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THE FORMAL-ANALYTICAL DESCRIPTION OF WOOD FOR THE PURPOSES OF THE CLASSIFICATION OF WOOD SPECIES. PART 2. WOOD FORMULAS

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ABSTRACT

The structure of wood can be examined at several qualitatively different levels of consideration (macro, meso, micro and nano). Each of these levels can be considered as a separate, single and relatively independent subsystem in the wood structure. They are determined by the characteristics of the species, the ecology of the global, regional and local habitats. Each of these levels requires a separate, more precise and comprehensive classification. If the quantities and distribution of the main tissues are known, the tree species can be grouped in groups of construction and conclusions can be made about its physical and mechanical properties.

This work examines the possibility for a more in-depth formal-analytical description of the individual tree species and a theoretical representation of wood structure that more adequately reflects its characteristic features.

Key words: wood, structure, levels, vessels, core rays, fibers, parenchyma, wood formulas.

INTRODUCTION

Wood can be examined at different levels, which show its structure in different ways. At the macro level – we describe what we see with the naked eye, or at a magnification of 2–5×. At the meso level, some of the anatomical features (parenchyma, core rays, resin channels, etc.) can be described, here the magnification is 10–15×.

Optical microscopes with reflected light are used and some of the macro features, such as the wood colour, can be combined. Wood can be described in the most detailed way at the micro level. Here the magnification is 25–50×, and all the tissues, forming the wood, can be well observed. They can be measured quantitatively and their structure determined precisely.

The main wood tissues can be represented by symbols, as follows: conductive tissue – "Ct" ("conductive tissue"); mechanical – "Mt" ("mechanical tissue"); reserve with "Rt" ("reserve tissue"). Another tissue should also be mentioned here – the secretory tissue. These are the various resin canals and ducts found in most coniferous as well as in some deciduous species. It can be labeled "St" ("secretory tissue"). However, the reserve tissue is divided into longitudinal and transversal one. Their symbols can be written: "LRt" (longitudinal) and "TRt" (transversal). Quantitative indicators of these tissues can be recorded as an index of each of these symbols.

WOOD FORMULAS REPRESENTING WOOD AS A COMPLEX OF TISSUES

Modern methods for scanning and examining the structure can calculate the distribution of individual tissues with sufficient accuracy. For example, a Scots pine can be written by the following tree formula:

$$Ct_{63}Mt_{26}LRt_{0,0}TRt_{5,5}St_{1,5} \quad \textbf{(1)}$$

Which shows that this species has 63% early wood, 26% late wood, no longitudinal parenchyma, but has 5.5% transversal parenchyma (core rays) and 1.5% secretory tissue (resin canals).

When recording wood in general, this type of record works, but important details are omitted here, without which the tree species will be difficult to distinguish from each other. It is necessary to find a possibility (even a small one) to present the wood structure taking into account an important characteristic of the structure of coniferous (and not only) wood – the transition between early and late wood.

It could be recorded as a separate item "Tt" ("transitional wood"). This record will represent better and more fully coniferous wood. Small values of the "Tt" index is going to show species with sharp transition between early and late wood – larch (*Larix*), pine (*Pinus*) and others. The medium values can refer to Douglas fir (*Pseudotsuga*), cedars (*Cedrus*), etc., and the large values to spruce (Picea) and fir (*Abies*) species. This index can also be used for deciduous species, especially for the ring-porous ones. They also have some form of transition, which must be described correctly, due to their proximity to wood with a transitional structure (especially with semi-ring-porous). Here, however, immediately stands out the need to describe the vessel diameter as well. The reason is that a distinction must be made between ring-porous and semi-diffuse-porous species, in which there is also an accumulation of vessels in the early wood, but they are much smaller in diameter than those of the ring-porous.

Even within the group of diffuse-porous species the structure of the annual ring may be a serious difference between the species. Here the value of the index will be high, because the ring can be divided into three parts, while in the tropics this index will be equal to "0". A solution to this problem is to indicate the construction group by the author examining the sample. Here, however, the quantitative assessment is replaced by a qualitative one, and the objective assessment by a subjective one.

