Proposed Contract with the Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN. 37831 for Research on 'Detection of Forest Response to Increased Atmospheric Carbon Dioxide' (Darrell C. West, P.I.)

Laboratory of Tree-Ring Research
University of Arizona
Tucson, Arizona 85721

# Tree-Ring Growth Response to Increasing Atmospheric Carbon Dioxide

Amount Requested: $15,000 Proposed Duration: 3 months - 07/01/84-09/30/84

Name of Principal Investigator: Donald A. Graybill
Social Security No. [redacted]
Title: Research Associate in Dendrochronology
Telephone: (602) 621-2945
or: (602) 621-2191
Department Affiliation: Laboratory of Tree-Ring Research

Endorsements:

| Principal Investigator | Department Head | Approving Administrative Official |
|---|---|---|
| Donald A. Graybill | William J. Robinson | Charles H. Peyton |
| Donald A. Graybill | | |
| Research Associate in Dendrochronology | Director, Laboratory of Tree-Ring Research | Vice President for Research |
| Date: | Date: | Date: |

# INTRODUCTION

This section is an overview of work to be undertaken by the Laboratory of Tree-Ring Research under contract with the Oak Ridge National Laboratory project on "Detection of forest response to increased atmospheric carbon dioxide" (Darrell C. West - P.I.).

The federal agency sponsoring the research is the Department of Energy, Carbon Dioxide Research Division. Research is scheduled for July-September of 1984 and all of federal FY 1985 and 1986. The principal investigator for the research at the University of Arizona is Dr. Donald A. Graybill (Research Associate). Dr. Harold C. Fritts (Professor) will be available as a cooperating faculty scientist.

The major goals of the project are:

1. Identify tree-ring records where increasing $CO_2$ over the past century has had an effect on tree growth as measured by annual ring-width increments and quantify the nature of the effect. This will involve selection and analysis of chronologies in our current data bases as well as field collection efforts.

2. Furnish O.R.N.L. with replicated samples of cores for densitometric analysis from trees at sites we consider promising in terms of showing a $CO_2$ effect on growth.

3. Collaborate and cooperate on statistical analyses, especially those concerning the respective results that may be obtained from densitometric and ring-width data.

4. Publish research findings in a timely manner.

## RESEARCH PROCEDURES

I. Laboratory based research

A. Data Collections

1. Tree-ring data: Select a set of ring-width chronologies that have been indexed to remove non-climatic signals from the more than 1500 chronologies that are available in our local data banks.

2. Climatic data: Select appropriate monthly climatic records from our data banks for development of regional monthly climatic averages in the vicinity of tree-ring chronologies under examination.

3. $CO_2$ data: Obtain measurements since mid-20th century and estimates back to mid-19th century.

B. Data Analysis

Using a variety of statistical procedures we will attempt to separate, describe and specify the relative contributions to tree growth of temperature, precipitation and $CO_2$.

II. Field research

These efforts will in part be directed by the examination of older chronologies. Most only reach into the early 1960s. If they show a $CO_2$ effect and are reasonably accessible they should be updated. Some of our recent work suggests that sites at relatively high elevations are most likely to show a $CO_2$ effect on tree growth (see attached manuscript). Further collections in these types of sites is warranted. Duplicate sets of cores for densitometric and ring-width analyses will be taken in all field work.

Proposed Research FY 1984 (July 1-September 30)

