LUNDQUA Report 34

TREE RINGS AND ENVIRONMENT

Proceedings of the International Dendrochronological Symposium,

Ystad, South Sweden, 3-9 September 1990

Managing Editor:
Ólafur Eggertsson

Lund 1992
Lund University, Department of Quaternary Geology

Recent dendrochronological investigations in Kirghizia, USSR

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This interim report summarizes current progress on a cooperative dendrochronological project in mountainous sectors of Kirghizia in the southern USSR (Figure 1). This research was begun in 1988 under the auspices of a US-USSR agreement on environmental protection, project 02.03-21, Pollution Effects on Vegetation. The program was administered by the US Environmental Protection Agency, the Soviet Academy of Science and the Soviet State Committee on Environment and Hydrometeorology.

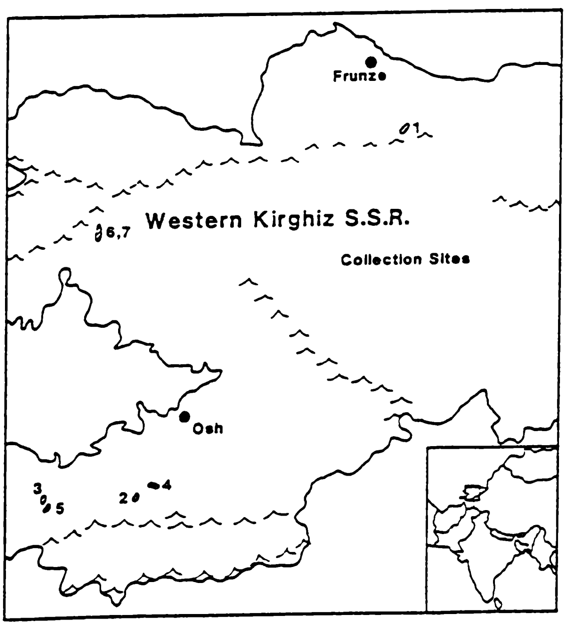

Fig. 1. Locations of tree-ring collections

Anthropogenically induced increases in carbon dioxide during the past century may be acting to increase the rate of coniferous tree-ring growth at high elevations (LaMarche et al. 1984, 1986, Graybill 1987, Peterson et al. 1990). This hypothesis was developed from observations of extraordinary 20th century growth increases in long-lived conifers (primarily Pinus longaeva and Pinus aristata, Great Basin and Rocky Mountain bristlecone pine) from a large network of sites in the western USA. Variations in temperature and precipitation during the past century there do not appear to be solely responsible for this phenomenon. Stands with trees having such growth increases are all growing at or near upper treeline (ca. 3000 - 3500m) on relatively xeric sites with limited soil development. These growth rate changes may not only be due to the increasing availability of carbon for photosynthesis but to concomitant gains in water use efficiency of these trees.

Our research in Kirghizia was an attempt to begin a network of long tree-ring chronologies that might be used in further and independent evaluation of the hypothesis of CO^2 fertilization of natural vegetation. This area was selected for a control study because it is one of the few in Eurasia with strong environmental similarities to the mountainous and semiarid mid-latitudes of the western USA. One of the few major differences is that the most widespread coniferous genera in the mountains of Kirghizia are Juniperus while the observations in North America were solely based on the genus Pinus. We are not aware of any comparative field or laboratory work that would allow us to predict whether this difference might limit the results of our study. Another difference in the two regions involves human impact on the landscape. Animal grazing has been a feature of the Central Asian landscape for times on the order of a few thousands of years, and portions of some living trees have been used for artifacts or firewood. We recognized these issues and avoided sampling trees that were