Resin canals, as the main diagnostic feature of coniferous species, also have qualitative indicators (for example, the condition of the cell walls of the constructive parenchyma), which must be described by quantitative methods. It can be added to the record according to the third condition in addition to the number of resin channels in % and their location in the annual ring, starting from its beginning - ⅓, ½, ⅔ or ¾.

With the inclusion of the transition zone, the construction group and the location of the resin channels, the wood formula of the pine wood (1) will get the form:

$$ICt_{63}Tt_{4,0}Mt_{26}LRt_{0,0}TRt_{5,5}St_{1,5\ ¾}. \quad \textbf{(2)}$$

In ring-porous, in addition to the "II" symbol, the values for early wood will be much smaller and similar (at a normal ring width) for most members of the group. This will also help the record difference with other construction groups. In addition, the structure for the annual ring can be supplemented with the indicator "EW" (early wood) and "LW" (late wood).

The "TtW" indicator may remain for the transition wood. The amount of conductive tissue can be recorded before the "EW" symbol. It is important to be noted that there is a difference between mechanical and reserve tissue in early and late wood. However, these differences will be difficult to be shown by the ring structure record. Rather, the vessel will be described as far as possible.

Regarding the type of parenchyma, "AP" (apotracheal) or "PP" (paratracheal) may be added as an index to the symbol "LRt10". Then the record will look like this (for example, for ash (*Fraxinus*):

$$IICt_{14EW25}Ct_{TW7}Ct_{LW68}Mt_{62}LRt_{AP4,0}LRt_{PP5,0}TRt_{15}St_{0,0}. \quad \textbf{(3)}$$

Which shows that the recorded species is ring-porous, with 14% conductive tissue, of which 25% are vessels in the early wood, 7% vessels in the transition zone, vessels in late wood occupy 68% of the annual ring, 62% mechanical tissue, 4% longitudinal apotracheal parenchyma, 5% longitudinal paratracheal parenchyma, 15% transverse parenchyma (core rays) and lack of excretory tissues.

In diffuse-porous species, the main difficulty is how to record the transition zone, because in some of them there is indeed a noticeable transition between early and late wood, while in others one can only determine the difference in the vessels located at the beginning, middle and end of the ring.

The ring can then be divided into three zones, approximately determining the size of each one. In addition, we know from previous experience that the longitudinal parenchyma is very difficult to determine. Therefore, the following record of a wood formula of beech (*Fagus*) can be suggested:

$$IIICt_{17EW30}Ct_{TW50}Ct_{LW20}Mt_{62}LRt_{AP8,0}\ LRt_{PP0,0}TRt_{13}St_{0,0}. \quad \textbf{(4)}$$

It shows a species with diffuse-porous wood, having 17% conductive tissue, 30% of its vessels are in the early wood, 50% are in the middle of the ring and 20% are at the end of the ring (where the vessels are small and few in number). In addition, the mechanical tissue is 62%, 8% longitudinal apotracheal parenchyma, 0% longitudinal paratracheal parenchyma, 13% transverse parenchyma (core rays) and lack of excretory tissues.

Some tropical species (*Anisoptera*, *Shorea*, etc.) have resin canals. Unfortunately, their location, which is very typical for meranti, cannot be recorded. There is no way to record the possible groups formed by the resin canals. It is well known that in some species (*Sh. gratissima, Sh. laevis*) they are arranged in a continuous tangential strip, in others (*Sh. maxwelliana*) they are in short tangential strips, and in *Anisoptera* they are located mainly alone or in small groups.

