

FORESTS AND WOODED LANDS IN MULTI-SCALE TOPOGRAPHIC AND THEMATIC DATABASES

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1. INTRODUCTION

Forests occupy over 4 billion hectares on the surface of the globe accounting for 31 % of the total land area (FAO, 2010). There are five most forest-rich countries (Canada, the Russian Federation, Brazil, USA and China) which account for more than half of the total world's forest area. Distribution of forests across the globe shows figure 1 (Fig.1). About 50 countries have forest on less than 10% of their total area and 10 of them have no forest at all (Fig.2).

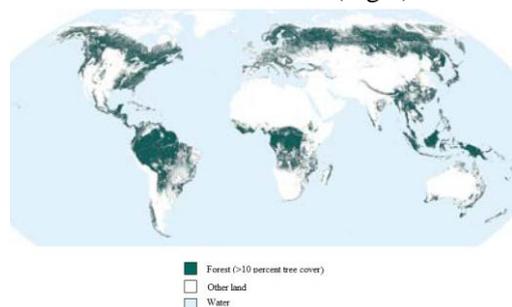


Fig. 1. The world's forests, (FAO, 2010).

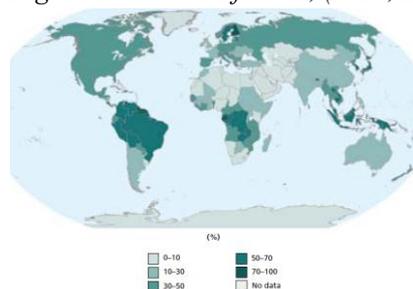


Fig. 2. Forest area as % area of countries 2010(FAO, 2010).

According to European Environmental Agency's definition- land is the terrestrial bio-productive system that comprises soil vegetation, other biota, and the ecological and hydrological processes that operate within the system. Land cover classification bases on the observed physical and biophysical cover of the earth's surface independently of its uses such as vegetation, water, sand surface, etc.). Information is obtained from land surveys or through remote sensing (Di Gregorio and Jansen, 1997). The land surface is very heterogeneous and the standards for acquiring, representing and generalizing land characteristics are as different as the land surface itself (Herold et al., 2006a). Because of the difference among the world's surface, many definitions for basic land cover categories exist.

2. NATIONAL FOREST DEFINITION

There are a few basic criteria used for defining forestland for the purpose of the national definition. Four basics – area [ha], crown cover [%], tree height [m], strip width [m]- describe forest with minimum threshold values. Depending on the country, definition of forest varies not only in terms of size of the elements taken into account, but also their quantity. Differences in the minimum area of the forest class are located between 0.01 ha (Belgium) to 4 ha (Jamaica). Many countries do not specify a minimum value. Crown cover is the most common element of forest description and its value ranges from 10 - 60%, while most oscillate around at 20 - 30%. Tree height is less common than crown cover, however, is a characteristic part of the definition and its value oscillates on the average between 2 - 7 m. A strip width is rarely used parameter but it occurs in some national forest definitions and its value ranges from 10 to 40 m. Laws of individual countries define forests usually using at least one of these parameters. Statutory definitions of the forest do not reflect the characteristics and capabilities of belonging to a class of global land cover classification, therefore there have been created unified languages to describe the reality such as LCCS – Land Cover Classification System developed by the FAO and UNEP.

3. LAND COVER CLASSIFICATION SYSTEM

LCCS is an appropriate base of land cover legend description and interpretation with use of standardized but elastic set of classifiers and thresholds. LCCS is an unquestioning classification system that consists of universally applicable and independent land cover diagnostic criteria, in spite of pre-defined classes of objects. It may be exploitable around the whole world for land cover features description in any scale or detail's level for every type of user. (Di Gregorio, 2005). LCCS became a base in creating standard ISO 19144-2 Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML). The class creation in LCCS is made by dynamic combination of land cover diagnostic attributes called classifiers (FAO-UNEP, 2004). As in any language there exist words (classifiers) and syntax (classification rules) which allow to create semantic concept (land cover features).

For the purpose of this paper description of class creation is done on forest and wooded land features. According to the overview of environmental attributes of each major land cover type of the classification system, these were assigned to two basic groups: primarily vegetated and non-vegetated. Subsequently first group is divided for three: A11-Cultivated and managed land; A12-Nat. and semi-nat. terrestrial vegetation; A24-Nat. and semi nat. aquatic vegetation, each of those groups has its own division: for example (Table 1).