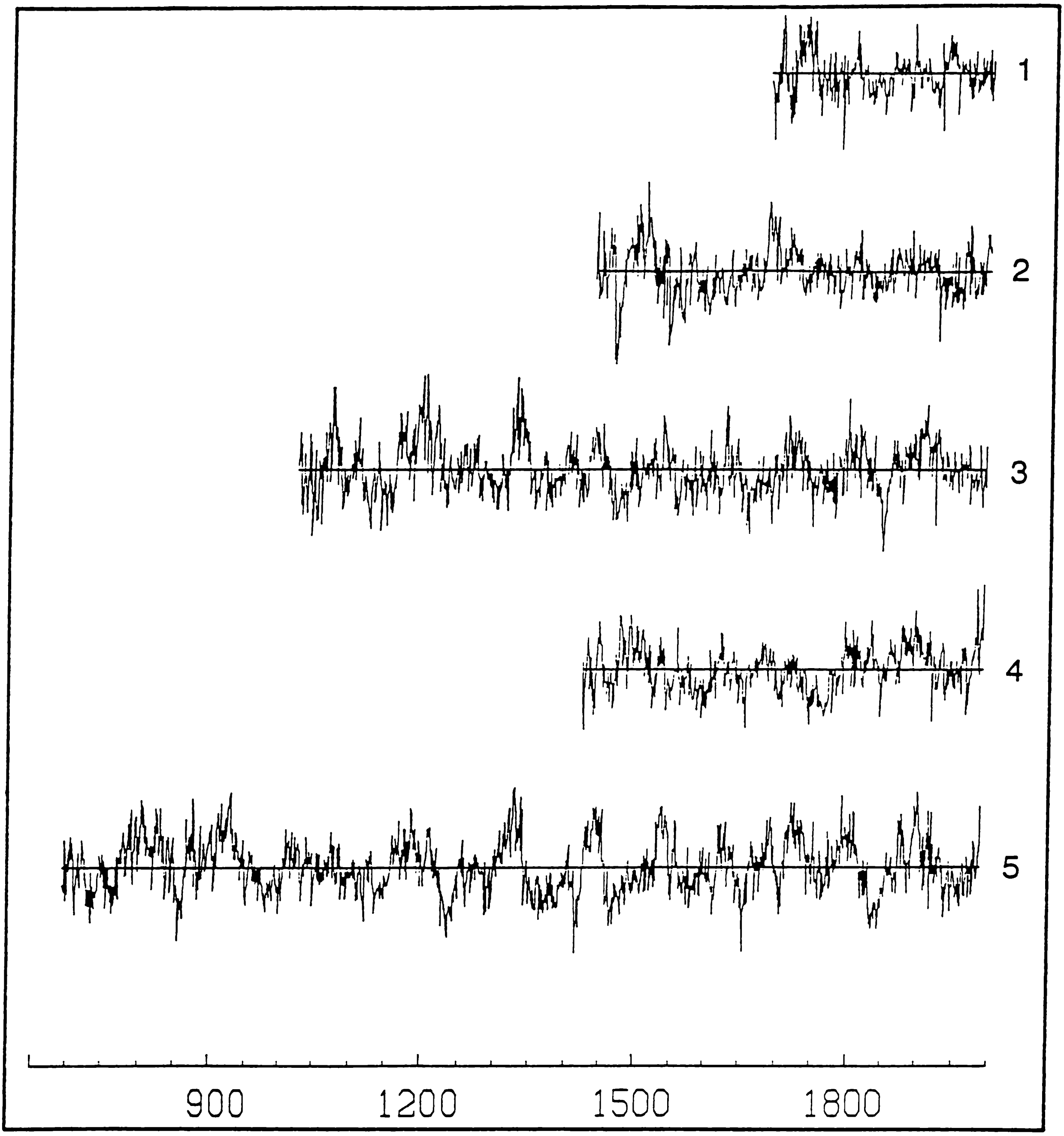

Fig. 2. Tree-ring indices

obviously subject to these environmental disturbances. These kinds of disturbances are not apparent in the North American Bristlecone pine stands.

