# LITHUANIA'S ENVIRONMENT

## STATE, PROCESSES AND TRENDS

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**Produced by:**

A. Bukantis, G. Ignatavičius, J. Satkūnas, S. Sinkevičius, G. Šulijienė, S. Vasarevičius, D. Veteikis

**Designer:**

Ieva Serafinaitė

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*Kuriame Lietuvos ateitį*

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# Preface

Clean and healthy environment, unpolluted nature is the most precious asset of the mankind and a prerequisite for its survival and existence. Our entire future depends on the way we protect our nature, use natural resources, nurture and preserve the environment. Therefore, the protection of the natural environment against physical, chemical, biological and any other negative impact or consequences, which emerge from the implementation of plans and programmes, performance of economic activity or usage of natural resources, is the main target and objective of the environmental protection in Lithuania. The Constitution of the Republic of Lithuania provides for the duty of the State and each entity located within the territory of the Republic of Lithuania to protect the environment: "The State and each person must protect the environment from harmful influences".

The environmental protection includes monitoring of the state and changes of natural environment, its individual objects (land and its depths, air, water, fauna and flora, forests and other especially valuable localities), assessment and forecasts of the anthropogenic impact on these objects, their rational usage, implementation of various legal, biological, technical and other measures in order to protect natural objects for future generations, ensure the entirety of phenomena and conditions of natural environment inhabited by people, populations or species of various living organisms. Successful state management of environmental protection – the activity of state institutions and municipalities ensuring the implementation of the legal acts regulating the environmental protection and usage of natural resources – is essential to the implementation of this goal. It is obvious that seeking for a successful implementation of environmental goals it is crucial to provide the society and concerned institutions with objective and timely environmental information.

In view of the current international obligations and national needs, Lithuania must submit reliable information on the state of natural environment and the changes conditioned by the anthropogenic impact to the responsible national and international institutions and society. Furthermore, the society and decision-making institutions need updated information about the reasons that result in improvement or deterioration of our natural environment. This is a fundamental pre-requisite for the achievement of objective management of the quality of Lithuania's natural environment and also it is a contribution in the control and improvement of the state of environment in the entire European Union.

This publication assesses the state of the Lithuania's natural environment by highlighting its changes from the accession to the European Union until the recent years, analyses the achievements and emerging challenges. The publication also tries to reveal (at least partially) the causes and mechanisms that conditioned the changes of Lithuania's natural environment. It provides an overview of instruments of environment protection and their effectiveness in seeking to reduce the negative consequences of economic activity pursued by the mankind and to preserve clean and healthy environment for future generations. The possible scenarios of the change of separate environment sectors in the near future are presented. Furthermore, this publication also seeks to familiarise the Lithuanian society, environmentalists and politicians with the current most relevant environmental issues, the resolving of which requires joint efforts of society, executive power and political institutions.

In the recent decades, the entire world witnesses a change of attitude of the society towards the nature and its protection, which is followed by a cardinal revaluation of the established values in view of the requirements of sustainable development. The ecologists and environmentalists formerly focused their attention and efforts mainly on the protection of certain endangered species and individuals; however, the increase in environmental pollution and consumption of natural resources in the last decades of the 20th century has led to necessity to shift gradually to a wider and qualitatively new strategy of environmental protection. It became clear that in order to protect the environment and, first of all, the person, one must protect the living environment.

After the restoration of Independence, the principles of environment protection in Lithuania were legalised in the Law on Environmental Protection of the Republic of Lithuania, which was adopted back in 1992. This law laid the grounds for the regulation of public relations in the area of environmental protection, established the main rights and duties of legal and natural persons in preservation of the biodiversity, ecological systems and landscape that are characteristic to the Republic of Lithuania by ensuring a healthy and clean environment, rational use of the natural resources in the Republic of Lithuania, its territorial waters, continental shelf and economical area. Any other laws and normative acts regulating the use of the natural resources and environmental protection are adopted based on namely this law.

The priorities of the environmental policy in the environmental sector are inseparable from the priorities of the sustainable development of Lithuania – reduction of impact of the main fields of economy on the environment and danger to the public health, as well as mitigation of global climate change and its consequences. Approved in 2003, the National Sustainable Development Strategy provided for the improvement of the systems of assessment and management of environment quality in order to ensure the quality of air, which is necessary for the public health and ecosystems, across the country.

Today we are glad to note that Lithuania's environment is better than that of many other countries in the world. The high rating of the Lithuania's environmental welfare of the recent years was caused by several significant aspects, e.g., Lithuania was recognised as the global leader in the terms of improvement of air quality and increase of forest area.

The data on the state of natural environment in the Republic of Lithuania and the main trends of its changes which are provided in this publication clearly indicate that after becoming the member of the European Union Lithuania managed to achieve the essential breakthrough in the improvement of country's environmental status: pollution of the environment is continuously reducing, focus on the ensuring of the quality of environment and rights of residents to safe and healthy environment is increasing. The current Lithuanian environmental policy and the institutions in charge of the implementation of this policy have achieved major development in the area of improvement of country's environmental status. This, of course, does not mean that we do not have any current problems related to the preservation of the environmental quality. This publication seeks to present not only the positive changes, but also to emphasise the essential problems and the most topical objectives of environment protection.

During the first years of independence the especially favourable changes to the environment occurred due to general downturn of economy, therefore another positive fact is that today the results of the improvement of the state of environment are conditioned by the implemented purposeful environmental means and improvement of the environmental system. It should be noted that even in light of the recent global economic slowdown, which also affected our country, the focus on the environment has not decreased and the environmental interests were not sacrificed for short-term economic indicators. Therefore, in general terms the environmental situation of Lithuania is improving.

Since it is already the third publication of such type in Lithuania, its preparation was based on the experience of the previous publication and the analysis of previous mistakes. In the course of preparation of this publication, the authors tried to use as much versatile and new information as possible. It was collected not only at the official environmental institutions, but also at various scientific organisations and specialised offices.