Background

It was recently hypothesized (see accompanying ms., p. 3) that " - - subalpine vegetation generally, and upper treeline conifers in particular could now be exhibiting enhanced growth due directly to rising levels of atmospheric $CO_2$." At the time the paper was written in late 1983 and early 1984 the available data that appeared to demonstrate this effect into the 1980's were ring widths of limber pine (Pinus flexilis James) from 3325 m. altitude on Mt. Jefferson, central Nevada and of Great Basin bristlecone pine (Pinus longaeva D.K. Bailey) from 3400-3500 m. altitude in the White Mountains of eastern California. Recently, two more data sets have been developed that show similar trends. The record in figure 1 is from foxtail pine (Pinus balfouriana Grev. and Balf.) at 3560 m. altitude on Cirque Peak in the southern Sierra Nevada range of California (Louis Scuderi, Department of Geography, UCLA, personal communication). The other is from cores of bristlecone pine I collected at 3450 m. altitude on Mt. Washington, eastern Nevada in August of 1983. The data are currently in process so no final averaged chronology is available but a large majority of the cores have a marked and continuing increase in ring width from about 1850 onwards. A typical example is shown in figure 2.

Examination of seasonalized temperature records for the region or for single stations near the tree-ring collection sites does not provide evidence of trends that would likely be responsible for the recent increases in growth at any of the sites mentioned above. (see figures in attached ms.)

In addition to the upper treeline sites I have been working with other Great Basin bristlecone pine sites, in the same or nearby mountain ranges, that are near the lower elevational limits for the species of ca. 2600-2800 m. altitude. The variability and trends in these records appear to parallel annual precipitation and are dissimilar from those seen in the higher site chronologies.

Therefore we now have a transect of ca. 500 km. across the Great Basin with current tree-ring data from several localities that span the elevational range of 2600-3500 m. Evaluation of this data strongly suggests that our efforts to detect and study the effect of $CO_2$ on tree-ring width

