is shown in Figure 5.

The new programs are written in Fortran IV that conforms to ANSI standards at the present time. They have been extensively tested on a Control Data Corporation Cyber 175 using a Fortran compiler (FTN version 4.6), under the SCOPE and NOS/BE operating systems. No major difficulty should be encountered in adapting the programs for use on other computing systems.

A detailed operating manual for the programs (Graybill 1979), a tape with the Fortran source statements, test data and sample output can be ordered for a nominal processing fee. Please direct inquiries to:

Data Processing
Laboratory of Tree-Ring Research
The University of Arizona
Tucson, Arizona 85721
U.S.A.

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