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THE APPLICATION OF CLIMATOLOGICAL DATA IN THE DETERMINATION OF CLIMATE FAVOURABLENESS FOR THE FOREST VEGETATION OF CROATIA

Primjena klimatoloških podataka u utvrđivanju povoljnosti klime za šumsku vegetaciju Hrvatske

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Abstract - The Meteorological and Hydrological Service in Zagreb has been monitoring the values of climatological elements and phenomena in the atmosphere and on the ground for a long period of time. A data bank has been established of exceptional value which is being used for research in natural sciences. The Forest Research Institute, Jastrebarsko, has produced the Pluviothermal climate favourableness indices for forest vegetation based on the Climate Atlas and the Institute data. 19 different climate favorableness indices in Croatia (KL-1 to KL-19) and the index of the greatest favorableness have been determined on the basis of a hypothesis that the most favourable climatic conditions dominate on those areas where the biocoenoses members are the most numerous. This hypothesis has been confirmed by the central position of the best favourableness index (KL-10) in a sequence of 19 members. The indices distribution in Croatia has been shown on the map (scale 1:1,350.000). The relative values of the indices have been determined by attributing the highest value to the highest climate favourableness index (KL-10) and the smallest value to the lowest favourableness index (KL-1 and KL-19).These indices can be applied to numerous natural science research fields and in forestry.

Key word index: Climatology, vegetation, pluviothermal climate favourableness indices.

Sažetak - Državni hidrometeorološki zavod u Zagrebu već dugi niz godina trajno prati vrijednosti klimatskih elemenata i pojava u atmosferi i na tlu. Ostvaren je fond podataka izuzetne vrijednosti, koji se koristi za prirodoznanstvena istraživanja. U Šumarskom institutu Jastrebarsko, na osnovi Atlasa klime i podataka Zavoda, izrađeni su Pluviotermički indeksi povoljnosti klime za šumsku vegetaciju. Utvrđeno je da u Hrvatskoj ima 19 različitih indeksa povoljnosti klime (KL-1 do KL-19), a indeks najveće povoljnosti je utvrđen na temelju hipoteze da najpovoljnije klimatske prilike vladaju na onim prostorima na kojima je najveća brojnost članova biocenoze. Hipoteza je potvrđena središnjim položajem indeksa najveće povoljnosti (KL-10) u nizu od 19 članova. Rasprostranjenost indeksa u Hrvatskoj prikazana je na karti u mjerilu 1:1,350.000. Relativne vrijednosti indeksa utvrđene su tako da je indeksu najveće povoljnosti klime (KL-10) dodijeljena i najveća vrijednost, a ostalim indeksima vrijednosti linearno i simetrično opadaju do indeksa najmanje povoljnosti (KL-1 i KL-19). Indeksi se mogu primijeniti za brojna prirodoznanstvena istraživanja, a u šumarstvu za utvrđivanje životnih prilika šumskih staništa.

Ključne riječi: Klimatologija, vegetacija, pluviotermički indeksi povoljnosti klime.

INTRODUCTION

The Meteorological and Hydrological Service in Zagreb has been measuring the values of climatological elements and monitoring weather phenomena in the atmosphere and on the ground for a long time. Measurements are carried out at many weather stations in Croatia and the results are daily sent to the central data processing office. According to international methods the values of some weather elements are measured up to three times a day.

A data bank of exceptional value has been created, its value is growing every day not only because of the growing amount of data, but also because of the growing data measuring and keeping period.

Today it is possible to reconstruct the weather conditions of past years as well as their consequences and thus come to conclusions on the current impacts of climate on living beings and matter in general.

The Meteorological Service data bank has much been used in recent research on the life conditions of forest sites and the impact of climate on the flora composition of the vegetation, and owing to the application of these climatological findings, the climazonal character of the vegetation has been determined.

The application of these data to the climate properties of particular regions in Croatia makes only partial use of their value. A possible further application is the determination of climate favourableness for the forest vegetation.

A new term has recently been introduced at the Forest Research Institute, Jastrebarsko (Medvedović, 1992): "Pluviothermal climate favourableness indices for forest vegetation" and an indices map for Croatia (scale 1:1,350.000) has been made. The indices and the map have been published in the Forest Research Institute (1992) and the Scientific Council of the Forest Research Institute has later allowed the author, J. Medvedović, to publish the map in this Journal.

The term "climate favourableness" can be used in scientific research on life environment conditions as well as in everyday life. Life communities (biocoenoses), plant (phytocoenoses) and animal (zoocoenoses) are distributed over different climatic conditions, i.e. climate favourablenesses, and their biocoenological composition is the reflection of particular, characteristic, conditions. This means that life conditions, in this case climatic, can, even without measurements, be recognized by the presence of particular plant and animal species. However, this can be done only on a global scale and therefore it is indispensable to measure the values of climatic elements by intensive research and then determine the different favourablenesses by their constellation.

