RECONSTRUCTION OF PAST CLIMATIC VARIABILITY

(A Progress Report)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A total of 177 tree sites have now been collected under this project, and 66 of these have been dated and computer processed. These new tree-ring chronologies have been screened and used to develop five improved and enlarged grids that can be used to upgrade the climatic reconstructions. Progress is also reported on

1) the development of an International Tree-Ring Data Bank and international cooperation,
2) the development and use of our new remote computer terminal.
3) calibration and reconstruction of past climate from tree rings, and

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4) improvement of the techniques for describing and interpreting the more than 2000 reconstructed maps of past pressure variations that now exist on computer tape.

SUMMARY (nontechnical)

The purpose of this project is to reconstruct past climatic variations by applying multivariate techniques to well-dated proxy series of climate such as tree rings. Progress is reported on three areas of research: A) the development and expansion of our tree-ring and climatic data base (Tasks 1 and 2), B) experimentation on multivariate methods for reconstructing past climatic parameters from variations in past tree growth (Task 3), and C) developing, evaluating and summarizing the actual reconstructions of past climate (Task 4).

A total of 12 new sites have been collected or made available to the ARPA project since June 30, 1974, making a total of 177 collected sites. Forty-four of these sites were found to yield inadequate information for reconstruction of climate, so they have been rejected. Others have been dated and are in various phases of data processing. At present, we have completed computer processing of 66 of the 133 valid tree sites, and from these several new tree-ring chronology grids have been selected for western North American analysis. One grid is made up of 89 tree sites with chronologies all extending to A.D. 1700, another grid is comprised of 65 tree sites with all chronologies complete to A.D. 1600, and a third grid contains 40 tree sites with chronologies complete to A.D. 1500. Sixty tree sites which cover Arizona and portions of neighboring states extend back to A.D. 1700. Twelve regional chronologies for the Colorado Plateau area, plus separate chronologies for each species within the region, match archaeological chronologies and will allow climatic reconstruction for that geographical area from A.D. 700 to the present. The use of these new data grids for actual climatic reconstruction is just beginning.

Other items reported herein are: 1) progress on international collaboration and the development of an International Tree-Ring Data Bank, 2) the selection of seasons and development of models yielding the best climatic reconstruction, 3) development of interactive computer software to aid analysis work and text preparation, and 4) the development of typing, analysis of variance, and other procedures used to describe and test climate reconstructions.

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GENERAL SYNOPSIS

Prepared by H. C. Fritts

There is a growing awareness that climate does change, that the world's food and energy supplies may become increasingly affected by climatic variations, and that more effort needs to be directed to the task of anticipating future modes of climate. It is also becoming apparent that climatic changes occur on all time scales, and that our knowledge of the spatial and temporal character of climatic variations becomes less accurate as we work back in time from the present (Gates and Mintz, 1974).

One can be optimistic about the possibility of statistical forecasting of weather and climatic variations for a few days, weeks, or even months in the future, because relatively good physical models already exist for such, and there are a sufficient number of observations to develop the necessary statistics. On the contrary, however, there is insufficient knowledge of and a lack of studies on climatic variations for time scales of 1 to 100 years. Therefore, it is still difficult to anticipate long-range changes in climate. This lack is in part imposed by unavailability of data. For example, there are only 25 to 30 years of upper air data and only 70 years of surface observations from a moderately dense network available for analysis of yearly climatic variations; and a relatively small number of weather stations have long enough records to provide even 10 independent observations of decades (100 years), which is a number generally considered too small to derive meaningful statistics. In order to obtain more information on the nature of past climatic variability on time scales of years to millenia, it is necessary to go beyond existing weather records to proxy data, i.e., environmentally sensitive chronologies that have recorded past variations in climate for a particular region or site.

This report covers the first half of the third year of a five-year project to extend our knowledge of year-to-year variations in climate back in time by use of well-dated proxy series of climate such as tree rings. Such climatic reconstruction is possible because ring-width growth on stress sites is limited in years of minimal moisture or anomalous temperatures. Therefore, biological records of climate can be obtained from replicate sampling of rings from trees on a variety of sites over a wide geographic area. Spatial variations in tree growth for each year can be calibrated with recorded climate and the calibration equation is applied to growth in past years to estimate the associated variations in past climate. Work up to now has focused mainly on arid site trees from western North America and pressure over North America and the North Pacific Ocean. The first objective of this study is to expand the tree-ring data base. This widened data base is to be applied to an expanded set of climatic data to include the North Atlantic, Europe, and Asia. During the period since June 30, 1974, progress on the ARPA-supported work has kept pace with the originally proposed schedule, and in one case it has exceeded our expectations.

This project has been divided into 4 basic tasks. <u>Task 1</u> includes all work connected with tree-ring collection, dating, and data processing of material from various tree-ring sites. In the first two reports, Martha Wiseman and Jeffrey Dean describe the excellent progress that has been made in this task.

Task 2 includes efforts to stimulate collaboration with Europeans and Asians. There has been considerable progress here through the development of plans for an International Tree-Ring Data Bank. We have postponed trying to actually accept contributed data until these plans are complete and the required information well defined. However, as reported by Karen Babcock, these decisions have now been made and we are ready to start the Data Bank.

Task 3 includes the development of procedures and tests that facilitate the efforts to calibrate tree-ring width variation with variations in climate. The fourth report, by D. W. Stevens, describes some interactive computer software that was developed for the calibration work. The fifth report, by D. J. Shatz, describes his work in selecting new sets of tree-ring chronologies now available from the previous ARPA work. In place of our 49 sites which extended back to A.D. 1700, we now have a new set of 89 high quality western North American sites, 40 of which are complete back to A.D. 1500. The report by T. J. Blasing summarizes the progress in modeling and some climatic reconstruction efforts.

Task 4 includes the actual climatic reconstruction work. In addition to the progress described by Blasing, G. R. Lofgren describes his work with typing of the present-day climate, evaluating pressure reconstructions, and developing climatic parameters that better represent the response of tree growth to climate. The last report under Task 4, by C. L. Winter, describes additional ideas concerning climatic reconstructions and analysis.

The last report, by M. C. Ares, describes the use of the remote computer terminal for manuscript preparation.

DETAILED TASK REPORTS

Task 1A reported by M. A. Wiseman. Progress on North American Collections Except the Southwest Plateau Area.

The two-phase effort of Task 1, to develop final tree-ring chronologies from areas other than the previously established western United States grid, is proceeding well. During the first 2½ years of the ARPA project, a total of 111 sites have been collected or provided by collaborators for northeastern and midwestern United States, southern California, Mexico, and the American Arctic (Table I). (Included also on Table I are chronologies from Sweden which we have already developed, and which in the future will be included under Task 3.) Of these 111 sites, 38 sites have been deleted from the data file after examination because of poor quality, and 5 have been consumed by site mergers. A total of 20 sites have been finalized and incorporated into the ARPA data file. There remain 48 sites in various stages of progress (for the most part in computer processing), which must eventually be evaluated and either deleted or included in the data file.

Between 30 June and 31 December 1974, 11 new site collections were added from eastern North America. Six of these were collected in interior Labrador in August, 1974, by H. C. Fritts with the collaboration of Dr. Jaan Terasmae, Brock University, St. Catherines, Ontario. Two coastal Labrador sites were provided by H. E. Wright, University of Minnesota, and three additional dated site chronologies were generously provided by Edward Cook, graduate student at the Laboratory of Tree-Ring Research. Scanning of two Labrador sites so far shows them to be lengthy and sensitive chronologies. During the last 6 months progress on other sites includes dating checked on 2 sites, 8 sites measured, 11 measurement sets checked, 4 sites completed through data processing, and 13 sites reviewed or in the last stage of review.

