This book is one of a results of close cooperation between Serbian Environmental Protection Agency and European Environmental Agency - for CORINE Land Cover. Forest land change analyzed at national level could be useful for environment and forest experts, decision makers and others involved in nature issues and nature using. Looking in past and present for trends of changes we can understand the rules and with a little luck we could know what to expect in the future.

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Serbian Forest Indicators by CORINE Land Cover

I have been working in Serbian Environmental Protection Agency since 2004 as an adviser for biodiversity, forestry, hunting and fishery. Precisely, I prepare indicators, data base, key stories for national and international Environmental Reports. I take part in preparing strategies and strategic plans for biodiversity, forestry, sustainable use.

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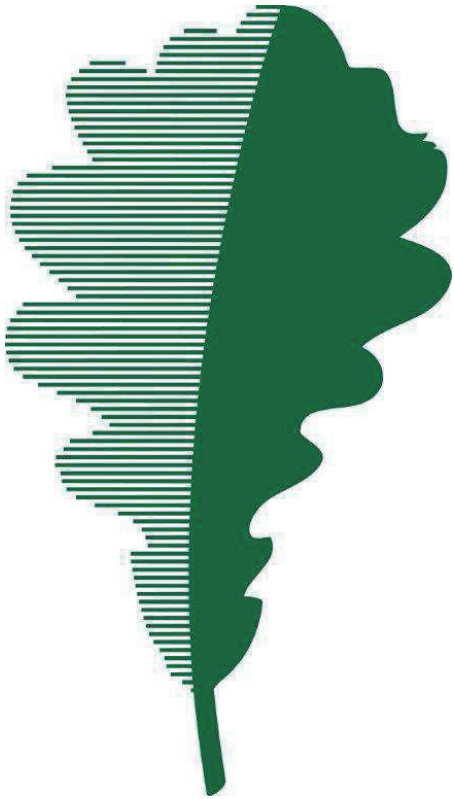
SERBIAN FOREST INDICATORS BY CORINE LAND COVER



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Contents

1. INTRODUCTION

1.1. Land cover

Understanding of land cover and land use changes requires good planning of sustainable development. Land cover and land use transformation induced by human activity strongly affects natural resource system integrity and ecosystem's goods and services output. Implementing carefully planned aims, developing new patterns of land cover and land use, people's well-being can be enhanced (Millennium Ecosystem Assessment, 2005).

Accounts are often used form performing many types of environmental assets. Similar to these, land accounts are created in order to describe how resource stock changes over time in a consistent and systematic way. Using information provided by this accounts the implication of land type changes can be understood.

Land cover does not represent just simple attribute of land quality, but also present basic and concrete set of natural and anthropogenic features produced by its use. Since land cover represent dynamic system it can be changed, modified, degraded or destroyed (consumed) and as result new types can be generated. The transformation of capital goods is very similar to these changes of land cover - consumption and new formation. Generally, land cannot be created or destroyed, excluding the process of costal erosion and accretion that cause noticeable changes. Therefore land cover changes are generally characterized in terms of different flow types between land cover patterns. A key focus of land cover accounts, regarding aforementioned facts, should be on understanding the way of different land use and land cover stocks transformation over time.

Asset accounts, regarding the goal of sustainable development, are generally relevant for progress measuring. Since people tend to maintain their well-being, the focus should be on either furnishing natural resource ecosystem to retain its capacity or finding substitute for the natural capital in economy for delivering an equivalent input. At the same time, asset accounts are also relevant to the intra- and inter-generational equity issues that are coming from the sustainable development, since they are used for track changes in the stock quality of natural capital over time.

Importance of connection that land accounts assets have with both habitats and biodiversity is at significant level. Results of the work undertaken under the auspices of the Millennium Ecosystem Assessment has shown that many aspects of human

well-being depend both on individual species or elements of the natural environment, and on the goods and services generated by whole ecosystems (Millennium Ecosystem Assessment, 2005). Therefore, an understanding of ecosystem functions that lead to this goods and services together with understanding effects of human activity on the ecosystem integrity are fundamental part of planning for sustainable development (Mijovic et al., 2012).

European Commission, at mid-1980s, started initiative of CORINE (Coordination of Information on the Environment) in order to create first database and geographical reference system for the European environment.

Land cover data for CORINE have been derived from the analysis of remotely sensed satellite imagery (EEA Report, 2006). Information obtained by this way is particularly useful for the purposes of constructing a land cover account. Different stocks of each land cover type that can be found in Europe can be estimated using this kind of information and at the same time can be used for tracking changes between years, e.g. 1990 and 2012. When focus is on forestland, consumption and formation are opposing processes like deforestation and reforestation, and together with internal processes of felling and replanting are parts of the forest management cycle.

Basic CORINE mapping were done using scale of 1:100 000. Even though this level of spatial resolution is sufficiently detailed for assessments at the European scale, it is relatively coarse for the local mapping. Regarding the aforementioned facts CORINE Land Cover (CLC) can be useful for understanding of environmental context change. One more aspect of limitations comes from spatial resolution of CORINE data since they concern the size of the minimum mapping unit, which is set at 25 ha, and minimum width of 100 meters (Heymann et al., 1994). For tracking change detection, minimum mapping unit was set at 5 ha. Regarding spatial resolution of mapping units for stock, many classes are heterogeneous.

Two major elements of forest are standing forests and transitional woodland and shrub vegetation. First of them, standing forest can be divided in the group of broadleaves, group of coniferous and group of mixed woodlands. Second element, transitional woodland and shrub represent the smaller component and appear to be much more dynamic.

Between 1990 and 2000, forestland cover increased for about 4% on a global level, but in Serbia change has been hardly measurable (Popović et al., 2011). Nevertheless, since magnitude of flows for consumption and formation were almost

the same as those for standing forest, there was a meaningful turnover of initial stock of this resource. Regarding the facts that land account shows almost 34% of the initial cover of transitional and shrub woodlands vegetation were turned over, where only 85% of the stock from 1990 was carried over to 2000 (EEA Report, 2006).

Character of the transitional woodland and shrub element compared with standing forest most probably reflects its 'successional' status. Therefore, it can be said that there is significant transfer from one to another element over accounting period, and at the same time significant additions through process of reforestation and agricultural abandonment. Interesting fact to notice is also that transitional woodland and shrub presents the most vulnerable part of vegetation, due to the susceptibility of its conversion to agricultural or artificial surface.

The data, used for tracking change in the extent of forest and semi-natural areas, provide a good baseline for assessing future spatial planning policy and impacts of development, especially impacts of agriculture to natural resource system.

Although these data can be useful for identifying broad trends insights into the active processes on the ground, probably can be only gained through more detailed spatial analysis. Analysis like this and similar can be made using the accounting grid on which these data are held.

1.2. General information about indicators

Plenty of forest indicators are used in Europe. Some of them have been standardized on a Ministerial Conference on the Protection of Forests in Europe (Ministerial Conference on the Protection of Forests in Europe, 2007). Regarding the field characteristics each country adapted these indicators to their specific situation.

Nowadays indicators have become hot topic in environmental issues. Many ideas and definitions about what they should present exist. From the reference point, following statements present short summary of what an indicator is and how reports coming from it can support the development and integration of environmental concern into sector base issue.

Most important and main function of indicators is to provide good tool for communication. Environmental indicators should give critical information for understanding the development of environmental problems. Using these information decision-makers based their reply to take or not the action. Mainly indicators

represent the approximation of the true instead of reality picture, presenting information form of the raw data and carried information.

At the same time, indicators can be used for expressing condition of the complex system by condensing it into the more manageable and simple message. Each indicator shows only part of the story, and combining them it becomes possible to gain necessary, complex view.

1.3. Indicators fundamental background

Organization for Economic Co-operation and Development (OECD) has the main aim to promote policies that will improve indicators, by facing three basic criteria (OECD, 2001):

- To be policy relevant,
- To have scientific soundness and
- Feasibility regarding the data availability
- Interpretation in a way that is clear and easy to understand.

1.3.1. Policy relevance of indicators

Indicators must be useful and relevant for helping policy making and making assessment. Up till recently, simple existence of statistics was used as indicators, and they were not recognized as the best solution. Therefore, indicators should be developed based on a policy quality of be useful for policy and decision making. OECD defined its relevance based on the Pressure/State/Response system (PSR), or its expanded assessment of framework version, adopted by European Environmental Agency (EEA) known as Driving forces/Pressure/State/Impacts/Response (DPSIR) (EEA, 2007).

Further explanation of the aforementioned DPSIR can be explained by following:

- Driving forces refer to human activities like production, consumption, transport and housing;
- Pressure includes emission of pollutants, waste deposition, natural resource extraction and land use;
- State explain effects of pressure on the physical media referring to its quality;

- Impacts are used to explain effects of pressure and quality of physical media on the ecosystem state, public health and life conditions;
- Response refers to societal responses to environmental issues.

More or less every country published many indicators at national level on a more or less regular basis. Some of them have focus on headline indicators and others on environmental performance indicators.

United Nations Sustainable Development Commission (UNSDC), together with many other scientific research institutions recently suggested testing longer and more detailed list of sustainable development indicators, rather than short one.

On the other side, this can cause many problems in overlapping due to the over-abundance that cause questioning, doubts and criticism. The expression that explains precisely this problem is well known like „graveyard of indicators". In case that indicator should help in decision-making process and assessment, using too many indicators can create "noise" instead of enlightening the situation. At the same time, it is not feasible to develop many relevant indicators. For that reason, in case of lack of data availability or sufficient funding, these indicators would remain unrealized well in the medium or long term.

1.4. The land dimension of indicators

Importance of land use and land cover change is significant for various themes and issues due to its mutual linkage in every aspect. For example, in the study of global environmental change information of land use/land cover has the most important role. This presents the major base-ground for sustainable development, livelihood systems and Earth biogeochemical cycle, and also for atmospheric levels of greenhouse and other trace gases.

This can be explained well by facing situation at Europe's mountain regions, since the climate has significant implication on vertical distribution of biota. At mountain region occurs vertical gradient of distribution flora and fauna. They are ranged from reduced alpine zones with specific endangered species to the zones where dominate indirect impact on ecosystems and populations at nearby plains, that depends upon the water from mountain region (Millennium Ecosystem Assessment 2005).

Similar to the global topic of climate change, many other examinations can be done by using information about land use/land cover changes. Nevertheless, topics about sustainability are the most used one and include following topics:

- Soil use and erosion rates
- Marinating of soil nutrients
- Water use
- Agro-ecological potential/carrying capacity
- Rural planning/environment and development
- Policy at national and international level (Dedijer et al., 2007).

Information about land use/land cover change can be useful for supporting and even directing developments in integrated modeling and assessment. Due to the numerous important functions, ecosystems together with supporting land are valued as resources. Therefore, degradation, regardless if it is ecosystem's or supporting lands', leads to loses in terms of uses or irreversible changes that has to be considered as a depletion of an available resources for determining quality or potential for reproducing this resource.

Due to the aforementioned reasons political/policy objectives should maintain and improve the resources availability for various uses and conserving their potential for renewal. Changes of the natural systems and human demands in the future should be followed by policies with overall approach. Multiple uses of the same resources leads to defining optimal policies that require debates and consideration of trade-offs for all possible options.

1.5. Linkage between forest ecosystems and people

Long time ago people recognize forest as one of the main important resources for their existence providing amenities for them, biodiversity, possibility for soil conservation. At the same time, forest ecosystems present vulnerable and endangered systems, for example they present subject of damaging by fires etc. (Radović, 2015).

Urbanization can have both impacts, positive and negative. Well known examples for negative ones include water run-off (increasing in quantity and speed of flows) followed by concentrating pollutants into drainage systems, deforestation and increased level of soil erosion, habitat fragmentation etc. Positive side include forestation for improving sport and recreational potentials, as well as water

infiltrations meaningful for amount of drinkable water, impact on conservation and biodiversity improvement.

It is well known that forests are important part of the urban environment both for inhabitants and tourists. Forest around the cities can be used depending on its accessibility and availability. Amount of forest around the city (50 km) varies greatly in Europe and CORINE Land Cover has been used in order to quantify this information. Results of analysis showed that in eastern, central and northern Europe forest areas near the cities tend to cover larger areas. Regarding the survey's results, the most urban inhabitants live within 15-minutes' walk from at least one green area, even though there is a different distribution of a green areas in various cities. If landscape of a city has enough high-ration of near-by forest, there is a high risk of their fragmentation.