Detailed knowledge of climate favourableness is very important in forest management because it ensures the most suitable manner of maintaining the forest ecosystem stability, a high production of wood, the health condition of the stand and generally useful forest function.

Research workers dealing with climate have long ago defined different climatic formulae which by one numerical expression present the climate properties of a certain region. The pluviothermal ratio (Emberger, 1942) functions in the same way, only it does not present climatic favourableness. Climate atlases show the distribution of certain climatic element values, but not their favourableness for the living world in particular regions.

Because of these reasons, a comparative analysis of the results of research on vegetation and climate has been carried out in the Forest Research Institute in Jastrebarsko, and by means of the Climate Atlas the climate favourableness of different parts of Croatia has been determined.

ELABORATION METHOD OF THE PLUVIOTHERMAL CLIMATE FAVOURABLENESS INDICES FOR THE FOREST VEGETATION

First a hypothesis was set: "The most favourable climatic conditions are dominant in those areas where the members of biocoenoses are most numerous". This hypothesis was set on the basis of an analysis of the quantity of plant species on phytocoenological photographs taken by research workers studying the floral composition of forest vegetation during the five decades (Horvat, Glavač, Ellenberg, Rauš, Pelcer, Vukelić, Medvedović), the result being that the greatest plant resources, the greatest quantity of floral elements have been found to exit in sessile-flowered oak forests. With this knowledge, all the forest communities of which the sessile-flowered oak is a characteristic species, were transferred from the Forest Species Map (scale 1:100.000) into a special map as one cartographical unit. All areas not belonging to forests, but to meadows or ruderal vegetation, but still belonging to the climatic zone of sessile-flowered oak forests have been included into the same cartographic unit. This has been because research (the authors of the Vegetation Map of Croatia, (scale 1:100.000) determined these areas also contained the largest number of phytocoenosis members of these vegetation formations compared to their numerousness in phytocoenoses outside the sessile-flowered oak forests.

An informative insight into zoocoenological photographs (entomocoenoses and ornitocoenoses) also revealed that the greatest number of animal species coincides with the zone of greatest number of plant species. An analysis of population density in early human settlements points to the same conclusion, but this has changed recently since settlements are no longer established according to natural, but according to civilization requirements.

The hypothesis of the most favourable climate apparently fails to hold given the fact that all living beings can adapt to different, even extreme climatic conditions. This is, however, only apparently because adaptation means struggle, loss of energy, loss of mass and individual. Thus, adaptation means also a decrease in numerousness and we should, therefore, stick to the concept of the greatest numerousness.

The most favourable climate - the climatic universe must exist somewhere - really exist. The climatic universe for Croatia has been looked for and found by means of the hypothesis of the greatest numerousness of biocoenosis members and the Climate Atlas of Croatia. Forest communities of sessile-flowered oak and other life communities of the sessile-flowered oak forest vegetation zone with their areals have been transferred to the Climate Atlas (by a transparent matrix). This marked the beginning of a mathematical struggle between the areal of the sessile-flowered oak vegetation zone on one side and climatic elements on the other side. The three most important climatic elements, i.e. four climatic parameters were taken into account: mean annual

air temperatures, quantity of precipitation, annual distribution of precipitation and wind frequency. Two of these parameters were taken as their quotient and the other two as their correction factor.

The results of the calculation of the quotients of temperature amounts and precipitation (read from the Climate Atlas) for the sessile-flowered oak forest areal fell within a 0.0091 to 0.0100 span. They were later, for simplicity of presentation in Table 1, multiplied by 100 (Fig.1). Following the calculation of the temperature-precipitation (pluviothermal) quotients of the sessile-flowered oak zone, the quotients of all the existing temperature and precipitation amounts in Croatia were calculated. It has been stated that there are 85 different quotients, i.e. pluviothermal combinations (Tab.1) on the territory of Croatia. All of them are grouped into one decimal value classes (0.01-0.10; 0.11-0.20 etc.) for easy reference. With no intention to state the number of classes, but grouping all the existing combinations according to the one decimal value, it was determined that in the whole of Croatia there are 19 classes, i.e. groups. Thus, a mathematical sequence resulted of 19 members in the climate favourableness sequence. Every sequence member was marked "KL", the first member KL-1, the last KL-19, as shown in Table 1.
Now let as return to the hypothesis. Sessile-flowered oak forests are the richest in species. In the sequence of pluviothermal climate favourableness indices, the sessile -flowered oak forests in Croatia occupy the central part of the sequence KL-1 to KL-19, i.e. KL-10. This is not accidental. The central position of the KL-10 index is a point of support between the two extremes KL-1 and KL-19. This does not mathematically cancel the extremes , because the extremes continue to act. The center is also an extreme: the extreme of the most favourable climate-the climatic universe. The hypothesis has been confirmed.

