Tree ring evidences of Little Ice Age from the northern Russian forest borders

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A comparative study of tree ring data (1458-1975) of Lovelius (1979) prepared from northern forest limits of Russia with archives, historical and other proxy climate records from the region is given. The decrement and aggrandize in tree growth seem to reflect the climatic events especially temperature fluctuations. Extremely reduced growth period from 1570-1850 is the indication of Little Ice Age, during that time most of the glaciers expanded to the extent comparable to that of the last stadial of the fourth Quaternary glaciation..

Key-words—Tree-rings, Little Ice Age, proxy records, Northern Hemisphere, Russia.

INTRODUCTION

HIGH latitude regions are considered to be very sensitive to climate change and may serve as the indicator of fluctuations over much wider range because such regions are known to give magnified view of hemispheric climate change. For example, a warming of about 1.5^0 C was recorded at the Arctic stations over the past century whereas the Northern Hemisphere as a whole warmed about $0.5^0 - 0.7^0$C (Kelly *et al.*, 1982; Hansen & Lebedeff, 1987). Bryson (1976), Lamb and Morth (1978) and Goody (1980) have also noted the significance of high latitude area in temperature changes of hemispheric scale. The implicit indicators or proxy climatic data from such climatically sensitive zones would provide valuable information about the past hemispheric and global climatic fluctuations.

The location of northern tree-line and tree growth in the region is strongly influenced by temperature regimes at these latitudes. The trees growing in such areas are known to produce wider rings in warmer summers and narrower rings in cooler summers, the fact which was realized long back by Swedish naturalist Linné in the mid seventeenth century who studied oak trees growing near their northern most limits (Rothlisberger, 1980). Subsequently recent studies (Mikola, 1961; Haugen, 1967; Garfinkel & Brubaker, 1980; Cropper & Fritts, 1981; Jacoby & Cook, 1981; Bitvinskas. 1982; Jacoby *et al.*, 1985; Jacoby & D' Arrigo, 1989; Yadav, 1992) have further added to the understanding of climatic informations recorded in tree rings from high latitude regions. High temperature sensitivity of trees from such regions offers significant potential for tree ring proxy data in the study of climate dynamics.

The Little Ice Age event recorded in the Northern Hemisphere earlier in this millennium was characterized by colder climate and expansion of glaciers. Its dates determined from historical and other proxy records vary depending on the geographical location and observed parameters (Lamb, 1977; Robock, 1979; Flohn & Fantechi, 1984). Recent ice core evidences from the tropics of South America have added to the understanding that the Little Ice Age was a global event (Thompson *et al.*, 1986).

Lovelius (1979) prepared tree ring chronology from different conifer species growing in the northern tree limit zones in various geographical areas in Eurasian part of Russia. High correlation of the present ring-width series with temperature (Chernovskaya, 1988) have indicated that the series could be used as a sensitive measure of temperature variability in the region. Ring width series of Lovelius (1979) in comparison to other proxy data available from the area was studied to understand the effect of Little Ice Age cooling on tree growth and has been presented in the present article.

TREE RING DATA

Lovelius (1979) prepared the tree ring chronology extending from 1458-1975 from trees collected from different forest border zones of Eurasian parts of Russia (Table 1, Text-fig. 1). The species used were *Pinus sylvestris* L., *Picea obovata* Ledeb., *Larix sibirica* Du. Tour, L. *gmelinii* (Rupr.) Rupr. and *L. cajanderi* Mayr. As the growth pattern of all these species was very similar, he combined them to form single chronology. The decadal growth fluctuations of the ring-width series is shown in Text–figure 2.

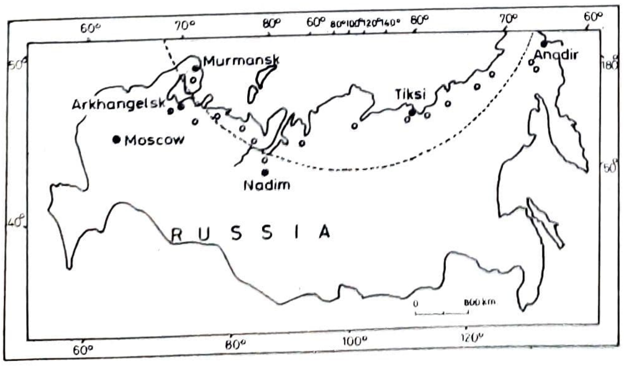
Table 1. Tree ring chronology data for sites shown in Text-figure 1.