In the terms of quantification of different relationships between forests and urban areas, indicators are recognized as very useful, especially for policy makers. Information obtained by this way should include conservation, sustainability of forest ecosystem, water supplies, urban tourism, sprawl and transport links (Popovic et al., 2011).

Changes in rate and quality landscape can be easily determined by suitable indicator as land cover. Also, for maintaining ecological stability and taking proper decision-making and planning, it is necessarily to study both changes in landscape caused by natural and artificial process as well as to do and consider results of impact assessments. Results of land-cover analysis can help in revealing the connection of socio-economic and political interventions (Popovic et al., 2015).

At the same time, development trends assessment, regarding the environmental and ecological point of view, can be obtained by analysis of land cover changes. So, nowadays using this kind of methodology it is possible to evaluate landscape characteristics in the first line diversity, ecological importance, carrying capacity, stability and attractiveness (important for assessing eco-stabilizing function of landscape). Results of landscape analysis change provide important information for landscape planning and management.

Regarding all above mentioned facts it is easy to conclude that land cover change as indicator can show:

- potential causes of main type change of landscape by understanding socio-economic pressures;

- relevant information on the magnitude and spatial distribution of change comes from the combination statistics and maps work;
- reclassified CORINE Land Cover classes into main landscape changes gives proper and relevant information for policy (including urbanization, deforestation, etc.);
- Landscape changes information combined with intensity intervals for these changes together with recalculated changes into a grid presentation provides suitable presentation for mapping.

Serbian Environmental Protection Agency (SEPA, Serbia) established indicators for monitoring forest area for the territory of Serbia according to their importance and given data for period of 1990-2012 (Radović, 2015). For monitoring forest area in Serbia five indicators have been created:

- Forest area,
- Forested landscape,
- German model of Forested landscape,
- Forest land and
- Forest and semi-natural area.

It is important to mention that these indicators are overlapping, showing at the same time similarities but, as well differences in some segments. This overlapping can be useful for counting dynamic of vegetation changes analyzing each of them and presenting spatial and temporal characteristics (trend of dynamic).

These indicators provide also useful information for vegetation analysis on the national level or for the part of state territory, or for different economic analysis.

Reasons for establishing these indicators in Serbian Environmental Protection Agency are their compatibility with indicators of European Environmental Agency, Copenhagen, Denmark and other relevant international institutions, as well as with qualification at the national level.

Here will be presented results of analysis of forestland indicators based on the CORINE Land Cover methodology, for period 1990-2012.

2. METODOLOGY

2.1. DATA- CLC Classis

CORINE Land Cover (CLC) Program started development by applying methodology of collecting land cover data based on hardcopy of satellite imagery. In the mid-eighties and for starting period of Program this was the most feasible approach but its use was limited for only image processing and GIS software's use. This procedure showed good results that proved its merits as valuable.

Explanations about defining classes are given here and present criteria defined by CORINE Land Cover (Bossard et al., 2000).

2.1.1. Agro-forestry area (class 243)

Land principally occupied by agriculture, with significant areas of natural vegetation is defined as Class 243 (Fig. 2.1.)

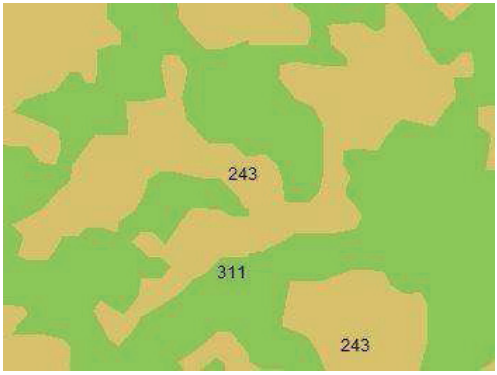


Fig.2.1. Representative demonstration of the mentioned classes on example of arable land with significant amount of areas under natural vegetation in Serbia (class 243).

This class predominantly refers to an areas principally occupied by agriculture, but intersected with significant amount of natural areas. Significant amount of natural areas include both natural and semi-natural vegetation origin including wetlands and water bodies, out of crops.

Agro-forestry area include parcels of arable land smaller than 25 ha, parcels of orchards, vineyards and berry plantations smaller areas than 25 ha; then parcels of the rests of natural forests, groups of trees and shrubs smaller areas than 25 ha small areas of water bodies; sporadically occurring houses of rural settlement, or farm buildings; linear structures of trees organized for truffle production; hortillonage (vegetable crops and canals); agriculture and scattered heaps of stones.

This heading excludes agricultural land associated with small plots of fruit trees/olive groves without natural vegetation (class 242); small islands of vegetation marked as class 243 made by mapping the forest units < 25 ha with a buffer of agricultural land to reach units > 25 ha; areas in which the share of agricultural areas is above 75 % (classes 21x, 22x or 23x); areas in which semi-natural areas predominate (more than 75 %) (classes 3xx).

2.1.2. Forests

According to the criteria defined by CORINE forest area in temperate climatic zone is defined as area principally occupied by forests and woodlands with a vegetation pattern composed of native or exotic coniferous and/or deciduous trees and can be used for the production of timber or other forest products.

The forest is defined as trees developed under normal climatic conditions higher than 5 m with a canopy closure of 30% at least. In case of young plantation, the minimum cut-off-point is 500 subjects by hectare.

Each of these classes is determined by using the following criteria:

Broad-leaved forests (class 311)

Broad-leaved forest is defined as vegetation formation composed principally of trees, with domination of broad-leaved species, including shrub and bushes understoreys (Figure 2.2.)

Fig.2.2. Representative demonstration of the quoted class on example of broad-leaved forest in Serbia (class 311).

This class includes areas with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure, where broad-leaved trees represent more than 75% of the planting pattern. In case of young plants or seedlings the proportion of broad-leaved plants to be considered is at least 75 % of the total amount of plants.

This heading includes: plantations of eucalyptus; young plantations of deciduous trees; walnut trees and chestnut trees used for wood production included into forest area context; sparse broad-leaved forests with a 30 - 60 % bracket of crown cover; evergreen broad-leaved woodlands composed of sclerophyllous trees (mainly *Quercus ilex*, *Quercus suber*, *Quercus rotondifolia*); arborescent mattoral with sclerophyllous species; olive-carob forests dominated by *Olea europaea sp. sylvestris*, *Ceratonia siliqua*; palm groves woodlands (one single case found in Greece); holly woods dominated by *Ilex aquifolium*; tamarix woodlands; broad-leaved wooded dunes; transitional woodland areas when the canopy closure of the trees cover more than 50 % of the area and if their average breast diameter is at least 10 cm; denuded spots and grassland.

From the broad-leaves forest are excluded burnt areas inside forest areas (classes 32x or 334); non-evergreen coniferous trees dominated by *Larix* species (class 312); woodland areas composed of broad-leaved trees smaller than 5 m high (class 322); vegetated areas where the crown cover of the broad-leaved trees is less than 25 % (class 324); forest nurseries specialized in reproduction situated inside broad-leaved

wooded areas (class 324); clear-cuts (class 324, applied for PHARE countries[1]); forest nurseries outside forests for commercial purpose (class 211); wooded parks (class 141).

Coniferous forests (Class 312)

This class includes vegetation that consists principally of trees, with domination of coniferous species, including shrub and bush understoreys (Fig.2.3.).

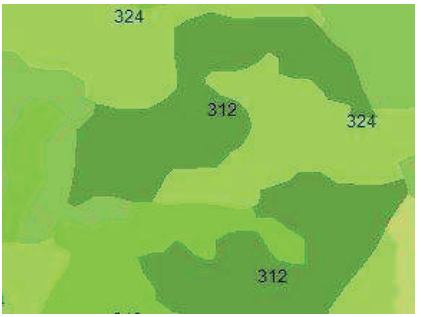


Fig.2.3. Representative demonstration of the quoted class on examples of coniferous forest in Serbia (class 312).

In this class coniferous trees represent more than 75 % of the formation. In case of young plants or seedlings, the proportion of coniferous plants to be considered is at least 75 % of the total amount of plants and their texture is very similar to a surrounding coniferous forest texture.

This heading includes: non-evergreen coniferous trees woodland composed of larch trees (*Larix spp.*); young plantations of coniferous trees; coniferous wooded dunes; arborescent mattoral with dominating *Juniperus oxycedrus/phoenica*; coniferous wooded land; Christmas tree plantations; denuded spots and grassland; clear-cuts (applied for European Union countries).

From the coniferous forest class are excluded: dwarf coniferous trees as *Pinus mugo* (class 322); sclerophyllous trees (class 311); vegetated areas where the crown cover of coniferous trees is less than 30 % (class 324, 231, 321); forest nurseries

[1] The PHARE Programme (established by EU Council Regulation 3906/89) is one of the three pre-accession instruments financed by the European Union to assist the applicant countries of Central and Eastern Europe in their preparations for joining the European Union.

specialized in reproduction situated inside coniferous wooded areas (class 324); clear-cuts (class 324, applied for PHARE countries).

Mixed forest (class 313)

Vegetation formation composed principally of trees, including shrub and bush understoreys, but neither broad-leaved nor coniferous species predominate (Fig.2.4.).

Fig.2.4. Representative demonstration of the quoted class on examples of mixed forest in Serbia (class313).

Mixed forests with a crown cover of more than 30% or a 500 subjects/ha density for plantation structure. The share of coniferous or broad-leaved species does not exceed 25% in the canopy closure.

This heading includes: mixed-forest wooded dunes; denuded spots and grassland; sporadically occurring shrub formations; clear–cuts (applied for European Union countries).

This heading excludes: young plantations (class 324); forest nurseries specialized in reproduction situated inside mixed-forest areas (class324); clear-cuts (class 324, applied for PHARE countries); burnt areas inside mixed-forest areas (class 3.3.4); woodlands with mixed species trees less than 5 m (class 3.2.2); vegetated areas where the crown cover of mixed species trees is less than 30 % (classes 324, 231, 321).

2.1.2. *Shrub and/or herbaceous vegetation associations*

Shrubby and herbaceous vegetation association include temperate shrubby areas with Atlantic and alpine heaths, sub Alpine bush and tall herb communities, deciduous forest re-colonization, hedgerows, dwarf conifers. Also, Mediterranean and sub-Mediterranean evergreen sclerophyllous bush and scrub (maquis, garrigue, mattoral, phrygana sensu lato), re-colonisation and degradation stages of broad-

leaved evergreen forests. Here are present as well dry thermophilous grasslands of the lowlands, hills and mountain zone, Poor Atlantic a sub-Atlantic mat-grasslands of acid soils; grasslands of decalcified sands; Alpine and sub Alpine grasslands. Also can be found humid grasslands and tall herb communities; lowland and mountain mesophile pastures and hay meadows.

Natural grassland (Class 321)

This class includes grasslands of low productivity that are often situated in areas of rough, uneven ground (Fig.2.5.). Frequently into this class have been included rocky areas, briars and heathlands. Natural grasslands include areas with herbaceous vegetation with maximum height of 150 cm and where gramineous species are prevailing. They are covering at least 75% of the surface covered by vegetation and which are developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass). Also, into this class are included grass formations of protected areas, karstic areas, military training fields and etc., since human impact is not significant and interference does not suppress the natural development or species composition of the meadows. Also as natural grasslands are included areas of shrub formations of scattered trees.

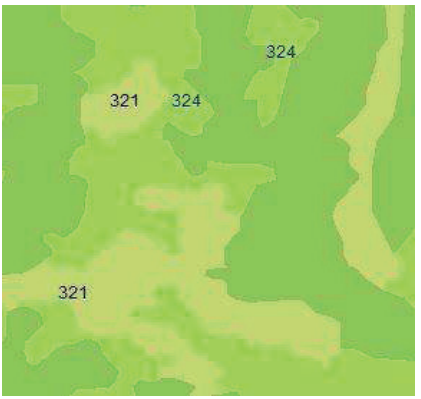


Fig.2.5. Representative demonstration of the quoted class on example of natural grassland in Serbia (class 321).

This heading includes: saline grasslands grown on temporary wet areas of saline soils; humid meadows where sedges, rushes, thistles, nettles cover more than 25 % of the parcel; natural grasslands with trees and shrubs if they do not cover more than 25 % of the surface to be considered; high-productive Alpine grasslands far from houses, crops and farming activities; herbaceous military training areas; grasslands which can be grazed, never sown and not otherwise managed by way of application of fertilizers, pesticides, drainage or reseeding except by burning; grasslands with a yearly productivity less than 1.500 units of fodder/ha; herbaceous grass covered composed of non-palatable gramineous species such as *Molinia spp.*and *Brachypodium spp.*; derelict natural grassland where ligneous vegetation cover less than 75 % of the area; grasslands found on calcareous soils with a high proportion of calcicole species of limestone, chalk Machair or Karst; grasslands dotted with bare rock areas which represent less than 25 % of the surface.