DEFINITION OF THE CONCEPT

Pluviothermal climate favourableness indices are the indices of climatic conditions and climate favourableness for the occurrence, development, and maintenance of forest vegetation in Croatia.

INDICES DISTRIBUTION

A map of pluviothermal climate favourableness indices for the forest vegetation of Croatia has been made, scale 1:1,350.000 (see Appendix). The distribution of the indices has been determined by the position of isotherms and isohyets in the Climate Atlas of Croatia.

INDEX CORRECTION FACTORS

The concurrence of areals of the sessile-flowered oak vegetation zone and the greatest climate flavourableness index (KL-10) is global and not detailed because there are small areas where areals differ. The dif-

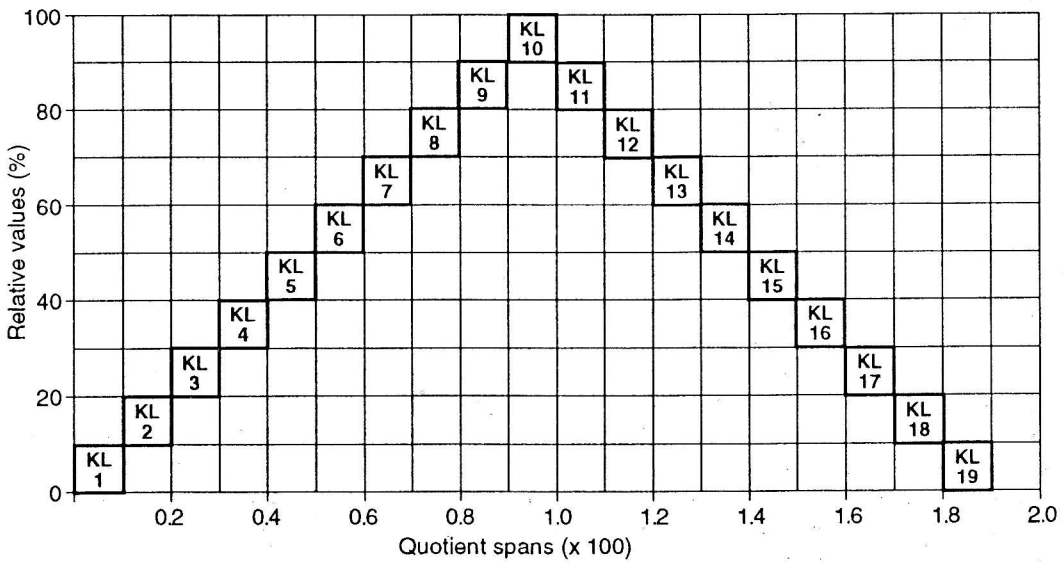

Figure 1. Graphic display of relative index values KL-1 to KL-19.

Slika 1. Grafički prikaz vrijednosti relativnog indeksa od KL-1 do KL-19.

Table 1. Pluviothermal climate favourableness indices with corresponding spans of air temperature (°C) and amount of precipitation (mm).

Tablica 1. Pluviotermički indeksi povoljnosti klime s pripadajućim rasponima temperature zraka (°C) i količina oborine (mm).

Pluvio-thermal indices	KL 1	KL 2	KL 3	KL 4	KL 5	KL 6	KL 7	KL 8	KL 9	KL 10
Quotient spans x 100	0.01-0.10	0.11-0.20	0.21-0.30	0.31-0.40	0.41-0.50	0.51-0.60	0.61-0.70	0.71-0.80	0.81-0.90	0.91-1.00
Spans of temperature and precipitation °C / mm	2-4 / 2500-3000 2-4 / 3000-3500 2-4 / 3500	4-6 / 2500-3000 4-6 / 3000-3500 4-6 / 3500 2-4 / 1500-1750 2-4 / 2000-2500	8-10 / 3000-3500 8-10 / 3500 6-8 / 2500-3000 6-8 / 3000-3500 4-6 / 1500-1750 4-6 / 1750-2000 4-6 / 2000-2500	10-12 / 2500-3000 8-10 / 2000-2500 8-10 / 2500-3000 6-8 / 1750-2000 6-8 / 2000-2500 4-6 / 1250-1500 10-12 / 3000-3500 8 / 2000-2500	14 / 2500-3000 12-14 / 2500-3000 8-10 / 1750-2000 6-8 / 1250-1500 6-8 / 1500-1750 8 / 1500-1750 8 / 1750-2000 10-12 / 2000-2500	12-14 / 2000-2500 8-10 / 1500-1750 8 / 1250-1500 8-10 / 1500-1750 10-12 / 1750-2000	14 / 2000-2500 12-14 / 1750-2000 10-12 / 1500-1750 8-10 / 1250-1500 6-8 / 1000-1250 16-14 / 2000-2500 8 / 1000-1125 12 / 1750-2000	14 / 1750-2000 12-14 / 1500-1750 10-12 / 1250-1500 8-10 / 1000-1250 16-14 / 1750-2000 11 / 1250-1500 12 / 1500-1750	14 / 1500-1750	16 / 1500-1750 12-14 / 1250-1500 10-12 / 1000-1250 11 / 1000-1250 16-14 / 1500-1750 8-10 / 900-1000