Site	Species	No. of samples	Series length
Tuloma, Murmansk	*Pinus sylvestris* L.	10	1629-1974
North Dvina, Arkhangalsk	*P. sylvestris* L.	11	1733-1974
Pechora, Narian-Mar	*Larix sibirica* Du Tour	10	1733-1974
Nadim	*P. sylvestris* L.	10	1603-1974
Enceiu, Dudinka	*Pieca obovata* Ledeb.	10	1608-1975
Hatanga	*Larix gmelinii* (Rupr.) Rupr.	29	1704-1970
Lena, Tiksi	*L. gmelinii* (Rupr.) Rupr.	10	1556-1973
Indigirka, Chokurdax	*L. cajanderi* Mayr	10	1458-1973
Kolima, Cherskiu	*L. cajanderi* Mayr	16	1720-1973
Anadir, Markovo	*L. cajanderi* Mayr	14	1640-1973

found to be very contrasting from the second half of the sixteenth century with severe winters and frequent cold summers (Loginov, 1988). During the first twenty years of seventeenth century (1600-1620) tree growth showed increasing trend and the climate during this time was recorded to be normal which became increasingly severe after 1620. It is mentioned that in the sixteenth century the Russian sailings along the north coast as far as the Gulf of Ob were common until as late as 1620 when a ship sailing from Cape Chelyuskin to the east side of Taimur Peninsula was trapped by ice (Lamb, 1977). After

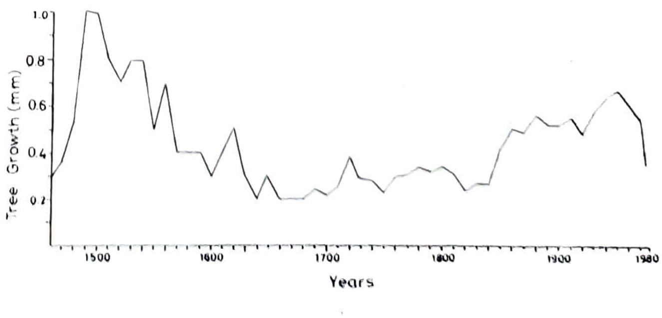
GROWTH DYNAMICS AND ITS COMPARISON WITH OTHER PROXY DATA

Decadal fluctuation of ring-width series (Text-fig.2) shows good growth during the early part of the chronology, i.e. from the second half of the fifteenth century to the first half of the sixteenth century. Good growth of trees indicates moderate climatic conditions which favoured tree growth during this period. Subsequently the growth started declining. The extremely reduced growth phase occurred from 1570 to 1850 years A.D. The archive and historical data of Russia for the region indicate that increasing number of climatic extremes occurred from the beginning of the sixteenth century and were



Text-figure 1. Map showing the location of sample sites (after Lovelius, 1979).

1620 growth again started consistently decreasing and extremely low growth continued until the first half of the nineteenth century but showing considerable fluctuation from time to time. Excessive cooling of climate from the second half of the seventeenth century resulted in the freezing of the Arctic from 1650 (Loginov, 1988). In first twenty years of the eighteenth century increasing growth trend reflects the amelioration of climate (Loginov, 1988). Warmer conditions shortly after 1700 seem to be global phenomenon and is also evident from the other proxy data from England, Greenland, California, New Zealand and China indicating partial amelioration of the Little Ice Age climate (Lamb, 1982). Excessive growth reduction again from 1740 to 1750 seems to be associated with the return of very extreme winters and cold summers during this period. Tree growth afterwards



Text-figure 2. Ring width series (1458-1975) showing decadal mean values.

showed slight recovery in second half of the eighteenth century. Tree growth again declined from 1810-1840 which seems to be caused due to the return of cold phase with frequent severe winters (Liaxov, 1987). Since the middle of the nineteenth century tree growth showed consistently improving trend. But slightly reduced growth occurred from 1880-1920. This reduced growth phase seems to be associated with excessive cooling occurred during this period in the Northern Hemisphere (Vinnikov *et al.*, 1987). Increasing growth trend coupled with the warming recovery from 1920-1950 is observed to be a global phenomenon (Vinnikov *et al.*, 1987). This warming trend has also been observed in other high latitude tree-ring data from North America (Jacoby & D' Arrigo, 1989). The Northern Hemispheric warming from 1920-1950 resulted in excessive reduction of Arctic snow and is reported that during 1920-1930 glacier line moved northward upto 120 km (Zaxarov & Strokima, 1978). The warming and increased solar radiation would have also been enhanced due to feed-back effect of reduced albedo effect (Budiko & Vinnikov, 1973).

Ring width series further indicates a recent decline in growth trend from 1950 and is associated with Northern Hemispheric cooling. Due to this cooling event from 1950 snow content in the Arctic is reported to have increased to the extent of 10 times as compared to that in 1920-1930 (Budiko & Vinnikov, 1973; Zaxarov & Strokima, 1978). The increased albedo effect due to increased snow area resulted in reduced solar radiation reaching to the ground from 1950-1970 (Budiko & Vinnikov, 1973). This cooling event from 1950 was a wide spread phenomenon and has been indicated in various data sets (Kukla *et al.,* 1977) and tree ring evidences from Yukan Tertiary in Canada (Jacoby & Cook, 1981).

CONCLUSION

The study of present tree ring data prepared from the northern forest borders of Russia and Russian chronicles and historical data indicates that most of the widespread climatic events especially temperature fluctuations are reflected in tree ring width sequences. Depressions in tree growth have been found to be closely associated with decline in temperature. The reduced tree growth phase from 1570-1850 indicates the Little Ice Age event. Clear reflection of hemispheric climatic events in the tree-ring series indicates that tree ring proxy records from the high latitude regions are very important for the understanding of spatial and temporal climatic variations. Such studies would also provide information, how large the natural climatic changes have affected the natural ecosystems in border lines during the transition from Ice Age Interglacial climates.

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