IMPACT: THE EFFECT OF CLIMATIC CHANGE ON PREHISTORIC AND MODERN CULTURES IN TEXAS (FIRST PROGRESS REPORT)

Edited by

Joel Gunn and Royce Mahula

Center for Archaeological Research
The University of Texas at San Antonio
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PREFACE

The pages of this report contain an assortment of materials which reflect the status of climatic change studies at The University of Texas at San Antonio. The effort is interdisciplinary, drawing on the talents of persons trained in geography, prehistory, anthropology, and mathematics and other fields. The goals of the project include (1) efforts to understand how prehistoric and modern economies respond to significant climatic changes and (2) the application of such understanding to our own time and nation.

Long-term climatic change as an important factor in the everyday life of 20th century people is a relatively recent issue. With notable exceptions, attitudes toward climate during the last century have been fostered by increasingly warmer and more comfortable winters, longer growing seasons and consequently higher agricultural productivity. Only in the last decade have the energy crisis and increasingly severe winters combined to create a general public awareness of the instability of global climate. Public awareness has risen to the point that there is a best-selling book on the topic, entitled *Climates of Hunger* by Bryson and Thomas. One can hardly open a newspaper today without seeing an article on the impact of climates.

By contrast, prehistorians are often brought face-to-face with evidence of cataclysmic climatic shifts. The climatic concerns expressed in the following pages originated out of prehistoric archaeology where climatic change is often a direct mechanism affecting cultural change. For instance, an article Wenland and Bryson published in the journal *Quaternary Research* demonstrates that most of the prehistoric cultures identified by archaeologists started and ended during recognized periods of radical climatic change.

Although our research interests started with prehistory, we very soon widened the scope to include problems of modern climatic change. The reason was that ideas which explain prehistoric relationships between climate and culture are, at least in part, most easily tested by examining weather data carefully collected by the weather services of various nations over the last few years. The realization that the past could be studied through the present, and vice-versa, eventually led to expanded research into historic and modern records for climatic patterns. Also, our sense of the usefulness of these efforts has grown. In the context of a growing demand for practical applications from all fields of research, we feel that our research will lead to a better understanding of the climatic forces affecting our own times, and to direct assistance to those responsible for planning our future national needs.

As the table of contents indicates, the first section of the report is devoted to brief summaries of talks presented during a planning symposium at The University of Texas at San Antonio on March 4, 1978. The six presentations summarize the status of various fields of research and projected funding needs for the next two years. The summaries were prepared by Royce Mahula of the Center for Archaeological Research staff. Subsequent pages contain (1) an abstract of a paper the research group is planning to prepare for the International Conference on Climate and History to be held in England during 1979, (2) the proposal

letter for a project now underway to monitor the effect of climatic change on vegetation via satellite, and (3) a recent newspaper article relative to our research group's activities. This last item is included as a demonstration of our intention to inform the public of our activities and to assure the taxpayer that the knowledge gained from our efforts is put to practical use. Another item published here is a summary of a proposal recently funded by the Ewing Halsell Foundation of San Antonio for the study of climatic change in southern Texas. Finally, we have listed the major participants in the evolving climatic research effort.

I. THE IMPACT SYMPOSIUM

Program

IMPACT: THE INFLUENCE OF CLIMATIC CHANGE
ON MODERN AND PREHISTORIC ECONOMIES
IN THE SAN ANTONIO AREA

A PLANNING SYMPOSIUM

THE UNIVERSITY OF TEXAS AT SAN ANTONIO
THE CENTER FOR ARCHAEOLOGICAL RESEARCH

TIME: 9:00-12:00 a.m.
DATE: March 4, 1978 Saturday
PLACE: Humanities and Business Building, Room 2.0.104

Order of presentations:

Joel Gunn: "Overview: The Impact Project and Climatic Change in South and Central Texas"

Thomas R. Hester: "Climate and Prehistoric Culture Change: Potential Archaeological Benefits"

Ralph Robinson: "Prehistoric Climatic Indicators"

Max Witkind: "Historic Records of Climatic Change in the San Antonio Area"

Richard Jones: "The Impact of Climatic Change on Modern Agriculture"

William Hupp: "Satellite Remote Sensing of Vegetation: Some Possible Tests of the Effect of Climatic Change on Modern Vegetation"

The progress of the presentations will be moderated by the Chairperson. Speakers will be spaced less than thirty minutes apart with intervening periods of discussion. The panel and invited guests are encouraged to contribute to the proceedings. The intention of the symposium is as much to generate ideas as it is to present them.