Quality control of the produced data has required a major effort during this reporting period. To facilitate control we have now established a routine analysis procedure which includes: 1) Independent checking of tree-ring dating, 2) independent measurement checking with unique criteria developed for each new tree genus involved, 3) evaluation of curve fitting to the tree-ring data by the computer, and 4) evaluation of chronology plots with $\pm$ 2 standard deviation bands indicating years of high data dispersion. Before use in climatic analyses, steps (3) and (4) may be repeated more than once for refinement of the data. Final data review includes checks to assure 5) that final climatic summaries contain only the longest and most homogeneous records of ring-width variation, and 6) that each chronology designated for the ARPA file exhibits required minimal statistical characteristics for use in climatic reconstruction.

In summary, the work of chronology development from nonwestern grid sites has been finalized on 57% of the collections. The majority of the remaining sites will be usable and are near completion. By the end of December, 18% of the collected sites had been included in the ARPA file. We have found that the percentage of unsuitable sites is greater among Mexican and eastern materials than in western collections, for two major reasons: 1) New species are being encountered in these areas, and each presents unique problems. For each new species a master dating chronology must be generated without prior work to rely upon. 2) Most important is that these new sites are in areas where ecological factors which limit tree growth are far more complex than in the areas of our prior experience. Our screening process stringently removes those specimens or sites in which the limiting effects of climate are obscured by other factors in the growth of the trees. For these reasons, we consider the data review on sites from these new regions as a critical step to insure internal agreement in the basic tree-ring data to be used in the climatic analyses discussed elsewhere in this report.

Key to Species and Sponsors

Abbreviation	Common Name	Scientific Name
BCS	bigcone spruce	*Pseudotsuga macrocarpa*
BF	balsam fir	*Abies fraseri*
CP	Chihuahua pine	*Pinus leiphylla*
CS	Chihuahua spruce	*Picea chihuahuana*
DF	Douglas fir	*Pseudotsuga menziesii*
ERC	eastern red cedar	*Juniperus virginiana*
HM	hemlock	*Tsuga canadensis*
JP	jeffrey pine	*Pinus jeffreyi*
JUN	juniper	*Juniperus* ssp.
LALA	tamarack	*Larix laricina*
LBP	limber pine	*Pinus flexilis*
LD	incense cedar	*Libocedrus decurrens*
MWP	Mexican white pine	*Pinus strobiformis*
PCGL	white spruce	*Picea glauca*
PCMA	black spruce	*Picea mariana*
PIRI	pitch pine	*Pinus rigida*
PNN	pinyon pine	*Pinus edulis*
PNNc	Mexican pinyon pine	*Pinus cembroides*
PNNq	Parry pinyon pine	*Pinus quadrifolia*
PO	post oak	*Quercus stellata*
PP	ponderosa pine	*Pinus ponderosa*
PV	Va. scrub pine	*Pinus virginiana*
QUPR	chestnut oak	*Quercus prinus*
RP	red pine	*Pinus resinosa*
RS	red spruce	*Picea rubens*
SCP	scotch pine	*Pinus sylvestris*
SLP	shortleaf pine	*Pinus echinata*
TMP	table mtn. pine	*Pinus pungens*
WF	white fir	*Abies concolor*
WO	white oak	*Quercus alba*
WP	white pine	*Pinus strobus*

Abbreviation	Sponsor (source)
A. Douglas	Arthur V. Douglas, University of Arizona, Tucson
ARPA	Advanced Research Projects Agency
E. Cook	Edward R. Cook, University of Arizona, Tucson
Estes	Eugene T. Estes, Rend Lake College, Ina, IL
Harlan	Thomas P. Harlan, University of Arizona, Tucson
Jonsson	Bengt Jonsson, Royal College of Forestry, Stockholm
MNA	Museum of Northern Arizona, Flagstaff
NPS	National Park Service
Siccama	Thomas G. Siccama, Yale University, New Haven, CT
R. Tosh	Robert W. Tosh, Mentone, CA
T. Naylor	Thomas H. Naylor, University of Arizona, Tucson
TRL	Laboratory of Tree-Ring Research, University of Arizona, Tucson
Wright	H. E. Wright, University of Minnesota, St. Paul

Abbreviation	Meaning
X	This step completed since last report
*	This step completed previous to last reporting period

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
NORTHEASTERN UNITED STATES											
ARPA	Nancy Brook, NH	RS	36/18	*	*	1561-1972	*	*	*	*	26/13
ARPA	Livingston, MA	RS	31/15	*	*	1696-1972	*	*	*	*	20/10
ARPA	other New England sites	RS, WP	26/20	*	-	-	-	-	-	-	too few, deleted
Siccama	Camel's Hump A, VT	RS	22/11	*	*	1687-1972	*	*	*	*	combined site
Siccama	Camel's Hump B, VT	RS	15/8	*	*	1778-1972	*	*	*	*	
Siccama	Camel's Hump C, VT	RS	16/8	*	*	1635-1972	*	*	*	*	50/25
E. Cook	Mohonk Lake, NY	HM	40/20	*	*	1636-1973	X	X			
E. Cook	Mohonk Lake, NY	PIRI	50/25	*	*	1656-1973	X	X			
E. Cook	Mohonk Lake, NY	QUPR	56/28	*	*	1695-1973	X	X			
Siccama	Giant Ledge, NY	RS	22/11	*	*	1678-1972	*	*	*	*	20/10
Siccama	Cornell Mtn., NY	RS	20/10	*	*	1817-1972	-	-	-	-	short, deleted

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
MIDWESTERN UNITED STATES											
ARPA	Seagull Lake, MN	RP	58/30	*	*	1624-1971	*	*	*	*	26/13
ARPA	Saganaga Lake, MN	RP	117/63	*	*	1619-1971	*	*	*	*	34/14
ARPA	Itasca St. Pk., MN	RP	53/27	*	*	1672-1971	*	*	*	*	36/18
	University of Chicago Collection										
ARPA	Boone Co., ARK (A-Bo)	oak	26	scanned		ca 1700-1940					good site, but not yet updated
ARPA	Franklin Co., ARK (A-Fr)	pine	27	scanned	-	-	-	-	-	-	deleted from analysis
ARPA	Garland Co., ARK (A-Ga)	pine	46	scanned	-	-	-	-	-	-	deleted, poor dating
ARPA	Independence Co., ARK (A-In)	WO	27	scanned		ca 1640-1940					good site, but not yet updated
ARPA	Johnson Co., ARK (A-Jo) (updated by ARK/SAL/A)	WO	39	scanned		ca 1640-1940					dense network at this site, low priority
ARPA	Marion Co., ARK (A-Ma)	oak	25	scanned		ca 1770-1940	-	-	-	-	deleted, short
ARPA	Montgomery Co., ARK (A-Mo) (updated by ARK/BBR)	SLP	45	*	*	1666-1939	*	*	*	X	39/39

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Newton Co., ARK (A-Ne)	WO	49	scanned		ca 1680-1940					good site, but not yet updated
ARPA	Polk Co., ARK (A-Po) (updated by ARK/BHM)	WO	13	*		1676-1940					
ARPA	Polk Co., ARK (A-Po) (updated by ARK/CRM)	pine		scanned		ca 1640-1940					dense network, low priority
ARPA	Pope Co., ARK (A-Pp) (updated by ARK/RUS/A)	WO	61	*	*	1642-1939	*	*	*	X	30/15
	statistical chronology					1642-1939	-	-	*	X	20/10
ARPA	Saline Co., ARK (A-Sa)	pine	45	scanned		-	-	-	-	-	deleted, poor crossdating
ARPA	Stone Co., ARK (A-St.)	oak	50	scanned		ca 1690-1940					not updated
ARPA	Yell Co., ARK (A-Ye)	SLP	7	scanned		ca 1730-1940	-	-	-	-	short, deleted
ARPA	Carter Co., MO (Mo-Ct)	WO	45	*	*	1642-1936	*	*	*		
	statistical chronology					1642-1936	-	-	*		20/10
ARPA	Jefferson Co., MO (Mo-Je)	ERC	103	36	*	1746-1942	*	*	-	-	short, deleted
ARPA	Shannon Co., MO (Mo-S)	WO	106	*	*	1588-1936	*	*	*		
ARPA	Shannon Co., MO (Mo-S)	pine		scanned		ca 1690-1940					not updated
ARPA	St. Francis Co., MO (Mo-StF)	ERC	9	scanned		-	-	-	-	-	deleted, poor crossdating

