# MONITORING OF THE SEASONAL PROGRESS OF VEGETATION BY THE NORMALISED PHENOLOGICAL DATA

# MONITORING SEZONSKE PRIRASTI VEGETACIJE NA PODLAGI STANDARDNIH FENOLOŠKIH PODATKOV

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## POVZETEK

Težava pri fenoloških podatkih je, da so v veliki meri nemerljivi in tako kvalitativne narave. V znanosti in tudi pri praktični uporabi se za razliko od meteoroloških parametrov, kjer zapisujemo vrednosti parametra ob določenem času, zapisuje čas, ko do določenega pojava pride - kvantificiranje fenoloških podatkov. Pri kartiranju fenoloških podatkov tako na določenem območju prikazujemo čas kot parameter, ko je bila dosežena obravnavana fenofaza rastline. V članku je obravnavan nov pristop, pri katerem bi analogno meteorološkim parametrom, tudi pri kartiranju fenoloških parametrov nanašali stopnjo razvoja vegetacije ob določenem času. Pri tem naletimo na problem, kako na nekem območju spremljati fenološki razvoj vegetacije, ki vključuje različne rastlinske vrste in kako je fenološki razvoj posameznih vrst med njimi povezan (npr. celotni travnik, gozd,...). Raziskava je na podlagi obravnavanja 6 letnih podatkov na 43 lokacijah (429 fenoloških fenofaz, 45 rastlinskih vrst - 16 dreves, 16 grmov, 21 zelišč ter enega travnika kot celote) pokazala, da vzporednost med fenološkim razvojem posameznih rastlinskih vrst ni idealna, je pa še vedno signifikantna. Osnova novega pristopa je letni fenološki koledar, ki predstavlja idealiziran časovni potek razvoja vegetacije na določenem območju oziroma v določenem kraju. Slabost fenološkega koledarja je potreba po dolgoletnih podatkih za posamezne lokacije, ki pa v večini držav niso na voljo. Zaradi namena primerjave ERS podatkov s fenološkimi podatki, so bile obravnavane fenološke faze, ki so direktno povezane z gostoto klorofila na obravnavanem območju.
Začetek vegatacijske dobe je definiran kot povprečje šestih fenoloških faz: začetek cvetenja (10 %) pri navadni jelši in lapuhu ter pojav popkov (10 %) gorskega jesena, breze, macesna in leske. Konec vegetacijske dobe pa je definiran kot povprečje petih fenofaz: konec odpadanja listov (100 %) pri macesnu, kostanju, bukvi, navadni jelši ter sivi jelši. Na podlagi klasičnih fenoloških podatkov ter ocene začetka in konca rastne dobe, je bila izdelana nova metoda, ki kot izhodni parameter podaja parameter biološki čas. Biološki čas je parameter, ki predstavlja merilo za razvojno stopnjo obravnavane vegetacije tekom leta.

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**Ključne besede:** fenološki koledar, biološki čas, navadna jelša, lapuh, gorski jesen, breza, macesen, bukev, siva jelša

## ABSTRACT

A very important disadvantage of phenology is that this type of information has qualitative nature - phenological stages and development itself represent a row of morphological or physiological events based prevailingly on change of structure and shape. Thus, phenological stage is typically a structural pattern where is nothing to measure nor count; it is purely qualitative and discontinuous function with some additional parameters - mainly time (terms of occurrence), locality, name of plant species (genotype).

Both in science and practice, use of phenological information has its most common principle in comparison with meteorological, physical or geographical quantitative variables that have the same or analogical parameters of time and /or space. What is compared in these cases, is not phenological stage itself but the parameters. It is substantial to know that pure phenological information plays here the role of qualitative constant ( e.g. .,"beginning of flowering").

In phenology , conventional mapping usually means to depict an area (using space parameters) as a field of data on terms (time parameters) of certain phenological stage, which is the same („constant") for all points of the area. The new approach considered here is to refer to development using a quantified and generalised phenological variable that should have a shape of continuous function (i.e., it gives the unique value for every point of time axis). Then, we could obtain fields („charts") where various points have various values of such phenological function for the same moment („time constant"). More commonly defined, we could dispose of a tri-dimensional matrix involving time-space information about development.

From the syn-ecological (spatial) point of view, there exist another problem connected with the discussed qualitative character of phenological information : it is question how to watch development of some important syn-ecological or phyto-geographical units (e.g., main forest formations, meadows or generally „vegetation cover" of certain area). The question is extraordinarily serious in earth remote sensing applications and modern mapping techniques, where often these vegetation units and not individual plant species are used as studied objects.