OVERVIEW: THE IMPACT PROJECT AND CLIMATIC CHANGE IN SOUTH AND CENTRAL TEXAS

Joel Gunn

Interest in the study of climatic change patterns in central and south Texas began with the discovery of accounts by early explorers and settlers of Texas of climatic conditions much different from those observed today. Enrique de la Peña, for example, in his 1836 march with Santa Anna from Mexico to the Alamo, related instances of knee-deep snow, heavy rains, hail and cold winds in areas where such occurrences would be unheard of today. Since climatic change is important in promoting cultural change, it is natural to question how past climate differed and how this different environment might have influenced cultural responses. Initial investigations have taken global temperature changes as causal factors in local climatic change. Although analysis of global temperatures does not yield a precise analysis of the local situation, global temperatures do affect the weather systems that generate local climate. For example, the position of the jet stream is responsive to changes in global temperature and this positioning is a central factor in determining increases and decreases in local precipitation. Investigations into the changing patterns of global and local climate are underway. U.S. Weather Bureau tapes have been acquired with data on 37 variables dating from 1948 in San Antonio and the south Texas area. With this data "types" of years may be examined with hopes of projecting trends back into unrecorded time and forward into the future so that the impact of climate on past and future cultures may be assessed.

Discussion: The nature of the correlations between temperature and precipitation was discussed, as well as the importance of supportive historic research for documenting the regularity of severe weather occurrences in earlier times.

CLIMATE AND PREHISTORIC CULTURE CHANGE: POTENTIAL ARCHAEOLOGICAL BENEFITS

Thomas R. Hester

Archaeologists have become increasingly interested in understanding culture change. Of the many variables involved in causing a culture to change, one of the most important must be the climatic variation that generates long or short term adaptive responses. To date, archaeologists have used a set of standard approaches to investigate paleoclimatic change, principally through the interdisciplinary cooperation of other specialists in the chemical and biological sciences, as well as through analysis of archaeological materials. Archaeologists using these techniques have succeeded in establishing fairly complete environmental sequences in certain areas and have estimated the effect of climatic change on societies. There are, however, other areas where these techniques are hard to apply due to problems in preservation. This is especially true in central Texas and the south Texas coastal plain where the standard approaches have failed to produce any substantial evidence on paleoclimatic conditions. Fortunately, some new projects initiated by the Center for Archaeological Research have accelerated work in studying the past environments

of south and central Texas. Joel Gunn has made substantial progress with his approach which places great emphasis upon new techniques such as computer simulations based upon modern and historic meteorological data. There is also the very exciting phytolith research being done by Ralph Robinson. Utilizing these methodologies we should be able to examine the changes in plant populations and be better equipped to trace the patterns of resources available to the prehistoric people of the region. We are very optimistic about the utility of these new approaches for studying the manner in which not only prehistoric but also modern economies adapt to climatic change.

PREHISTORIC CLIMATIC INDICATORS

Ralph Robinson

Phytoliths, tiny silica particles formed in and around the cells of plants, are one of the most promising botanical indicators of past climate. Biological evidence has two sources, fossilized plants and animals. To be useful, this evidence must meet three requirements: it must be able to withstand decomposition, lend itself to classification, and be preserved in sufficient quantity in a wide variety of environmental conditions. Unfortunately, both sources have significant problems in meeting these criteria. Animal evidence must be used with caution. Larger species, though often better preserved, are less sensitive to climatic change. The smaller, more sensitive ones are often destroyed. Plant evidence includes items visible to the eye, such as seeds and wood and the microscopic materials: pollen, diatoms and phytoliths. All large plant specimens, as well as diatoms and pollen, are seldom preserved and are often rarest where evidence is needed most. Phytoliths, however, like bits of stone, are more resistant to the chemical and biological processes. Phytoliths have been found in all levels in archaeological sites across Texas and in the East, thus serving as evidence of the presence of certain plant species and types of environments. At the present time, analysis is slow due to the absence of a well-developed computer capability for quickly and automatically measuring and classifying these remnants of earlier vegetation. The techniques and equipment have been developed and tested and are awaiting funding, and preliminary findings foretell the exciting prospects for phytoliths in climatic research.