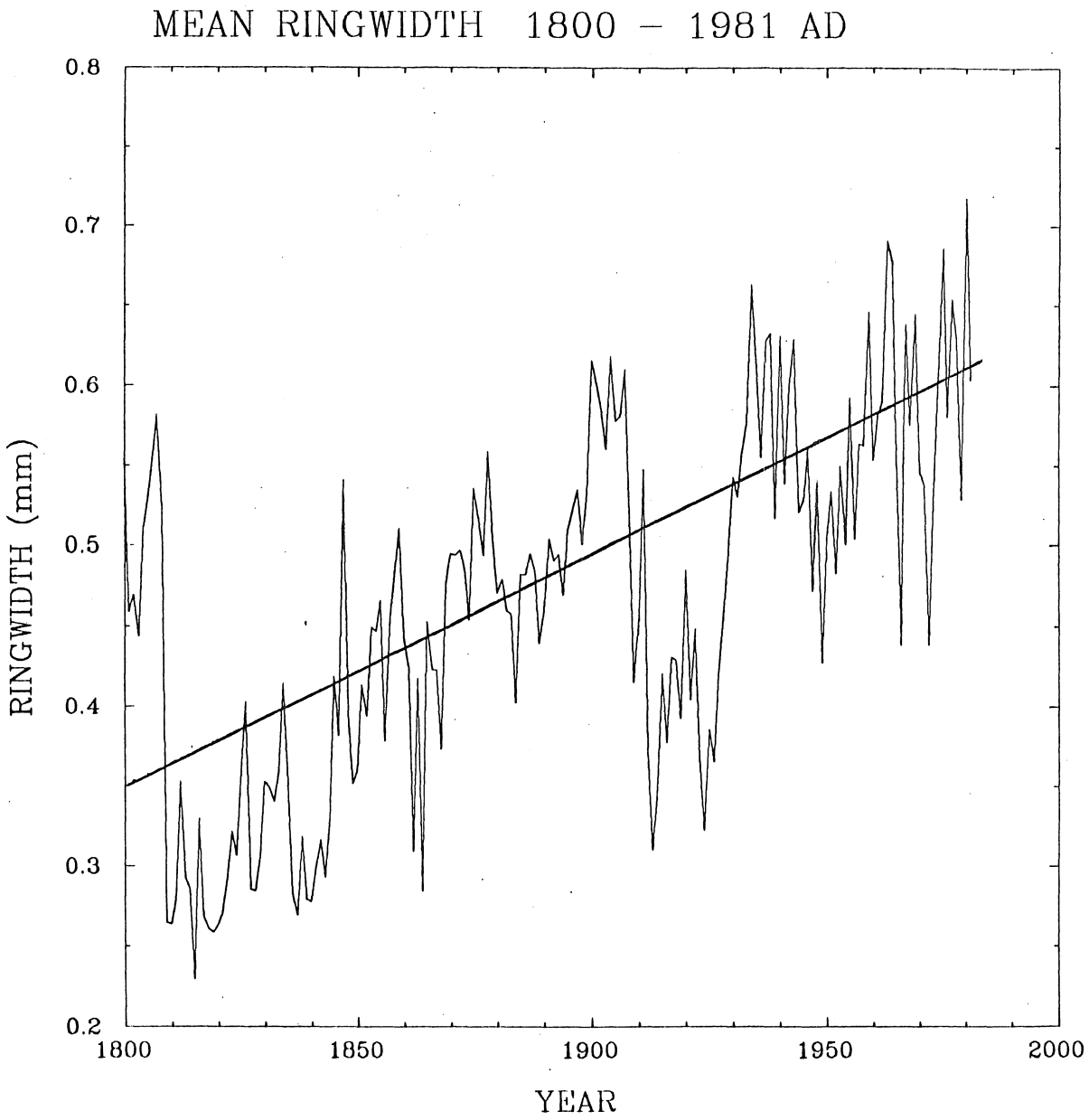
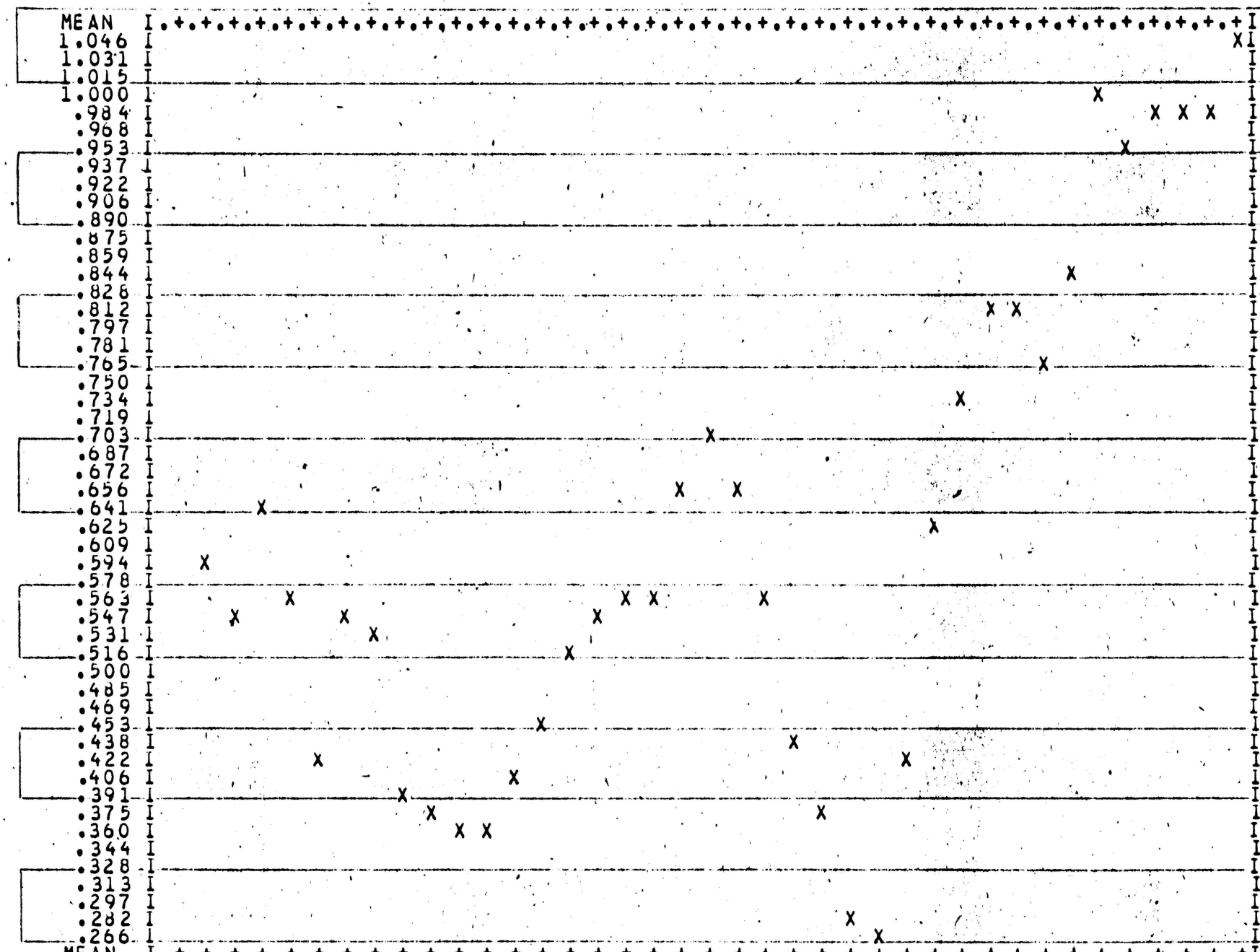