In order to efficiently assess the progress of the quality of national environment, the producers of this publication, relying both on their own experience and that of other Lithuanian scientists and specialists as well as global practice, have used five main sources of information – archival information, data of the state environmental monitoring, results of the environmental research performed by Lithuanian and foreign scientists, as well as information held by the European Commission and European Environment Agency. The data of various specialised services (Department of Statistics, Hydrometeorology Service, Land Service, Forest Survey Service, Geology Survey and other institutions) served as additional information resources.

The environment specialists are aware that in the course of analysis of processes occurring in our surrounding environment it is very important to disclose what reasons influence (in varying degrees) the changes, i.e. to show the main links of cause and effect between the state of

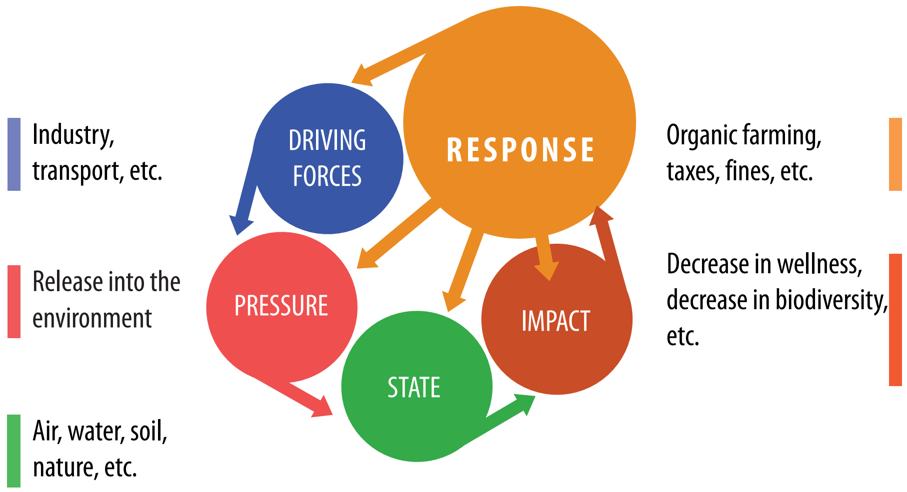


**Fig. 1.** DPSIR model used for the establishment of causal links between separate processes. *Source: State of Environment, 2002*

Lithuania's environment and processes affecting it. It is impossible to settle the environmental objectives successfully without understanding the entire chain of causes and effects. However, the general understanding that a certain action results in a certain reaction of changes of environment is not sufficient. In order to choose the most effective environmental measures and apply them successfully, on should possess reliable data, be able to evaluate the reasons and consequences of their changes. The environmental indicators are the best choice to raise such objectives. Lithuania has prepared a list of such indicators that is helpful in effectively controlling and improving the environmental situation in our country.

This publication with an overview and assessment of development of the state of environment in Lithuania over the two decades from the restoration of the Independence, same as the previous similar publications, is prepared according to the principles of delivery and evaluation of information on the environment, which are generally recognised in the Member States of the European Union and used in the system of the Ministry of Environment of the Republic of Lithuania and on the basis of which the development of the state of environment is evaluated by employing the information of indicated indicators.

The structure of thematic chapters of publication was composed by using the DPSIR model developed based on concept of the European Environment Agency (EEA) and European Economic Cooperation and Development Organisation.

The DPSIR (driving force – pressure – state – impact – response) model that is based on the principles of causal links is applied by the European Environment Agency and the majority of European countries when submitting information on the state of environment. The EU directives and UN conventions usually set quantitative targets to be met by the countries. Due to specific indicators, one can assess country's progress in the achievement of the set targets.

Of course, application of this model same as any other model significantly simplifies the processes that occur in reality. Relations between certain phenomena are, in fact, much more complicated and ambiguous. Still analysis of the main or resultant factors enables us (event if gropingly in some cases) to notice trends of environmental changes, their causes, and, where necessary, to select the most proper means for the improvement of situation.

When preparing this overview of the development of the state of Lithuania's natural environment, the producers of this publication received considerable assistance from the insights and consultations of the scientists of the Vilnius University and Vilnius Gediminas Technical University, the Ministry of Environment, the Environmental Protection Agency, the Lithuanian Geological Survey, the State Service for Protected Areas, the Lithuanian Hydrometeorology Service, the Centre for Marine Research, specialists of other national, scientific and public organisations. The authors would like to express their deepest appreciation for the patience, understanding and honest assistance in this complex and important work. Hopefully, this publication will be interesting and useful not only those, who directly face the problems of environment protection and management of natural resources, but also to the Lithuanian society at large, to the academic community, students and pupils, who are interested in various issues of environmental protection and use of resources. The authors take a chance to say "thank you" to each and every reader of this book for constructive comments and proposals. This would be a valuable assistance in preparation of next publications of similar type.

Producers

# DRIVING FORCES OF THE STATE OF ENVIRONMENT IN LITHUANIA

# Social and Economic Factors Influencing the State of Environment

## OVERVIEW OF FACTORS OF SOCIAL AND DEMOGRAPHIC DEVELOPMENT OF LITHUANIA HAVING INFLUENCE ON THE STATE OF ENVIRONMENT

Due to negative vital events and large-scale migration, Lithuania has suffered a rapid decrease in its population for twenty years already. In the early 2013, Lithuania's population was 2 million 973 thousand. This is by 70.4 thousand less than the population in the early 2011 (Fig. 2). The only situation, when population of Lithuania was less numerous, was recorded only after World War II – according to the data of 1950 there were slightly more than 2.5 million residents in Lithuania.