However, this would significantly complicate the reading of the information. Therefore, the record of the tree formula should be described as follows (Meranti):

$$IVCt_{26EW0,0}Ct_{TW0,0}Ct_{LW0,0}Mt_{45}LRt_{AP7,0}LRt_{PP4,0}TRt_{16}St_{2,0}. \quad \textbf{(5)}$$

It shows tropical wood having 26% conductive tissue evenly spaced (ie no outlined early, transitional and late wood). The mechanical tissue is 45%, the longitudinal apotracheal parenchyma is 7%, the paratracheal parenchyma is 4%, and the transverse parenchyma (ie core rays) is 16%. Secretory tissues occupy 2%.

REFINING WOOD FORMULAS

If we try to comply with the conditions set out in the first part of the article, we can further refine the records of the tree formulas. This will of course complicate the formula itself, but it will make it possible to describe some quantitative and qualitative features. Only practice can show the extent to which these records can be used.

The grouping of the late vessels, which are the main feature of circular-porous wood (quality feature) can also be added to the record of wood formulas. An index from "a" to "g" related to the diameter of the vessels and an index from "I" to "VI" for their density can be added to the symbol "$Ct_{LW0,0}$". These two indicators have been studied mainly in early and late wood, so they will be included only in them.

Then the record (3) will take the form:

$$IICt_{14EW25gIV}Ct_{TW7}Ct_{LW68aV}Mt_{62}LRt_{AP4,0}LRt_{PP5,0}TRt_{15}St_{0,0}. \quad (6)$$

To describe the core rays more fully, an index from "a" to "h" indicating the relative position of the rays and an index from "I" to "V" for the density can be added to the symbol for the transverse parenchyma "TRt". Then the record (6) will take the form:

$$IICt_{14EW25gIV}Ct_{TW7}Ct_{LW68aV}Mt_{62}LRt_{AP4,0}LRt_{PP5,0}TRt_{15eII}St_{0,0}. \quad (7)$$

In the tropical species there is no difference between the density and size of the vessels within the observed section (detail). Therefore, an index of "0,0" should be added to the "$Ct_{EW}Ct_{TW}Ct_{LW}$" symbols to emphasize the absence of an early, late and transitional zone. Then the grouping, diameter and density of the vessels indices can be added after the "Ct_{EW}" symbol. Rays indices will be added after "TRt".

This will make Shorea's record look like:

$$IVCt_{26EW0,0eII}Ct_{TW0,0}Ct_{LW0,0}Mt_{45}LRt_{AP7,0}LRt_{PP4,0}TRt_{16bII}St_{2,0}. \quad (8)$$

When wood is examined at a higher magnification, mechanical cells can be described more accurately. To describe the dimensions and wall thickness of the fibers, the symbol "Mt62" must be supplemented by "a" to "e" for the diameter of the fibers and from "I" to "V" for their wall thickness.

To describe the wood density, to the symbol "Dt" must be added from "a" to "e". Then the proposed records of the wood formulas will look like and be read like this:

$$ICt_{63}Tt_{4,0}Mt_{26}LRt_{0,0}TRt_{5,5}St_{1,5\ ¾}Dt_{b}. \quad (9)$$

1 2 3 4 5 6 7 8

Coniferous tree species (1) with early wood occupying 63% of the ring width (2), with a abrupt transition between early and late wood occupying 4.0% of the ring width (3), and an average amount of late wood occupying 26% of the width of the ring (4), without a longitudinal parenchyma in the wood (5), the core rays occupy 5.5% (6), the resin channels occupy 1.5% of the volume of the wood, located at ¾ from the beginning of ring (7), the wood is light (8) (*Pinus sp.*).

$$IICt_{14EW25gIV}Ct_{TW7,0}Ct_{LW68aV}Mt_{62cII}LRt_{AP4,0}LRt_{PP5,0}TRt_{15eII}St_{0,0}Dt_{d}. \quad (10)$$