Sampling and Chronology Development

Collection efforts were focused on obtaining samples from stands along environmental gradients similar to those sampled in the USA. All sites were relatively xeric and elevations of the stands ranged from 1400m (lower forest border) to 3450m (upper treeline). This was done not only for comparative purposes but also to allow a preliminary understanding of the range and kinds of growth patterns that are common in the region. Locations of the stands are shown in Figure 1. Four of them (#'s 2-5) were on thin soils derived from dolomite or limestone, the same parent materials of soils of most Great Basin bristlecone pine stands. Stands one and six were growing on soils derived from mixed volcanics while stand seven was on a calcareous conglomerate. All stands were open canopied and inter-tree competition was essentially non-existent. This is again, similar to the nature of the stands in the western USA network.

Dominant to co-dominant individuals were selected for increment coring. In some cases the older trees had experienced normal cambial dieback and were sustained by a limited strip of active cambium. This growth form is also common in older individuals of bristlecone pine. Trees with unusual defects such as lightning scars or other obvious injuries were avoided in both world regions.

A summary of the new data that were collected and processed is presented in Table 1. Two collections from the lowest elevations have not yet been dated. This is due to several factors that we have previously encountered with junipers growing near their marginal limits with respect to moisture availability. False rings (intra-annual growth bands) are present, some radii appear to have missing rings, and there are areas of severe growth depression where rings are visually difficult to discern. It will probably be necessary to use cross-sections instead of cores to establish chronologies from these stands.

At higher elevations the dating problems were not severe. Most ring-widths were dated and then measured to the nearest 0.01mm. This was followed by personal examination as well as by computer aided procedures to check both the dating and measurement accuracy (Holmes 1983). The final ring width series were then individually standardized and converted to tree-ring indices (Graybill 1982). This procedure removed biological growth trend and resulted in a new time series that was more homeoscedastic than the ring widths. Importantly, standardization also allows direct comparison of the variation in growth patterns of all trees, regardless of age or rate of growth. We primarily used simple deterministic curves such as negative exponentials or straight lines to model age-related growth trends. Use of these curves minimizes the chances of removing growth trends of interest that are not age related. Indices for individual ring width series were computed and averaged to form a mean index chronology for each collection. The averaging process has the effect of reducing the unique error associated with each component series and maximizes the common signal.

Chronology Characteristics

Descriptive statistical characteristics of the index chronologies are summarized in Table 1 and their time series plots are presented in Figure 2. There is notable correspondence in trends in some of the chronology statistics with the elevations of the stands. High frequency variation as measured by mean sensitivity, as well as the amounts of common variance generally increase with elevation. This suggests that common growth stresses are greatest at or near upper treeline in this data set. However, the undated tree ring series from the lowest elevations are exceedingly sensitive so we do not have a complete elevational transect of data for full discussion. Based on similar studies elsewhere, we might normally expect that the highest mean sensitivity and amounts of common variance will be found near the extremes of tree distribution where various environmental factors become severely limiting to growth (Fritts et al. 1965, LaMarche 1974a).

In the lower frequencies of variation, Box-Jenkins (1976) time series modelling indicated that the best fit model for each series was of ARMA(1,1) form. The amounts of variance accounted for by the model fits covaries positively with elevation. Similar patterns in the degree of autocorrelation with respect to elevation are found along transects of bristlecone pine (Graybill 1985). In those circumstances the elevational differences in autocorrelation are thought to be at least partially related to differing numbers of years of needle retention (LaMarche 1974b). Whether this is the case for junipers in Kirghizia, or elsewhere, is unknown.

Visual inspection of the time series plots (Figure 2) does not suggest any monotonic trend during the past century that is correspondent with increases in CO_2. However, the climatic variability in these chronologies is not yet understood. When that variability can be controlled and removed, then it will be possible to better evaluate and compare coniferous growth trends within and between regions.

As far as we are aware, chronologies three and five are the longest in the Soviet Union that are based on replicated series from different living trees in the same stand. All

Table 1. Kirghiz tree-ring chronology descriptions.