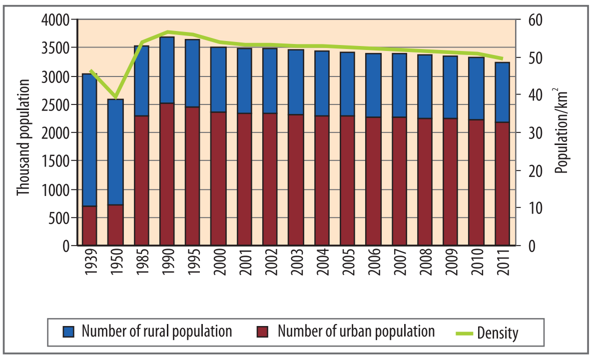


**Fig. 2.** Population number and density in Lithuania. *Source: Lithuanian Department of Statistics*

During the last decade (2001–2010), due to negative net migration, Lithuania lost 140.5 thousand of its population, and due to negative vital events – 101.9 thousand of population. Back in 2010, there were 42.1 thousand deaths, which means 12.8 deceased people per 1,000 population. The overall mortality of population in the Baltic States, including Lithuania, is one of the highest in the European Union. The standardised indicators of the overall mortality in the Baltic States are by 1.5 times higher than in the EU Member States.

During the last ten years, the total new-born index increased in Lithuania (2002 – 1.23, 2007 – 1.35, 2011 – 1.76), however, it still has not achieves the rate of 1990 – 2.03. To ensure the reproduction of population this index should be no less than 2.1.

The natural conditions in Lithuania are similar throughout the country; therefore, density of residents is even – approx. 50 per km$^2$. For comparison, the average density in Europe is 70 per km$^2$. Same as throughout the world, the highest density is observed in the cities, however, in Lithuania, the area of major cities includes quite significant areas of forests, parks, old towns, and in recently expanded industrial cities, the major part is occupied by residential blocks, therefore, they are characterised by a higher population density – Vilnius (1,354 per km$^2$), Kaunas (2,281 per km$^2$), Klaipėda (1,926 per km$^2$), Marijampolė (2,271 per km$^2$), Panevėžys (2,236 per km$^2$), Mažeikiai (2,956 per km$^2$). The suburban territories are also quite densely inhabited.

Similar to the situation in Europe, with the decrease in the number of newborns and lengthening of the average lifespan in Lithuania, the tendency of population ageing is observed. The most unfavourable situation occurs in the society when persons aged over 60 years compose more than 12% of the total population. In order to ensure a sustainable number of populations, the proportion of children should be no less than the proportion of old or elderly people, or approximately 25% (Fig. 3).

In the early 2011, the number of children under 15 was by 1.4 times lower than the number of persons of 60 years of age or older, whereas in the early 2001, the number was by 2.7% higher. In the early 2011, 701.2 thousand or 21.6% of residents were of the age of 60 or older, while in the early 2001 this number was 668.6 thousand or 19.2%, i.e., the proportion of persons of the age of 60 or older is increasing as compared with the total number of population. A trend has been observed for the past five years that children under 15 compose approx. 16%, whereas people over 65 – approx. 20 percent of all population.

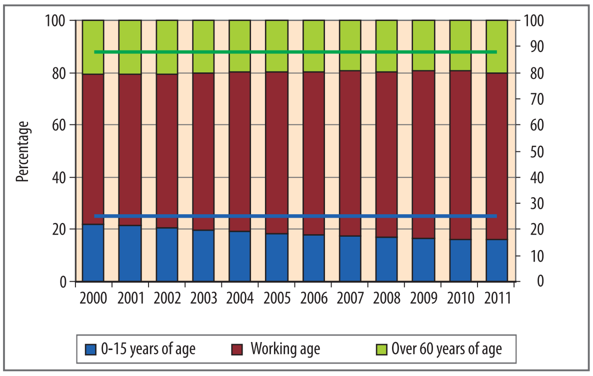


**Fig. 3.** Composition of population by age in Lithuania. *Source: Lithuanian Department of Statistics*

In 2011, the average life expectancy in Lithuania reached 73.89 years. This is the highest index in Lithuania during the last ten years. The average life expectancy of women remains to be longer than that of men: slightly more than 79 years of women and 68.5 of men. During the recent three years, the rapidly decreasing mortality of men conditioned the elongation of their life expectancy by 3.1 years. The life expectancy of women has accordingly increased by 1.6 years. The difference between the life expectancy of men and women also decreased – the rate of 10.8 years is one of the highest among the EU Member States. The trend of improvement is obvious, however, the average life expectancy of men is one of the shortest in the European Union, whereas of women – approached the average of the new Member States of the European Union. The longest life expectancy of women among the EU Member States is in France (85 years) and Spain (84.9 years), of men – in Sweden (79.4 years) and Italy (79.1 years).

In the early 2011, 2 million 171.2 thousand (66.9 percent) of country's population was residing in the cities, 1 million 73.4 thousand (33.1%) – in rural areas (Fig. 2). The ratio, when more residents live in the cities, is recorded for more than 10 years now. It has been observed that 25% of urban population live in Vilnius, whereas in the major 5 cities – 60% of urban population. A completely different situation was in Lithuania during the inter-war period, when rural settlements were inhabited by 3/4 of the total population of the country. During the Soviet times, the state's implemented rural policy was aimed at stopping the migration of population from the village to the city by improving the living conditions of the rural residents. The target was reached and the ratio between the village and city population was stabilised. During the first decade of the Independence, the number of rural population decreased very insignificantly. This was conditioned by an increasing unemployment in cities and land restitution when unemployed urban citizens chose farming as their main source of living. Rural territories of the new EU Member States have a typical characteristic – a large number of residents. This was caused by a high rate of rural population during the inter-war period (75% of population were living in rural settlements) and the rural policy, which was pursued in Soviet times and which was aimed at stopping the migration of residents from the village to the city.