Table 1. Overview of environmental attributes of example land cover type of the classification system.

1. A life Form for the Main Strata	
Woody	A1
Trees	A3
Shrubs	A4
Herbaceous	A2
Forbs	A5
Graminoids	A6
Lichens/Mosses	A7
Lichens	A7
Mosses	A9
A. Cover	
Closed (> 70-60%)	A10
Open (70 - 60 - 20-1-%)	A11
(70-60 - 20-40%)	A12
(40-20 - 10%)	A13
(...)	
B. Height	
7-2 m (for Woody)	B1
>30-3 m (for Trees)	B2
> 14 m	B5
(...)	
C. Spatial Distribution	
Continous	C1
Fragmented	C2
(...)	
2.D. Leaf Type	
Broadleaved	D1
Needleleaved	D2
Aphyllous	D3
E. Leaf phenology	
Evergreen	E1
Semi-Evergreen	E2
Decidous	E3
(...)	

Compiled according to (Di Gregorio, 2005).

If there is a need of creation forest class in LCCS, the concept is required, next with the use of basic features from LCCS language it is possible to write down the "definition". For example A3A10B5D2E1 means: Tree, Closed, Height (>14 m), Needleleaves, Evergreen. (FAO-UNEP, 2004), what according to the LCCS standard class description means that the layer consists of needleleaves evergreen closed to open trees. The crown cover is between 100 and 15% (a further sub range can be defined – Closed to Open 100 – 40%). The height is in the range of >30 - 3m but may be further defined into a smaller range (JRC Website).

Global and regional databases have been derived in response to the need of information about land cover. Their development was driven by national or international initiatives; the subsequent adopted mapping standards reflect the varied interests, requirements and methodologies in database creating. (Herold et al., 2006b)

4. GLC2000, GLCNMO, GLOBCOVER, CLC2000

Forest is one of the main elements of the land cover - key environmental parameter, so its differentiation plays an important role in land cover classification (Tateishi R. et al..2008). There are available a few data products, which include global land cover: for the year 2000 –GLC2000 produced by EC Joint Research Centre (Bartholome´ and Belward,2005), GLCNMO-Global Land Cover by Mapping Organizations (produced using mainly MODIS data observed in 2003)(Tateishi R. et al..2008), new dataset of global land cover GLOBCOVER (produced using ENVISAT-MERIS data observed in the year 2005, prepared by the European Space Agency)(Thibaut A., 2011). Available data products include European land cover – CORINE2000 (taken by the European Environmental Agency (EEA).

The GLC2000 is a hierarchical classification system defining the boundaries between ecosystems such as forest, grassland, and cultivated systems. It is prepared on the base of Land Cover Classification System (LCCS) what gives possibilities of translation regional classes into the more generalized global ones. In GLC2000 were separated 22 classes, 12 of which relates to forests and woodlands (Fig. 3) (Neumann K., et al.2007), where according to LCCS tree cover, broadleaved evergreen is one of land cover class where the tree is determined by: >15% tree cover, tree height >3 m (examples of sub-classes at regional level: closed > 40% tree cove; open 15 - 40% tree cover).

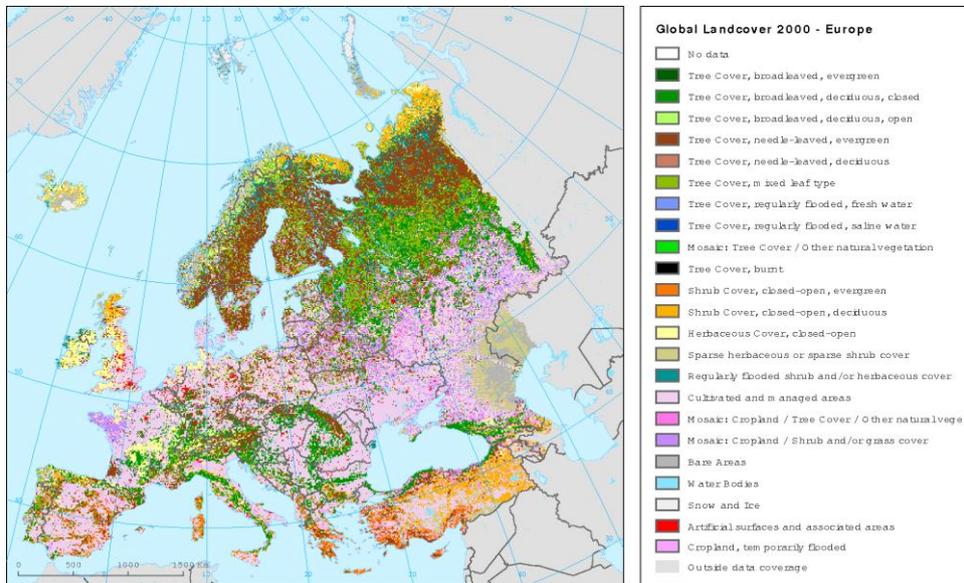


Fig.3. Globe Land Cover - Europe

The produced global land cover data is released from the web site <http://www.eea.europa.eu/>