Discussion: The usefulness of archaeologically-recovered mollusks as climatic indicators, as well as possible species which might be most highly sensitive to change in certain areas were discussed.

THE IMPACT OF CLIMATIC CHANGE ON MODERN AGRICULTURE

Richard Jones

The importance of understanding the impact of weather changes on modern economics, specifically agricultural (grain) production, is evident. Because grain is such an important item in world trade and because the U.S. and Canada are the "world's granaries," severe weather changes could have disastrous effects not only by causing major food shortages, but also by threatening the world economy. A number of studies treating the impact of climatic changes on grain

yields and production in North America have presented sobering results. For example, should average annual temperatures level out over the next 25 years to 1°C less than present, wheat production in the northernmost one-third of the Canadian wheat belt would be precluded. This, when combined with Siberian wheat losses, would generate losses of 15% of the present world production of wheat and could reduce the gross income of U.S. spring wheat farmers by $131,000,000. We at UTSA are currently involved in a project to study the effect of climate on modern agriculture at the local level. Should the apparent cooling trend continue, Texas could be subject to an infusion of people and industry from less clement areas. It becomes, therefore, vital to understand the impact of weather changes on the Texas economy and in particular on Texas agricultural yields. To this end, we are presently investigating the effects of climatic fluctuations on sorghum production in Texas over the last 50 years. Sorghum was chosen because of its importance to Texas agriculture, its sensitivity to climatic variations and the interesting yield fluctuations which appear in the agricultural records over the last 50 years. Crop yields, weather data from the U.S. Weather Service, and other economic and geographical data will be analyzed in order to both study past trends and to enable predictions of future yields.

HISTORIC RECORDS OF CLIMATIC CHANGE IN THE SAN ANTONIO AREA

Max Witkind

In the absence of systematic, detailed recorded weather observations, one of the only avenues left open for researching early historic climatic conditions is the careful scrutiny of historic accounts located in libraries and archives. Here in the journals and letters of early explorers, settlers and gentlemen farmers, many useful observances of early weather are chronicled. In addition, pre-Civil War newspapers located in the San Antonio Library, the Institute of Texan Cultures and the San Antonio College Library preserve information on the nature of early Texas weather. These records, located in San Antonio and Austin, are presently being carefully researched and all references to early climate are being noted and catalogued.

When the historic research is complete it should reveal the general character and patterning of weather through the early historic period in this area.

Discussion: Comments included suggestions of additional sources for historic research of climate, as well as discussion of possible patterning of massive floods in this area. The feasibility of tree-ring analysis of native hardwoods in south Texas was also discussed. T. R. Hester noted the tree-ring research and climatic studies conducted by Jacob Kuechler at Fredericksburg in the 1850's. (See T. N. Campbell, 1949, "The Pioneer Tree-Ring Work of Jacob Kuechler," *Tree-Ring Bulletin* 15(3):16-20. Laboratory of Tree-Ring Research, University of Arizona.)

SATELLITE REMOTE SENSING OF VEGETATION: SOME POSSIBLE TESTS OF THE EFFECT OF CLIMATIC CHANGE ON MODERN VEGETATION

Sam McCullouch and Bill Hupp

Remote sensing, literally the recording of data from a sensor at some distance from the object, includes in addition to conventional photography, the technique of thermal infra-red imagery from satellites. Recently, its use by archaeologists has greatly expanded due to its potential to detect features which are not visible by conventional photography. The NASA Landsat remote sensing program utilizes a satellite-based sensor which measures reflected light in the red and green parts of the visible light spectrum and in two invisible bands. It is capable of detecting types and densities of vegetation, urban areas, water, etc. The Texas Natural Resources Information Service (TNRIS) is a state-funded data bank which utilizes the Landsat capability. TNRIS will consider a joint project with UTSA using this infra-red system to test the effect of climatic change on vegetation in climatically sensitive south Texas. Yearly and seasonal readings of a study area could be analyzed by a program employed by TNRIS' computer analysis section to discover changes in densities and distributions of vegetation types. The results of this study should provide further insight into the impact of climatic change on the prehistoric and modern economies of south and central Texas.