The substance of this problem is, to what extent phenological phenomena work on parallel or analogical principles at various species in a vegetation unit ; in other words, whether main tendencies in development of a species are detectable on the other species (at least selectively and with some transformation ). In a row of years, this parallelism or synergism is considered as not fully rigid, rather statistical function,

significance of which is to be tested. A special part of this heap of problems is, how reliable are these relations between wild plants and field crops; we notice here the term „phenological indicator“.

It was just the idea to apply phenological data on wild plants as the „ground truth“ for MERA/MARS project purposes, that directed us to formulate these questions. Here we felt it would be useful to test if ERS data, mainly NDVI, are in good correlation with plant development or not and, moreover, if an above mentioned hypothetical development describing function which we hope to find couldn't be connected with or built into a crop production model, such as WOFOST.

In Czech Republic, we have worked out a method that may contribute to solving of this problem. The data system we want to introduce now in a brief presentation, needs on preparatory level both operative and long-term phenological data on wild plants. The fundamental idea is based on phenological annual calendar for a certain site, which is a time row of averaged data about the occurrence of a sufficient amount of phenological phases that are distributed over the whole vegetation period from early spring to late autumn. We have found that the mentioned parallelism between species or their phases is not perfect but still significant , which has been proved by sequential tests (6 years, 43 localities, 429 phenological phases, 45 plant species - 16 trees, 8 shrubs, 21 herbs plus permanent meadow hay harvesting) .

Phenological calendars represent an idealised time plan of development of vegetation for given region or site and, practically, they were applied in a few cases in CR and probably in other countries, too.

A disadvantage of these calendars is connected with the high need of long-term data from the locality, which is a rare feature of databases in most countries. Nevertheless, a modernised approach to the „calendar“ method seems to be the best way to quantification and generalisation of phenological information. In the connection with our intention to compare somehow phenological and ERS data we oriented ourselves to such phenological phases which are narrowly connected with the density of the chlorophyll in the scanned country.

The start of the vegetation period is defined as averaged term of six phenological phases:
first flowers (10%) : common alder, coltsfoot and budding (10% ): mountain ash, birch, larch, hazelnut.
The end of the vegetation period is defined as averaged term of five phenological phases:
end of fall of the leaves (100%): larch, hornbeam, beech, common alder and grey alder.

The complete information about involved species and phases is possible to obtain from authors during this meeting as a specimen of the input file. By means of gradual testing of a row of selected expressions that were partly found in literature, partly were formulated as our hypotheses, we finally found as the best the following formal procedure :

$$SN = (SF1 + SF2 + SF3 + SF4 + SF5 + SF6) /6 ; \qquad [1]$$

$$KN = (KF7 + KF8 + KF9 + KF10 + KF11) /5 ; \qquad [2]$$

$$BTF = (NF - SN) / (KN - SN) ; \qquad [3]$$

$$BTDN = (BTFa + BTFb \ldots + BTFi)/ i ; \qquad [4]$$

$$BTDA = (BTFa + BTFb \ldots + BTFi)/ i ; \qquad [5]$$

where

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|---|---|
| SN | ng-term start of vegetation period gained from phases F1 to F6 - see above; |
| SF1, SF2, …, SF6 | long-term values of these „starting“ phases; |
| KN | long-term end of vegetation period gained from phases F7 to F11; |
| KF7,KF8,KF9,KF10,KF11 | long-term values of these „finishing“ phases; |
| BTF | biological time corresponding to given phase (its permanent value); |
| NF | long-term value of the given phase; |
| BTDN | biological time corresponding to given day (its permanent value); |
| BTFa, BTFb, ..., BTFi | BTF - values of the phases long-term averages of which fall on the given day; |
| BTDA | actual value of the biological time for the given day; |
| BTFa, BTFb, ..., BTFi | BTF -values of the phases actual terms of which fall on the given day. |

According to our conception ,the gained time row of the BTDN values create contents of the term „biological time“, briefly „biotime“. Practically , the most important is the fact, that comparison with analogical actual time row composed of BTDA values and representing actual year is easy possible. The obtained differences express quantitatively the acceleration or deceleration of the development of the vegetation during actual year.

Recently, the software enabling computation of the biotime was finished (KALEND_7) and a few years have been already worked out. Final results including ERS data are planned to be obtained during the next year.