To avoid semantic problems and misunderstandings in LCCS and thus in GLC2000 is predefined set of basic elements which qualities and attributes can be arranged in different types of strata to describe variety of detailed lands (Di Gregorio, 2005). As an example of LCCS utilization Closed Broadleaved Deciduous Forest shown on the LCCS schema (Fig. 4).

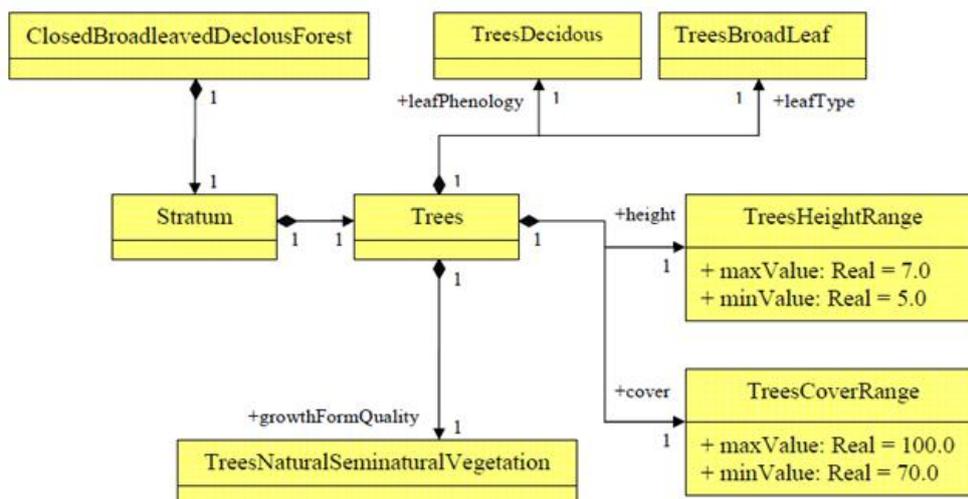


Fig. 4. Schema with trees description

Schema created on the base of draft standard ISO 19144-2 Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML) and Di Gregorio, A., 2005

GLCNMO is one of eight layers of Globe Map, it has 20 land cover classes defined with LCCS- Land Cover Classification System. 14 of all classes is classified with unsupervised methods, to the rest of them are used MODIS and other data sources (Tateishi R. et al..2008). All classes were defined with a significant amount of source data used as training ones.

GLOBCOVER same as GLCNMO and GLC2000 is labeled on the basis of LCCS and has 42 land cover classes(Thibaut A., 2011).

CLC2000 – program CORINE was initiated in the European Union in 1985. CLC2000 represents the state of land cover for the year 2000 but the main aim of the program is to make repeatedly inventories of the earth’s cover in 44 classes with three levels of hierarchical classification (CLC2000) with the minimum mapping unit size of 25 ha with the maximum resolution of 60 x 90 m. First level of CLC consist of 5 basic classes: Artificial areas(1), Agricultural areas (2), Forests and semi-natural areas (3), Wetlands (4) and Water bodies (5). On the second level class number 3 is divided into 3 more detailed classes: Forests (3.1), Shrubs and/or herbaceous vegetation associations (3.2) and Open spaces with little or no vegetation (3.3). Class 3.1. divides for three: Broad-leaved forest 3.1.1, Coniferous forest 3.1.2, Mixed forest 3.1.3.

Forest, according to technical guide of CLC2000, is an area which is occupied by forests and woodlands with a vegetation composed with coniferous and/or deciduous trees- with normal climatic condition- higher than 5 m with the canopy closure of at least 30%. In situation of young plantation there has to be minimum 500 objects for ha. Broad-leaved forest is a vegetation formation composed principally of trees including shrub and bush understoreys, where broad-leaved species predominate, where broad-leaved trees represent more than 75% of the planting pattern. Coniferous forest is a vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate with at least 75%.