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Washington Co., MO (Mo-W)	ERC	22	scanned		-	-	-	-	-	deleted, poor crossdating
ARPA	Comanche Co., OK (O-Cm) (updated by OK/MST)	ERC	32	scanned		one specimen ca 1640-1940	-	-	-	-	deleted, poor crossdating
ARPA	Canadian Co., OK (O-Cn)	ERC	59	scanned		-	-	-	-	-	deleted, short and poor cross-dating
ARPA	Murray Co., OK (O-Mr)	ERC	22	scanned		-	-	-	-	-	deleted, short and poor cross-dating
ARPA	Anderson Co., TN (T-An)	SLP	6	*	*	1719-1938	-	-	-	-	used for chronology verification, deleted
ARPA	Bradley Co., TN (T-Br)	pine	114	*	*	ca 1745-1938	-	-	-	-	short, deleted
ARPA	Cumberland Co., TN (T-Cu)	SLP	5	*	-	ca 1840-1940	-	-	-	-	short, deleted
ARPA	Sevier Co., TN (T-Se)	HM	13	*	*	ca 1740-1940	-	-	-	-	short, deleted
ARPA	Warren Co., TN (T-Wa) (updated by TENN/FCF)	WO	25	*	X	1669-1941	X	X			
ARPA	Norris Basin, TN	ERC	215	27	*	1752-1934	*	-	-	-	poor cross-dating & short, deleted

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
	ARPA 1973 Collections (updates for University of Chicago Collection)										
ARPA	ARK/SALUS/A (update for Johnson Co., ARK)	WO	32/17	scanned		ca 1851-1972					dense network, low priority
ARPA	ARK/Russellville/A (update for Pope Co., ARK)	WO	27/12	*	*	1713-1972	*	*	*	X	25/12
	statistical chronology					1713-1972	-	-	*	X	20/10
ARPA	ARK/RUS/A	SLP	24/12	*	-	1731-1972	-	-	-	-	short, deleted
ARPA	ARK/Big Brushy Mtn. (update for Mont. Co., ARK)	SLP	41/20	*	*	1760-1972	*	*	*	X	41/20
	statistical chronology					1760-1972	-	-	*	X	20/10
ARPA	ARK/Crystal Mtn (update for Polk Co. pine and A-Mo)	SLP	32/16	*		1719-1972					dense network, low priority
ARPA	ARK/Brush Heap Mtn. (update for Polk Co. oak)	WO	30/15	*	*	1720-1972	*	X			
ARPA	Tenn/Falls Creek Falls	PO	9/4	*	*	1678-1972	X	X	X	X	9/4
	statistical chronology					1678-1972	-	-	X		8/4
ARPA	Tenn/Falls Creek Falls (update for T-Wa)	WO	34/17	*	*	1767-1972	X	X	X	X	23/12
	statistical chronology					1767-1972	-	-	X	X	20/10

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Tenn/Falls Creek Falls	PV	26/13	scanned	-	ca 1827-1972	-	-	-	-	short, deleted
ARPA	Tenn/Savage Gulf High statistical chronology	SLP	28/14	*	*	1646-1972 1646-1972	* -	X -	X X	X X	26/13 combined 20/10 sites
ARPA	Tenn/Savage Gulf Low statistical chronology	SLP	28/14	*	*	1734-1972 1734-1972	* -	* -	* *	X X	26/13 48/24 20/10
ARPA	Tenn/Clingman's Dome	BF	28/14	*	-	1745-1972	-	-	-	-	short, deleted
ARPA	Tenn/Steiners Woods	WO	14/7	*	*	1625-1972	X	X			
ARPA	Tenn/Greenbriar Pinnacle	TMP	28/14	*	*	1830-1972	-	-	-	-	short, deleted
ARPA	Tenn/Norris Watershed Bdry.	SLP	24/12	*	X	1628-1972					
ARPA	Tenn/Wolf Penn Hollow	TMP	24/12	*	-	1810-1972	-	-	-	-	short, deleted
ARPA	Newfound Gap, NC	RS	30/15	*		1685-1972					
ARPA	Ferne Clyffe A, IL (update for Estes' FC)	WO	20/10	*	*	1685-1972	*	X			
ARPA	Ferne Clyffe B, C, D, IL	ERC	84/42	*	*	-	-	-	-	-	poor cross-dating & short, deleted
Estes	Ferne Clyffe, IL	WO	20/10	*	*	1870-1959	*	*	*		
ARPA	Soc. Am. Foresters Plot, MO (update for Shannon Co.)	WO	24/12	*	*	1725-1972	*	*	*		

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Mark Twain Nat. For., MO (update for Mo-Ct)	WO	35/17	*	*	1783-1972	*	*	*		
	statistical chronology					1783-1972	-	-	*		20/10
ARPA	Mark Twain Nat. For., MO	SLP	38/19	*	-	-	-	-	-	-	short, deleted
Estes	Winona, MO	WO	20/10	*	-	1780-1966	*	*	*		
ARPA	Mount Scott, OK (update for Comanche Co.)	ERC	28/14	*	*	-	-	-	-	-	poor cross-dating, delete[illegible]
SOUTHERN CALIFORNIA, UNITED STATES											
R. Tosh	San Gorgonio	LBP	238/101	*	*	18 BC-1971	*	*	*		being rerun on polynomial option
A. Douglas	Santa Ana Mtns	BCS	36/18	*	*	1610-1972	*	*	*	*	30/15
MEXICO											
	State of Coahuila										
ARPA	Sierra del Carmen/ Madera Canyon A	DF	26/14	*	*	1675-1971	*	*	*		
ARPA	Madera Canyon B	MWP	14/6	*	*	1676-1971	*	*	*		
ARPA	Madera Canyon C	PP	13/7	*	*	1782-1971	*	*	*		deleted, too short

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Cojos Canyon	PNNc	18/10	*	*	1827-1971	*	*	*		short, deleted
ARPA	Santa Fe del Pino	PP	57/28	*	-	1815-1972	-	-	-		short, deleted
ARPA	Sierra de Madera A	DF	4/2	*	-	1603-1972	-	-	-	-	deleted, not enough replication
ARPA	Sierra de Madera B	MWP	10/5	*	-	-	-	-	-	-	deleted, not enough replication
ARPA	Sierra De Madera C	PP	42/21	*	-	-	-	-	-	-	deleted, poor crossdating
ARPA	Saltillo, Coahuila	PP	51/26	*	-	1892-1972	-	-	-	-	too short, deleted
	State of Chihuahua										
ARPA	Sierra Rica, Chihuahua	PNNc	33/18	*	-	-	-	-	-	-	deleted from analysis
ARPA	Sierra del Nido A1	PNNc	30/15	*	-	-	-	-	-	-	deleted, poor crossdating
ARPA	Sierra del Nido A2	CP	20/11	*	-	-	-	-	-	-	deleted, poor crossdating
ARPA	Sierra del Nido B1	DF	11/6	*	*	1569-1971	*	*	*		
ARPA	Sierra del Nido B2	MWP	7/4	*	*	1634-1971	*	*	*		