This heading excludes also: grey dunes (class 331); swampy grassland (class 411); fallow land (class 211).

Transitional woodland/shrub (class 324)

Transitional woodland/shrub class includes bushy or herbaceous vegetation with scattered trees, woodland degradation or forest regeneration/recolonization also can be represented by this class (Fig.2.6). Areas of natural developmental forest formations like young broad–leaved and coniferous wood species with herbaceous vegetation and dispersed solitary trees for instance are presented as this class. Also natural vegetation succession of abandoned meadows and pastures or after calamities of various origins, part of this class may also present various degenerative stages of forest caused by industrial pollution, etc.

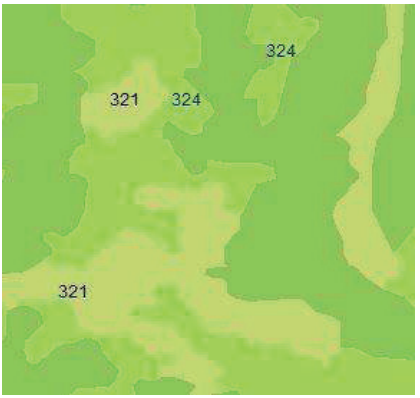


Fig.2.6. Representative demonstration of the quoted class on examples of transitional woodland/shrub vegetation surrounded by forest and natural grassland (class 324).

This heading includes: arborescent mattorals which are pre- or post-formation of broad-leaved evergreen forest with a usually thick evergreen shrub stratum composed of evergreen oaks (*Quercus suber/ilex/ rotundifolia*), olive trees, carob trees or pines the crown cover density of which is less than 30 % of the surface; agricultural lands (classes 2xx) under recolonizing process with occurrence of forest trees which cover more than 30 % of the surface (scattered trees or small plots of forests); abandoned fruit tree plantations and orchards; clear cuts in forest areas; young plantations; forest nurseries inside forests areas; natural grassland areas with small forests < 25 ha and/or with trees intermixed which cover more than 30 % of the surface; open clear-felled or regeneration areas with regrowing during transition stage which last for maximum 5-8 years; forest burning areas which do not show black tones any more in the satellite image but are still visible; heavily damaged forests by wind, snow-brake or acid rains and other pollution with more than 50 % dead trees; marginal zones of bogs with a vegetation composed of shrubs and pine bogs which cover more than 50 % of the surface; bare rocks with scattered trees that cover more than 10 % of the surface.

This heading excludes: transitional woodland areas when the area has been overgrown with forest vegetation. The canopy closure which is at least 50 % and if the average breast diameter of trees is at least 10 cm (class 311); abandoned olive groves (class 323); agricultural lands (classes 2xx) with occurrence of forest

vegetation with an overgrowing rate less than 50 % (class 243); stable/climax tree-like forest formations with a tree height less than 4 m and *Pinus mugo* forests (class 322); arborescent mattoral with trees of which the crown cover is more than 30 % (class 311).

2.1.3. Open spaces with little or no vegetation

As it can be seen from titles into this area have been included natural areas covered with mall amount of vegetation or there is not vegetation at all. Here are included open thermophile formations of sandy or rocky grounds distributed on calcareous or siliceous soils frequently disturbed by erosion, than steppic grasslands, perennial steppe-like grasslands, meso- and thermo- Mediterranean xerophile vegetation, mostly open, short-grass perennial grasslands, alpha steppes, vegetated or sparsely vegetated areas of stones on steep slopes, screes, cliffs, rock fares, limestone pavements with plant communities colonizing their tracks, perpetual snow and ice, in land sand-dune, coastal sand-dunes and burnt areas.

Beaches, dunes, and sand plains (class 331)

This class includes beaches, dunes and expanses of sand or pebbles in coastal or continental locations, as well as beds of stream channels with torrential regime (Fig.2.7.). Into it are included supra-littoral beaches and dunes developed at the back of the beach from high water mark towards land.

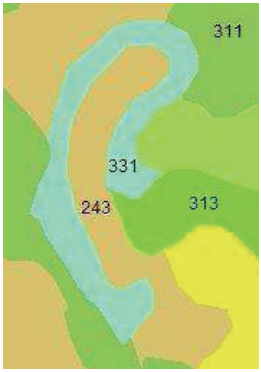


Fig.2.7. Representative demonstration of the quoted class on examples of sandy in Serbia (class 331).

This heading includes: river dune formation in the immediate vicinity of great rivers; inland and lacustrine dunes; shifting dunes with mobile, unvegetated or open grasslands (white dune); grey dunes fixed, stabilized or colonized by more or less closed perennial grasslands; machair formations (nature coastal sand-plain with more or less surface and grassland vegetation); ergs (continental dune field located in desert); accumulation of gravels along lower section of Alpine rivers.

This heading excludes: inland dune heaths (crowberry and heather brown dunes) (class 322); inland dunes thickets occupied by dense formations of shrubs including sea buckthorn, privet, elder, willow, gorse or broom often festooned with creepers (class 322); dune juniper thickets and woods (class 32x); dune sclerophyllous scrubs (class 323); wooded dune (class 31x); humid dune-slacks (class 411); unvegetated gravels on steep Alpine mountain side (class 332); vegetated islands inside stream beds (class 3xx).

Bare rock (class 332)

Class of bare rocks include scree, cliffs, rock outcrops, together with active erosion, rocks and reef flats situated above the high-water mark.

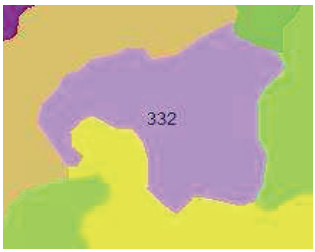


Fig.2.8. Representative demonstration of the quoted class on example of the cliff relief forms in Serbia (class 332).

This heading includes: unvegetated abandoned extraction sites; sparsely vegetated areas where 75 % of the land surface is covered by rocks; stable rocks with limestone pavements, block litter and mountain-top-debris; unvegetated lapiaz; sites and products of recent volcanic activities, volcanic ash and lapilli fields, barren lava fields; unvegetated supra-littoral rocky zones.

This heading excludes: white dunes (class 331); mediolittoral rocky sea beds (class 423); bare rocks with scattered trees that cover more than 10 % of the surface (class 324).

Sparsely vegetated areas (class 333)

Steppes, tundra and badlands are included into a sparsely vegetated area, as well as scattered high-altitude vegetation, that is composed of gramineous and/or ligneous and semi-ligneous species for determining the ground cover percentage, excluding cryptograms (Fig.2.9.).

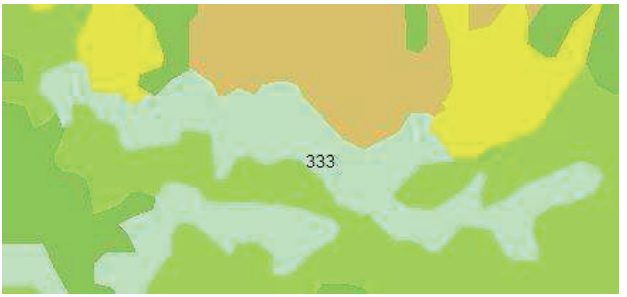


Fig.2.9. Representative demonstration of the quoted class on example of scattered high-altitude vegetation in Serbia (class 333).

This heading includes: sparsely vegetated and unstable areas of stones, boulders, or rubble on steep slopes where the vegetation layer covers between 15 % and 50 % of the surface; sub-desertic steppes with gramineous species (*Artemisia spp.*) mixed with alfa (*Stipa spp.*) when they cover between 15 % and 50 % of the surface; vegetation of ‘lapie’ areas or limestone paving; bare soils inside military training areas; karstic areas of gramineous, ligneous and semi-ligneous vegetation.

This heading excludes: windblown part of dune areas (class 331); areas where ground cover more than 85 % of the surface (class 332); areas where the vegetation layer covers more than 50 % of the surface (class 321); dense alfa (*Stipa ssp.*) coverage (class 321).

Burnt areas (Class 334)

This class includes areas affected by recent fires, still mainly black (Fig.2.10.). Burnt forest areas, moors and heathlands, transitory forest-shrub formations, areas with sparse vegetation are presented by this class.

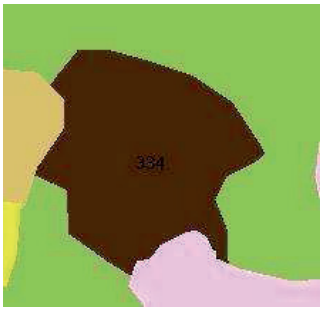


Fig.2.10. Representative demonstration of the quoted class on examples of burnt forest areas in Serbia (class 334).

This heading includes: burns which are younger than three years and still visible in the satellite images; all natural and semi-natural vegetated areas.

This heading excludes: human farming management by burning arable lands (class 211).

2.2. Methodology for indicators calculation

In this section have been presented methodology for calculation of following indicators:

- Forest area,
- Forested landscape,
- Forested landscape (German model),
- Forest land,
- Forest and semi-natural area.

2.2.1. *Indicator: Forest area*

This indicator has the strictest criterion for counting forest area, due to the fact that it only count compact forest area larger than 25 ha. Forest area as indicator maps all major forest complexes. This indicator gives useful information for both planning in forestry and the biodiversity analysis of habitat.

This indicator can be calculated following Formula 1, where 311, 312 and 313 representing sum of relevant classes of CORINE Land Cover.

Formula 1: 311+312+313=

2.2.2. *Indicator: Forested landscape*

Forested landscape indicator is similar, but at the same time different than previous mentioned one. Difference is that it doesn't include only compact forests, but also forests and trees that are included into other land categories. This forests and groves doesn't form consistent forest ecosystem area in eco-physiological terms, but at the same time, are involved in the production of oxygen and its emission capacity at more or less the same level as the forest.

Calculation can be done following Formula 2, using relevant classes of CORINE Land Cover.

Formula 2: 311 + 312 + 313 + 0.5×324 + 0.33×243=

2.2.3. *Indicator: Forested landscape based on the German model*

Forested landscape, regarding the German model, can be calculated using Formula 3.

Formula 3: 311 + 312 + 313 + 324 + 0.33×243=

2.2.4. *Indicator: Forest land*

According to the European Environment Agency (2006) one of the most common ways for calculation area of forest land is summing the class of forests and transitional woodland-shrub vegetation (Formula 4) using relevant classes of CORINE Land Cover.

Formula 4: 311 + 312 + 313 + 324=

2.2.5. *Indicator: Forests and semi-natural areas*

One more possible way to calculate forestland and semi-natural area is by using the information shown by classes 3XX. It includes forest and transitional woodland-scrub vegetation, then natural grasslands (class 321), sandy beaches and dunes (class 331), bare rock (332), sparsely vegetated area (class 333) and burnt area (class 334) (Formula 5) using relevant classes of CORINE Land Cover.

Formula 5: 311 + 312 + 313 + 321 + 324 + 331 + 332 + 333 + 334=

3. RESULTS AND DISCUTIONS

3.1. FORESTRY INDICATORS

The analysis of forestry indicators included data for 1990, 2000, 2006 and 2012 years. Into all analysis were included data for territory of Serbia but without taking into consideration data for the territory of Kosovo and Metohija. Results are presented in following paragraphs by indicators.

3.1.1. *Indicator: Forest area*

Following the data obtained by CORINE Land Cover for 1990 year, Forest area in Serbia is estimated to 2 259 643 hectares, or 29.13% of the territory.

Forest area (1990) = 26.67 + 0.99 + 1.46 = 29.12 % = 2 259 643 ha

Regarding the data, provided by CORINE Land Cover for 2000 in Serbian forest area is amounted to 2 266 333 ha, which represents 29.2% of the territory (Fig.3.1.).

Forest area (2000) = 26.664 + 1.05 + 1.5 = 29.21 % = 2 266 333 ha

In central Serbia, forest area in 2000 year was 2 126 099 ha, which represents 37.72 % of the Central Serbia territory, while in Autonomous province Vojvodina was 140 234 ha, representing 6.61 % of its territory.

Fig.3.1. CORINE Land Cover 2000 Serbia.

In Serbia, data about forests also provides National Forest Inventory, under Ministry of Agriculture, Forestry and Water Management of Republic of Serbia, Department of Forests, (Bankovic et al. 2009). According to the data of National Forest Inventory in 2000, Forests in Serbia occupied 2 252 400 ha, that represent 29.1 % of its territory.

