Eco. Env. & Cons. 28 (4) : 2022; pp. (2214-2216)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04.086

Global Ecopotential of Dendrochronology

D. Rumyantsev

Mytischi Branch of Bauman Moscow State Technical University,
Department of Forest Management, Ecology and Forest Protection, Moscow, Russia

(Received 9 June, 2022; Accepted 18 September, 2022)

ABSTRACT

Drought is a meteorological phenomenon that has influenced the life of human society for ages and still has a great impact on it. This phenomenon can be divided into a group of sub-phenomena, e.g. soil and air droughts, winter droughts, etc.… From a physiological point of view, drought may have different consequences in different periods of a growing season. It seems however difficult to describe quantitative characteristics of a physiologically important drought using any meteorological parameters because within an ecosystem the results of interaction of ecological factors may change the way plants respond to a certain limited number of values of meteorological parameters. Photosynthesis and transpiration characteristics predetermine that the function modelling annual tree ring variability will always and under any conditions have a variable that will depend on drought. The objective of dendroclimatic studies can be either to separate a drought-associated climatic signal from the tree ring chronology or, on the contrary, to search a chronology with a "clear" and easily detected drought-associated signal. Having retrospective aspects, dendroclimatic studies show considerable promise for the evaluation of droughts including those that have an impact on crop yields. Such studies can give further information for crop yield forecasts.

Key words: *Forest, Drought, Crop yields, Dendrochronology, Plant physiology.*

Introduction

The transition of human societies from hunting and gathering towards agriculture resulted in establishing a strong link between their economy, history, politics and such a weather event as drought. Crop yields became an essential factor to determine living conditions of human populations. Cereal crops are a product that can be stored for a long time, accumulated, and transported – so in general it is better for organizing a more complicated economical exchange and contributes to development of a more differentiated society structure and sophisticated state systems. However, being a factor affecting crop yields, drought has taken on a particular significance since then as a factor having an impact on stability of the first agricultural societies. It seems that from this moment on drought has become an object of thorough studies.

The first drought studies began in southern Mesopotamia about six thousand years ago. The Sumerian civilization developed a sophisticated agricultural and technical system, which made it possible to create a society where a part of the population was fully engaged in scientific activities. They worked out the most advanced astronomy and mathematics in the Middle East. Today we still divide a year into four seasons and 12 months and measure angles, seconds and minutes based on their original sexagesimal number system. The Sumerians are known to invent writing, to have advanced medicine and a juridical system. The Sumerian literature heritage includes the Epic of Gilgamesh [4], which, in a certain way, has some common plot elements with the Bible texts (e.g. the Great Flood Myth), but tells evidently about much more ancient periods of the human history. Here we can find the first evidence that drought reasons were understood and studied. Gilgamesh and his companion Enkidu, the primitive man covered in hair, set off to the Lebanon Mountains to kill Humbaba, the local guardian of the forests, and to cut down the cedar trees in the area he protects. It is with great difficulty that they manage to achieve this goal so that they final can carry out illegal logging. However, the local gods are angry with them and decide that they have to pay for this crime with their lives – "the one of them who pulled up the Cedar of the Mountain must die!" Eventually the gods take a decision to kill only Enkidu who was actually the one to cut down the trees and let Gilgamesh live though the latter was the driving force behind the journey (perhaps, they decide to spare Gilgamesh because he is a two-thirds god and therefore kin to them).

It is clear that this myth is too sophisticated to be a simple fairy tale and reflects some historical processes and natural and scientific notions of the ancient civilization. Friedrich Engels explained this in simple words in his Dialectics of Nature (Engels, 1950): "The people who, in Mesopotamia, Greece, Asia Minor and elsewhere, destroyed the forests to obtain cultivable land, never dreamed that by removing along with the forests the collecting centres and reservoirs of moisture they were laying the basis for the present forlorn state of those countries. When the Italians of the Alps used up the pine forests on the southern slopes, so carefully cherished on the northern slopes, they had no inkling that by doing so they were cutting at the roots of the dairy industry in their region; they had still less inkling that they were thereby depriving their mountain springs of water for the greater part of the year, and making it possible for them to pour still more furious torrents on the plains during the rainy seasons."

Long ago, the inventors of the wheel, the Sumerians, understood that forests, drought and crop yields were interconnected and this fact has not been disproved ever since. On the other hand, despite being well known this problem has not been resolved yet.