Pluvio-thermal indices	KL 11	KL 12	KL 13	KL 14	KL 15	KL 16	KL 17	KL 18	KL 19
Quotient spans x 100	1.01-1.10	1.11-1.20	1.21-1.30	1.31-1.40	1.41-1.50	1.51-1.60	1.61-1.70	1.71-1.80	1.81-1.90
Spans of temperature and precipitation °C / mm	14-16 / 1250-1500 14 / 1250-1500 8-10 / 800-900 15 / 1250-1500	16 / 1250-1500 12-14 / 1000-1250 11 / 900-1000 10-12 / 900-1000 8-10 / 700-800 16 / 1250-1500	14 / 1000-1250 11 / 800-900	14-16 / 1000-1250 12-14 / 900-1000 15 / 1000-1250	16 / 1000-1250 14 / 900-1000 11 / 700-800	14-16 / 900-1000 12-14 / 800-900	16 / 900-1000 14 / 800-900 11 / 600-700	14-16 / 800-900 12-14 / 700-800	16 / 800-900 14 / 700-800

ferences result from locally conditioned site conditions such as the properties of litostratigraphic parent substratum rocks, hydrological conditions, microclimate impact, past management, as well as from other ecological - anthropogenous influences. A further reason is the elaboration of the Climate Atlas. It was made on the basis of data gathered by measuring the value of climatic elements and phenomena at weather stations located in all the major towns in Croatia (cca 75 stations), very rarely out of urban settlements (Sljeme-Puntijarka on Medvednica near Zagreb, Zavižan on Velebit). Data for the regions between stations were obtained by interpolation and also by application of physical laws and knowledge of changes in the atmosphere depending on changes of altitude. At the time when the weather stations were being established, it was almost impossible to establish more stations in forests because of their distance from communication links. In the future the establishment of a weather stations network will be possible due to the development of measuring techniques.

Then the pluviothermal climate favourableness but also point to the main ecological parameters of the distribution of forest and other life communities to the real and possible (potential) climazonality of biocoenoses.

The climate favourableness indices have been determined on the basis of pluviothermal quotient, but besides the amount of precipitation, their annual distribution is also relevant. Precipitation distribution is, thus, only the first of index correction.

Although recognizing the necessity of introducing correction, in this first step in the determination of climate favourableness, this was not possible. The Croatian Climate Atlas does not contain the spatial distribution of different precipitation patterns during the year, nor the wind speed and direction distribution. These data are given only for climatological stations and refer only to particular locations and not to areas defined by borders as the case is with temperatures and amount of precipitation (isotherms and isohyets).

The elaboration of the index map of Gorski Kotar, scale 1:100.000, including correction factors has already begun in collaboration with the Meteorological and Hydrological Service in Zagreb and the Forest Research Institute in Jastrebarsko. The map will be published in 1994. The method of application of the correction index for climate favourableness for the forest vegetation of Croatia will be described.

RELATIVE INDEX VALUES

The highest climate favourableness index (KL-10) has been attributed the highest value among other indices, while the lowest favourableness indices (KL-1) and KL-19) have the smallest value. The value of the indices between the two extremes changes linearly, in percentage increments of 10% as shown in Figure 1 and Table 2. The indices located symmetrically in relation to the index of highest favourableness have identical value i.e. KL-9 has the same value as KL-11, KL-8 as KL-12 and KL-1 as KL-19.

Although the indices located symmetrically in relation to the KL-10 index have identical relative values, they are nevertheless presented in the index map because they, apart from climate favourableness, also present the precipitation-temperature properties of particular regions in Croatia.

Table 2. Relative index values.

Tablica 2. Relativne vrijednosti indeksa.

Index		Values (%)
KL-10		91-100
KL-9	KL-11	81-90
KL-8	KL-12	71-80
KL-7	KL-13	61-70
KL-6	KL-14	51-60
KL-5	KL-15	41-50
KL-4	KL-16	31-40
KL-3	KL-17	21-30
KL-2	KL-18	11-20
KL-1	KL-19	-10

At the back of the index map attached to this paper is a table of relative index values which differs from Table 2 in this section. The table on the map was elaborated according to a method which has in the meanwhile proved to be insufficiently justified, so a table of linear changes of index values from the most to the least favourable climate has been used instead.

THE APPLICATION OF THE CLIMATE FAVOURABLENESS INDEX

These indices can be successfully and extensively applied in ecological research, some of them being the determination of generally useful forest functions, the health condition of forest stands and the energy fund of forest types.