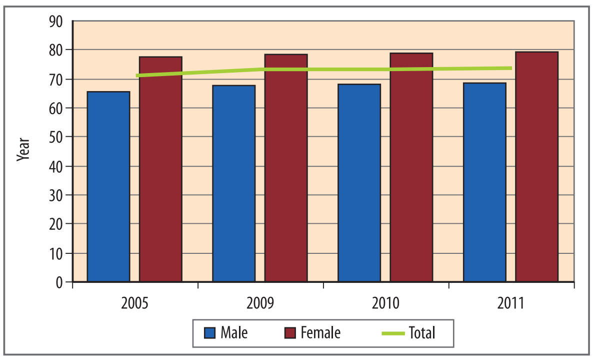


**Fig. 4.** Average life expectancy in Lithuania. *Source: Lithuanian Department of Statistics*

However, since 2005, the migration balance has become negative and emigration from rural areas especially increased after the economic crisis in 2009. Quite a significant number of working age population departed to live and work abroad. The decrease in the number of population is also conditioned by negative vital events, because the majority of the population of rural settlements is composed of elderly persons. The proportion of elderly population between rural residents is continuing to increase due to migration of young people to the cities or foreign countries.

The mortality structure of Lithuanian population according to the main causes of death has not changed for many years already. The main three prevailing causes of mortality – the diseases of bloodstream system, malign tumours and external death causes amounted to 85% of all death causes in 2010. The majority of residents, who died due to bloodstream system diseases, were older than 64. These causes amounted to 61.7% of their mortality. However, the age of deceased persons is increasingly younger – in the age group of 45-64 years, 34.1% of Lithuanian population die from diseases related to bloodstream system.

The standardised indicators of mortality caused by ischemic heart disease has gradually decreased in Lithuania since 2006, still they remain at the highest rate among the EU Member States – in Lithuania there were 321.3 mortalities per 100,000 population, whereas in the European Union – 91.8.

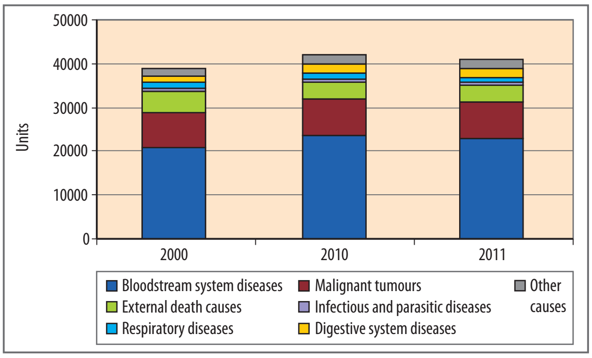


**Fig. 5.** Mortality causes in Lithuania. *Source: Health information Centre of the Institute of Hygiene*

When assessing the health of the population, a very important index is of new-born mortality. The new-born mortality has been decreasing since 1993 and amounted to 4.3 per 1,000 in 2010. Accordingly, in Sweden, this index is only 2.5 per 1,000 population, in Finland – 2.3 per 1,000. In the European Union, the average is slightly above four per 1,000 (EU-25 average – 4 per 1,000, EU-27 – 4.3 per 1,000).

In 2010, there were more than 3 million residents in Lithuania, 1 million 634 thousand or 50.3% of who were attributed to the labour force (all employed and unemployed residents).

In 2010, the majority of population worked in the area of commerce – 18.1%, in industry – 17.7%, in education sector – 11% of the total employed population. Within a year, the number of employed residents mostly decreased in the construction sector – 29.3 thousand, and industry – 22.2 thousand. It slightly increased in the vocational, scientific and technical activity – 4.2 thousand, and in the companies of real estate sector – 1.6 thousand.

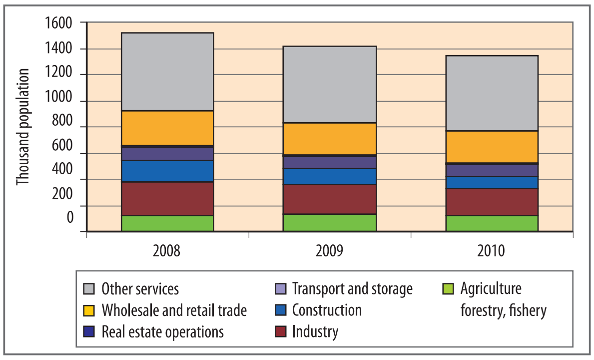


**Fig. 6.** Employed residents based on the types of economic activity. *Source: Lithuanian Department of Statistics*

In 2010, the number of unemployed persons amounted to 291.1 thousand and increased by 1.3 times, as compared with 2009. In 2010, every tenth resident aged 15-74 was unemployed, whereas only a year earlier this number was one out of twelve. In 2010, the unemployment rate reached 17.8%, i.e. was 4.1% higher than in 2009. Unemployment rate of men was higher than that of women and amounted to 21.2% in 2010 (women – 14.4%). Similar unemployment rate was recorded in Lithuania only in 2000, and later it only decreased. During the period of economic rise in 2006–2008, the unemployment rate was even below 6%. Of course, it was conditioned by the fact that a part of population of the working age departed to work abroad. However, at the end of 2008, when the economic crisis struck Lithuania and many other European countries, the unemployment rate drastically increased in the country. The decreasing opportunity to find a job has become one of the arguments of emigration from Lithuania, especially for young persons, as the unemployment rate of young persons (of the age of 15-24) amounted to 35.1% in 2010 and was twice higher than the total unemployment rate in the country.

However, the entire European Union today faces a complex economic situation, the average unemployment index in the European Union amounts to 10% (according to the newest data, in the midst of 2012, the unemployment rate in Greece amounted to 23%, in Spain – 25%), unemployment rate of young people amounted to 22.5% in the European Union. The lowest index of unemployment of young people was recorded in Germany (8.0%), Austria (8.9%), whereas the highest index was recorded in Greece (53.8% in May 2012) and Spain (52.9%).