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Ring-porous tree species (1) with conductive tissue occupying 14% of the volume of the wood (2), the early wood occupies 25% of the width of the ring (3), with very large early vessels located in high density (4), with an abrupt transition between early and late wood, occupying 7.0% of the width of the ring (5), and a significant amount of late wood occupying 68% of the width of the ring (6), with late vessel located singly and with very high density (7), the mechanical tissue occupies 62% of the volume of wood, the fibers are medium in diameter and thin-walled (8), the longitudinal parenchyma is apotracheal, which occupies 4.0% of the volume of wood (9) and paratracheal, which occupies

5.0% of the volume of the wood (10), the core rays occupy 15% of the wood volume (11) as they are low and narrow and have a low density (12) in the wood there are no resin channels (13), the wood is heavy (14) (*Fraxinus sp.*).

$$IIICt_{17EW30bVI}Ct_{TW50}Ct_{LW20}Mt_{62cIV}LRt_{AP8,0}LRt_{PP0,0}TRt_{13hIII/I}St_{0,0}Dt_{d}. \quad \textbf{(11)}$$

1 2 3 4 5 6 7 8 9 10 11 12 13

Diffuse-porous wood species (1) with conductive tissue occupying 17% of the volume of wood (2), early wood occupies 30% of the width of the ring (3), with small early vessels located with hyper high density (4), the main part of the ring is occupied by the transition zone - about 50% of the width of the ring (5) and a small amount of late wood, occupying 20% of the width of the ring (6), mechanical tissue occupies 62% of the volume of wood, the fibers are medium in diameter and thick-walled (7), the longitudinal parenchyma is apotracheal, which occupies 8.0% of the volume of wood (8) and no paratracheal parenchyma (9), the core rays occupy 13% of the volume of wood (10), as they are from low and narrow with medium density to wide with very low density (11), there are no resin channels (12), the wood is heavy (13) (*Fagus sp.*).

$$IVCt_{26EW0,0e,d\text{-}gII}Ct_{TW0,0}Ct_{LW0,0}Mt_{45b\text{-}eII}LRt_{AP7,0}LRt_{PP4,0}TRt_{16bII}St_{2,0}Dt_{c}. \quad \textbf{(12)}$$

1 2 3 4 3 3 5 6 7 8 9 10 11 12

The tree species has a tropical structure (1), as the conducting tissue occupies 26% of the volume of the wood (2), there are no areas with early, late and transitional wood (3), with very large vessels ranging from large to hyper large, located with low density (4), the mechanical tissue occupies 45% of the volume of wood (5), as the fibers are from small to very large in diameter and thin-walled (6), the longitudinal parenchyma is apotracheal, which occupies 7.0% of the volume of wood (8) and paratracheal, which occupies 4.0% of the volume of wood (8), the core rays occupy 16% of the volume of wood (10) and they are of low and narrow, which have a low density (10), the resin channels occupy 2.0% of the wood volume (11), the wood is medium heavy (12) (*Shorea sp.*).

Table 1: Tree formulas of the most commonly used tree species in our country

I. Coniferous	
Pinus silvestris	$ICt_{63}Tt_{4,0}Mt_{26}LRt_{0,0}TRt_{5,5e}St_{1,5\ ¾}Dt_{b}$
Pinus nigra	$ICt_{54}Tt_{5,0}Mt_{34}LRt_{0,0}TRt_{5,3e}St_{1,7\ ¾}Dt_{c}$
Pinus peuce	$ICt_{65}Tt_{7,0}Mt_{22}LRt_{0,0}TRt_{5,1e}St_{0,9\ ½}Dt_{a}$
Pinus strobus	$ICt_{89}Tt_{1,0}Mt_{5,0}LRt_{0,0}TRt_{4,5e}St_{0,5\ ¾}Dt_{a}$
Picea abies	$ICt_{68}Tt_{10}Mt_{15}LRt_{1,0}TRt_{4,6e}St_{1,4\ ¾}Dt_{b}$
Pseudotsuga douglasii	$ICt_{45}Tt_{5,0}Mt_{43}LRt_{0,0}TRt_{5,8e}St_{1,2\ ¾}Dt_{c}$
Larix europeae	$ICt_{53}Tt_{3,0}Mt_{35}LRt_{0,0}TRt_{8,5e}St_{0,5\ ¾}Dt_{c}$
Abies alba	$ICt_{55}Tt_{9,0}Mt_{25}LRt_{1,5}TRt_{9,5a}St_{0,0}Dt_{a}$
Sequoiadendron giganteum	$ICt_{60}Tt_{6,0}Mt_{23}LRt_{3,0}TRt_{8,0a}St_{0,0}Dt_{a}$
Juniperus communis	$ICt_{42}Tt_{8,0}Mt_{33}LRt_{3,0}TRt_{14a}St_{0,0}Dt_{d}$
Taxus baccata	$ICt_{38}Tt_{6,0}Mt_{42}LRt_{0,0}TRt_{14a}St_{0,0}Dt_{d}$
II. Ring-porous	
Ailanthus glandulosa	$IICt_{15EW25gIV}Ct_{TW7,0}Ct_{LW68bIII}Mt_{50cII}LRt_{AP2,0}LRt_{PP2,0}TRt_{31fII}St_{0,0}Dt_{d}$