Generally useful forest functions

Generally useful forest functions are a benefit which a forest provides by its own existence. The forest influences out-of-the-forest areas, areas very far away, the atmosphere, the formation of climate and microclimate, the maintenance of clean water sources and many other phenomena which preserve life in its natural form. The overall value of these forests is so high that it measures with nothing else, but it is also possible to partially assess the value of its particular parts, each part individually, which is also necessary because they differ in their direct impact on the environment.

Up to now, different methods have been applied, mainly based on the estimation of particular factors of the environment (Prpić, 1992) and they are being assessed by research workers.

If pluviothermal climate favourableness indices were used for the determination of climatic values, the general benefit not only of forests but also of other natural resources could be determined by a combination of estimated and measured parameters.

The health condition of forests

One of the possibilities of demarcating natural, in particular climatic, impacts from all others is by using a map of pluviothermal climate favourableness indices for forest vegetation. This could be done by producing a map of forest communities in Croatia on the same scale as the index map (1:1,350.000), as a transparent matrix and then making the two maps overlap. If the comparison between the maps revealed that one forest community is located in an area of several different climate favourableness indices it would mean that the community is either of wide climatic (ecological) amplitude, or that the community is at places out of its natural location. This cannot be known immediately, so we would need a third chart-a map of the health condition of forests in Croatia. If we overlapped all three maps, we might expect to find an interrelation between different climate favourableness, forest community

areals and health condition. Different levels of health condition within one forest community would probably be demarcated by boundaries between different climate favourableness indices. All expectations confirmed, we would find out that the health level is a consequence of belonging to different pluviothermal regimes. Naturally, other factors too influence health, however, they would be easier to survey if we singled out climate as the crucial ecological factor in forest community distribution.

Energy fund of forest types

The concept of energetics in forestry is linked to the quantity of energy contained in organic matter produced in a forest by the assimilation process. This energy form is fixed and passive in the matter and is used only after forest exploitation, for the production of static elements (construction industry, furniture), in chemical processing (cellulose) and for energy production (fuel). However, another energy form exist in forests: life energy, the energy of the transformation of nonliving, anorganic matter into living, organic matter which, like energy itself, is released by the biological decomposition of living matter on the very spot of its genesis, in the forest.

Life energy in the forest has its source in the energy of the Sun. Forest trees and the whole world of flora takes the energy of the Sun, but unevenly, and uses it unevenly, too. We could direct natural processes to increase plant production, maintaining at the same time the stability of natural resources if we could only find out how to, most favourably, distribute the energy entering the forest, the energy which is the prima-mover and the result of life energy, together with the energy originating from decomposition.

It is possible to asses the energetic fund by determining the energy regime of particular forest communities, i.e. ecological-climatic research, by the application of new methods and new measuring instruments (Medvedović, 1991). For this purpose, microclimatic stations have been established on the Medvednica, the Bilogora and in the river Česma valley, and as soon as the first measurements become available, aerophotographing on infracolour film will be carried out. The energy regime will thus be presented by infracolour effects and by the numerical expressions of the values of microclimatic elements which are the result of the energy process. Elaboration of an energy survey will then be easy.

EVALUATION BY FORESTRY SCIENTISTS OF CLIMATE FAVOURABLENESS INDICES FOR THE FOREST VEGETATION OF CROATIA

After the forestry public had been notified of the indices of climate favourableness for the forest vegetation of Croatia (Radovi, Vol. 27, No.1, 1992, Forest Research Institute, Jastrebarsko) some of the most eminent forestry scientists asked the level of forest production in some parts of Croatia on the other side. The indices of climate favourableness were discussed in Šumarski dom (Forestry club) on 1 April 1993.

Climate favourableness can be limited to three characteristic, disconnected areas: the Pannonian Plain, Gorski Kotar and South Dalmatia.

The dominant favourableness index in the Pannonian part of Croatia is KL-13 (65% of KL-10, the index of highest favourableness). It seems unbelievable that the world famous Slavonian oak can grow in conditions of medium climate favourableness. The reason for this is the fact that in the Pannonian Plain the main ecological factor is soil water and not climate. The climate has conditioned the development of steppe-like vegetation where grassy plant species like cereals, terminate their life cycle before the summer high temperatures. Forest trees are then supplied with water from the soil and not only from the atmosphere. Recently, after ammelioration and water-stream regulation, the site water regime has changed giving climate the role of the crucial ecological factor with the consequence of a decline in the number of peduncled oak forests, the absence of seed production and difficult regeneration.

The most valuable, high production forests are located in Gorski Kotar with an index range from the least to the medium favourable (10-50% of highest favourableness). The main three species is fir. Firs in Gorski Kotar grow in six different pluviothermal climate favourableness and in all of them they are the main type of association. Other species too grow in different favourableness but are not always the main, characteristic type of association. Gorski Kotar is characterized by low climate flavourableness due to a lot of precipitation and low temperatures. This, however, has little effect on the natural value of Gorski Kotar since its beauty surpasses by far the beauty of other localities with more favourable climate. The whole living world can tolerate the unfavourable climatic conditions of the area it occupies, but this adaptation requires an effort and loss of individuals.