LCCS definition of forest and its threshold values are different from CORINE basic definition of forest. Amount of classes and its division do not allow to direct comparison. First, the translation of CLC2000 legend dictionary to LCCS has to be done.

After reconciliation was done by Neuman et al. (2007) thematic and spatial differences were explained. These are divided into three basic groups: semantic problems of definitions, similarities in cover between classes and confusion matrix. Differences and confusions in the legend of those two is shown on Fig. 5. One class in CLC2000, for example broad-leaved forest corresponds to three first forest classes of GLC directly and also may appear because of its semantic confusions in a few other classes.

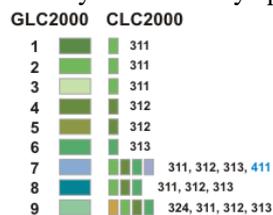


Fig 5. Comparison of GLC2000 and CLC2000 - forest classes

Complies according to Neuman et al.(2007) and <http://exploremaps.info/doc/en/landscape.html>

5. FORESTS AND WOODED LANDS IN TOPOGRAPHIC MAPS

As a fundamental problem taken under consideration in this paper is widespread diversity of defining and presenting forest’s elements. Depending on the type and destination of databases, there are many different definitions and classifications of forests and wooded lands. Forests because of the position they occupy in the actual surface of the earth, determine existence in scientific studies, economy, politics and every other sphere of life. On the purpose of topographic maps/databases (detailed and accurate graphic/descriptive representation of cultural and natural features on the ground(Topo maps)) elements of ground cover – natural and semi-natural- are defined in different countries in various ways. In Europe there are 11 currently working topographical database at scale 1:10 000. Those are : TOP 10v – GIS (Belgium), ZABAGED (The Czech Republic), TOP10DK(Denmark), Eesti Põhikaardi 1:10 000 Digitaalkaardistuse (Estonia), NLS (Finland), BD TOPO Pays. (France), TOP10vector (Nederland), Carta de Portugal, ATKIS (Germany), DTA_10 (Hungary), TBD (Poland)(Bac-Bronowicz J., 2006)

For the purposes of this study the technical documentation of three topographic databases was examined. The dossiers are available on the websites of the agencies responsible for cartographic databases. Some of dossiers are not available, some are misses because of translation troubles.

As is apparent from the technical specification (Structure et des CODAG DONNÉES TOP10V – GIS et TOP50V - GIS, 2000) database TOP10V – GIS contains 18

information layers, which contains of 240 types of objects (surfaces, lines, points). One of the layers is LANDUSE which contains objects of land surface, including:

characteristic of the Belgian coast sandy land, land covered with slime, and gravel, with bushes lands, lands with the presence of coniferous or deciduous trees. Types of deciduous forests (for TOP10V – GIS

there are highlighted two types dependent on form of growth), and coniferous forests, mixed forests (in TOP10V - GIS with a predominance of deciduous in forest stand or coniferous trees or without any predominant), greenwoods hardwood, poplar plantations, nurseries, orchards, shrubs, areas without vegetation (Bac-Bronowicz, 2006).

BD TOPO Pays is a French topographic database which contains 10 main classes: the communication roads, railways and other modes of transport, energy and fluids transport, surface hydrography, business areas and urban areas, land use, orography, technical and administrative divisions, other objects and digital terrain model. Land use class distinguishes: tree or group of trees (> 80 m²), coniferous forest, deciduous forest, shrubbery, hedge, mangrove forest, nursery, plantation of trees, tree line, young forest. According to the national forest definition the minimum forest area is 0.05 ha, with the canopy cover of 10% , minimum height of tree 5-7 m and the minimum width of strip 25 m.(FRA,2005)

Polish topographic database TBD 1:10 000

Definition of TBD by Head Office of Geodesy and Cartography says that "Topographic Database (abbreviation TBD) is the official name of a conceptually coherent nationwide system for collecting, managing and sharing of topographical functioning on the basis of the relevant legislation. The term "Topographic Database" includes both the resource data, data management system and an adequate system of financing and organization. The scope of information, functional and technological level, define appropriate guidelines and technical specifications".(GUGIK)

The main source of geometric data for TBD is digital orthophotomap. All facilities (elements) should be implemented according to their actual position in the field and keeping all the necessary topological relationships. In the case where the object is not visible or readable on orthophotomap, the object may be acquired from other data sources such as field reconnaissance, data from large-scale databases (basic map, cadastral map). As a source of support is considered the existing 1:10,000 topographic map sheets.