Fraxinus excelsior	$IICt_{14EW35gIV}Ct_{TW3,0}Ct_{LW62aV}Mt_{62cII}LRt_{AP4,0}LRt_{PP5,0}TRt_{15eII}St_{0,0}Dt_{d}$
Gleditschia triacanthos	$IICt_{13EW30dII}Ct_{TW2,0}Ct_{LW68bII}Mt_{50bIII}LRt_{AP1,0}LRt_{PP3,0}TRt_{33fII,III}St_{0,0}Dt_{c}$
Robinia pseudoacacia	$IICt_{12EW20dII}Ct_{TW15,0}Ct_{LW65bII}Mt_{58aIV}LRt_{AP0,0}LRt_{PP3,0}TRt_{27fII}St_{0,0}Dt_{d}$
Morus alba	$IICt_{18EW25eIV}Ct_{TW5,0}Ct_{LW70bIV}Mt_{50bIII}LRt_{AP0,0}LRt_{PP3,0}TRt_{29fII}St_{0,0}Dt_{c}$
Celtis australis	$IICt_{22EW33eIV}Ct_{TW7,0}Ct_{LW60bIV}Mt_{50c,dIII}LRt_{AP0,0}LRt_{PP8,0}TRt_{20cII}St_{0,0}Dt_{d}$
Ulmus campestris	$IICt_{27EW30cIV}Ct_{TW2,0}Ct_{LW68bVI}Mt_{51a,bV}LRt_{AP1,0}LRt_{PP2,0}TRt_{19fII,III}St_{0,0}Dt_{d}$
Vitis vinifera	$IICt_{29EW32gVI}Ct_{TW2,0}Ct_{LW66bVI}Mt_{48cIII}LRt_{AP1,0}LRt_{PP1,0}TRt_{21dII}St_{0,0}Dt_{c}$
Castanea sativa	$IICt_{23EW28gIV}Ct_{TW12}Ct_{LW60cIV}Mt_{56b,c,dII}LRt_{AP0,5}LRt_{PP0,7}TRt_{20aIII}St_{0,0}Dt_{c}$
Quercus robur	$IICt_{21EW25gIII}Ct_{TW10}Ct_{LW65cV}Mt_{52a,b,c,dIV}LRt_{AP5,0}LRt_{PP22}TRt_{20iIII,I}St_{0,0}Dt_{d}$
III. Diffuse-porous	
Fagus silvatica	$IIICt_{17EW30bVI}Ct_{TW50}Ct_{LW20}Mt_{62cIV}LRt_{AP8,0}LRt_{PP0,0}TRt_{13hIII/I}St_{0,0}Dt_{d}$
Platanus orientalis	$IIICt_{23EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{51a,b,cIII}LRt_{AP9,0}LRt_{PP0,0}TRt_{17dI}St_{0,0}Dt_{c}$
Acer pseudoplatanus	$IIICt_{15EW34bVI}Ct_{TW33}Ct_{LW33}Mt_{76cIII}LRt_{AP2,0}LRt_{PP1,0}TRt_{6cII,III}St_{0,0}Dt_{d}$
Alnus glutinosa	$IIICt_{19EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{58bII}LRt_{AP3,0}LRt_{PP0,0}TRt_{20aIV}St_{0,0}Dt_{b}$
Carpinus betulus	$IIICt_{22EW40bIV}Ct_{TW40}Ct_{LW20aVI}Mt_{62bV}LRt_{AP2,0}LRt_{PP0,0}TRt_{14bIII}St_{0,0}Dt_{d}$
Aesculus hippocastanum	$IIICt_{9EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{76a,b,cII}LRt_{AP2,5}LRt_{PP0,5}TRt_{12aIII,IV}St_{0,0}Dt_{c}$