It should be always kept in mind that it is necessarily to reconsider the methodology of obtaining data at two different Institutions, so possible differences in the result can be explained. Methodology used in National Forest Inventory is completely different than one used by CORINE, and even though, coincidence in results presents very encouraging information for the forest areas in Serbia.

It is important to mention that methodology of CORINE Land Cover analysis use planar surface, while the National inventory methodology is based on the cadastral area. Cadastral areas include more information than just simple geography, e.g. details of the ownership, the precise location (even GPS coordinates), the dimensions, the value of individual parcels of land and etc. Therefore can be expected, considering the fact that forests are particularly characteristic of hilly-mountainous regions, that the cadastral area of forest is much larger in Serbia.

Using the data about land cover obtained by CORINE methodology for 2006th year forest area in Serbia is estimated to 2 287 751 ha, that represent 29.5 % of the territory.

Forest area (2006) = 26.77 + 1.14 + 1.59 = 29.5 % = 2 287 751 ha

Analyzing CORINE Land Cover data for 2012 forest area in Serbia is amounted at 2 301 014 ha, representing 29.67 % of the territory.

Forest area (2012) = 26.80 + 1.19 + 1.68 = 29.67 % = 2 301 014 ha

According to the data obtained by CORINE Land Cover for 2012 year, forest area in Serbia is presented with 2 373 740 ha, and as it was mentioned before, this present 30 % of territory of Republic of Serbia.

Monitoring of forest area in Serbia has been done since 1938, and using relevant information can be determined trend of its changes.

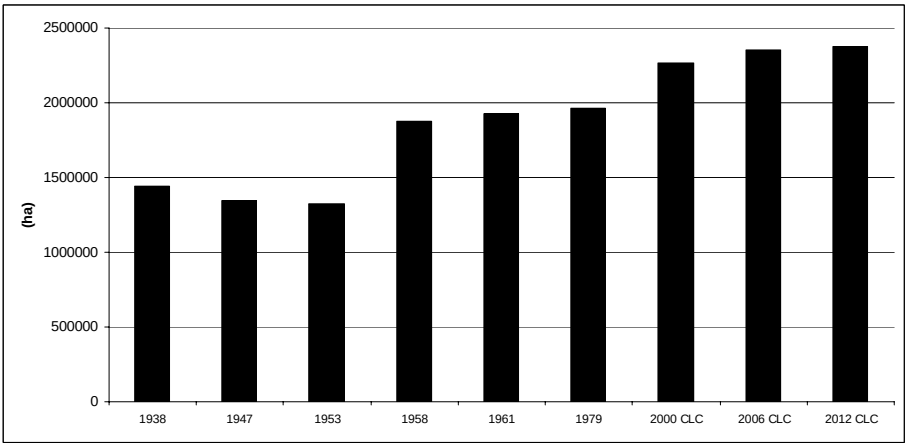


Fig.3.2. Trend of forest area changes in Serbia (excluding teritory of Kosovo and Metohija).

Regarding the results of monitoring forest area for time period 1953-2012 can be concluded that forest area increased for more than 1 million hectare, that present increment of 75 % compared with data from 1953 (Fig.3.2).

3.1.2. *Indicator: Forested landscape*

According to methodology for calculation Forested landscape indicator in Serbia for 1990 year area was estimated to a 2 822 832 ha, or 36.39 % of the territory.

Forested landscape (1990) = 26.67 + 0.99 + 1.46 + 3.07 + 4.19 = 36.39 % = 2 822 832 ha

Forested landscape indicator in Serbia in 2000 year was represented with 2 831 365 ha or 36.5 % of the territory. Distribution of forested landscape at Serbian territory is presented at Fig.3.3.

Forested landscape (2000) = 26.67 + 1.05 + 1.50 + 3.05 + 4.23 = 36.5 % = 2 831 365 ha

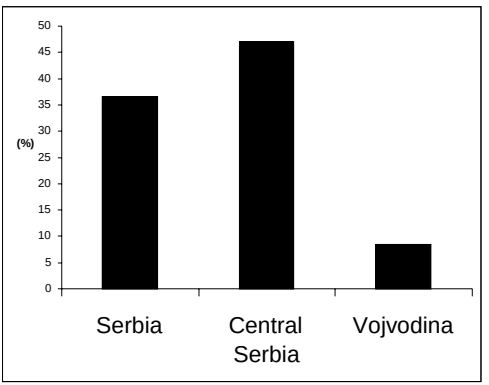


Fig.3.3. Forested landscape in Serbia 2000th.

Using the available CORINE data for calculation Forested landscape in Serbia, it was estimated that in 2006 year area of Forested landscape was 2 876 947 ha.

Forested landscape (2006) = 26.77 + 1.14 + 1.59 + 2.94 + 4.27 = 36.71 % = 2 876 947 ha.

Analyzing data for 2012 year, area presented by Forested landscape in Serbia was amounted to 2 876 947 ha or 37.1 % of the territory.

Forested landscape (2012) = 26.80 + 1.19 + 1.68 + 3.35 + 4.07 = 37.1 % = 2 876 947 ha

Forested landscape as indicator describes the land area under forest or vegetation that is very similar to forest, regarding its environmental characteristics. It is important to understand that these indicator criteria don't have to meet forest compactness, due to similarity in eco-physiological aspect of this vegetation. The similarities occur in leave surface and its structure (active area of plant cover) and therefore significantly participate in the "production" of oxygen and the emission capacity. Nevertheless, this fragmentation of forest area results in increment in overall landscapes biological diversity. Landscape biological diversity refers to a greater habitat and species diversity due to the fact that forests are intersected with meadow areas and shrubs.

Forest landscape indicator takes into account all classes which due to the discrimination criterion, at least 25 hectares of compact surfaces, and consideration the fact that many fields and other agricultural areas have been "intersected" by the trees and forests, particularly in rural areas, were not taken into account. Those, aforementioned areas, represent the vegetation of transitional woodland/shrub or class 324 and land principally occupied by agriculture with significant areas of natural vegetation marked as class 243.

Various countries of Europe have different criteria for indicator calculation. These criteria depend on the discrimination degree between different classes of intermediate shapes and sizes and their own share in the total area. Germany, as developed countries, use the criteria which show clear discrimination between forested and non-forested (agricultural or artificial) surface, but, at the same time include small representation of transitional, complex surfaces. Class 324 or transitional woodland-shrub vegetation occupies area less than 0.5 % of the total area, and the class of 243 or land principally occupied by agriculture, with significant areas of natural vegetation, integrity credited with forests, is less than 2.5 % (Keil et al., 2005).

On the other hand, Serbia, as developing country, has nearly a quarter of the territory (about 24 %) under vegetation that has complex nature and represents some form of transitional stages (Fig. 3.4.), that is contrary to the situation in developed countries. These classes present successional stages of reforestation process, or some of the stages in the process of degradation forested surface. Principally this has been notices in rural areas at higher altitude in hilly-mountain region of central Serbia. In Serbia, class 324 (transitional woodland-scrub) covers 6.1 %, and class 243 (land principally occupied by agriculture, with significant areas of natural vegetation) representative 15.8 %.

Distribution of these transitional classes in 2000th (324 and 243) in Central Serbia and Autonomous Province (AP) Vojvodina is quite different, in which is shown at Fig.3.4.

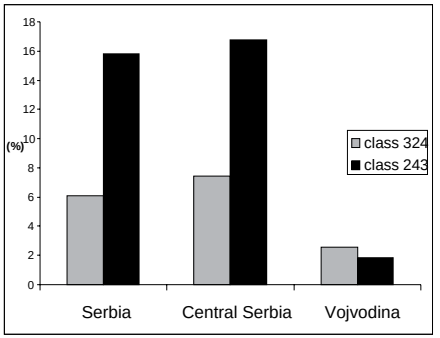
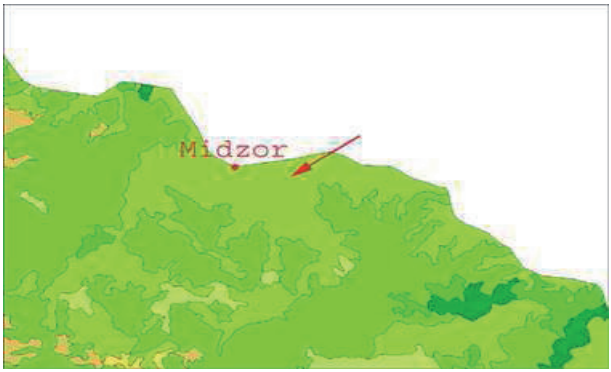


Fig.3.4. Classes 324 and 243 in Serbia 2000th.

Class 324 represent vegetation cover where dominate shrubby vegetation but also can be found scattered trees. This class can also represent one of the stages in process of degradation and / or regeneration of forests. Into this class have been included less parcels of land that are surrounded or intersected by forests. During the last decades it's been noticed migration trend from rural areas to urban, that have as a result occurring process of natural vegetation succession, for e.g. former fields and pastures are included in the process of succession towards forest. Into this class are also included areas of forests degradation that are damaged or over-visited by other processes (fires, disease). One illustrative example of the class 324 in Serbia is the region near the peak Midžor (2 168 m) at the Stara planina mountain (Fig.3.5.).



A

B

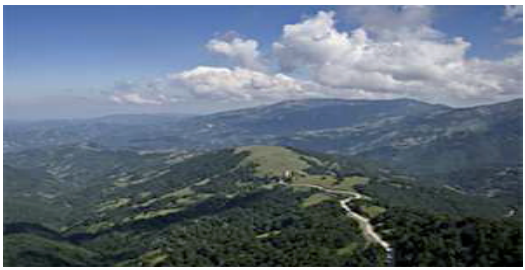
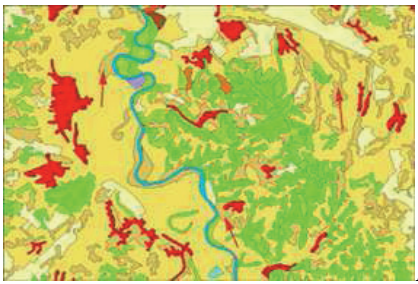

C

Fig.3.5. Midžor peak: A- CORINE Land Cover 2000, B-satellite imagery, C-image. (Red arrows indicate areas of class 324)

Region at Stara planina mountain area around it's the highest peak Midžor occupies an area of 7 000 ha is defined as class 324. This area is completely surrounded by broadleaf and coniferous trees (classes 311 and 312). Regarding the relevant images can be concluded that at least half of this area can be considered as a forest.

Class 243 has been represented by predominantly agricultural areas with a significant amount of natural vegetation, where agricultural land covers between 25 and 75 % of the total area surface. This class also includes natural grasslands or forest mainly in the nearby areas of a village. In Serbia this class can be found near river Morava, in lowlands, but it can be also found in the hilly-mountain areas by forest edges (Fig.3.6.).


A

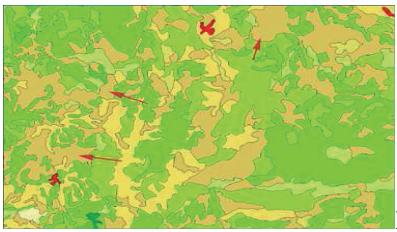

B

Fig.3.6. Class 243, CORINE Land Cover 2000th. A- near river Morava, B-in high mountain areas. Red arrows indicate areas of class 243.

3.1.3 Indicator: Forested landscape (German model)

Analysis Forested landscape area in Serbia, using German methodology and CORINE Land Cover data for 1990, estimate area to the 3 064 078 ha or 39.5 % of the territory.

Forested landscape-German model (1990) = 26.67 + 0.99 + 1.46 + 6.14 + 4.19 = 39.5 % = 3 064 078 ha

Calculation of this area, using CORINE Land Cover data for the 2000 year gives the result of 3 068 617 ha or 39.56 % of the territory.

Forested landscape-German model (2000) = 26.66 + 1.05 + 1.50 + 6.12 + 4.23 = 39.56 % = 3 068 617 ha.

Analyzing CORINE Land Cover data for 2006 year using German model of forested landscape in Serbia it was estimated that this indicator occupied 3 075 550 ha or 39.66 % of the territory.

Forested landscape-German model (2006) = 26.77 + 1.14 + 1.59 + 5.89 + 4.27 = 39.66 % = 3 075 550 ha

Using the newest CORINE Land Cover data for 2012 year and German model of forested landscape in Serbia, areas is estimated to the 3 136 744 ha or 40.45 % of the territory.