FIGURE 1. Pinus balfouriana: average of 29 cores
Cirque Peak, Sierra Nevadas: 3560 m. altitude
(from Louis Scuderi, UCLA, personal communication)

FIGURE 2. Pinus longaeva

RUN TITLE MT. WASHINGTON, NEVADA
DATE 03/15/84

PLOT OF 20 YEAR MEANS OF RING WIDTHS BY DECADE FOR SPECIMEN 801111



growth will be rewarded by concentrating on sites at upper treeline. However, this data set is limited to one region and limited to three species of pine.

After a preliminary review of numerous older chronologies in our data banks from western North America the notion that sites at upper treeline should receive initial attention was reinforced. Rocky Mountain bristlecone pine (Pinus aristata Engel.) appears particularly promising. The current collections are limited and all series end before 1971.

The research objectives for July-September of FY 1984 are designed to remedy some of the limitations of the data sets described above.

Research Objective 1: Geographic and generic expansion of upper treeline ring-width collections.

In terms of cost and time it will be most effective to extend collection efforts into the southwestern states of Arizona, New Mexico, Colorado and Utah. By reason of the same constraints we will be forced to collect at only those sites where reasonably close access is possible by vehicle. While this impairs our ability to design an elegant scheme of even regional coverage it provides us with an opportunity to determine whether we are pursuing the best avenues of inquiry at an early stage of the project.

Collection work will be directed at updating older chronologies of Rocky Mountain bristlecone pine and at the development of new chronologies in several sites. It should be possible to expand the genera to include fir (Abies) and spruce (Picea). One other species of pine (P. strobiformis Engel.) may also be collected.

It is anticipated that 12 man-weeks will be spent in this pursuit. The principal investigator will personally be involved in the collection work, assisted by at least one experienced laboratory employee. Funds for one month of salary for the assistant are included in the budget. Field work is tentatively scheduled for two weeks in mid July and for two weeks in early September.

Research Objective 2: Chronology development

One set of cores from each collection will be provided to O.R.N.L. and one will be processed at the Laboratory of Tree-Ring Research. The cores in Tucson will be dated and the ring widths measured by an experienced research assistant. The budget requests salary for nine weeks for this position.

Final chronologies will then be developed by the principal investigator. A copy of each will be furnished to O.R.N.L. for dating control as they become available.

Deliverables

(1) Monthly reports of research activity (July - September, 1984).

(2) Tree-ring cores collected in western U. S. for densitometric analysis at Oak Ridge (August and September, 1984).

(3) Final tree-ring chronologies for dating the cores in (2) above (August and September, 1984). Some chronologies may not be available until early FY 85 due to the processing time that lags collection.