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
ARPA	Sierra Madre/Creel Airport	DF	21/11	*	*	1642-1972	*	*	*		
ARPA	Sierra Madre, Rio Oteros	CS	21/10	*	*	1753-1972	*	*	*		
T. Naylor	Sierra Madre, Rio Verde	DF	26/13	*	*	1635-1973	*	*	*		
	statistical chronology					1653-1973	-	-	*		16/8
	Baja California										
ARPA	Sierra de la Laguna	PNNc	43/23	*	*	-	-	-	-	-	deleted, poor crossdating
ARPA	San Pedro Martir Low	JP	46/23	*	*	1440-1972	*	*	*	X	38/21
	statistical chronology					1449-1971	-	-	*	X	28/14
ARPA	Vallecito (SPM)	JP	34/17	*	*	1563-1972	*	*	*	X	32/17
	statistical chronology					1578-1972	-	-	*	X	24/12
ARPA	Tasajera	JP	32/16	*	*	1559-1972	X				
ARPA	Tasajera	WF	30/15	*	*	1664-1972	*	*	X	X	26/15
	statistical chronology					1664-1972	-	-	X	X	20/10
ARPA	Tasajera	LD	30/15	*	*	1473-1972	*	*	*	X	spotty temporal coverage
ARPA	Baja/N/Topo	JP	50/25	*	*	1616-1972	*	X			
ARPA	Baja/N/Pond	PNNq	58/29	*	*	1659-1960	*	*	*	X	being reprocessed

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
AMERICAN ARCTIC											
ARPA	Herring Alpine, AK	HM	24/12	*	*	1422-1972	*	*	*	*	26/13
Sheehy	Glacier Island, AK	HM	6/3	*	*	1445-1972	*	*	X		not enough replication yet
ARPA	Labrador 1-S	PCMA	15								
ARPA	Labrador 2-S	PCMA	15								
ARPA	Labrador 1-L	LALA	15								
ARPA	Labrador 2-L	LALA	3	scanned		ca 1756-1973					
ARPA	Labrador 3-L	LALA	7								
ARPA	Labrador 4-L	LALA	18	scanned		ca 1664-1973					
Wright	Nain A, Labrador Coast	PCGL	20/10								
Wright	Nain B, Labrador Coast	PCGL	20/20								
SWEDEN											
Harlan	Muddas Nat. Park	SCP	7/5	*	*	1647-1971	*	*	*		
Jonsson	Muddas Nat. Park (Additional)	SCP	42/21	*	*	1532-1973	*	*	*	*	30/15

TABLE I Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	CKD	DATA PROC	REVIEWED	CORES/ TREES SELECTED
Harlan	Muddas, Site A	SCP	13/11	*	*	1572-1971	*	*	*		
Harlan	Östersund	SCP	30/14	*	*	1670-1971	*	*	*		
Harlan	Grimnases	SCP	2/1	*	*	1848-1971	-	-	-	-	deleted, no replication
Harlan & Jonsson	Arosjak	SCP	8/7	*	*	1614-1971	*	*	*		

Task 1B reported by J. S. Dean. Progress on Collections from the Southwest Plateau Area.

The principal objective of the reported work is the construction of a geographical network of tree-ring chronology stations throughout the plateau area of the Southwest in order to assess tree-growth/climate relationships and to isolate spatial and temporal patterns of variation in past climatic conditions in the region. The network of modern tree-ring stations corresponds to an already existing grid of tree-ring chronologies based on samples from archaeological sites. Dendroclimatic analyses of the modern tree-ring series will be used to calibrate the archaeological sequences with local climatic conditions as a basis for more accurate reconstructions of past climatic variability in the Southwest. Those modern series that extend far enough back into the past will be merged with their archaeological counterparts to produce long-term chronologies suitable for detailed studies of past climatic conditions in the Southwest from A.D. 700 to the present.

One additional station, Hay Hollow Valley, Arizona, was collected during the past six months, bringing the total amount of material available for the study to 1642 cores from 816 trees representing 49 study sites in Arizona, New Mexico, Colorado, and Utah (Table II). Some of these sites include several chronologies, each representing a separate species, making a total of 66 chronologies.

Laboratory study of the collections is slightly behind schedule, because of programming problems in connection with the longer ring chronologies. As of December 31, 1974, specimen analysis has been completed for all 49 sites. Forty-six individual species chronologies from 36 sites have been constructed, and 4 additional dated species sets are in various stages of computer processing. Twelve of the living-tree chronologies that have been constructed are long enough to overlap with their archaeological counterparts to yield continuous chronologies that extend from the prehistoric past up to the 1970's. The areas for which we now have continuous chronological coverage are Tsegi Canyon, Hopi Mesas, and Flagstaff in Arizona; Natural Bridges in Utah; Mesa Verde in Colorado; and Gobernador, Cebolleta, Cibola, Jemez Mountains, Chama, Upper Rio Grande, and Santa Fe in New Mexico.

In summary, the original network of archaeological chronology stations has been duplicated as closely as possible with the modern tree-growth sites, each of which corresponds to one of the prehistoric chronology stations. Laboratory work and computer processing is directed toward the development of the network of standardized tree-ring chronologies that is beginning to be used as the basis for specifying the relationships of tree growth to climate, which in turn will provide the foundation for detailed reconstructions of climatic variability in the Southwest during the last 1500 years. These reconstructions will provide an expanded basis for modeling possible future trends in Southwestern climate.

Some of the Four Corners area chronologies have been incorporated into a dense grid of stations encompassing Arizona and parts of neighboring states. Analysis of this chronology network is now in progress and is discussed under Task 3B.

TABLE II

Progress of Task 1B. Collections on the Southwest Plateau Area

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	DATA PROC	CORES/ TREES SELECTED
ARPA[+]	Grasshopper, AZ	PP[+]	36/18	*	*	1641-1972	*	*	
ARPA	Salt River Draw, AZ	PP	21/10	*	*	1675-1972	*	*	
ARPA	Oak Creek, AZ	PNN	30/15	*	*	1694-1972	*	*	
NPS ARPA	Spider Rock, AZ	PNN	46/23	*	*	1601-1972	*	*	
NPS ARPA	Spider Rock, AZ	DF	32/16	*	*	1598-1972	*	*	
NPS ARPA	Canyon de Chelly, AZ	DF	20/7	*	*	1375-1972	*	*	
ARPA	Tseh Ya Kin Canyon, AZ	DF	24/12	*	*	1500-1972	*	*	
NPS ARPA	Tsegi Point, AZ	PNN	40/20	*	*	1411-1972	*		
NPS	Tsegi Point, AZ	DF	14/7	*	*	1532-1971	*		
ARPA, NPS, TRL	Betatakin Canyon, AZ	DF	77/24	*	*	1382-1972	*	*	
NPS ARPA	Kinbiko Rim, AZ	JUN	22/11	*		1672-1972			
NPS	Kinbiko Rim, AZ	PNN	18/9						

[+]See Key on p. 8 for explanation of abbreviations of species and sponsors.