Forested landscape-German (2012) = 26.80 + 1.19 + 1.68 + 6.70 + 4.07 = 40.45 % = 3 136 744 ha

Despite the results, applying the German methodology for calculation Forested landscape indicator in Serbia would not be entirely appropriate. The reason is that this methodology takes into account the whole class 324 and one third of the class 243. Relevant available data of CORINE Land Cover classification in different countries shows that 50-70 % of the transitional woodland-scrub vegetation belt (class 324) in non-Mediterranean countries can be counted as forest. Since Germany has very small area of class 324 (0.5 %) meaning that potential error in results would not be significant and therefore this model can be implemented (Keil et al., 2005). In Serbia, this is not the case, since Serbia has more than 6 % of the transitional woodland-shrub vegetation (Popovic et al., 2015). So, if into consideration has been taken this class for calculation forested landscape it would mislead final results. But, this class can be included for counting area of indicator Forest land, and it would not disturb results.

The results of this German model of forested landscape indicator give very useful information for future environmental analysis of emission capacity, as well as for habitat analysis from the aspect of biodiversity. Speaking about Serbia, regarding the results of calculation, Forested landscape in central Serbia is slightly above 47 % and in Vojvodina, is about 8.5 %.

3.1.4. *Indicator: Forest land*

Results of analysis CORINE Land Cover data for 1990 year, show that Forest land area is amounted to 2 735 565 ha, or 35.26% of the territory.

Forest land (1990) = 26.67 + 0.99 + 1.46 + 6.14 = 35.26 % = 2 735 565 ha

Estimation of the Forest land area in Serbia based on the CORINE Land Cover data for 2000 year is amounted to the 2 740 836 ha, or 35.33 % of the territory.

Forest land (2000) = 26.66 + 1.05 + 1.5 + 6.12 = 35.33 %

Distribution of different classes in Serbia, regarding the data for 2000 year is presented at Fig. 3.7. In central Serbia in 2000 year, forest land occupied 45.17 % and in AP Vojvodina 9.19 % of territory.

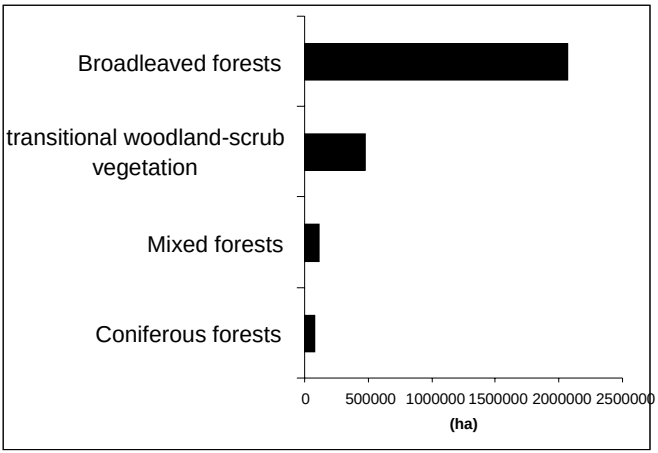


Fig.3.7. Categories of forest classes in Serbia 2000th.

Visual distribution of classes (311, 312, 313 and 324) included into Forest land indicator in 2000 year are presented at Fig. 3.8.

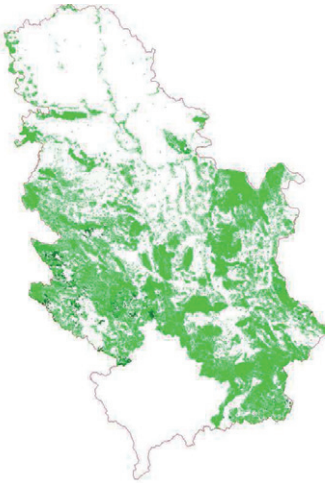


Fig.3.8. Forest land, CORINE Land Cover 2000.

In 2006 year according to CORINE Land Cover data, Forest land indicator in Serbia is amounted to 2 744 659 ha, or 35.39 % of the territory.

Forest land (2006) = 26.77 + 1.14 + 1.59 + 5.89 = 35.39 % = 2 744 659 ha

The newest CORINE Land Cover data for 2012 year, shows that Forest land in Serbia is estimated to 2 820 608 ha, or 36.37 % of the territory.

Forest land (2012) = 26.80 + 1.19 + 1.68 + 6.70 = 36.37 % = 2 820 608 ha

Forest land indicator gives very useful information for forestry planning and management. Due to the possible changes and increments in the vegetation capacity emission, this information can be relevant for eventually future “gases trading”.

3.1.5. *Indicator: Forests and semi-natural areas*

Following the formula and using the CORINE Land Cover data for 1990 year, Forest and semi-natural areas was amounted to 2 978 494 ha, or 38.40 % of the territory.

Forests and semi-natural areas (1990) = 26.67 + 0.99 + 1.46 + 2.8 + 6.14 + 0.03 + 0.002 + 0.3 + 0.008 = 38.4 % = 2 978 494 ha

In 2000, the calculated area of this indicator was 2 981 471 ha or 38.43 % of territory of Serbia.

Forests and semi-natural areas (2000) = 26.66 + 1.05 + 1.5+ 2.8 + 6.12 + 0.03 + 0.002 + 0.26 + 0.008 = 38.43 % = 2 981 471 ha

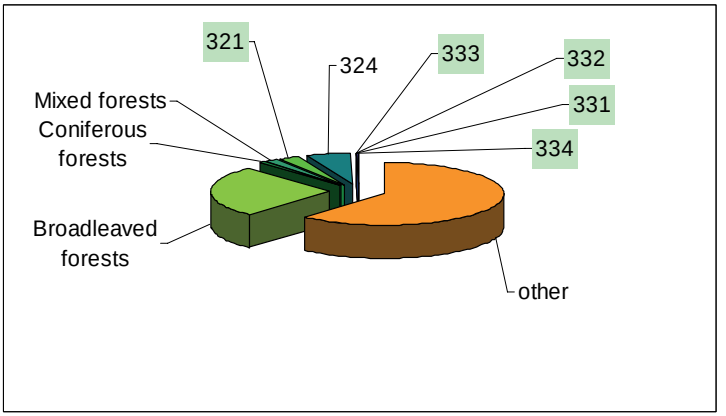


Fig.3.9. Forests and semi-natural areas 2000th.

In 2006, sum within the 3XX classes, representing indicator Forests and semi-natural area in Serbia amounted to 2 970 210 ha, or 38.3 % of the territory.

Forests and semi-natural areas (2006) = 26.77 + 1.14 + 1.59 + 2.64 + 5.89 + 0.02 + 0.002 + 0.25 + 0 = 38.3 % = 2 970 210 ha

According to the CORINE Land Cover data for 2012 year was calculated area of indicator Forest land in Serbia and its size was amounted to 3 045 230 ha, or 39.27 % of the territory.

Forests and semi-natural areas (2012) = 26.80 + 1.19 + 1.68 + 2.64+ 6.70 + 0.01 + 0.003 + 0.24 + 0.011 = 39.27 % = 3 045 230 ha

Total area covered by the classes, excluded from the class of forest and transitional woodland-scrub vegetation (natural grassland, beaches, dunes and sands, bare rocks, sparsely vegetated area and burnt areas), in 2000th was amounted to 3.1 % of total territory:

321 + 331 + 332 + 333 + 334 = 2.81 + 0.03 + 0.002 + 0.26 + 0.008 = 3.1 %

During the period 1990-2000, size of an area of natural grassland, beaches, dunes and sands, bare rocks, sparsely vegetated and burnt area, followed reduction trend of 0.04 %. In 2006 and 2012 decrement of this area continued (Fig.3.10.).

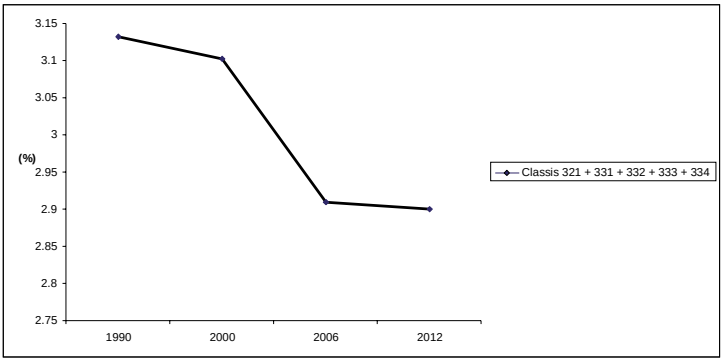


Fig.3.10. Reduction trend of surface of classes 321, 331, 332, 333, 334 in Serbia in period 1990-2012.

Regarding the CORINE Land Cover data for 2000 year can be concluded that all other categories of land, except natural pastures, are insignificantly small to affect the final sum. Nevertheless, it should be pointed out that natural pastures occupy area primarily at high mountain natural areas that can be hardly or not at all subject to the process of natural succession to forests, and therefore this criterion for indicator creation for Serbia is less adequate.

But fact that should be kept in mind is that this indicator can be used for monitoring the habitats dynamics, regarding its biodiversity, especially in high mountain areas.

3.2. COMPARATIVE ANALYSIS OF FORESTLAND INDICATORS

3.2.1. *Changes 1990-2000*

Monitoring trends of forestland indicators during the time period 1990-2000 year, can be concluded that there was noticeable increment in areas of all indicators. At the same time it is observed clear trend of increment of a share of meadow vegetation, that indicates a clear process of natural succession to bushy or forest vegetation. Natural succession of meadow to bushy vegetation is in general slower process than succession from bushy to forest vegetation.

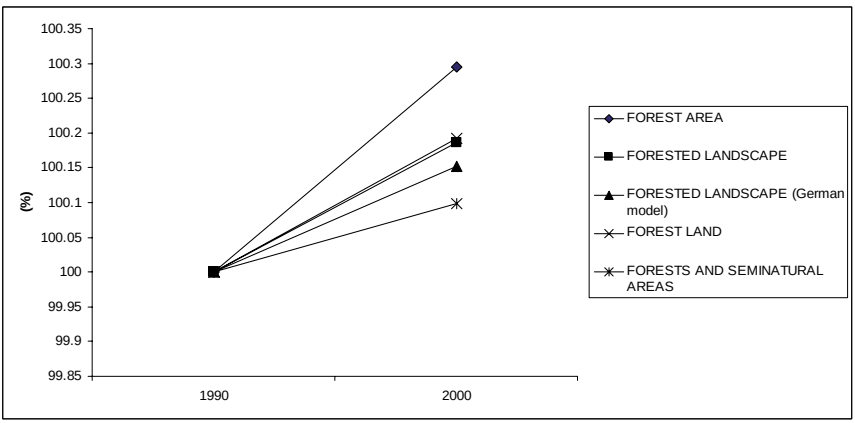


Fig.3.11. Rate of change of Forest indicators during time period 1990-2000.

Analyzing trends of changes of forest indicators significant variation in rates (Fig.3.11) was detected. Difference in rates of natural vegetation and its succession result in noticeable deviations in indicators Forest area and Forest and semi-natural areas. Since calculation of indicator Forest area is based on the area of compact forest stands (more than 25 hectares), share of meadow vegetation is very small and therefore is not relevant.

Regarding the changes in dynamics of Forested landscape and Forest land indicators can be recognized similar pattern and dynamic of succession. This

similarity occurs due to the approximately the same amount of meadow vegetation in mentioned indicators. Therefore, it is expected that significant share of meadow vegetation direct similar speed and manner of succession.

Since Forest area present the strictest criterion for determining forestland, as it was mentioned before, trend of changes for the period 1990-2000 shows increment in surface covered by the forests of 0.3 % or 6 690 ha. This increasing in forest area surface is useful for both planning in forestry, as well as for improving the forestry habitat biodiversity.

Regarding the analysis of Forestland landscape from 1990-2000, there was noticed trend of increment of 0.19 %, meaning surface change of 5 256.1 ha. In 2000, total area of aforementioned indicator was amounted to 2 828 088 ha. This indicator includes also fragments of forest in meadow areas as well as shrubs, which provide great habitat diversity and directly increase total biological diversity of landscape.

It is important to have in mind that 26.27 % of the previously mentioned area goes for meadow vegetation. Following the data for the time period 1990-2000, it is noticed increment of a meadow vegetation area of 619.6 ha. This fact is particularly important for area biodiversity.

Information provided by this indicator can be used for environmental analysis of emission capacity, as well for the habitat analysis, particularly in terms of biodiversity.