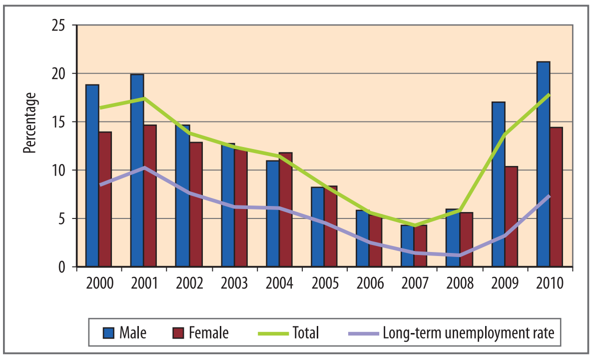


**Fig. 7.** Changes of population unemployment rate indices. *Source: Lithuanian Department of Statistics*

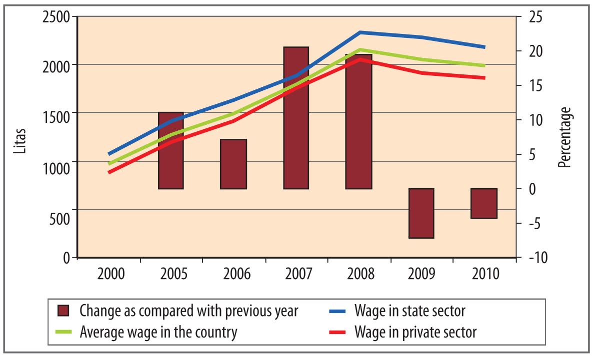


**Fig. 9.** Average monthly wage (gross). *Source: Lithuanian Department of Statistics*

In view of the social risk, the index of long-term unemployment, i.e., when a person is looking for a job for a year or longer, is of particular importance. In 2010, there were 120.6 thousand long-term unemployed persons. They amounted to 41.4% of the total unemployed population. A year before, the number of long-term unemployed persons amounted to 52.5 thousand – 23.2% of the total unemployed population. Long-term unemployment rate amounted to 7.4% in 2010; in 2009, it was 3.2%. The increase of the share of long-term unemployed population is a signal, that the situation in the labour market becomes more and more complex and the social problems become increasingly deeper.

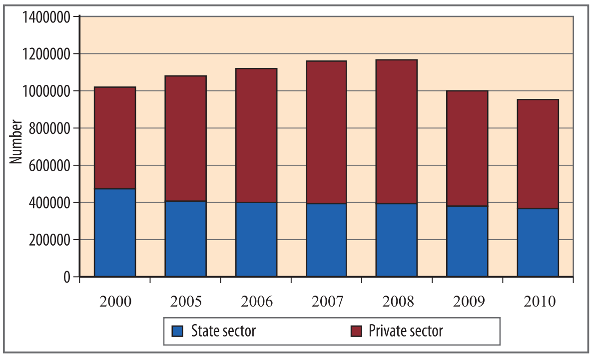


**Fig. 8.** Average conditional number of employees in the state and private sectors. *Source: Lithuanian Department of Statistics*

Nearly 2/3 of all employed population work in a private sector. The major part of them was employed in this sector during the period of economic upraise (2006–2008). At that time, 66% of all employees were working in a private sector (more than 750,000 employees). However, with the start of economic crisis, the number of employees decreased both in the private and public sectors and the ratio changed very slightly – 61:39. As compared with 2009, the decrease of the number of employees was the following (in total): national economy – 4.9%, public sector – 3.7%, and private sector – 5.7%.

In 2010, the average gross wage amounted to LTL 1,988.1 in the national economy sector, LTL 2,183.6 – in public sector and LTL 1,865.8 – in private sector. In 2010, as compared with the previous year, the average monthly gross wage in the national economy sector mostly decreased in the construction (7.2%), public management and defence (5.9%), financial and insurance activity (5.6%) companies.

In 2010, the lowest average monthly gross wage was in the accommodation and catering services, other servicing activity, agricultural, forestry and fisheries companies. As compared with 2009, a realistic wage decreased by 4.3% in the national economy sector in 2010.

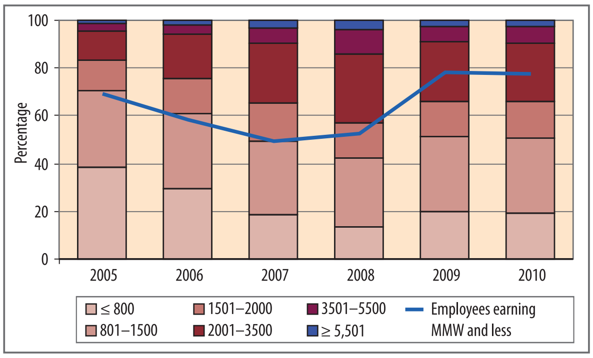


**Fig. 10.** Number of employees based on gross wage (MMW – minimum monthly wage). *Source: Lithuanian Department of Statistics*

As much as 19% of the employed population were full-time employees, however, their wage was equal to a minimum monthly wage or lower. This share of all employed population (slightly less than 20%) has not changed for several years now, whereas during the period of economic upraise it has decreased even down to 13%. In 2010, the majority of population working for a minimum monthly wage were employed in the accommodation and catering services companies – 25%, other servicing activity companies – 20.3%, construction sector – 14.1% of all full-time employees of this type of companies.

According to the data of 2011, a minimum monthly wage in Lithuania was one of the lowest in the European Union – 232 Euro (it was lower only in Czech Republic, Romania and Bulgaria), Latvia and Estonia has already surpassed Lithuania in terms of this index (282 Euro and 278 Euro, respectively). The highest monthly wage was recorded in Luxemburg (1,758 Euro) and Ireland (1,462 Euro).

According to the data of 2010, the average household in Lithuania consisted of 2.5 persons and one member of household received LTL 838 income per month (average household income per month – LTL 1,922). As compared with pre-crisis data of 2008, the expenses for one member of household decreased by more than 15%. However, even 25% of households received up to LTL 1,000 income per month (in this group, the average income per month amounted to LTL 786). It is worrying that the consumption costs of 1/10 of those, whose spending for consumption were the greatest, were almost 10 times higher than consumption costs of 1/10 of those with lowest expenses for consumption. It shows that a great difference exists between the wealthiest and poorest households and it tends to increase.