TABLE II Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	DATA PROC	CORES/ TREES SELECTED
TRL	Kiet Siel Canyon, AZ	DF	48/12	*	*	1688-1963	-	-	none
NPS	Northern Black Mesa, AZ	DF	12/6	*	*	1551-1968	*		
NPS	Northern Black Mesa, AZ	PP	16/8	*	*	1569-1968	*		
NPS	Northern Black Mesa, AZ	PNN	8/4	*	*	1600-1968	*	*	8/4
TRL	Dinnebito, AZ	PNN	44/20	*	*	1470-1972	*	*	
ARPA	Shonto Plateau, AZ	PNN	30/15	*	*	1369-1972	*		
ARPA	Show Low, AZ	PP	30/15	*	*	1595-1972	*	*	
ARPA	Jack's Canyon, AZ	PNN	30/15	*	*	1533-1972	*		
ARPA	Robinson Mt., AZ	PP	30/15	*	*	1610-1972	*	*	
ARPA	Medicine Valley, AZ	PP	30/15	*	*	1679-1972	*	*	
ARPA	White Horse Hills, AZ	PP	30/15	*	*	1658-1972	*		
ARPA	SP Mountain, AZ	PNN	30/15	*	*	1688-1972	*	*	
ARPA	Slate Mt., AZ	PP	24/12	*	*	1647-1972	*	X	
ARPA	Cross Canyon, AZ	PP	31/15	*	*	1611-1972	*	*	
ARPA	Defiance Plateau, AZ	PNN	26/13	*	*	1620-1972	*	*	
ARPA	Hay Hollow Valley, AZ	PNN	30/15	X	X	1676-1974			

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	DATA PROC	CORES/ TREES SELECTED
ARPA	Navajo Mountain, Utah	PP	30/15	*	*	1566-1972	*	*	
ARPA	Navajo Mountain, Utah	PNN	26/13	*	*	1468-1972	*	*	
ARPA	Kane Spring, Utah	PNN	30/15	*	*	1444-1972	*	*	
ARPA	White Canyon, Utah	DF	42/21	*	*	1346-1972	*	*	
USFS	Milk Ranch Point, Utah	PNN	20/10	*	*	1275-1971	*		
USFS	Milk Ranch Point, Utah	JUN	10/5	*	*	1745-1971	*		
USFS	Devil's Canyon, Utah	PP	12/6	*	*	1572-1971	X		
MNA	Cedar Mesa, Utah	PNN JUN	96 sections	*	*	1491-1972	-	-	none
ARPA	Bobcat Canyon, CO	DF	24/12	*	*	1388-1972	*	*	
ARPA	Wetherill Mesa, CO	PNN	24/12	*	*	1611-1972	*	*	
ARPA	Wetherill Mesa, CO	JUN	16/8	*	*	1817-1972	-	-	none
ARPA	Pueblito Canyon, NM	DF	29/14	*	*	1651-1972	*	*	
ARPA	Pueblito Canyon, NM	PNN	25/12	*	*	1599-1971	*	*	
ARPA	Ditch Canyon, NM	DF	28/14	*	*	1657-1972	*	*	22/11
ARPA	Ditch Canyon, NM	PP	28/14	*	*	1554-1972	*	*	
ARPA	Ditch Canyon, NM	PNN	24/12	*	*	1574-1972	*	*	

TABLE II Continued

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	DATA PROC	CORES/ TREES SELECTED
ARPA	Ditch Canyon, NM	JUN	24/12	*	*	1692-1972			
TRL	Aztec, NM	DF	12/6	*	*	1542-1970	*	*	12/6
TRL	Aztec, NM	JUN	12/6	*	*	1417-1970	*	*	12/6
ARPA	El Morro, NM	PP	70/35	*	*	1535-1972	*	X	
ARPA	El Morro, NM	PNN	40/20	*	*	1638-1972	*	X	
ARPA	Canyon Lobo, NM	PNN	40/20	*	*	1691-1972	*	*	
NPS ARPA	Satan Pass, NM	DF	54/27	*	*	1381-1972	*	*	
NPS ARPA	Turkey Spring, NM	PP	52/26	*	*	1594-1972	*	X	
NPS ARPA	Turkey Spring, NM	PNN	40/20	*	*	1410-1972	*	X	
NPS ARPA	Fort Wingate, NM	PNN	52/26	*	*	1476-1972	*	X	
ARPA	Mt. Taylor, NM	PNN	40/20	*	*	1690-1972	*	*	
ARPA	Cebolleta, NM	PNN	42/21	*	*	1660-1972	*	X	
ARPA	Agua Fria, NM	PNN	40/20	*	*	1490-1972	X	X	
ARPA	Tajique Canyon, NM	PP	32/16	*	X	1694-1972	X	X	

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	CKD	CHRON LENGTH	MSD	DATA PROC	CORES/ TREES SELECTED
ARPA	Tajique Canyon, NM	PNN	24/12	*	X	1655-1972	X	X	
ARPA	Paliza, NM	PNN	28/14	*	X	1651-1972	X		
NPS ARPA	Echo Amphitheater, NM	DF	34/13	*	*	1362-1972	*	*	
ARPA	Glorieta Mesa, NM	PNN	30/15	*	X	1554-1972	X	X	
ARPA	Ruidosa Ridge, NM	DF	42/21	*	X	1689-1972	X	X	
ARPA	Ruidosa Ridge, NM	PNN	30/15	*	X	1602-1972	X	X	
ARPA	Rito de los Frijoles, NM	PP	36/18	*	X	1716-1972	X		
ARPA	El Valle, NM	PP	32/16	*	X	1709-1972	X		

Task 2 reported by K. S. Babcock. Europe, Asia, and the International Tree-Ring Data Bank.

The gathering of tree-ring data from outside the North American continent has been arranged and is soon to be implemented, basically by means of collaboration with European and Asian dendrochronologists. The collaboration will be facilitated by the new International Tree-Ring Data Bank, which will offer long-term security of global materials while building the worldwide data base which is essential to our present paleoclimatic research. Already, some of the important European chronologies have been offered, and it is hoped that strong financial support at the present time will facilitate rapid collection of these key data. The present status of the work follows:

1) The organization is established for the development of the Data Bank System. Included are magnetic tape and microfilm backup facilities, and a Data Bank Newsletter for general communications to contributors and users of the system. Initially only climate-related samples will be accepted, but the system will have the flexibility to incorporate other branches of dendrochronology in the future.
2) The systems definition and programming needs for the Data Bank have been analyzed, and a cost estimate has been obtained on the basis of the storage of site information, ring-width measurements, and indices, plus the development of a multivariable retrieval system. Also included in the cost estimate is a storage and retrieval system for the climatic reconstructions which will be developed from tree-ring data. Funding for the development of

the International Tree-Ring Data Bank over a 2-year period has been requested in our recent proposal to the National Science Foundation (for the continuation of this project).

3) An official Site Information Sheet, required with all entries into the Data Bank, has been established by the International Tree-Ring Data Bank Committee, a group of 5 contributors.

4) Minimum requirements have been established for data to be entered into the Data Bank. In addition to the requirement of a completed Site Information Sheet, tree-ring samples

   a) must be replicated and absolutely dated,

   b) must have a minimum length of 100 years, but 200- to 300-year length is desirable,

   c) must represent a minimum of 10 trees, per species and site, hopefully with two measured radii per tree. For temperate sites 20 or more trees are most desirable.

The European and Asian collaborative work will primarily involve contacts with specific workers in their respective geographical areas, encouragement of their work, assistance in the processing of their data, and application of their data to the worldwide paleoclimatic analysis. A group of potential European collaborators includes Drs. Gustaf Sirén and Bengt Jonsson, Royal College of Forestry, Stockholm, Sweden; Drs. Jon Pilcher and Michael Baillie, Paleoecology Laboratory, Belfast, Northern Ireland; Dr. Malcolm Hughes, Liverpool Polytechnic, Liverpool, England; Drs. A. Munaut and A. Berger, Université de Louvain, Louvain, Belgium; Drs. D. Eckstein, Universität Hamburg, Hamburg, and Bernd Becker, Botanisches Institut, Stuttgart, West Germany; Drs. Karol Ermich and Zdzisław Bednarz, Akademia Rolnicza, Krakow, Poland; Drs. Teodoras Bitvinskas, Lietuvos TSR MA Botanikos instituto, Kaunas, and N. Lovelius, Komarov Botanical Institute, Leningrad, U.S.S.R.; Drs. Françoise Serre and A. Pons, Centre de St. Jerôme, Marseilles, France; and Dr. Yoav Waisel, Tel-Aviv University, Israel. A number of other workers have expressed interest in collaboration, and some of these show promise of increased activity (see Final Report AFOSR 74-2624). Many of the European collaborators will submit dated chronologies, others will wish our assistance with preparation, dating, and processing of their materials, and many will expect help in final multivariate analysis.