If into consideration and analysis are included data for the Forest land for time period 1990-2000, also is noticeable increment in its size for 0.19 %, that represent an increase in surface area of 5 271 ha. Area under forest land in Serbia in 2000th, according to CORINE data is amounted to 2 735 565 ha. This increment can be explained with changes in a class of transitional woodland-scrub vegetation, and increment in their variety. Based on CORINE Land Cover data it can be noticed that meadow vegetation occupies 23.46 % of the surface. Observed trend of increment in area covered by meadow vegetation, regarding the 1990th year, for 770.4 ha, reflects the increment of landscape diversity. Noticed increment can be explained by process of natural succession of meadow vegetation to shrubby and forest vegetation.

Usefulness of this indicator is that it can provide relevant information for planning in forestry, as well as to present possible changes in emission and increment the plant cover capacity that can be useful for future eventually “gases trade”.

Regarding the data for indicator Forests and semi-natural area for the analyzed period can be noticed increasing for 0.1 %. In 2000 year, area shown by this indicator is presented with 2 981 471 ha.

In this indicator can be noticed domination of woods and transitional woodland-shrub vegetation, together with meadow vegetation (natural pastures). During the period 1990-2000, classes excluded from forest and transitional woodland-scrub vegetation showed reduction trend for 0.03 %. Data obtained by CORINE Land Cover methodology in 2000 showed that meadow vegetation occupied 28.03 %, or 835 575.8 ha surface. Regarding the data from 1990th year, trend of enhancing meadow vegetation area is 15 052.8 ha. The largest share in class of meadow vegetation has class of natural pastures. In 2000 year, according to the CORINE Land Cover data, this category covers an area of 217.69 ha. Observing the trend of changes from 1990 year till 2000, it can be noticed reduction of aforementioned areas of natural grassland for 1.25 %.

3.2.2. *Changes 2000-2012*

Changes in the period of 2000-2012 are significantly different than changes discussed before, in period 1990-2000. In this period the most important changes occurred in classes Forest land where was noticed the biggest increment (Fig 3.12.) for about 3 % or 79 772 h. In previously discussed period, 1990-2000, Forest land increased area for only 0.19 % meaning enhancement of the surface area of 5 271 ha (Fig. 3.11).

Forest area indicator shows the smallest positive change in its size of 1.53 % or 34.68 ha (Fig. 3.12.). In the period 1990-2000 there has been an increase in the surface covered by forests of 0.3 %, meaning increase of the surface area of 6 690 ha (Fig.3.11.)

Indicator Forested landscape changes in almost the same pattern as indicator Forest area in the period 2000-2012 (Fig.3.12.), while analysis of data from previous decade showed increasing trend of only 0.186%, representing a surface change of 5 256.1 ha (Fig. 3.11.).

Monitoring changes of both indicators, Forests and semi-natural areas and German model of Forested landscape, can be noticed similar positive changes for period 2000-2012, for about 2.2 % or about 54 000 ha (Fig. 3.12.). In previous analyzed period, 1990-2000, has been noted positive change of indicators of Forests

and semi-natural area of 0.1 %, and increment of German model of Forested landscape for 0.15 % (Fig. 3.11.).

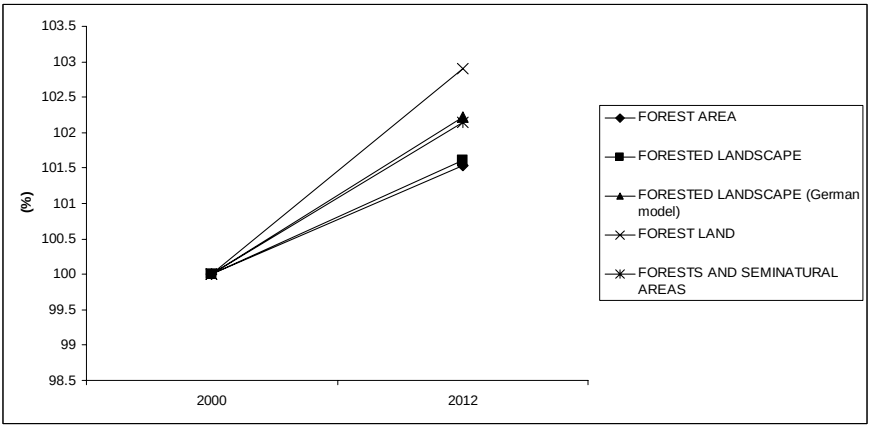


Fig.3.12. Relative change of indicators 2000-2012.

The unique conclusion that can be brought out comparing the changes in 2000-2012 and 1990-2000 is significant changes about tenfold in all indicators in the period 2000-2012. Therefore shown dynamic is remarkably highlighted.

On the other hand, together with changes in dynamic occurred changes in the amount of increment of very indicators. While in the period 1990-2000 the biggest change showed indicator Forest area, in the period of 2000-2012 this indicator showed the smallest change. Indicator Forest land showed the highest intensity of changes in period 2000-2012, followed by indicators Forests and semi-natural areas and German model of Forested landscape indicator.

It is important to highlight the fact that after 2000 year it is possible to track the changes in the number of polygons (Fig.3.13.). For 1990 year, there are no available data of number of polygons from CORINE Land Cover. The most significant change, in the polygons number for period 2000-2012, showed indicator Forest land (Fig. 3.13.) which increment of 4.4 % or 456 polygons.

Analysis of indicator Forest and semi natural areas, regarding the available CORINE data, showed increasing in number of polygons for 2.7 % or 326 polygons. Enhanced number of CORINE polygons for both indicators Forest area and German model of Forested landscape was about 0.8 % or for 50 polygons.

The only indicator that showed decrement in the number of polygons of 0.8 % or 87 polygons was Forested landscape.

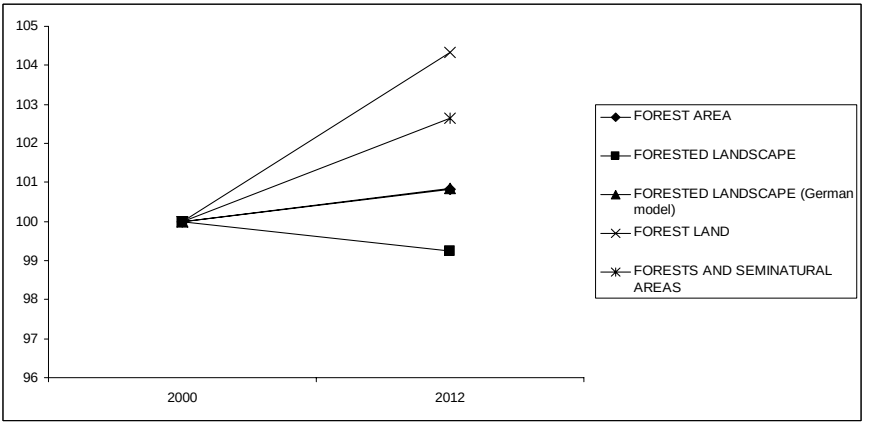


Fig.3.13. Change in number of polygons per indicator 2000-2012.

Changes in the number of polygons imply that occurrence of habitat changes showing its magnification or size reduction. Noticeable increment of 0.8 % in polygon numbers of Forest area indicator is presented at Fig.3.13., and results of the enhancing area under Forest cover was of 1.5 % or around 35 000 ha (Fig 3.12) in the time period 2000-2012. From this can be concluded that during the 12 years period formations of stable forest ecosystems occurred, as well as magnification of area under the forest.

Almost the same pattern follows indicator German model of Forested landscape that take into account whole transitional woodland/shrub vegetation (class 324). Some areas of transitional stages are developed to the climax forest ecosystems, while some forest areas, due to the degradation processes, become fragmented areas of transitional vegetation stages. Forest landscape indicator shows decreasing in the number of polygons in the time period 2000-2012 (Fig. 3.13) due to the fact that takes into account half of the class 324. At the same time, increasing the area under forest ecosystem overlaps with Forest area indicator (Fig. 3.12.).

This overlapping changes between these two indicators, together with changes in polygon numbers, Forest area and German model of Forested landscape indicators,

direct to a most significant linkage between classes of forest ecosystems (classes 311, 312 and 313) and transitional woodland/shrub vegetation (class 324).

Forest land indicator includes data of class 324 which define region with shrubby vegetation and scattered tree, and it is noticed that this class has the most significant increase of area and number of polygons. This indicator can represent both stages of degradation and / or regeneration of forests, and can be expected that into the 324 class are included small parcels of land surrounded or intersected by forests.

Nowadays, since is recognized well known migration trend of people from rural areas to urban, process of natural vegetation succession of the former fields and pastures towards forest frequently occurs. Regarding the number of polygons in the class of coniferous and mixed forest can be noticed increment of about 10 % in the period 2000-2012. At the same time, surface of aforementioned forests, was enhanced for about 13 %. Anyway, it should be kept in mind that these forests occupy only 10 % of total forest is in Serbia (Fig.3.7.), and the important fact is that transitional woodland-shrub vegetation (class 324) occupies bigger areas than coniferous and mixed forests together.

In Serbia, regarding the forest ecosystems, dominates broad leaves forests (90 %). Total number of polygons of broad-leaves forest was reduced for about 5 % in the period 2000-2012, while number of transitional woodland-shrub vegetation (class 324) increased for about 10 %. Together with reducing number of polygons of broadleaves forests, area under this type of forest increased for about 0.5 % during the 2000-2012. Regarding this two opposite facts, can be concluded that during this time period there was significant magnification of the area under broadleaved forests. Number of the polygons of transitional, 324 classes increased for about 10 %, and also are followed by increment of the area for about 10 % in the mentioned period. From this can be drown out conclusion that during this period were created new areas of transitional vegetation (class 324), meaning that significant amount of land from other classes were included into process of succession towards forest and new areas were included into transitional class 324.

Since Forest land indicator and German model of Forested landscape indicator takes into account whole class of transitional woodland-shrub vegetation, one logical question came out – why German model of Forested landscape indicator doesn't have the same intensity of increment as Forest land indicator? The explanation of this lays in fact that into calculation of German Forested landscape is included only one third of the class 243. Class 243 is used to mark predominantly agricultural area with a

significant proportion of natural vegetation. Amount of agricultural land that is included into this class is between 25 and 75 % of total surface.

Also, this class includes natural grasslands or forest mainly in the vicinity of a village. If we draw attention to the results of calculation German model of Forested landscape indicator during the analyzed period, it can be noticed that class 243 reduced area for 12.7 % in 2000 to 12.2 % in 2012. During the process of vegetation succession, class 243 (principally agricultural area with a significant proportion of natural vegetation) predominantly changes to the class 324 (transitional woodland-shrub vegetation). Class 243 is mainly distributed in rural areas where is noticed significant migration trend and decrement of livestock. German model of Forested landscape indicator shows less increment than Forest land indicator, during the period 2000-2012, due to the fact that it include only one third of decrement of class 243.

Forests and semi-natural areas also show significant increment during the period 2000-2012. Change in the results of summing classis 321 + 331 + 332 + 333 + 334 indicate decrement of an area in the analyzed period (Fig. 3.10.), but at the same time it was noticed decrement in the number of polygons for about 5 %. It shouldn't be forgot that Forest and semi natural areas takes whole transitional class (class 324) that shows significant increment in surface and number of polygons. Conclusion that can be point out from this fact is that land categories from the classes of natural vegetation were subject to a succession towards forests.

3.2.3. *Changes 1990-2012*

If we compare change of relative value of indicators in the period 1990-2012, all forestry indicators shows positive. Nevertheless, there is a difference in changes in dynamic of indicators.

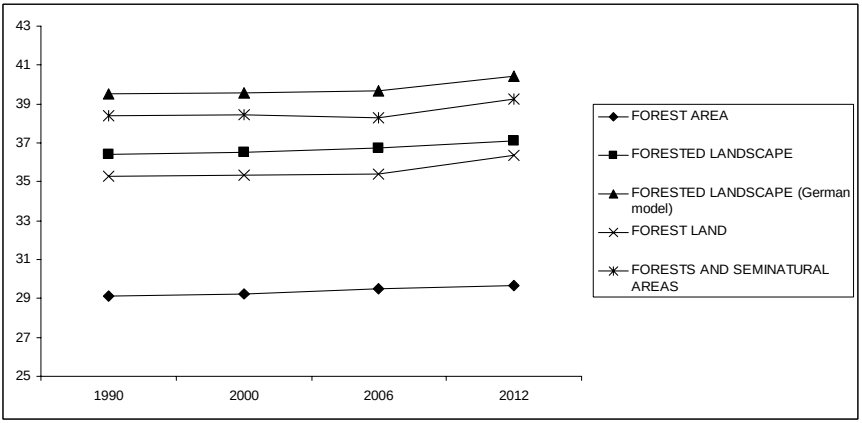


Fig.3.14. Indicators changes during the years 1990-2000-2006-2012.