Discussion: Comments centered on the ability of the program to chart minute changes in vegetational patterns.

II. IMPACT OF CLIMATIC CHANGE ON PREHISTORIC AND MODERN CULTURES ON THE PRAIRIE-FOREST ECOTONE OF SOUTH-CENTRAL UNITED STATES*

Joel Gunn, Richard Jones, Thomas R. Hester,
Ralph Robinson and Royce Mahula

ABSTRACT

Both historical records and recent severe winters suggest that the ecotone between the Austroriparian forests of southeastern United States and the Sonoran deserts of west Texas and northern Mexico are subject to drastic changes in precipitation caused by global climatic changes. An interdisciplinary team of researchers at The University of Texas at San Antonio is attempting to model the effect of changes in global temperatures on the local climate and assess the impact of these changes on prehistoric populations and on the modern economy of the area. The global-local climatic model is discussed. Its application in the context of a simulation to occupation frequencies for archaeological cultural resource management problems is demonstrated, and the implications for modern economies are also discussed. Supporting research includes historic climatic studies, analysis of U.S. Government Weather Service data tapes and plant phytoliths as prehistoric climatic indicators.

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* Submitted as a proposed paper for the INTERNATIONAL CONFERENCE ON CLIMATE AND HISTORY to be held at the University of East Anglia, England, July 8-14, 1979, H. H. Lamb, Organizer.

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March 7, 1978

III. PROPOSED COLLABORATIVE RESEARCH WITH TNRIS

Sam McCullouch
Texas Natural Resources
Information Service
P.O. Box 13087
Austin, Texas 78711

Dear Sam,

I would like to thank you again for participating in our project planning symposium Saturday. You impressed everyone and I am sure it will change the course of some of our research programs relative to climatic change.

With regard to our participation in a Landsat analysis program with your office, I would tentatively suggest the following outline for the project. Since we need to monitor the climatically induced changes in vegetation I would suggest that the study zone be located in south Texas. Our research has shown that south Texas is the most climatically sensitive area in the state. Since the project is basically diachronic in character, we need to sample vegetation during various years. I would suggest the following three phase program. The first phase is a pilot study and subsequent phases can be executed as research requires and funds become available.

Phase I - Two analyses of the study area placed as far apart in time as possible and during the same season of the year, preferably a climatically sensitive season such as August. Time of year would depend somewhat on the area chosen and might have to be placed earlier in the summer to maximize the effect depending on when summer drying typically sets in.

Phase II - Fill in the intervening years between the two Phase I years during the same season of the year.

Phase III- Sample different times of the year.

This research design is intended to test the redistribution of the four prevalent rain patterns proposed by Carr for Texas as caused by changes in global climate. I have proposed various models of global effects on local climate.

Sincerely,

Joel Gunn

Joel Gunn, Ph.D.
Assistant Professor
of Anthropology

JG/mle

Ice Age? Go South (Tex.), Young Man

South Texas will become "the place to be" if scientific predictions of a second Ice Age ring true, said the assistant professor of anthropology at the University of Texas at San Antonio.

"If the earth is headed toward a cooling trend, as most scientists believe, we can probably predict more dependency on South Texas," said Dr. Joel Gunn.

"It's just speculation," Gunn admitted, "but we're trying to set up a series of studies to find out whether we're going into another Ice Age or a warmer climate."

Gunn, who was moderator for a symposium on climactic change and economics Saturday at the university, said the South Texas region was densely populated by prehistoric inhabitants during the Ice Age, as evidenced through fossil remains.

He said the study of the global climate, which is part of a two-year-old on-going research of past and present environmental change conducted by the university, may provide a possibleeconomic guideline for the future.

"Changes in climate cause changes in culture," Gunn said. "We have to know the present and the past in order to study either."