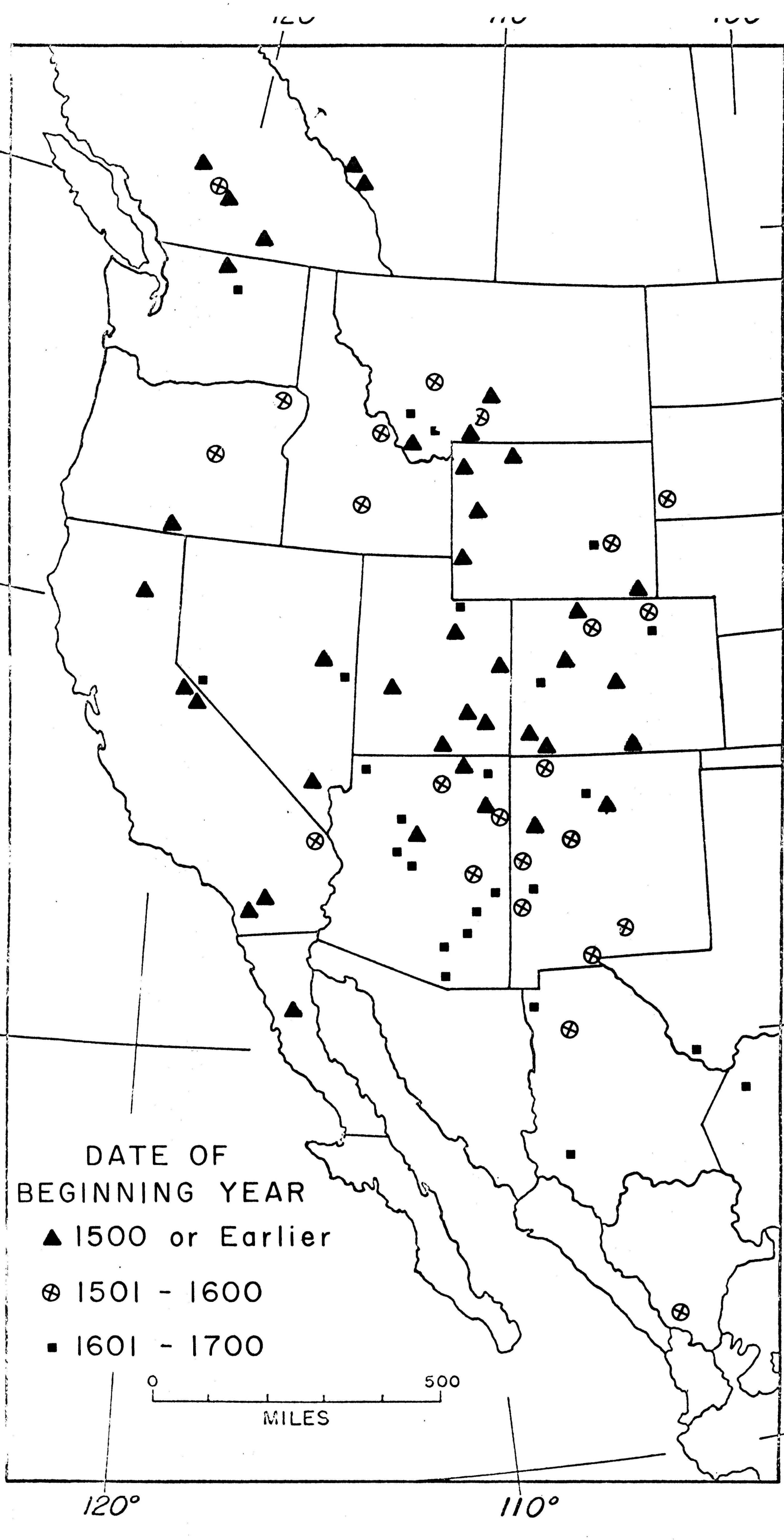
Task 3A reported by Donald Stevens. Development of Interactive Computer Programs to Assist Calibration Efforts.

In order to facilitate specialized data selection for new types of dendroclimatic analysis, a set of interactive computer programs for that purpose has been developed for use on the University DEC-10 computer system. Acquisition of a remote computer terminal from ARPA for this project has enabled us to catalogue all basic site characteristics such as species, length of record, altitude, geographical location, etc., for easy and efficient file searches through the terminal. The selected data can be printed at the terminal or on the line printer at the University Computer Center. The site information files on the system may be set up in any desired arrangement, and may be revised and/or extended at will. All related programs have been written and documented to enable their use by persons with little or no knowledge of computers.

Work also is in progress to develop interactive programs to facilitate short, initial analyses of selected data using the terminal and the DEC-10. These programs will allow a simple and inexpensive "quick look" capability to the researcher.

Task 3B reported by David Shatz. Development of New Tree-Ring Data Sets for Use in Calibration Efforts.

The climatic reconstructions obtained at the Laboratory of Tree-Ring Research are ultimately based upon the existence of tree-ring chronology networks from which we are able to reconstruct meteorological variables for periods of several hundred years. Virtually all of the reconstructions attempted in recent years were generated from a 1967 49-station western American tree-ring grid, consisting of sites each datable to at least 1700. However, in the past several years with the support of ARPA, an enormous increase has occurred in the sampling of climatically-sensitive trees, and it has been possible to replace the original grid with a new network of greater areal extent and superior statistical properties (Fig. 1). Almost 600 tree-site chronologies were analyzed before this new tree-ring network was established. In addition to having a larger spatial grid of 89 climatically-sensitive chronologies from A.D. 1700 on, subsets of this grid are available; 65 chronologies extend to A.D. 1600 and 40 extend to A.D. 1500. A grid for the state of Arizona and neighboring areas includes 60 tree sites. Climatic reconstruction eventually will be attempted based on all four of the aforementioned grids, with the new temporal and spatial dimensions proving to be of critical importance. In constructing western American networks datable to 1700, 1600, and 1500, and in developing a peripheral Arizona grid, certain criteria for network inclusion were established, based on various statistical and nonstatistical parameters. While these general criteria could not always be


120
110
100
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40°
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30°
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110°
DATE OF
BEGINNING YEAR
1500 or Earlier
1501 - 1600
1601 - 1700
0
500
MILES

Figure 1

satisfied, as in regions lacking adequate sampling, the vast majority of sites included in the aforementioned four grids possess superior statistical properties, indicative of sensitivity to yearly climatic fluctuations. Typically, selected chronologies are composed of at least ten trees, with two cores per tree, and have excellent primary statistics--that is to say, a low serial correlation, a high standard deviation, and a high mean sensitivity. For those sites which were subjected to variance analysis, known as statistical chronologies, the common year-to-year variation of the individual chronology indices usually exceeds 55% and frequently approaches 77%, reflective of a relatively uniform or internally consistent chronology response to climate. A final criterion for chronology acceptability involves a cross-correlation measure between proximate sites under consideration. Correlation coefficients are obtained for given sites both before and after the annual time-series of chronology indices are decomposed or split into specified frequency bands. A high-pass filter preserves high frequency variations (<8-year wavelength) but blocks low frequencies (>8-year wavelength). The low-pass filter does the reverse. If there has been nonclimatic disturbance or a nonclimatic factor has been operating in several sites, the correlations among the low-pass data are markedly lower. Using the values of correlations between chronologies that are both filtered and unfiltered, we can determine which chronologies are integrating the climate in a similar manner and which are responding differently at various frequencies. We can then eliminate stations in a given region that contain extraneous or redundant climatic information, while including those that are not so highly correlative but which contain a clear signal of climate. (One must be cognizant of the fact that almost all of the chronologies subject to the above analysis possess good to excellent primary statistics, as previously defined.) When correlate and filter data are coupled with the other statistical variables, selections of high quality chronologies can be made.