One of the attempts to resolve it radically was made by Joseph Stalin whose actions were quite in the spirit of the Great Construction Projects of Communism. The corresponding plan proposed by Stalin was approved and launched by the Decree of the USSR Council of Ministers and All-Union Communist Party (Bolsheviks) Central Committee as of October 20, 1948: "On the plan for planting of shelterbelts, introduction of grassland crop rotation and construction of ponds and reservoirs to ensure high crop yields in steppe and forest-steppe areas of the European USSR." Never before had the world seen such a large-scale nature transformation project. Within its scope, it was supposed to plant forest shelterbelts (windbreaks) to provide shelter from dry winds and change climate in the area of 120 million ha. The project started in 1949 and planned for completion in 1965 involved creating eight large state-owned forest shelterbelts across the steppe and forest-steppe areas. Their total length would be 5300 km. However, it was mostly abandoned, and today only decorations of the Paveletskaya metro station remind about this plan.

It appears that only studying the whole triad "Forest – Drought – Crop Yields" will help to resolve the global climate control problem successfully in the future. It seems however complicated to study an impact that forests might have on the climate. The humanity does not have any objective tools to analyse such biospheric processes efficiently.

It is much easier to study how the local climate affects forests, to determine past droughts and to forecast drought occurrence in this respect. On one hand, arid climate conditions result from physical atmospheric processes. Thus, they can be reliably studied using technical tools and devices. On the other hand, it is not possible to set any discrete parameters that would define drought as a condition of water deficit in plants. In brief, a plant responds to drought conditions and within an ecosystem various additive, cumulative, and compensating effects of interactions of ecological factors can change the way the plants respond to a certain limited number of values of meteorological parameters. It is also clear that the climate impact on plants varies based on a plant species, geographic area and growing conditions within one geographic area.

Thus, it is problematic to detect and evaluate a drought that is physiologically important for a plant, i.e. the drought causing a water deficit in a plant and therefore decreasing its productivity and stability. Such studies can be performed based on time series of crop yield indexes. However, such data can be obtained only from many years of direct observations. Another option is a tree-dating method that makes it possible to get the required data in a retrospective way within a few days. This information will not of course be equal to crop yield dynamics, but the time series will be based on the same variable related to the drought impact on the photosynthesis process. What is it?

Plants usually have enough water for photosynthesis to be performed (6ÑÎ2+6Í2Î= Ñ6Í12Î6+6Î2). However, lack of carbon dioxide can be a factor that limits this reaction (Kramer and Kozlovskiy, 1983). To compensate this, a plant has to open "gas exchange windows" – stomas on its leaves to let new portions of carbon dioxide inside. As a side effect, the plant loses some water (which is already in short supply) that evaporates through the open stomas. Most species have special "tools" that help to reduce a water loss during a period of water shortage, but at the same time, such tools slow down the gas exchange and reduce a photosynthetic rate. Although different species have different features of their ecological and physiological mechanisms, we can say that the above-mentioned process is in general typical for all species.

We can therefore point out that that the function modelling annual tree ring variability will always and under any conditions have a variable that will depend on drought. However, significance of this variable and its integral impact on radial growth variability within a time series may vary from case to case. The objective of dendroclimatic studies can be either to separate a drought-associated climatic signal from the tree ring chronology or, on the contrary, to search a chronology with a "clear" and easily detected drought-associated signal. One of such studies has been described in the monograph published by a team of authors led by O.N. Solomina, Doctor of Geography and the director of Institute of Geography of the Russian Academy of Sciences (Solomina *et al.,* 2017). This research confirmed the thesis that knowing fluctuation patterns of the drought-based signal through time makes it possible to map it in space and time, to study its periodic component, and consequently to forecast future drought dynamics.

This work has been sponsored by the Russian Science Foundation (Grant 14-17-00645) Reconstruktsiya i prognoz chastity zasukh v tsentre Vostocho-Evropeiskoy ravniny po dannym dendrochronologii i klimaticheskogo modelirovaniya [Reconstruction and Forecast of Drought Frequencies in the Central East European Plain Based on Dendrochronology and Climatic Modelling].

References

Kramer, P. and Kozlovskiy, T. 1983. *Fisiologiya Drevesnykh Rsteniy* [Tree Physiology]. Moscow: Lesnaya Promyshlennost Publ., 1983 – 464p.

Solomina, O.N., Matskovskiy, V.V., Dolgova, E.A., Dolgikh, A.V., Voronin, K.V., Rumyantsev, D.E., Semenov, V.A., Chernokulskiy, A.V., Cherenkova E.A., Kukhta, A.E., Kuznetsova, T.O., Zolotokrylin, A.N. and Khasanov, B.F. 2017. *Zasukhi Vostocho-Evropeiskoy ravniny po gidrometeorologicheskim i denrochronologicheskim dannym* [Droughts in the East European Plain Based on Hydrometeorological and Dendrochronological Data]. Saint-Petersburg: Nestor-Isoriya Publ., 2017 – 360p.

Engels, F. 1950. *Dialectics of Nature*. Leningrad: State Publishing House for Political Literature, 1950 – 328 p.

The Epic of Gilgamesh. Translated from Akkadian by I.M. Diyakonov. Moscow-Leningrad: USSR Academy of Sciences, 1961 – 214p.