In TBD on the first level are defined 11 main classes, where one of them is: Land cover complex. The division of this class is shown in table 2.

Table 2. Forest and wooded lands in TBD classification

Detailed classification of object					
Code	Level 1	Code	Level 2	Code	Level 3
PK	Land cover complex	PK_LA	Forest or wooded lands	PK_LA_01	Forest
				PK_LA_02	Scrub
				PK_LA_03	Other foliage
		PK_KR	Shrubby vegetation areas	PK_KR_01	Shrub scrub
				PK_KR_02	Thickets of dwarf pine

Prepared on the base of WT TBD cz.1, 2008

According to the Forest Act of 28 September 1991. (OJ 1991 No 101 item. 444) for the forest land is considered a homogeneous area of at least 0.10 ha, which is covered by forest vegetation (forest crop), i.e. trees, shrubs and forest undergrowth or temporarily deprived of that what is intended for forest production(...) (Forest Act, 1991). The same regulation also specified the definition of wooded land and bush, which says it is a type of land which "includes land covered with forest vegetation, whose surface area is less than 0.10 ha, and also the mid-field clumps of trees and shrubs not included in the forest areas, land covered in natural wicker and willow shrub forms, adjacent to surface water areas planted with trees or shrubs(...)(Dz. U, 1991).

National definitions of forest and wooded lands consistent in terms of minimal forest area. Forest and wooded lands class covers the area with dense plantings: forests, scrubs and others. The minimum width of a wooded area shall be 15 m and a minimum length of 40 m. Group of trees, small forest or scrub with the surface less than 1000 m² represent the class Natural Object. In the area of double-storied stand scrubs are included into the forest when their surface is less than 2000 m². TBD forest (PK_LA_01) is defined as natural or semi-natural ecosystem or set of ecosystems created by man, where the vegetation is dominated by short-growing trees over 2 meters in height. There are mandatory and optional attributes describing forest and wooded lands:1 - forest, shrub, other; 2 - type of forest stand (deciduous, conifers, mixed); 3 – species; 4, 5, 6, 7 – additional information (WT TBD, 2008).

Shrubs in TBD are defined as areas covered by vegetation with dense plantings of scrub shrubs and thickets of dwarf pines. In the area and on the edge of the forest area dense shrubs is separated when its surface is more than 2000 m² . (WT TBD, 2008).

According to the Land Cover Classification – LCCS – forest and wooded land are not described with the same way though both of classification process is being done mostly on satellite and airborne images.

Languages of description are totally different. TBD is written down with the GML (Fig 6). Figure shows the logical organization of application schema TBDGML 2.0.2

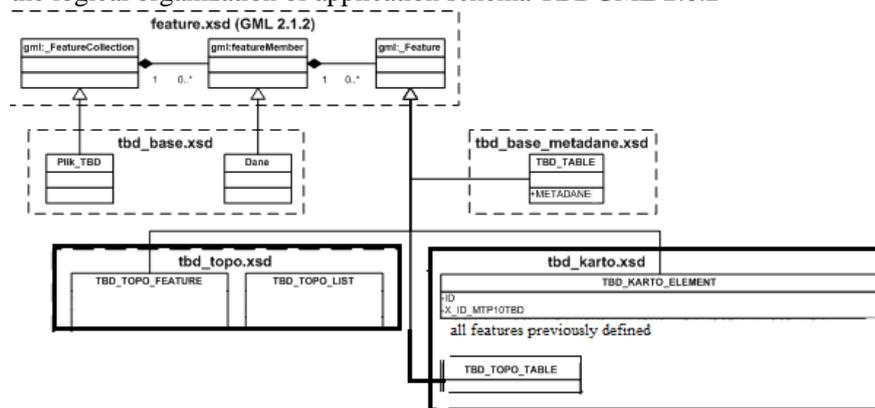


Fig 6. The logical organization of application schema TBDGML 2.0.2

Prepared on the base of WT TBD cz.1, 2008

6. FORESTS AND WOODED LANDS IN THEMATIC MAPS

Why forest thematic maps are being done? Who does it? And what for?

Forest it is not only land cover, it is the natural resource on which many areas of economy and science is focused. All over the world forest planning and management offices have the task in:

- inventory and assessment of forest, including soils, forest sites and forest stands identifying the natural relationship between them;
- identification of natural value of the forest and development program
- identification of forest functions in conjunction with the land development
- division of forest- according to their function and objective managements
- determination of the economic tasks in the next decades
- determination of the forest protection
- etc.