Among all the other species, the fir is special for its ICV-average genetic mass per chromosome (Drušković, Biološki vestnik, No. 36, Ljubljana, 1988). The fir has the highest ICV value compared to all other species, 205.13, while the sessile-flowered oak has no more than 21.67. A comparison with the sessile-flowered oak has been used because the range of sessile-flowered belongs to the index of the most favourable climate. ICV values can not for the time being be brought into relationship with climatic conditions and the health status of the fir, but this will be possible after a systematic research of the forest microclimate in Croatia.

There are regions in South Dalmatia in which, according to the map of pluviothermal indices of climate favourableness, the most favourable climate is dominant. Knowing the production potentials of these regions it seems impossible to accept the hypothesis of the most favourable climate. However, South Dalmatia

has one particularity because of which the application of correction factors to the pluviothermal (precipitation - temperature) regimes is indispensable: it is the annual distribution of precipitation and wind distribution. Precipitation is unevenly distributed during the year, i.e. the quantity of precipitation is the lowest when it is needed most, in the period of vegetation activity and the highest during vegetation passivity. The distribution of wind speed and direction is also an unfavourable ecological factor because of drainage and soil erosion. Apart from an extremely low quantity of precipitation, i.e. drought periods during the vegetation period, another phenomenon is present: the low efficiency of precipitation. Rain has no effect on vegetation, i.e. on soil humidity, if the air temperature is above and air humidity below limit values at the moment of rainfall. The limit values of precipitation and temperature amounts are not given at the present moment, but this will be done after the first year of stand phytoclimate research in Croatia.

The precipitation in the discussion agreed that the whole idea of indices of climate favourableness was a significant contribution to the development of science and that in future research other climatic elements should also be included.

CONCLUSIONS

The data of Meteorological and Hydrological Service in Zagreb present a remarkable value because they provide not only an insight into climatic properties of particular areas in Croatia, but they also contribute to the development of ecological sciences.

On the basis of the climatic data of the Climate Atlas, a new concept has been set in the Forestry Research Institute, Jastrebarsko (Medvedović, 1992): "Pluviothermal climate favourableness indices for forest vegetation" and the indices distribution in Croatia have been presented on a chart, scale 1:1,350.000.

The relative values of indices were determined by a common graphical system and the relation between the highest and lowest climate favourableness index is 10:1.

The indices can successfully be applied in research on climate and its impact on vegetation and for ecological research in general.

REFERENCES

Bertović S. (1975) Prilog poznavanju odnosa klime i vegetacije u Hrvatskoj. *Acta biologica* **VII**, Zagreb.

Cestar D., Cindrić Ž., Hren V., Kovačević Z., Martinović J., Pelcer Z. (1970) Tipološko istraživanje i kartiranje šuma i šumskih staništa Hrvatske. Savjetovanje o tipološkim istraživanjima u Hrvatskoj, *"Radovi"* **16**, svezak **4**, Šumarski institut, Jastrebarsko, Zagreb.

Emberger L. (1942) Un project d'une classification des climats du point de vue phytogeogrephique. Toulouse.

Horvat I. (1949) Nauka o biljnim zajednicama. Zagreb.

Horvat I., Glavač V., Ellenberg H. (1974) Vegetation Sudosteuropas. Stuttgart.

Medvedović J. (1991) Sinekologija zajednica obične jele (Abies alba Mill.) u sjevernoj Hrvatskoj i floristički parametri važni za gospodarenje bukovo-jelovim šumama. *Dizertacija*. Zagreb.

Medvedović J. (1991) Microclimatic research using new methods and new measure instrument. *10. svjetski kongres šumarstva.*

Medvedović J. (1992) Pluviotermički indeksi povoljnosti klime za šumsku vegetaciju. *Radovi* **27**, **1**. Šumarski institut, Jastrebarsko, Zagreb.

Prpić B. (1975) Posljedice promjene šumske fitoklime u ekosustavu poplavne šume hrasta lužnjaka. *Centar za znanstveni rad Vinkovci*, **II**. Zagreb.

Prpić B. (1992) O vrijednosti općekorisnih funkcija šume. *Šumarski list*, **6-8**. Zagreb

Rauš Đ., Trinajstić I., Vukelić J., Medvedović J. (1992) Biljni svijet hrvatskih šuma. *Monografija "Šume u Hrvatskoj"*, Zagreb.

Republički sekretarijat za urbanizam, građevinarstvo, stambene i komunalne poslove, u suradnji sa Republičkim hidrometeorološkim zavodom (1975) Atlas klime Hrvatske. Zagreb.

Šugar I. et al. (1964-1989) Vegetacijska karta Hrvatske. *Manuskript u Botaničkom zavodu* Prirodoslovno-matematičkog fakulteta, Zagreb.