A program has also been developed to determine means and standard deviations for relatively long-term winter precipitation data derived from a network established by Raymond S. Bradley at the University of Massachusetts. All of the meteorological stations included possess continuous precipitation records, extending at least as far back in time as 1909, and are located in the 5-state region of Wyoming, Montana, Idaho, Colorado, Utah. These data will be used in conjunction with tree-ring data for calibration purposes and for the verification of independent climatic data.

Task 3C and 4A reported by T. J. Blasing. Progress on Model Development and Climatic Reconstruction Accomplished in Part Under NSF Grant GA-26581.

Models have now been developed to reconstruct spring and autumn climate (sea-level pressure pattern) in the North Pacific and western North America. These models were tested with two questions in mind:

1) What groups of months comprise the best definitions of spring and fall, in terms of the climatic variance accounted for in the models? Might it be best to have, say, 6 seasons including early and late spring, early and late fall, as well as summer and winter?
2) How can we minimize the degrees of freedom used to calibrate the model while at the same time accounting for a satisfactory percentage of the climatic variance?

Results of our analyses indicate that early spring should be defined as March-April, late spring as May-June, and autumn as September-October-November. The winter, December-February, and summer, July-August, have already been defined. When simple and complex calibration models were compared the amount of statistically significant variance was the same or higher on the simpler models. Therefore, we are proceeding with the simpler models. The percentages of total variance reduced by these models are: Summer, 26.3%; autumn, 23.8%, winter, 18.7%; early spring, 18.7%; and late spring, 19.7%. For the present, we have calibrated only the original 49 ring-width chronologies in western North America against the climatic data. The same calibration will be made again, but using a new network of ring-width chronologies, and the results will be compared with the present calibrations in order to assess the change in climatic variance reduced due to improvements in the ring-width chronologies used. The first set of climatic reconstructions for all seasons from A.D. 1700 to present are complete and available on computer tape.

Task 4B reported by G. R. Lofgren. Reconstruction of Past Climates.

Our extensive collection of average monthly surface pressure, temperature, and precipitation records are being utilized to determine seasonally recurring types of climate over the continental United States since 1900, which can be used for interpreting our reconstructions of pressure. This analysis is being done for three seasons: Early spring (March-April), late spring (May-June), and autumn (September-October-November). Analyses of winter and summer were completed earlier by T. J. Blasing. As in the analysis for winter and summer, types of recurring anomaly pressure patterns have been determined for each season using surface pressure data for the first 70 years of this century. For the five years whose mean seasonal pressure pattern correlates most highly with a particular type, records of precipitation and temperature from 82 United States weather stations are averaged to obtain mean anomaly maps of the climatic variables associated with each type. Following this, a study of the climatic types for each season will be made by examining the published anomaly maps for the months in the particular years.

Another technique which we hope will assist with the interpretation of our reconstructions of pressure is an adaptation of a two-way analysis of variance. It is being applied to the anomalous pressure field reconstructions for North America, the northern Pacific, and eastern Asia for the period of 1700 to 1960. Significant variance in the rows or columns is used to identify patterns associated with the location of the Aleutian Low, latitudinal displacement of the westerlies (zonal flow), and anomalies in precipitation and temperature over western North America.

In connection with the reconstruction of climatic variables, it was noted that summer temperatures and precipitation were relatively difficult to predict from tree growth. We therefore are attempting to develop a model to calculate an average of climatic factors which resembles the ring-width variations better than do simple averages of temperature and precipitation. This is accomplished by taking the temperature and precipitation values for each month in the year, weighting them, and averaging them much as the tree averages the effects of climate. Thus, we calculate the expected tree growth for a hypothetical tree responding to the climate at each weather station used. Then we must find a way to compare this synthetic tree growth with actual tree growth to see how well we have done.

We plan to use the maps of eigenvectors of tree growth to interpolate the appropriate eigenvector weight for each weather station, and then to calculate the estimated eigenvector amplitudes using the assigned eigenvector weights and synthetic growth calculations from the data for climate. The resulting amplitudes can then be compared directly with the amplitudes of actual tree growth.

Task 4C reported by Larry Winter. Progress on Typing Reconstructions Accomplished in Part Under NSF Grant GA-26581.

A typing system devised by T. J. Blasing has provided a model for a first approximation, based on tree-ring records, of spatial patterns of winter climatic occurrences from 1700-1899. Blasing has identified four major winter pressure types for western North America and the Pacific Ocean by developing a correlation matrix from pressure data at 96 grid points extending from 1899 to 1966. For the development of the correlation matrix a subset of 67 years (1900-1966) was chosen to form an independent data matrix with 67 rows (years) and 96 columns (pressure grid points). Thus, the correlation matrix is a 67 by 67 matrix whose entries are the correlations between pressure patterns of all possible pairs of years.

The typing system chooses as a paradigm for Type 1 that year which is most highly correlated with all other years. It then chooses the 5 other years most highly correlated with the paradigm to form through averaging a typical pressure pattern for Type 1. These 6 years and all others correlating with the type at a given level are then removed from the selection set, and the year most highly correlated with all other remaining years is chosen as the paradigm for Type 2. The selection process continues until, in the case of winter, four types of pressure occurrence have been determined. The average tree-ring pattern for each type is developed from a grid of forty-nine tree-ring sites distributed throughout western North America. The typical temperature and precipitation patterns are developed similarly.

To reconstruct the occurrence of pressure types from 1700 to 1899, the tree-ring pattern of each year is correlated with the typical tree-ring pattern of each of the four types, and a year is defined as, e.g., Type 1, if its ring pattern is most highly correlated with that of Type 1. This procedure has been very satisfactory in the reconstruction of pressure patterns, and an attempt has been made to extend this typing scheme to the reconstruction of temperature and precipitation occurrence patterns for the same period.

In this case eighteen weather stations in western North America were used to reconstruct from tree-ring precipitation and temperature values for each year from 1700 to 1899. These values were then grouped by pressure type, averaged, and tested for significance to provide temperature and precipitation patterns for each type. The results of this attempt were neither as clear cut nor as encouraging as pressure typing had proven to be. With the exception of temperature in winter, the individual temperature and precipitation patterns reconstructed for each type did not agree well with the individual patterns predicted by Blasing, and only a few stations exhibited departures of temperature associated with the types that were significantly different from zero. Two avenues for improving temperature and precipitation typing are available. The quality and statistical reliability of the data used in typing can be improved, and David Shatz and Bob Lofgren, both of the ARPA staff, have recently provided refined data. Shatz has developed new tree-ring grids extending as far back as 1500, and Lofgren is preparing a grid of climatic stations for North America which will substantially increase the sample size available for the reconstruction of temperature and precipitation.

It may, additionally, prove fruitful to develop separate types each for pressure, temperature, and precipitation, rather than to classify the latter two under types derived solely from pressure. It is not, for instance, impossible that years of a single pressure type might include two related, but distinct, temperature regimens. Using much the same methods as outlined above, temperature, percipitation, and pressure types could be developed and related one to the other through contingency tables.

Other developments reported by Marna Ares. Computer Terminal Usage.

In order to increase efficiency in writing and editing multipage manuscripts, the ARPA research team has adapted text editing and formating programs which are available on the University of Arizona's DECsystem-10 computer. These programs allow for justifying of right and/or left margins, automatic hyphenation, text insertions and deletions of any size, changes of spelling, and the automatic building of tables of contents and indices. These attributes of the editing system make possible a great reduction of the amount of time consumed during revisions, since only insertions and deletions need be made, as opposed to complete retypings of the manuscript.

In training one person to use the programs, we have found that the time used to enter text is roughly comparable to the time one would spend using a typewriter, but that the time spent editing is greatly reduced by using the computer programs. Documentation is being prepared that will introduce new users to the terminal and the programs used for preparation of documents. A text editing program (SOS) is used to enter and revise text, while another program (CLYDE) is used to format the text entered into SOS. Familiarity with the programs aids greatly in decreasing the time and money spent to do a particular project.