Furthermore, each year we face an increase in the number of households, where the provider (person receiving the majority of income) is an unemployed or a retired person. According to the data of 2010, in more than every fourth (26%) household, there are no persons receiving income for work. It shows that number of households in Lithuania (especially in rural areas) that are entirely or partially dependent on social benefits is increasing.

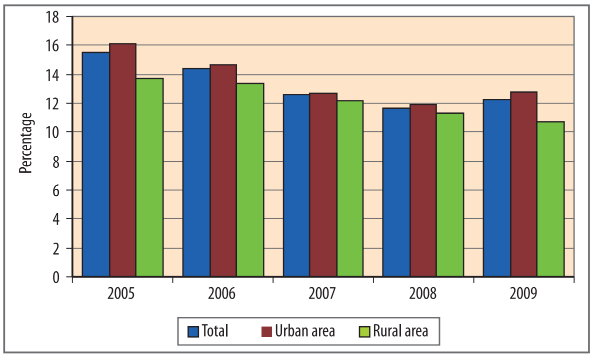


**Fig. 11.** Share of disposable income spent for the maintenance of accommodation. *Source: Lithuanian Department of Statistics*

Another especially relevant index and delicate socio-economic problem in Lithuania is the share of household's disposable income spent for maintenance of accommodation. In 2009, this index was the lowest during the last 10 years – on the average, the maintenance of accommodation required 12% of the total income.

***At-risk-of-poverty rate*** *is the share of people with an equalised disposable income below the at-risk-of-poverty threshold.*

In 2011, 20% of Lithuanian households or 660 thousand of country's population were living below the at-risk-of-poverty threshold, which is LTL 691 per month for a person, who lives alone, and LTL 1452 for a family consisting of two adult persons and two children under 14. As compared with 2010, this number decreased slightly – by 0.2%. Living below the at-risk-of-poverty threshold was characteristic to 14.7% of urban population (12.6% in the major cities and 17.9% – in other cities), and 30.7% of rural population.

Due to provisional Law on Recalculation and Payment of Social Benefits, which resulted in reduced pensions for persons of the age of 65 and older, the at-risk-of-poverty rate increased and amounted to 12.1% in 2011 (10.2% in 2010), however, remained significantly lower than the national average. Even with the payment of reduced persons, the paid out average old-age pensions significantly exceeded the at-risk-of-poverty threshold in 2010. It means that old-age pensioners receiving at least the average or even smaller than the average old-age pension found themselves above the at-risk-of-poverty threshold.

Based on the composition of households, the risk of poverty is usually characteristic to the persons living in households composed of one adult and dependent children (at-risk-of-poverty rate – 42.4%), two adults with three or more children (33.1%), and single persons (26.9%).

As already mentioned, social benefits are of importance in Lithuania, as in case of annulment of social benefits (except for old age and widower pensions), the at-risk-of-poverty rate would increase up to 31.8%. In 2011, the at-risk-of-poverty rate was characteristic to 19.3% of Latvia's population and 17.5% of Estonia's population.

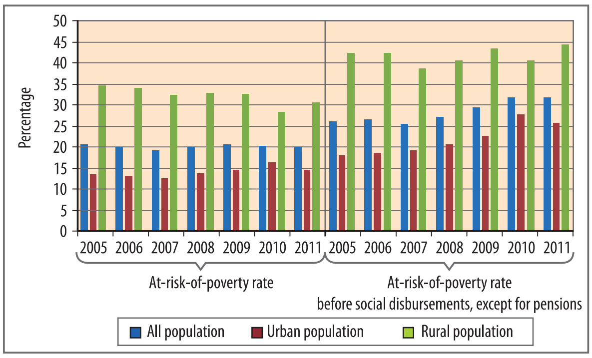


**Fig. 12.** At-risk-of-poverty rate. *Source: Lithuanian Department of Statistics*

According to the European Commission (Eurostat) data on the share of residents facing the risk of poverty or social exclusion, in 2009 Lithuania was among the five most disadvantageous countries – the share of such people was close to 30%. However, since 2005, the situation improved, as in 2002, the share of such persons amounted to as much as 41% of the total population (in 2009, such situation was in Bulgaria and Romania). One should note that so far the EU data is provided only for the year 2009. In 2011–2012, the economic situation changed – worsened – in Greece and Spain.

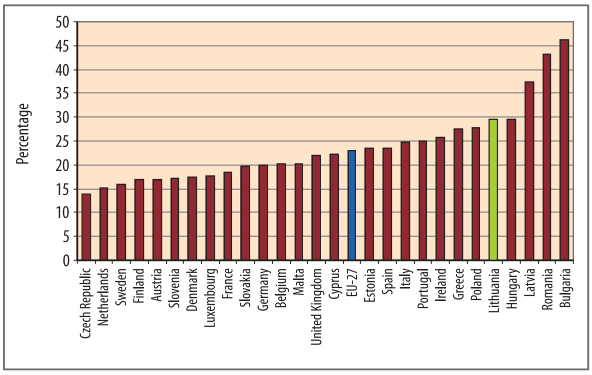


**Fig. 13.** Share of population facing the risk of poverty or social exclusion in Europe, 2009. *Source: Eurostat*

At the end of 2010, the national stock of dwellings composed 84.8 million m$^2$ of useful area: in the city – 53.8 (or 63%), in the village – 31 million m$^2$ (or 47%). Such ratio between the dwellings in the village and city has not changed for more than 10 years, meaning that new dwellings are built both in cities and villages (in villages, these are mostly the growing suburban districts). On the average, one resident received 26.1 m$^2$ useful area of dwellings, in the city – 24.8 m$^2$, village – 28.9 m$^2$. The resident of Vilnius received 25.5 m$^2$, Kaunas – 25.4 m$^2$, Klaipėda – 23.4 m$^2$, Šiauliai – 22.9 m$^2$, Panevėžys – 22.4 m$^2$ useful area of dwellings. For comparison, in the old EU Member States, this index amounts to 45 m$^2$, whereas in the member that acceded most recently – up to 20 m$^2$.