Trinajstić I., Rauš Đ., Vukelić J., Medvedović J. (1992) Vegetacijska karta šumskih zajednica Hrvatske. *Monografija "Šume u Hrvatskoj"*. Zagreb.

KARTA PLUVIOTERMIČKIH INDEKSA POVOLJNOSTI KLIME ZA ŠUMSKU VEGETACIJU HRVATSKE

CHART OF PLUVIOTHERMAL INDICES OF CLIMATE FAVOURABLENESS FOR THE FOREST VEGETATION OF CROATIA

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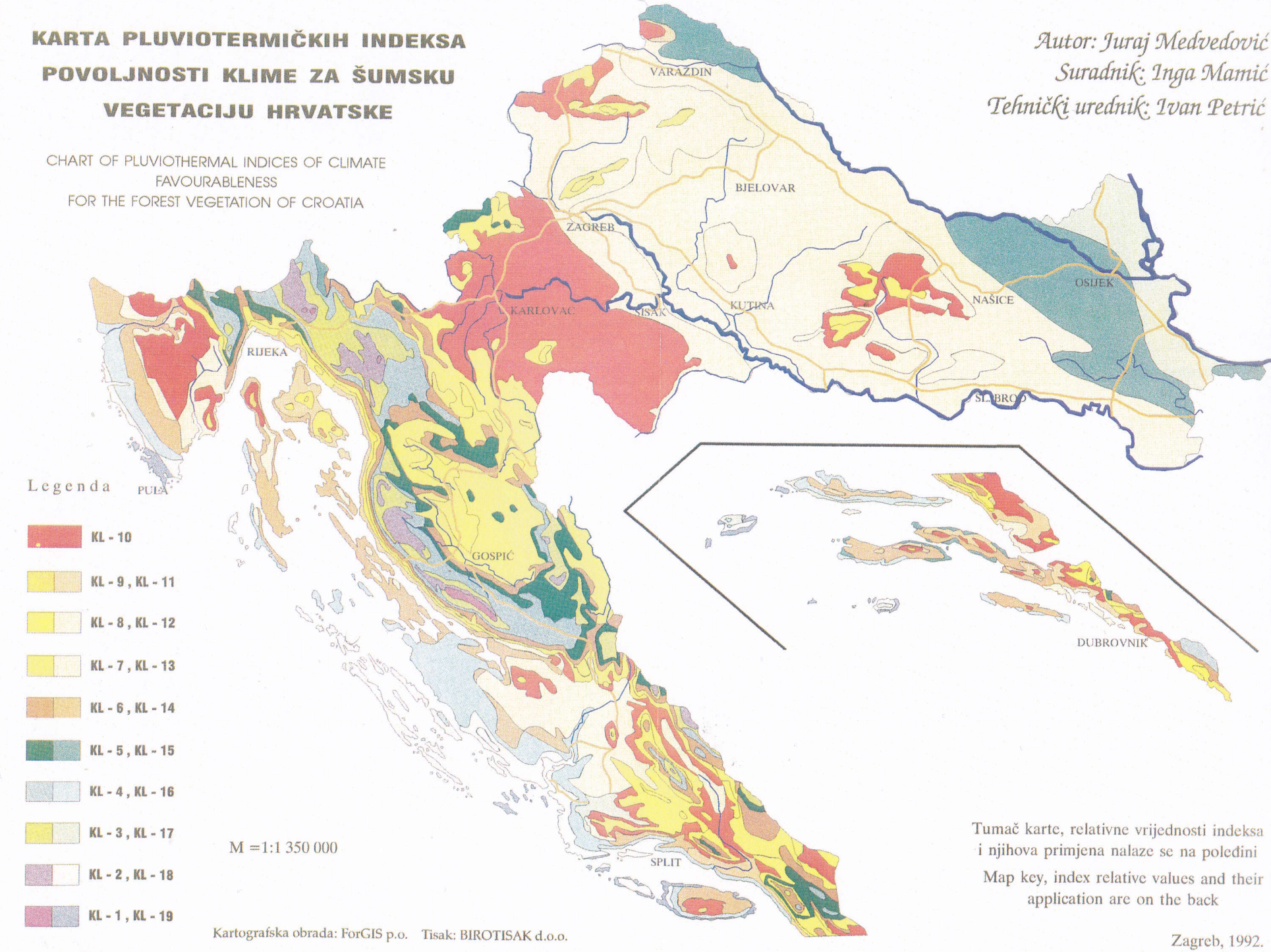

Legenda

- KL - 10
- KL - 9 , KL - 11
- KL - 8 , KL - 12
- KL - 7 , KL - 13
- KL - 6 , KL - 14
- KL - 5 , KL - 15
- KL - 4 , KL - 16
- KL - 3 , KL - 17
- KL - 2 , KL - 18
- KL - 1 , KL - 19

M =1:1 350 000

Tumač karte, relativne vrijednosti indeksa i njihova primjena nalaze se na poleđini

Map key, index relative values and their application are on the back

Kartografska obrada: ForGIS p.o. Tisak: BIROTISAK d.o.o.