Gunn said the present stage of the research deals with the agricultural aspect of change in climate over the last three decades and how the change affects profits.

He said the studies will not only measure climactic change on vegetation in Texas, but will provide a basis by which to discover climate patterns in existence for thousands of years.

Other participants in the symposium included other UTSA faculty members as well as members of the Texas Natural Resources Information Service in Austin, San Antonio Home Builders Association, San Antonio Economic Development Foundation and Southwest Texas Agricultural Resources Program.

V. THE IMPACT OF GLOBAL CLIMATIC CHANGE ON PREHISTORIC AND MODERN CULTURES IN CENTRAL TEXAS (HISTORIC DATA)*

Joel Gunn

Introduction

During the last two years, staff members of the Center for Archaeological Research and members of the Division of Social Sciences at The University of Texas at San Antonio initiated a series of research programs intended to assess the effect of global climatic change on local, long term weather patterns. Initially our interests were paleoclimatological and archaeological. Eventually it became clear that the models developed from this research could be applied to historical cultures and perhaps to projections of future climate, provided one accepts the assumptions those projections are based upon.

The model (Gunn 1977) which our research is currently testing incorporates elements of jet stream meteorology (Reiter 1961) and land-sea air circulation patterns (Orton 1960, Bryson 1966) to explain the distribution of precipitation. These climate producing phenomena are modified through time by changes in global temperature fluctuations (Sanchez and Kutzback 1974).

We are attempting to test this model through three avenues of research. The first is by analysis of United States Weather Bureau records. The second is historic records and the third is paleoclimatic indicators recovered in the course of archaeological excavations. This proposal specifically deals with the analysis of Weather Bureau records of the San Antonio area and of adjoining regions which serve to illuminate the progress of San Antonio climate.

Discussions with various businessmen in San Antonio and agriculturalists in the surrounding region suggest to us that in addition to providing new knowledge about climate in south-central Texas, our findings may be put to such practical uses as projecting air-conditioning costs for factories and determining the effect of climatic change on crop and range lands.

The archaeological applications of this study are varied but on the main imply the ability to establish a reasonable estimate of the effect climatic change may have had on the prehistoric people of Texas. Whether the manner in which prehistoric people reacted to climatic change can be of service to us, the present day inhabitants of the region, remains to be seen. On the surface, the answer could be "yes." For instance, during prehistoric times aboriginal populations appear to have relied more heavily on south Texas for their subsistence. Our preliminary studies of climatic change in south Texas suggest that this may also be a viable strategy for modern populations.

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* This is the text of a grant proposal funded by the Ewing Halsell Foundation, San Antonio, 1978.

Global Climate

To determine the effect global climate has on local climate, it is necessary to accurately measure weather fluctuations at both levels and compare the results. After 1940 a widespread network of weather stations was posted all over the world to measure daily weather variations. Climatic researchers have compiled these data, along with temperature measurements of sea water from ships, to obtain an overall average change in global temperature from year to year (Reitan 1974, Waltraud 1976). Thus, fortunately, the work has already been done at the global level. In fact, the U.S. government, the United Nations and many other organizations are spending large amounts on climatic studies, and continued improvement can be expected in our understanding of global climate over the coming years.

Prior to 1940 direct weather observations are scarce. Numerous indirect measures are available, however. Tree-rings, C14 dates, severity of winters from historic records, tree line movements and ice core analysis of O^{16}-O^{18} ratios are among a proliferation of climatic indicators developed over the past few years. While these records lack the day-to-day detail of weather records, they do define the general character of global climatic change. It is our hope that we will be able to calibrate the post 1940 period of automated weather data gathering with these earlier climatic records. Fortunately the period 1940-1978 corresponds to the down leg of the cold-warm-cold cycle which started at the end of the last century. It, therefore, contains a few years representative of climates under variously warm and cold global conditions. As Bryson and Murray (1977) point out, these typical years can be used to study local weather patterns during extreme and intermediate conditions. The Institute of Ecology sponsored by the Charles F. Kettering Foundation has used the typical year or "scenario" technique to study the impact of climatic change on major North American food crops (Institute of Ecology 1976). In the case of this study, we would be interested in the relationship of a global scenario to a corresponding local scenario.