Populus tremula	$IIICt_{26EW20bVI}Ct_{TW60}Ct_{LW20}Mt_{61b,c,dII}LRt_{AP1,0}LRt_{PP0,0}TRt_{12aIII}St_{0,0}Dt_{b}$
Salix alba	$IIICt_{19EW20bVI}Ct_{TW60}Ct_{LW20}Mt_{71a-eII}LRt_{AP1,0}LRt_{PP0,0}TRt_{9,0aIII}St_{0,0}Dt_{a}$
Tilia cordata	$IIICt_{17EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{72a,b,cIII}LRt_{AP1,0}LRt_{PP0,0}TRt_{10bI}St_{0,0}Dt_{c}$
Betula pendula	$IIICt_{21EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{62a,b,cIII}LRt_{AP1,0}LRt_{PP0,0}TRt_{16bIV}St_{0,0}Dt_{c}$
Pyrus communis	$IIICt_{20EW40aVI}Ct_{TW40}Ct_{LW20}Mt_{50a,b,cIV}LRt_{AP8,0}LRt_{PP0,0}TRt_{22bIII}St_{0,0}Dt_{d}$
Malus silvestris	$IIICt_{19EW40bVI}Ct_{TW40}Ct_{LW20}Mt_{55a,b,cIV}LRt_{AP3,0}LRt_{PP0,0}TRt_{23bIII}St_{0,0}Dt_{d}$
IV. Tropical	
Aucoumea klaineana	$IVCt_{19EW0,0g,b-gIII}Ct_{TW0,0}Ct_{LW0,0}Mt_{66a-eII}LRt_{AP0,0}LRt_{PP2,0}TRt_{13bI,II}St_{0,0}Dt_{a}$
Entandrophragma cylindricum	$IVCt_{20EW0,0c,b-eIII}Ct_{TW0,0}Ct_{LW0,0}Mt_{50a-eIII}LRt_{AP2,0}LRt_{PP14}TRt_{14bI,II}St_{0,0}Dt_{c}$
Eucalyptus diversicolor	$IVCt_{21EW0,0c,a-dII}Ct_{TW0,0}Ct_{LW0,0}Mt_{49a-cIII}LRt_{AP6,0}LRt_{PP10}TRt_{14bIII}St_{0,0}Dt_{d}$
Khaya ivorensis	$IVCt_{18EW0,0d,a-eII}Ct_{TW0,0}Ct_{LW0,0}Mt_{57a-eII}LRt_{AP1,0}LRt_{PP3,0}TRt_{21cI,II}St_{0,0}Dt_{b}$
Nesgordonia papaverifiera	$IVCt_{22EW0,0b,a-cIV}Ct_{TW0,0}Ct_{LW0,0}Mt_{34a-cIII}LRt_{AP2,0}LRt_{PP23}TRt_{19bII}St_{0,0}Dt_{d}$
Swietenia macrophylla	$IVCt_{9,0EW0,0c,b-dII}Ct_{TW0,0}Ct_{LW0,0}Mt_{74b-eII}LRt_{AP1,0}LRt_{PP3,0}TRt_{13bII}St_{0,0}Dt_{c}$
Anisoptera cochinchinensis	$IVCt_{24EW0,0c,a-eII}Ct_{TW0,0}Ct_{LW0,0}Mt_{30a-dV}LRt_{AP1,0}LRt_{PP7,0}TRt_{37cI,II}St_{1,0}Dt_{d}$
Piptadeniastrum africanum	$IVCt_{17EW0,0d,b-eI}Ct_{TW0,0}Ct_{LW0,0}Mt_{48a-dII}LRt_{AP3,0}LRt_{PP20}TRt_{12cII}St_{0,0}Dt_{d}$