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Karta pluviotermičkih indeksa povoljnosti klime za šumsku vegetaciju prikazuje prostorni raspored 19 indeksa različitih povoljnosti klime u Hrvatskoj. U legendi karte je na prvom mjestu naveden indeks najveće povoljnosti klime (KL–10), zatim indeksi manjih povoljnosti i na kraju indeksi najmanjih povoljnosti klime (KL–1 i KL–19). Najveća povoljnost klime je prikazana jednim indeksom, dok su sve manje povoljnosti prikazane sa dva indeksa, koji imaju jednako manju povoljnost u usporedbi s najvećim, jer su prema njoj simetrično smješteni. Dakle, jednaku vrijednost imaju po dva indeksa, koji su prikazani jednom bojom. Unutar jedne boje postoje dvije nijanse radi toga što indeksi osim povoljnosti prikazuju i glavne značajke klime pomoću pluviotermičkih koeficijenata (tab. 1).

Relativne vrijednosti indeksa su utvrđene na temelju jedinstvenog grafičkog sustava, koji je izrađen pomoću podataka o trajanju dnevne insolacije i indeksnog niza od 19 članova (KL–1 do KL–19). Iz grafičkog sustava su očitane relativne vrijednosti indeksa i prikazane u tablici (tab. 2).

Indeksi povoljnosti klime se primjenjuju u istraživanjima vegetacije i u ekologiji, prvenstveno za istraživanje klimatske funkcije općekorisnosti šuma, zatim za utvrđivanje zdravstvenog stanja šumskih sastojina i za utvrđivanje energetske bilance tipova šuma. Za svaku od navedenih mogućnosti primjene indeksi se koriste tako, da se prvo iz karte očita pripadnost nekog određenog mjesta indeksu povoljnosti klime, a onda, pomoću tablice (br. 2) se odredi njegova relativna vrijednost.

Tab. 1:
INDEKSI POVOLJNOSTI KLIME SA PRIPADAJUĆIM PLUVIOTERMIČKIM KOEFICIJENTIMA (×100)

Indeksi	KL–1	KL–2	KL–3	KL–4	KL–5	KL–6	KL–7	KL–8	KL–9	KL–10	KL–11	KL–12
Koeficijenti	0,01–0,10	0,11–0,20	0,21–0,30	0,31–0,40	0,41–0,50	0,51–0,60	0,61–0,70	0,71–0,80	0,81–0,90	0,91–1,00	1,01–1,10	1,11–1,20
Indeksi	KL–13	KL–14	KL–15	KL–16	KL–17	KL–18	KL–19					
Koeficijenti	1,21–1,30	1,31–1,40	1,41–1,50	1,51–1,60	1,61–1,70	1,71–1,80	1,81–1,90					

Tab. 2:
RELATIVNE VRIJEDNOSTI INDEKSA POVOLJNOSTI KLIME U ODNOSU NA INDEKS NAJVEĆE POVOLJNOSTI (KL–10)

Oznaka indeksa	Vrijednost u %
KL–10	100
KL–9 = KL–11	82
KL–8 = KL–12	73
KL–7 = KL–13	65
KL–6 = KL–14	58
KL–5 = KL–15	51
KL–4 = KL–16	44
KL–3 = KL–17	36
KL–2 = KL–18	27
KL–1 = KL–19	10

Map of pluviothermal indices of climate favourableness for forest vegetation shows the distribution of 19 indices of diffe rent climate favourableness in Croatia. In the map key the first stated index is the index of highest climate favourableness (KL–10), then follow indices of lower favourableness and in the end indices of lowest climate favourableness (KL–1 and KL–19). The higgest climate favourableness is presented with one index, while all lower favourablenesses are presented with two indices whose favourableness is similarly lower as compared to the highest according to which are they symmetrically located. Thus, similar values have two by two indices presented with one colour. Within one colour there are two nuances because indices, apart from favourableness display also the main climate properties by means of pluviothermal coefficients (Tab. 1: Climate favourableness indices with corresponding pluviothermal coefficients × 100).

Relative index values are stated on the basis of uniform graphic system made by data on the duration of day-time insolation and index-line of 19 items (KL–1 to KL–19). Relative index values are read off from the graphic system and presented in table (Tab. 2: Relative index values of climate favourableness in relation to index of highest favourableness KL–10).

Climate favourableness indices are applied in research of vegetation and in ecology primarily for research of climatic function of general benefit from forests for determination of health condition of forest stands and for the determination of energy regime of forest types. For each of the stated applications indices are used in such a manner that, as a first step, the climate favourableness index is stated for some particular location and then its relative value is determined from the table (tab. 2).