(IUL, 2003)

Inventory and assessment of forest is a task for many different institution in the world, for example in Poland, General and the Regional Directorate of State Forests and individual forest divisions take care of forest management. In South Australia in the state Victoria, Department of Sustainability and Environment manage of forest inventory and assessment. Data collected on forests by such institutions vary considerably from simple data collected for the purpose of land cover.

As it is said before General and Regional Directorate of Forests collect the data on the purpose of creating Numerical Forest Map prepared with the SLMN (standard for NFM) with whole attributes which are needed to create maps like:

- map of forest possession
- economic map for the separation of forest
- map of territorial forest divisions
- map of forest stands
- map of forest sites
- map of forest damages

In SLMN forest is defined as an area of land use categories Ls wooded, with trees older than 20 years. Forests in superintendence and intendances are divided into precincts and separations, and for each separation data are collected. With the development of forest management and the increasingly intensive use of the forest, there is a need to determine optimal forest stand conditions for the selection of the desired species composition of stands. It was began to draw attention to the relationship between soil and vegetation (Wazyński B). This relationship is described by forest sites in which soil and vegetation conditions are hidden. For example for fresh mixed coniferous forest(forest site) dominated species in the composition of the trees is the pine, which has the optimum conditions. Fresh mixed coniferous forest

cover about 18% of the total forest area in Poland. Map of forest sites from voivodship dolnośląskie in Poland with the appropriate legend is being done on the backing map at scale 1:5000 (economic forest map)(Fig. 7)

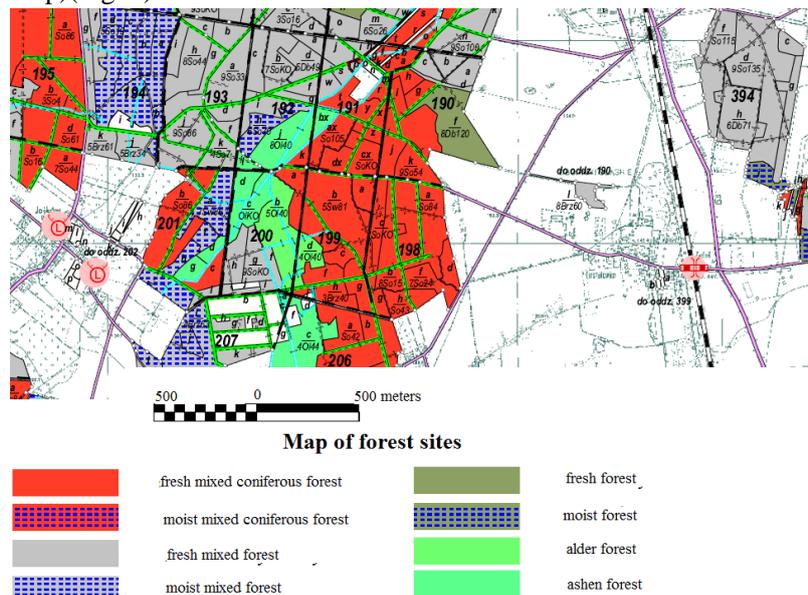


Fig. 7 Map of forest sites with the appropriate legend

Map of the forest sites includes many other information such as species, density, age of trees, the number of separation and sub-separations, stand density, the percentage of dominant species. For example k/9So55 means that on the sub-separation “k” dominant species is pine aged 55 with the 90% of domination (Ważynski, B).

The second important map created by foresters is map of forest sands(Fig. 8).