Relative value (percentage of territory of Serbia, without Kosovo and Metohija) cannot clearly present dynamic and intensity of changes even though there is difference in dynamic. That's why dynamic is presented comparing to the referent 1990 year (100 %). From here can be concluded that changes in period 1990-2000 have similar intensity and relatively small dynamic, while changes in period 2000-2006-2012 are prominent (Fig.3.14.).

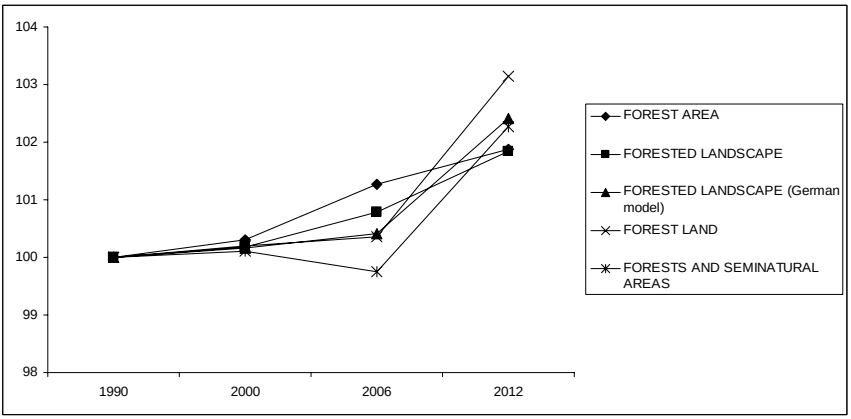


Fig.3.15. Relative indicators changes during the years 1990-2000-2006-2012 (100%=1990.)

Figure from above (3.15.) points out fact that all indicators shows distinct increment in the period 2000-20012. Detailed analysis of period in between, 2006 year showed that all indicators, except Forest and semi-natural areas, have positive trend change (Fig. 3.15.).

During the period 2000-2006, indicator Forest land had the most incensed increment, for about 1 %. The same indicator in the following six years period, 2006-2012, shows the smallest positive changes, for about 0.6 %.

Indicators Forest land and German model of Forested landscape in the time period 2000-2006, showed increment of about 0.15 %, where Forest land indicator shows the most significant positive change of 2.7 %, while German model of Forested landscape has had increased value of about 2 %.

Forested landscape indicator has very stable dynamic of increase showing in the period 2000-2006 increase of about 0.6 % and in the period 2006-2012 increase of about 1.1 %.

Even though Forest area and Forested landscape indicators have different dynamic of change in period 2000-2006 and 2006-2012, they have identical value in 2012. Regarding the changes in 1990-2000, this change is totally different, due to the fact that both of indicators had totally different changes (Fig.3.11.).

If we pay attention to the relative changes of indicator value, in the way that data for each previous captured epoch are presented as referent one (100 %), then can be noticed a bit different change dynamic. The most significant information is that indicator Forest area shows decrease in the period 2006-2012, if 2006 present referent one. (Fig.3.16.).

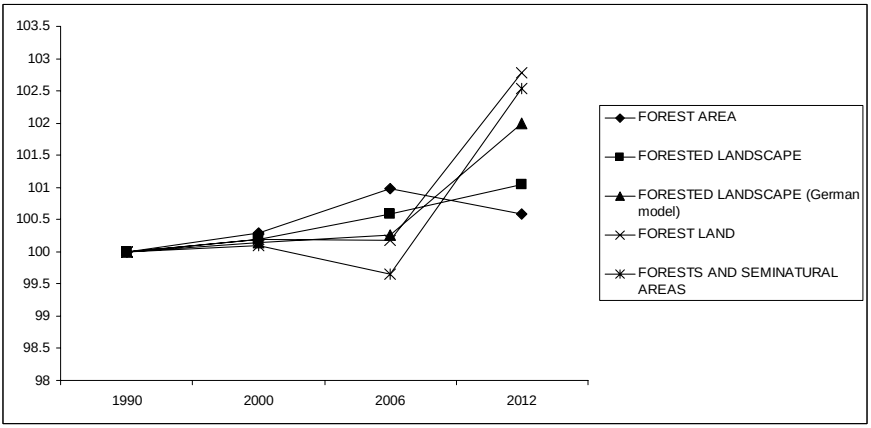


Fig.3.16. Relative indicators changes during the years 1990-2000-2006-2012 (every previous year is 100 for next year)

All other indicators show similar change dynamic, even when 1990 year is considered as referent one. It is noticed that the biggest increase occurs in period 2006-2012 in the indicator Forests and semi-natural areas indicator for about 3%. Positive trend in Forest land indicator was detected, and its value was about 2.6 %. German model of Forested landscape had increment in value for about 1.7 %, while Forested landscape indicator has increase of about 0.5% (Fig.3.16.).

Simplifying the representation of indicators changes dynamic, excluding data for 2006 year, and analyzing changes during the ten and twelve year's period, 1990-2000-2012, clear picture of dynamic changes is obtained. Regarding the changes of dynamic, taking 1990 year as referent one presented with 100 %, all indicators show increment. At the same time can be noticed that in the period 1990-2000 dynamic change is very small (Fig.3.17.). Forest area and Forested landscape indicators shows different increase in the period 1990-2000 and almost identical increase in the period 2000-2012 (Fig.3.17.). Simultaneously, in the period 1990-2000 Forest area indicators had the highest increase, while in period 2000-2012 had the smallest value increase.

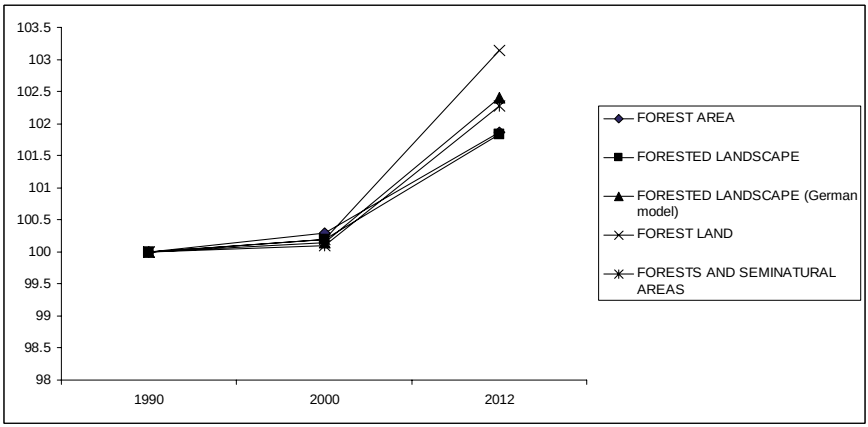


Fig.3.17. Relative indicators changes during the years 1990-2000-2012 (100 %=1990.)

Three other indicators, including German model of Forested landscape, showed almost the same changes in value but smaller than Forest area indicator, in the 2000-2006 showed significant change (Fig. 3.16.). As it can be seen from the Fig.3.17., Forest area and Forested landscape indicators have identical value in 2012. The highest intensity of changes in period 2000-2012 is noticed for indicator Forest land indicator. Similar increment shows indicators Forest and semi-natural areas and German model of Forested landscape indicator in the period 2000-2012.

Identical changes of indicators can be noticed if into consideration is taken relative changes in indicators value, in a way that each previous captured epoch is represent 100 % for the next one (Fig. 3.18.)

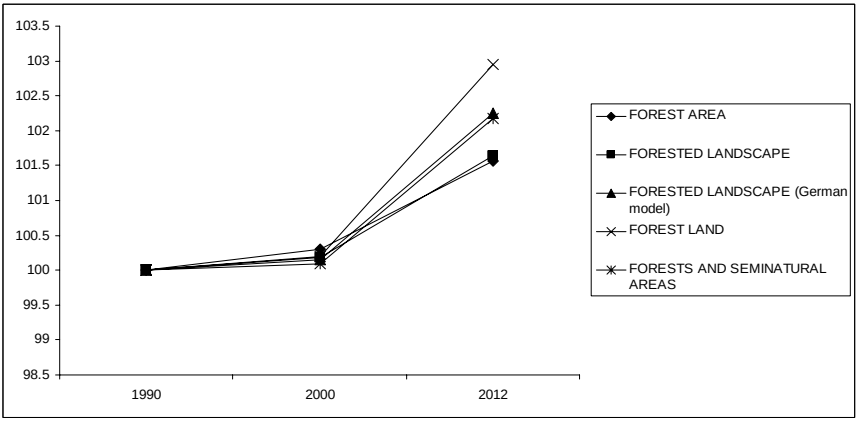


Fig. 3.18. Relative indicators changes during the years 1990-2000-2012 (every previous year is 100 for next year).

From the all aforementioned facts can be draw out conclusion that in this period there was increment of area that can be marked as potential forests. Even though the highest increment was noticed for indicator Forest area, in the period 1990-2000 (Fig.3.11.) and the following twelve years period, 2000-2012, it showed minimal increase (Fig.3.18.). This indicator takes into consideration only complex forest ecosystems already formed polygons of forest, without taking into consideration transitional stages of vegetation or potential forests area. Due to it, increment of Forest area indicator showed the smallest changes in period 2000-2012, even though all other indicators, each of them on its on specific way, include and consider transitional vegetation and potential forest areas, in the period 1990-2000 showed increment.

It should be highlighted that increment of transitional vegetation patterns and potential forest ecosystem areas can lead to the increment forest areas in the future. But, it is hard to say in which intensity this increment of areas under transitional and potential forest vegetation can influence the succession in the following period and forming forest areas.

For that reason in following paragraphs it should be analyzed changes in number of polygons.

3.2.4 *Number of polygons changes 2000-2012*

Results of monitoring changes in the numbers of polygons in period 2000-2012 are presented in Fig.3.19. Analyzing results can be concluded that absolute number of polygons is almost identical in the period 2000-2012.

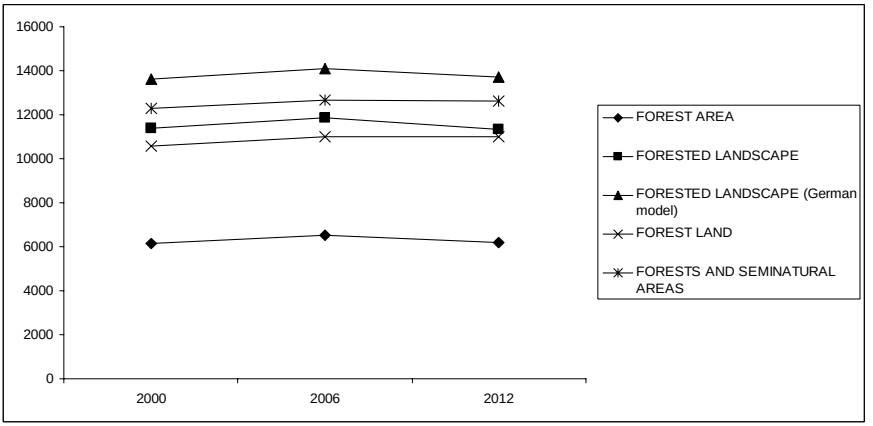


Fig.3.19. Number of indicator polygons change per year 2000-2006-2012.

On the other hand, if we track the changes of absolute number of polygons of each indicator (Fig.3.20.) it is noticed that Forest area, Forested landscape and German model of Forested landscape indicators follows almost the same dynamic pattern in period 2000-2012. Numbers of polygons of each indicator for 2006 year is higher than numbers of polygons in 2000 and 2012 year. This is, most probably, consequences of using different methodology in CORINE Land Cover, but as well it can be result of intense dynamic habitat changes in the field.