Local Climate

Information on climate and weather in the San Antonio region is available in three forms. The first, earliest and least detailed are the reports of Spanish explorers who crossed the Rio Grande Plain of south Texas as early as the 1690's. While these records are limited to certain times of the year, they do provide insights into unusual floods, droughts, severe winters, freezes, snow storms, etc., which can be helpful hints toward determining climatic conditions. De la Peña, for instance, reported more snows during a 15 day march to the Alamo from north Mexico than today's citizens of south Texas see in a lifetime (1975).

Records such as newspapers date back to the 1800's. One of the members of our research team (Max Witkind of San Antonio College faculty) is currently involved in exploring the extent of newspaper and archival potential for this research. Hopefully we will be able to quantify weather variables such as temperature and precipitation to between one and two centuries into the past. This would

provide us with a trajectory of climatic change spanning parts of the Little Ice Age. Only the archaeological data can provide the full range of past climatic fluctuations, but the closer we can come to examples of the full range in historical records, the more detailed our comprehension of climatic change will be.

The most recent period of weather data collecting in San Antonio commenced about 1940 when the National Weather Service began installing automated weather observation instruments in the area. These records are more accurate and more extensive than any previous ones. In addition to reporting temperature and precipitation, first class weather stations provide information on wind direction and travel, evaporation, barometric readings and type of precipitation. Our plans for this data include the analysis of San Antonio data in conjunction with data from eight first class weather stations strategically distributed over the state to sample weather regimes which contribute influences to the San Antonio region. This pattern is ideally suited to test the model we are using to explain the effect global climate has on local climate. Should our results prove positive, we hope to use the results to estimate the effects of climatic change on the vegetation of the past and its effect on past cultures. If we make assumptions, such as that the downward trend exhibited in global temperature over the last four decades continues, then we can project the effect these changes will have on future productivity of the south Texas economic region.

Conclusion

That the research proposed above will be of use to archaeologists studying prehistoric cultures in south-central Texas is made apparent by the fact that we are heavily involved in the project. As was pointed out, it seems possible that the results of archaeological research on the adaptations of past cultures in the region may aid our own economic planners in making productive decisions in a world which many think is in danger of food shortages (Bryson and Murray 1977). Certain aspects of climatic and weather research may be directly applicable in situations where companies moving into the area are interested in projecting building and air conditioning costs. Discussions with businessmen such as John T. Saunders of Saunders and Trieschmann Co. and Ralph U. Thomas of the San Antonio Development Foundation have encouraged us in this direction.

Support for this project is being provided by the Center for Archaeological Research in the form of eight TD-1440 surface observation data tapes from the U.S. Weather Bureau and basic research facilities. The University of Texas at San Antonio is providing computer time. The support which we are requesting in this proposal is for wages for a data analyst to do programming and archival research and to assist in the write-up phase of the project. Also funds are requested to provide a typist for the final report and for the publication of the final report.

VI. PERSONS INVOLVED IN CLIMATIC IMPACT RESEARCH

Gunn, Joel	Center for Archaeological Research, Division of Social Sciences, The University of Texas at San Antonio	Archaeologist, Data Management, General Coordinator
Hester, Thomas R.	Center for Archaeological Research, Division of Social Sciences, The University of Texas at San Antonio	Archaeologist
Hupp, William	Texas Natural Resource Information Service	Geographer, Pattern Recognition
Jones, Richard D.	Division of Social Sciences, The University of Texas at San Antonio	Economic Geographer
Mahula, Royce	Center for Archaeological Research, Division of Social Sciences, The University of Texas at San Antonio	Data Analyst
McCullouch, Sam	Texas Natural Resource Information Service	Project Coordinator
Robbins, Kay A.	Division of Mathematics, Computer Sciences and Systems Analysis, The University of Texas at San Antonio	Consultant, Fluid Dynamics
Robinson, Ralph	Center for Archaeological Research, Division of Social Sciences, The University of Texas at San Antonio	Biologist
Witkind, Max	San Antonio College	Historian, archival research, popular writer
Wright, Stacey	Center for Archaeological Research, Division of Social Sciences, The University of Texas at San Antonio	Research Assistant

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