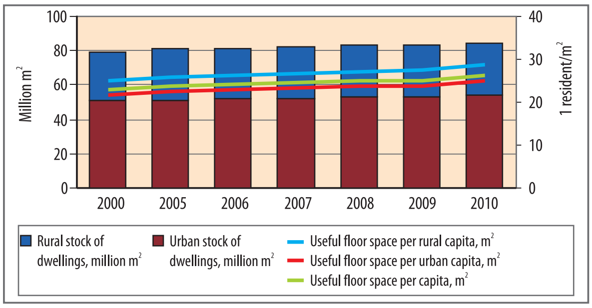


**Fig. 14.** Stock of dwellings in Lithuania. *Source: Lithuanian Department of Statistics*

Private ownership formed almost 97% of the stock of dwellings; the remaining 3% are owned by the state and municipalities. At the moment, 88% of Lithuanian residents own a private house or apartment and only 12% rent the housing, whereas in the European Union, only 42.9% of residents (on average) have a home that was purchased for their own funds. This situation was partly conditioned by the fact that the restoration of independence was followed by the privatisation of homes, when the majority of residents became the owners of their residential homes, where they live until this day or transferred them to their relatives, donated to children, etc. In addition, there is a tradition to prefer the purchase of home and not rent, therefore, the majority of young persons try to become the owners of their own residential home as soon as their financial possibilities allow them to do so. As it was shown by the researches, 96% of country's population would like to live in a private home, whereas those, who selected the rent, indicate this choice as a temporary solution.

In 2009, more than a quarter (27.1%) of EU-27 residents lived in private homes that were still on unpaid mortgage or other loan and nearly half (46.5%) – in private apartment without mortgage or other loan.

Thus, almost nearly three quarters (73.6%) of residents lived in private homes, 13.0% – in homes rented at a market price, whereas 13.5% – in homes rented at a preferred price or free of charge.

In 2009, no less than half of population of each Member State of the European Union lived in their own apartments: from 57.5% in Austria, up to 96.5% in Romania. In Netherlands (59.2%), Sweden (56.8%) and Denmark (52.8%) more than half of population lived in private homes, for which the mortgage or other loan was unpaid yet, the same situation was in Iceland (70.6%) and Norway (61.3%).

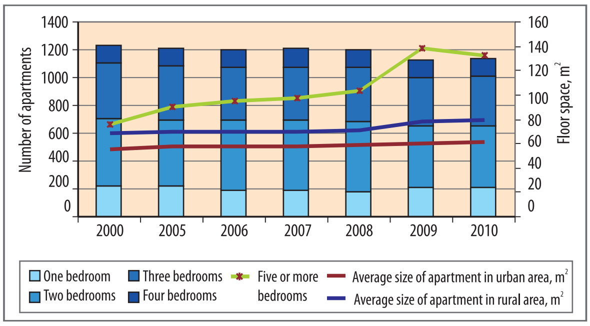


**Fig. 15.** Number of the stock of dwellings in Lithuania. *Source: Lithuanian Department of Statistics*

In 2010, the national stock of dwellings was composed of 1,274.4 thousand apartments. Two bedroom apartments were dominating in the city (39%), and three bedroom apartments were dominating in rural areas (32.4%). There were 393 apartments per 1,000 population. One apartment was approximately of the size of 66.6 m$^2$: in the city – 60.9 m$^2$, in the village – 79.3 m$^2$.

# Economic Development

***The Gross Domestic Product (GDP)*** *is defined as the gross income generated in the country's territory as well as the income received by the foreign production in a respective country minus the income of citizens earned abroad. These are the income generated domestically (when the balance of economic foreign relations is not calculated).*

During the first years of Independence, Lithuania suffered several transfers from one currency to another and hyperinflation. In 1990 to 1991, the roubles were still circulating in Lithuania. Due to complex economic situation, seeking to protect the commodity market in Lithuania against the flow of devaluating roubles, in the summer of 1991the Bank of Lithuania issued the common talons, which were used along with roubles to purchase the industrial goods of high demand. On 1st of May 1992, the circulation was supplemented with substitutes for roubles – talons that circulated along with roubles. At the end of 1992, the provisional money (talons) was issued and the roubles were recalled from the circulation. Based on the resolution of the Litas Committee of 14 June 1993, Litas and cents have been put into circulation since 25th of June.

The restoration of Lithuania's Independence lead to the collapse not only of the economic system that existed for 50 years, when the entire Lithuanian economy was firmly integrated into the economy of the Soviet Union, but also of the suppliers of raw materials and sales markets. After 1990, Lithuania's GDP dropped down significantly. The deepest crisis struck Lithuania's market after 1992, when the economy dropped down by more than 21%, as compared with the precious year. Until 1995, GDP decreased twice, as compared with the last years of the Soviet Lithuania.

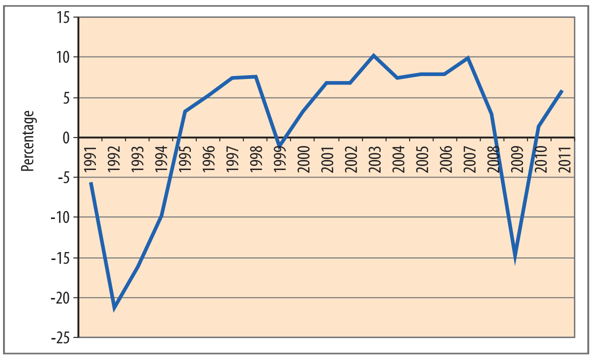


**Fig. 16.** GDP change rate. *Source: Lithuanian Department of Statistics, the World Bank*

The major part of Lithuanian industry of that time was very susceptible to energy and resources and less competitive under the conditions of market economy. There were no trade relations with western and other markets, whereas the trade relations with the long-standing partners – former republics of the USSR were broken due to political and unstable economic situation. The agriculture generated more than 11% of GDP. Still there was no external market and the internal market was too small. The economic breakthrough occurred in 1995, when a 3.3% increase of GDP was recorded in Lithuania for the first time. In the following years, GDP increased by several percent per year, however, the Russian crisis of 1998 has once again suppressed the growth and brought Lithuania's economy back to the situation recorded several years ago. In 1998, Lithuania's GDP comprised only 68.5% of the index of 1990.