FULL CHRONOLOGY							COMMON PERIODS				
Chron #	Species[a]	Count[b]	First[c]	Last	Elev. (m)	% Low f.var.[d]	First year	Last year	N of trees[e]	M.S[f]	S/N[g]
1	Js	1674	1473	1987	2550	24.3	1870	1987	12	.25	2.7
2	Js,t	1427	1477	1987	2930	33.7	1760	1987	11	.30	2.1
3	Jt	1019	1066	1987	3150	42.8	1700	1987	13	.32	2.8
4	Jt	1420	1540	1987	3200	47.6	1750	1987	20	.29	6.3
5	Jt	694	876	1987	3450	59.2	1805	1987	10	.33	5.0

a. Js = Juniperus semiglobosa (Regel), Jt = Juniperus turkestanica (Komarov).
b. First year with only one sample.
c. First year with samples from three different trees.
d. % variance accounted for by ARMA model fit.
e. All chronologies have one sample per tree.
f. Mean sensitivity.
g. Signal to noise ratio, e.g. 2.7:1.

of the trees were growing on remote mountain slopes that had limited impact from animal grazing or human disturbance. Further dendrochronological sampling of similar stands in the Tien Shan Mountains would probably permit the development of more chronologies of similar quality and length. Analysis of a larger data set of this nature should also increase our understanding of the natural environmental factors that are forcing tree growth.

References

Box, G.E.P., and G.M. Jenkins 1976: Time Series Analysis: Forecasting and Control. Holden-Day, San Francisco.

Fritts, H.C., D.G. Smith, J.W. Cardis, and C.A. Budelsky 1965: Tree-ring characteristics along a Vegetation gradient in northern Arizona. Ecology 46(4), 393-401.

Graybill, D.A. 1982: Chronology development and analysis. In Climate from Tree Rings, ed. by M.K. Hughes, P.M. Kelly, J.R. Pilcher, and V.C. LaMarche, Jr., pp. 21-28. Cambridge University Press, London.

Graybill, D.A. 1985: Western U. S. tree ring index chronology data for detection of arboreal response to increasing carbon dioxide. No. 026 in the US Department of Energy Green Book Reports on the Response of Vegetation to Carbon Dioxide series. Laboratory of Tree-Ring Research, University of Arizona, Tucson, 63 p.

Graybill, D.A. 1987: A network of high-elevation conifers in the western United States for detection of tree-Ring Growth response to increasing carbon dioxide. Proceedngs of the International Symposium on Ecological Aspects of Tree-Ring Analysis, compiled by G.C. Jacoby and J.H. Hornbeck, pp. 463-474. Conf. 8608144, National Technical Information Service, US Department of Commerce, Springfield Virginia.

Holmes, R.L. 1983: Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43, 69-78.

LaMarche, V.C. Jr. 1974a: Paleoclimatic inferences from long tree-ring records. Science 183:1043-1048.

LaMarche, V.C. Jr. 1974b: Frequency-dependent relationships between tree-ring series along an ecological gradient and some dendroclimatic implications. Tree-Ring Bulletin 34, 1-20.

LaMarche, V.C., Jr., D.A. Graybill, H.C. Fritts and M.R. Rose 1984: Increasing atmospheric carbon dioxide: tree-ring evidence for growth enhancement in natural vegetation. Science 225, 1019-1021.

LaMarche, V.C., Jr., D.A. Graybill, H.C. Fritts and M.R. Rose 1986: Carbon dioxide enhancement of tree growth at high elevations. Science 231, 860.

Peterson, D.L. , M.J. Arbaugh, J.R. Lindsay and B.R. Derderian 1990: Growth trends of whitebark pine and lodgepole pine in a subalpine Sierra Nevada forest, California, U.S.A. Arctic and Alpine Research 22(3), 233-243.

Acknowledgements

Travel funds for some of this research were provided by the ANL Foundation and the University of Arizona Office of International Programs. We also acknowledge the organizational assistance of Dr's R. Noble and Y. Martin, the American and Soviet Project Officers for this exchange. Substantial logistic support was provided by many employees of the Soviet Forest Service.