Pterocarpus soyauxii	$IVCt_{15EW0,0c,a-dI}Ct_{TW0,0}Ct_{LW0,0}Mt_{55a-cIV}LRt_{AP2,0}LRt_{PP14}TRt_{14eII,III}St_{0,0}Dt_{e}$
Shorea polysperma	$IVCt_{26EW0,0e,d-gII}Ct_{TW0,0}Ct_{LW0,0}Mt_{45b-eII}LRt_{AP7,0}LRt_{PP4,0}TRt_{16bII}St_{2,0}Dt_{c}$
Tieghemella heckelii	$IVCt_{23EW0,0c,b-eIII}Ct_{TW0,0}Ct_{LW0,0}Mt_{38a-eII}LRt_{AP16}LRt_{PP0,0}TRt_{23bII,III}St_{0,0}Dt_{c}$
Antiaris africana	$IVCt_{13EW0,0d,c-gII}Ct_{TW0,0}Ct_{LW0,0}Mt_{56a-dII}LRt_{AP0,0}LRt_{PP12}TRt_{19bII}St_{0,0}Dt_{a}$
Chlorophora excelsa	$IVCt_{11EW0,0d,b-gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{56a-eII,III}LRt_{AP8,0}LRt_{PP10}TRt_{15fII}St_{0,0}Dt_{c}$
Lovoa trichilioides	$IVCt_{19EW0,0c,b-dII}Ct_{TW0,0}Ct_{LW0,0}Mt_{60a-dIII}LRt_{AP2,0}LRt_{PP2,0}TRt_{17fII}St_{0,0}Dt_{c}$
Pterygota macrocarpa	$IVCt_{10EW0,0d,c-eI}Ct_{TW0,0}Ct_{LW0,0}Mt_{47a-eII}LRt_{AP17}LRt_{PP5,0}TRt_{20gI}St_{0,0}Dt_{b}$
Sterculia oblonga	$IVCt_{13EW0,0e,c-gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{40a-cV}LRt_{AP4,0}LRt_{PP30}TRt_{13dI}St_{0,0}Dt_{d}$
Turraeanthus africana	$IVCt_{15EW0,0c,b-dII}Ct_{TW0,0}Ct_{LW0,0}Mt_{75b-eII}LRt_{AP0,0}LRt_{PP3,0}TRt_{7,0bI,II}St_{0,0}Dt_{b}$
Alstonia congenzis	$IVCt_{11EW0,0c,b-dII}Ct_{TW0,0}Ct_{LW0,0}Mt_{62a-eII}LRt_{AP6,0}LRt_{PP2,0}TRt_{18eII}St_{1,0}Dt_{b}$
Gonystylus bancanus	$IVCt_{10EW0,0c,b-dIII}Ct_{TW0,0}Ct_{LW0,0}Mt_{72a-eIII}LRt_{AP0,0}LRt_{PP6,0}TRt_{12aII,III}St_{0,0}Dt_{c}$
Ochroma lagopus	$IVCt_{4,0EW0,0d,c-dI}Ct_{TW0,0}Ct_{LW0,0}Mt_{4a-dII}LRt_{AP72}LRt_{PP2,0}TRt_{18cI}St_{0,0}Dt_{a}$
Pycnanthus angolensis	$IVCt_{4,0EW0,0e,d-gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{58a-eI,II}LRt_{AP0,0}LRt_{PP10}TRt_{28bII}St_{0,0}Dt_{b}$
Terminalia superba	$IVCt_{12EW0,0d,b-gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{62a-eII}LRt_{AP1,0}LRt_{PP9,0}TRt_{16eII,III}St_{0,0}Dt_{c}$