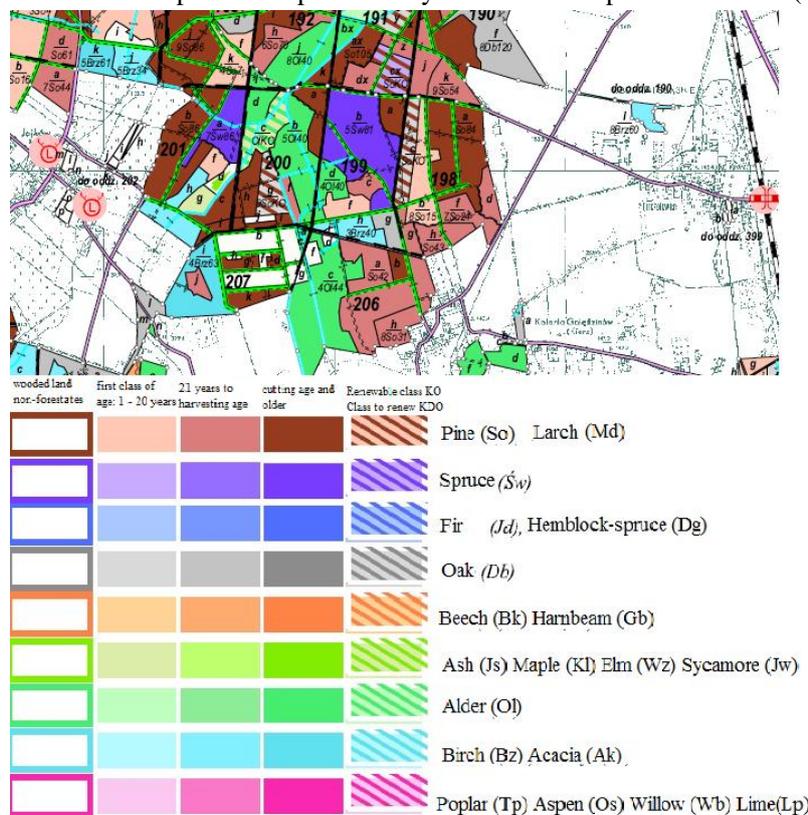


Fig. 8. Map of forest sands with the appropriate legend

As a comparison to Polish SLMN products there are shown Australian products of forest inventory .(Fig. 9, Fig. 10)

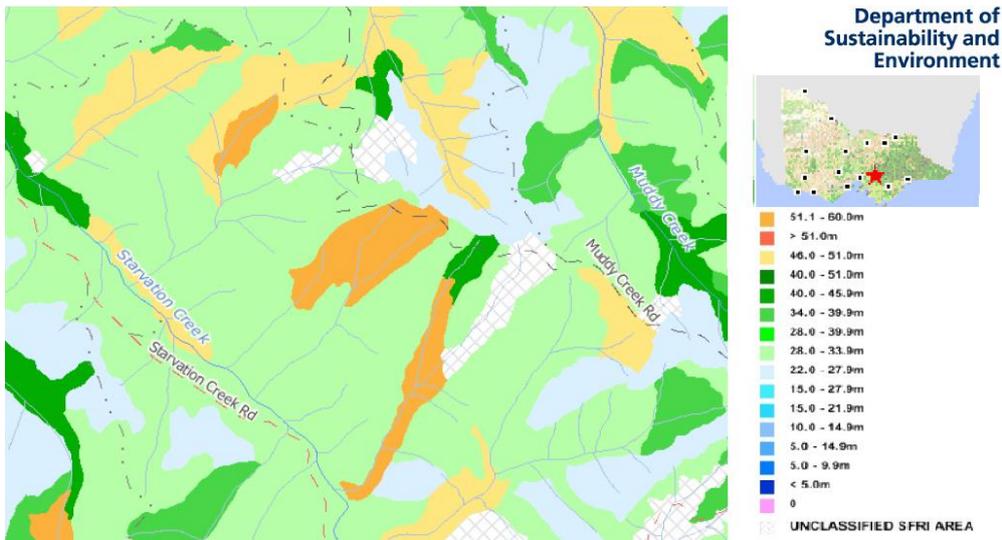


Fig. 9 Map of tree's height created with the Forest Explorer Online (<http://www.dse.vic.gov.au/>)