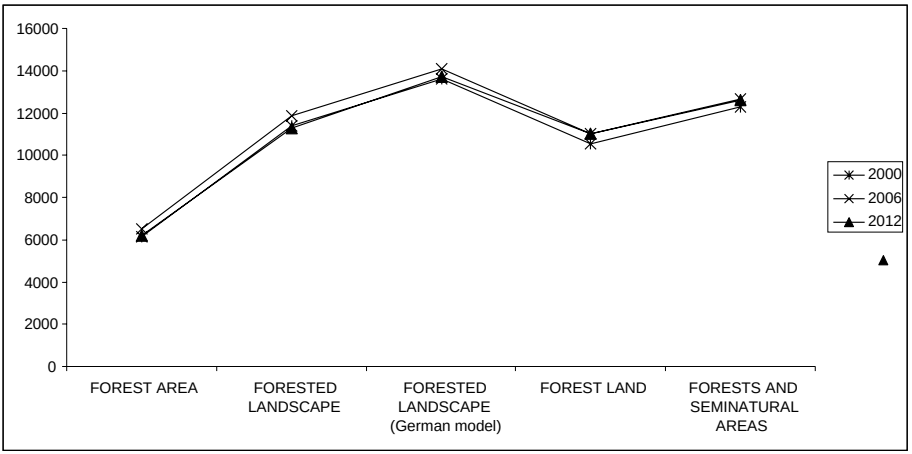


Fig.3.20. Change in number of polygons per indicator.

Analyzing data presented on right part of the Fig.3.20. can be concluded that number of polygons of indicators Forest land and Forest and semi-natural areas indicators in 2012 (line with triangles) is higher than in 2000 (line with snowflakes). This is direct indicator of intense dynamic changes of habitat in the field, due to the indicators Forest land and Forest and semi-natural areas that takes into account transitional woodland-shrub vegetation (class 324) or class of natural grassland (class 321) or class of open space with scrubby vegetation (classes 331, 332, 333 and 334). Since this classes have the most significant change dynamic, these naturally open or half-covered areas present ideal areas for starting succession towards forests. One more fact is that these areas, as well as rural areas, are adequate for settling and covering by allochthone, invasive species that in early stages of succession provide rapid development of bushy vegetation and in later succession stages transformation into trees cover. This can be also a reason of increment of the number of polygons by indicator.

This change is more noticeable on the Fig.3.21., comparing relative change in numbers of polygons, where number of polygons in 2000 is taken as 100 %. In the period 2000-2012 number of polygons of Forest land and Forest and semi-natural areas indicators in 2012 year is higher than on 2000, while indicators Forest area, Forested landscape and German model of Forested landscape indicators shows equal or lower number in polygons in 2000 year. Also, it is noticed that polygon's number

of all indicators in 2006 had higher value compared to the data in 2000, while in 2012 total polygon number of Forest land and Forest and semi-natural areas indicators was identical to the data for 2006. Three other indicators showed that polygons number in 2012 year is significantly lower than 2006.

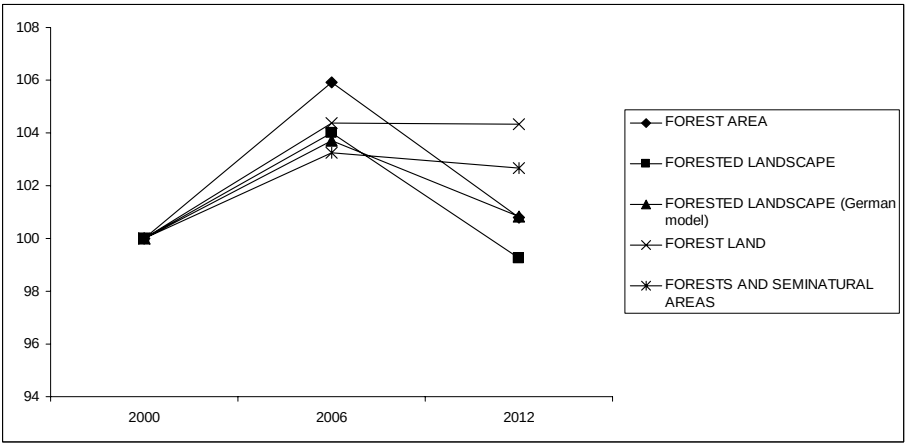


Fig.3.21. Relative change in number of indicators polygons 2000-2006-2012 (100%=2000.)

If dynamic changes in polygon numbers is presented as relative change where data for each previous year are 100% for the next one (Fig.3.22.), it can be notices that decrease in polygon number is expressed well in indicators Forest area and Forested landscape indicators in the period 2006-2012, and also in 2000-2012. It is important to point out that these results present the most impressive fact that magnification of forest area happened. Since Forest area indicator takes only classes of forest areas (classes 311, 312 and 313), and at the same time this indicators shows increment in area covered by forest for about 35 000ha in the period 2000-2012 (Fig.3.12.), only conclusion that can be draw out is that smaller areas were merged into big ones.

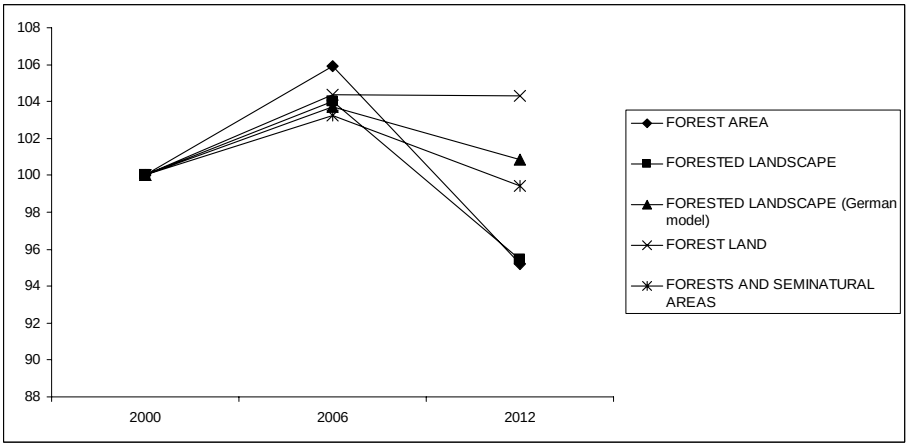


Fig.3.22. Relative change in number of indicators polygons 2000-2006-2012 (every previous year is 100 % for next year).

The same conclusion can explain status and changes in Forested landscape indicator that beside the forest areas count as well transitional woodland shrub vegetation (class 324) and agroforestry areas (class 243). These transitional classes present the last stadium of vegetation before it reach the last one, forests.

German model of Forested landscape indicator considers transitional woodland shrub vegetation (class 324) and agro-forestry areas (class 243) including different share in comparison with previous indicator, and follows the same pattern of polygon number change in period 2000-2012 as Forest area indicator in the same period (Fig. 3.13.)

In general, it can be concluded that decrement in polygon numbers of forest classes (classes 311, 312 and 313) together with increment of area under forests, occurred due to the transitional woodland shrub vegetation (class 324) and agro-forestry areas (class 243). These classes of land cover are in the last stadium of succession before forest and many smaller areas of transitional vegetation and agro-forestry areas were merged with existed polygons of forests or formed new forest areas. It is interesting that Forested landscape indicator shows decrement in polygon number in period 2000-2012 year, compared to Forest area and German model of Forested landscape indicators. Most probably this is result of inclusion only half of the classes of transitional woodland shrub vegetation (class 324), regarding the German model of Forested landscape indicator that include whole class 324.

Regarding the results it is important to point out that in the period 2000-2012 Forested landscape indicator has been showed as the strictest one in monitoring changes of forest vegetation.

4. CONCLUSIONS

The CORINE land cover data accounting database is highly flexible, and its full value will only be recognized when other users begin to explore the data for themselves. Its value is shown within the data and associated tools that are primarily intended as an aid to problem solving. Value of the data and tools reflects both the insights that they can bring but as well as innovative techniques that have been used in their construction. Presentation of information in this chapter has the aim to give an overview of the methodologies so potential users can understand how they can be used as accounting tools both to reproduce the analysis for themselves and to continue to design new types of output.

4.1 *Changes 1990-2000*

Based on the above presented data and results of analysis of changes in 1990-2000 can be concluded that Forest area indicator provides rigorous information of large forest complexes that can be used for future management and planning, for sustainable use and conservation. Observed increment of indicator of 0.296% and increment of surface indicators during the period 1990-2000 can be very important, both for planning in forestry, as well as for the habitat, analysis, particularly from the aspect of biodiversity.

In the period 1990-2000, indicator Forested Landscape follows the increasing trend of 0.186%. Since it provides information about eco-physiological parameters, primarily can be used in the calculation of emission capacity and in a possible “gases trade”. This increment of value gives very optimistic information for mentioned activities.

In the analyzed period 1990-2000, increment in area under meadow vegetation of 619.6 ha has been noticed as well. This information is important and encouraging especially for habitat biodiversity.

Increment in Forest land and indicators for 0.193 % during the period from 1990 to 2000, have been observed. This data is valuable primarily for the possible expansion of area under forest as well as for the planning of sustainable use and a possible “gases trade”.

Based on data obtained by CORINE land cover methodology, meadow vegetation occupied 23.46 % of the surface. In relation to the 1990th, trend of increasing the surface area, for the 770.4 ha is encouraging for increment of landscape diversity.

In the analyzed period, also is observed positive change in the size of Forests and semi-natural areas indicator by 0.1 %. Usefulness of this information is in possibility for analysis of area expansion (in terms of sustainable use and development), but also for determining of stability of certain habitats, especially in high mountain areas.

Results of analysis data, obtained by CORINE land cover methodology, showed that meadow vegetation occupies 28.03 %. Regarding the 1990 year, it's been noticed increasing trend of the surface covered by meadow vegetation for 15 052.8 ha.

4.2 *Changes 2000-2012*

Unique conclusion that can be draw out comparing the changes in period 2000-2012 to previous analyzed one, 1990-2000, is that changes in all indicators, in period 2000 – 2012, are tenfold times bigger. This is the most important conclusion of whole research work. So, vegetation changes in 2000-2012 were significant and intense compared to the earlier period.

On the other hand changes occurred in the amount of increment for each indicator. While in period 1990-2000 the most significant change occurred in indicator Forest area (increment of surface covered by forests of 0.296 %, that present increase in surface area of 6 690 ha), in period 2000-2012 same indicator showed the smallest change for 1.53 % or 34 681 ha.

Indicator Forest land showed the highest intensity of the changes in the period 2000-2012, followed by indicators Forests and semi-natural areas and German model of Forested landscape indicator. Regarding the results of analysis, in the period 2000-2012, as one of the most significant obtained information and the most significant change, is the highest increase in Forest land area (Fig.3.12.) for about 3 % ili 79 772 ha. During the period 1990-2000, also have been noticed increase in value of indicator Forest land for 0.19 %, representing an increase in surface area of 5 271 ha.

Indicators Forests and semi-natural areas and German model of Forested landscape indicator showed similar change in two year period, 2000-2012, for about 2.2 % or about 54 000 ha. Regarding the results of analysis data from the period 1990-2000 it was noted occurrence the increasing size of the indicators of Forests and

semi-natural area by 0.1 %, and increase of German model of Forested landscape for 0.152 %.

4.3 *Changes 1990-2012*

Regarding the results of analysis can be concluded that in period 1990-2000 change dynamic was not significant, and were almost stable (Fig.3.11.). In the Forest area and Forested landscape indicators were noticed different increase in the period 1990-2000 (Fig.3.11.) and almost the same increase in the period 2000-2012 (Fig.3.12.). At the same time, in period 1990-2000 indicator Forest area had the highest increase, while in period 2000-2012 showed the smallest increase.

Three other indicators, Forest land, Forest and semi-natural areas and German model of Forested landscape, even though in the period 1990-2000 showed similar increase, this increment was lower than Forest area indicator, while in the period 2000-2012 was marked significant increase (Fig.3.12.). As it can be seen at Fig.3.12. Forest area and Forested landscape indicators have identical value in 2012. The highest intensity of increment in period 2000-2012 shows Forest land indicator. Almost similar increase has Forest and semi-natural areas indicator and German model of Forested landscape indicator in the period 2000-2012.

In general can be concluded that in period 1990-2000 natural vegetation succession went towards forest ecosystems with increment of an area of transitional vegetation, and in the following period, 2000-2012, this transitional vegetation already reached forest stadium and significantly increased both area covered by the forest as well as other areas that were included into forest vegetation stadium.

Process of reforestation is one of the most dominant one in Serbia. It is hard to recommend which indicator would be the most adequate one, because of variety of purposes and different indicator adaptability. For e.g. if it is needed to estimate or monitor possible future gaseous trade Forest land and Forest and semi-natural areas can be proper as precise and preferred one. But in case that we should monitor or estimate potentials for development of wood industry then Forest area and Forested landscape indicators are the most useful ones. Regarding the biological parameters of habitat changes, Forest area and Forested landscape indicators are very adequate one, representing the stability of forest ecosystems and at the same time can show decrease or even disappearance of „small" habitats as classes of natural areas (classes 32x and 33x).

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