The Texas Instruments computer terminal, acquired in August through ARPA, not only allows staff use of the editing software, but will facilitate work with the International Tree-Ring Data Bank, various types of data retrieval, and program development.

REFERENCES CITED

Gates, W. L. and Yale Mintz. 1974. Understanding Climatic Change: A Plan for Action. Panel on Climatic Variation of the U. S. Committee for GARP National Research Council.

ANNOTATED BIBLIOGRAPHY

Publications and Manuscripts Resulting from or Highly Related to AFOSR Grant 72-2406

1. Fritts, Harold C. 1974. Relationships of Ring Widths in Arid-Site Conifers to Variations in Monthly Temperature and Precipitation. Ecological Monographs 44:411-440.

ABSTRACT

Two multivariate techniques are described which allow one to evaluate ring-width growth and climatic relationships. One technique produces response functions which express in mathematical form the relative effect of monthly temperature and monthly precipitation during a 14-month period on ring-width variations at a given site. Response functions are calculated for 127 coniferous tree sites in western North America. The other technique is a cluster analysis which is used to identify similarities among the response functions and to separate them on the basis of their differences. The climatic factors, precipitation and temperature, for different months vary in their relative importance to ring width. Precipitation is most important and is commonly directly related to growth while temperature is less important and often inversely related to growth. Precipitation is sometimes inversely related to growth and temperature directly related to growth for sites at high altitudes, high latitudes, or on north-facing slopes. Site differences appear to be more responsible for variations in the response functions than species differences, although certain species such as the bristlecone pine have a more or less unique growth response. Suggestions are made as to the physiological and environmental relationships causing the differences. Response functions allow assessment of the effects of certain climatic factors on ring width. The significance of these data and techniques to dendroclimatic analysis and to modeling productivity of forest ecosystems is discussed.

2. Fritts, H. C. and T. J. Blasing. 1974. Tree-Ring Analysis and Its Potential Contribution to the Mapping of Past Climates. Proceedings of the International (CLIMAP) Conference held at Norwich, 17-22 May 1973. Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, England. Climatic Research Unit Research Publication No. 2.

ABSTRACT

The short length of many climatic records presents a major limitation to the study of climatic change. However, tree-ring widths can be a useful source of climatic information for times before written climatic records were begun. Recent developments have led to the identification of five common types of summer climate in the North Pacific sector and western North America. Occurrences of each type since 1700 A.D. are estimated from ring-width data.

3. Blasing, T. J. and H. C. Fritts. 1975. Past Climate of Alaska and Northwestern Canada as Reconstructed from Tree Rings. Proc. 24th Alaskan Science Conf. "Climate of the Arctic." Fairbanks, Alaska, August, 1973.

ABSTRACT

Spatial anomaly patterns of sea-level pressures over North America, the North Pacific, and eastern Asia in the twentieth century can be statistically calibrated with spatial anomaly patterns of tree growth in semiarid western North America. Growth anomalies prior to 1900 were substituted into the calibration equations to reconstruct past circulation features for the eighteenth and nineteenth centuries. The success of the reconstructions for the Arctic was tested against climatic data where possible and against the variations in growth of Arctic trees which respond to variations in climate. Ten different types of tree-growth anomaly patterns were identified in the Arctic between 1800 and 1939. Climatic conditions inferred from the growth anomalies of Arctic trees were compared to circulation anomalies over the Arctic as reconstructed from the arid-site trees to the south. Both of these sources of information were used to infer climatic conditions for the period 1800-1939. Tentative inferences are presented as to climatic conditions for each of five regions in Alaska and northwestern Canada in hope that they may be tested against other lines of evidence.

4. Blasing, T. J. 1975. Methods for Analyzing Climatic Variations in the North Pacific Sector and Western North America for the Last Few Centuries. Ph. D. Dissertation, University of Wisconsin. Submitted. (Major Professor, John Kutzbach)

ABSTRACT

The investigation of summer and winter climatic variations in the North Pacific sector and western North America during the last few centuries is the subject of this study. Analysis of monthly mean (sea-level) pressure data in the area of study led to the selection of July and August as the summer months and December, January, and February as winter.

Some multivariate statistical techniques for describing climatic variability are discussed and compared. On the basis of the comparison, a non-orthogonal spatial correlation method is chosen to identify and describe the major types of general circulation, as reflected in anomaly patterns of sea-level pressure, during the twentieth century. Five such anomaly type-patterns are identified for summer and four for winter. These are each associated with an assemblage of generalized weather patterns and a corresponding pattern of temperature and precipitation anomaly in the United States, as well as with a spatial anomaly pattern of tree-ring widths from 49 sites over western North America. The occurrence of one of these ring-width patterns for some year in the past is suggestive of the corresponding occurrence of the associated climatic anomaly type.

Orthogonal eigenvector techniques are then selected for use in the development of a statistical model to estimate departure patterns of sea-level pressure using the ring-width departures as predictor data. The model is first calibrated using available pressure data since 1899. The

model is then applied to estimate winter pressure departure patterns since 1700 A. D. As a means of summarizing these climatic reconstructions, the estimated pressure departure pattern for each winter is compared with each of the type-patterns using correlation coefficients as a measure of comparison. The time series of correlation coefficients between a type-pattern and each winter's estimated departure pattern provides an indicator of the occurrence, or non-occurrence, of the corresponding anomaly type through time. Graphs of the time series of correlation coefficients corresponding to each of the four type-patterns are presented as an indicator of reconstructed winter climatic variations for approximately the last two and one-half centuries.

If an estimated pressure departure pattern is highly correlated with one of the type patterns, the simultaneous occurrence of the temperature and precipitation anomalies associated with twentieth century occurrences of that pressure type-pattern is implicitly specified. These implicit estimates of temperature and precipitation anomaly are then independently verified using available data for the United States from the last half of the nineteenth century. The climatic reconstructions are in good agreement with the recorded data and are found to complement and augment the findings of other investigators.

5. Blasing, T. J. 1974. Linear Statistical Transfer Operations. Presented at the CLIMAP-ARPA-sponsored workshop on transfer functions, Madison, Wisconsin, April, 1974.

ABSTRACT

Advantages and limitations of three multivariate techniques (straightforward multiple regression, regression of orthogonalized variables, and canonical regression) are discussed for various types of applications. All techniques reduce to the same thing (multiple regression) if all variance is preserved. However, variance may be eliminated by eliminating variables in multiple regression or by eliminating transformed variables in the other two approaches. It is in the elimination of unwanted variance (noise) that the three techniques differ. These differences are discussed conceptually so as to aid an investigator in technique selection.

6. Blasing, T. J. and H. C. Fritts. In preparation. Reconstructing Past Climate Anomalies in the North Pacific and Western North America from Tree Rings.

ABSTRACT

Winter climatic conditions in the North Pacific sector and western North America are reconstructed back to 1700 A.D. from tree-ring data in western North America via a simple statistical model. The results are verified using climatic data from the last half of the nineteenth century, which is prior to the calibration period of the model. The results are then incorporated into a discussion of the climate of the last half of the nineteenth century. Some aspects of the climatic reconstructions back to 1700 A.D. are also discussed.

7. Fritts, Harold C. and T. J. Blasing. Submitted. Contributions of Dendroclimatology to the Problem of Changing Climate. Food Supply in Changing Climate. Sterling Forest (New York) Workshop, December 2-5, 1974.

ABSTRACT

Variations in the width of tree rings from many temperate climate species can be used to reconstruct past climate. This is possible because growth-controlling processes in the trees are often limited by climatic factors. Some of the unique principles and practices of tree-ring analysis are described and illustrations are given of applications to a variety of problems of environment and climate. Special mention is made of new multivariate techniques which allow detailed reconstruction and mapping of large-scale variations in past climate from the variations in tree rings of western North America. The current status of reconstructions is summarized and their possible significance to planning for the future is discussed.