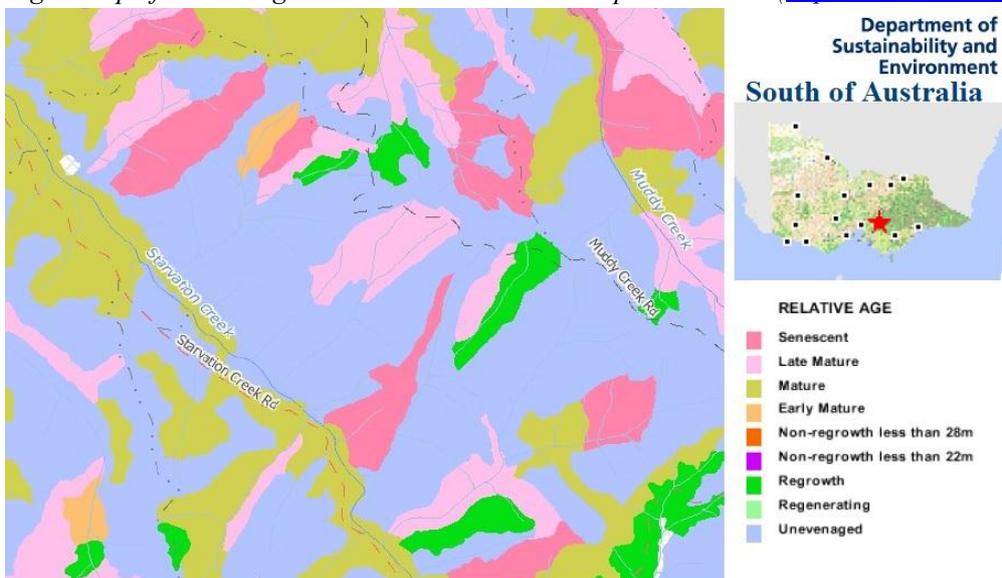


Fig. 10 Map of tree's age created with the Forest Explorer Online (<http://www.dse.vic.gov.au/>)

7. INTEGRATION POSSIBILITIES

There is always a question if we can join two totally different database, with different objectives and purposes. So the answer is that we can try. It is possible to “upload” some information from SLMN to TBD to broad the scope of information, but layers and objects are coded in the different language so it is not direct process which needs to invent a new dictionary of classes based for example on the new draft standard ISO 19144-2 Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML).

There exist differences with the areas of forest and wooded land defined by two different technical specifications (TBD and SLMN, Fig. 11). The timeliness and quantity of information contained in the TBD, which relate to forests is incomplete. Attribute for a kind of stand, it is not necessary in the TBD and a very large group of objects does not have such information. There are large discrepancies between the borders of databases. Another factor which may have an impact on this state of affairs is that the borders of forests were in TBD determined on the basis of orthophotos. In SLMN forest boundaries are the result of surveys that are performed on behalf of the BULiGL -Bureau of Equipment of Forest Management and Geodesy. Determination of boundaries is significantly better here, because it is made for the map scale 1: 5000.The differences between SLMN and TBD boundaries can be also the result taking under consideration all forest areas in TBD while in SLMN there are only state-owned.

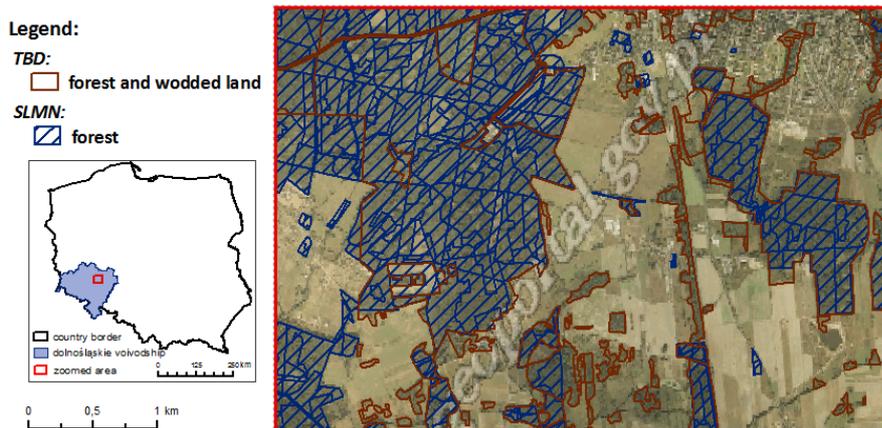


Fig. 11 Comparison of layers for TBD and SLMN

8. CONCLUSIONS

Due to the variety of land cover on the surface of the globe are different national definitions of forest and woodlands. In connection with the planned entry standard ISO 19144-2 Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML) there is no problem for classifying land cover.

Forest definition presentation with use of a unified description language would facilitate the harmonization and the connection of different databases. It would reduce the semantic ambiguity.

In the conjunction with developing technology and the rising costs of acquiring information producers of databases should begin to combine the interests, participate in costs and use the freer access to information flow.

Differences in acquiring data in last years improves that global systems of data raising slowly replacing the standard measurements of forest and woodlands.

It is possible to derive information between TBD and SLMN to fill in missing information, for example, the species composition of forests for TBD. However, it requires a proper recoding of the individual layers and create a single data dictionary to facilitate this process and reduce the risk of making mistakes in the description of phenomena.

Defining phenomena requires a precise and unambiguous description. Should not be used to describe the definition of density "strongly compact", it should be determined the degree of fault.

There exist a need of data standardization and harmonization.

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