Triplochiton scleroxylon	$IVCt_{10EW0,0d,b\text{-}gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{35a\text{-}eIV}LRt_{AP24}LRt_{PP7,0}TRt_{24cII}St_{0,0}Dt_{a}$
Afzelia bipindensis	$IVCt_{12EW0,0d,c\text{-}eI}Ct_{TW0,0}Ct_{LW0,0}Mt_{51a\text{-}cIII}LRt_{AP2,0}LRt_{PP20}TRt_{15bII}St_{0,0}Dt_{d}$
Autranella congolensis	$IVCt_{18EW0,0c,b\text{-}cIV}Ct_{TW0,0}Ct_{LW0,0}Mt_{40a\text{-}dV}LRt_{AP17}LRt_{PP0,0}TRt_{25eII}St_{0,0}Dt_{e}$
Caesalpinia echinata	$IVCt_{14EW0,0c,b\text{-}cIV}Ct_{TW0,0}Ct_{LW0,0}Mt_{69a\text{-}cV}LRt_{AP1,0}LRt_{PP5,0}TRt_{11eII,III}St_{0,0}Dt_{e}$
Dalbergia nigra	$IVCt_{8,0EW0,0d,b\text{-}gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{47b\text{-}eII}LRt_{AP15}LRt_{PP7,0}TRt_{23eII}St_{0,0}Dt_{d}$
Diospyros celebica	$IVCt_{10EW0,0b,b\text{-}cII}Ct_{TW0,0}Ct_{LW0,0}Mt_{57a\text{-}cIV}LRt_{AP11}LRt_{PP2,0}TRt_{20aIV}St_{0,0}Dt_{e}$
Guaiacum officinale	$IVCt_{10EW0,0b,a\text{-}dIII}Ct_{TW0,0}Ct_{LW0,0}Mt_{75a\text{-}cV}LRt_{AP2,0}LRt_{PP1,0}TRt_{12aIV}St_{0,0}Dt_{e}$
Guibourtia tessmannii	$IVCt_{8,0EW0,0c,b\text{-}dI}Ct_{TW0,0}Ct_{LW0,0}Mt_{66a\text{-}dIII}LRt_{AP2,0}LRt_{PP8,0}TRt_{16eII}St_{0,0}Dt_{e}$
Mansonia altissima	$IVCt_{21EW0,0b,b\text{-}cIV}Ct_{TW0,0}Ct_{LW0,0}Mt_{54a\text{-}eIII}LRt_{AP7,0}LRt_{PP0,0}TRt_{18eII,III}St_{0,0}Dt_{c}$
Millettia laurentii	$IVCt_{6,0EW0,0e,b\text{-}gI}Ct_{TW0,0}Ct_{LW0,0}Mt_{43a\text{-}cV}LRt_{AP0,0}LRt_{PP31}TRt_{20bII}St_{0,0}Dt_{d}$

CONCLUSION

Quantitative levels represented as conditions are intended to lay the foundations of a new formal-analytical description of wood. The wood of each tree species falls into some of these levels of variation. Although the inhomogeneity of wood is one of its defining characteristics, the variation in the properties of the cells that form it is not so high which provides the opportunity to describe the structure of wood more completely and accurately.

Although formal analytical records have been well known for many years, they have not been practically used yet. The records allow to describe and categorize the structure of wood completely and with sufficient accuracy. Using the possibility to present the anatomical features as qualitative and quantitative characteristics makes the quantitative description of the wood structure available. If introduced and applied in practice, such records will allow tree species to be presented briefly and categorized according to the structure of their wood.

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