Since 2000, the situation started to change for the better – the country's economy started to revive, the production was reorganised by installing new low-energy technologies, the export volumes were increasing annually, new markets were launched, and after the stabilisation of economy the relations with the former markets in CIS were renewed. Another main feature of the new Lithuania's economy was the ever-decreasing importance of agriculture. Neither extensive support from the European Union nor the increasing demand of production, which was stimulated by the developing food industry, served any purpose in this situation.

At the accession to the European Union, Lithuania was one of the poorest Member States in terms of the economic indices – GDP accounted only for 38% of the European Union's average. However, from 2002, the Lithuania's economy became one of the most growing economies in the European Union - the average annual growth was 5-7%, whereas the average economic growth of the European Union was 2-3%. The main sources of growth of Lithuania's economy included the change in the economy structure (the share of limited efficiency agriculture and industry sector decreased, whereas the share of more dynamic sector of services increased), the acquired skills and knowledge of work under the conditions of competitive market economy, convergence effect. However, this rapid growth rate decreased in 2008 (by 2.9%), and suffered a deep recession in 2009 (-4.8%). Currently, Lithuania's economy is "climbing" out of the recession ditch. In 2010, the economy increased by 1.3%, whereas in 2011 – by 5.9% already, as compared with the previous year.

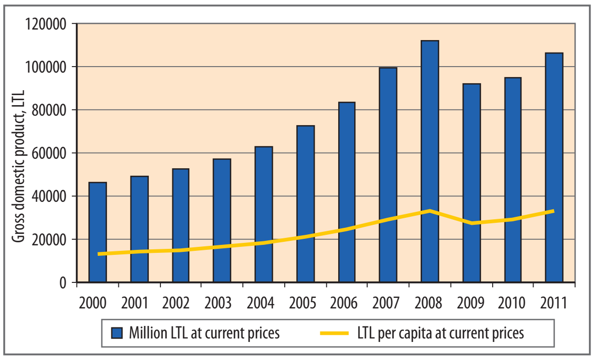


**Fig. 17.** GDP at current prices. *Source: Lithuanian Department of Statistics*

The values of macroeconomic indices of 2011 show the revival of Lithuania's economy – GDP increased by 5.9%, whereas the nominal value of GDP exceeded 106 million Litas per capita – LTL 32,905,00 or by LTL 3,979.00 more than in previous years. However, expressed in purchasing power standards, this did not reach even 60% of the EU's average. It should be noted that the share of GDP per capita is constantly growing in Lithuania, however, does not reach the value even of the closest neighbours – Latvia and Estonia (97% in Latvia and 79% in Estonia).

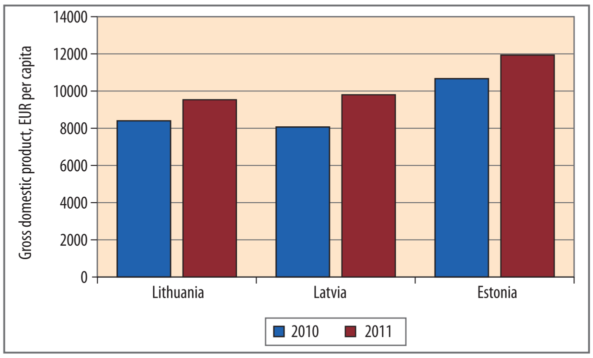


**Fig. 18.** GDP (in Euro) per capita in Lithuania, Latvia and Estonia. *Source: Lithuanian Department of Statistics*

*The aim of the European Comparison Programme (ECP) is to establish the* ***purchasing power parities (PPP)*** *of national currencies of countries and perform the international GDP comparisons by removing the differences of the price level between the countries. The focus is on the GDP per capita and its components.*

When comparing Lithuania's situation with other countries participating in the ECP, based on distribution of GDP per capita, even larger differences become obvious – according to the results of 2009, among the newest EU Member States the most developed economies are of Cyprus, Slovenia, Czech Republic and Malta, whereas the worst economic situation was in Bulgaria and Romania. Latvia and Lithuania were the next ones after these countries in the list. In these countries, only half of the average GDP of EU-27 per capita expressed in the purchasing power standards was recorded. The highest index was recorded in Luxemburg. It exceeded the EU-27 average by 2.7 times. One of the reasons of this high index in real terms is that a large share of the employed persons was composed of employees arriving to work in Luxembourg from other countries. They generate GDP; however, GDP per capita is calculated only in accordance with the number of permanent residents of the country. High index in real terms was also in Norway, Switzerland, and Netherlands and exceeded the EU-27 average by 1.8, 1.5 and 1.3 respectively.

The structure of Lithuania's economy is miscellaneous, however, it changed significantly during the Independence period – the increasingly larger share of GDP was generated by the sectors of services and high technologies. The agriculture sector, which was the representative field of Lithuania's economy during the Soviet times, becomes less important.

The major share (nearly 31%) of GDP was generated in the areas of wholesale and retail trade, transport, accommodation and catering. The second important place (24%) of GDP generation was the industry, the third – construction and real estate operations (6% each). Differently than during the first years of Independence, the agriculture, forestry and fishery sectors generated only 3% of GDP and this share has been stable for several years already.

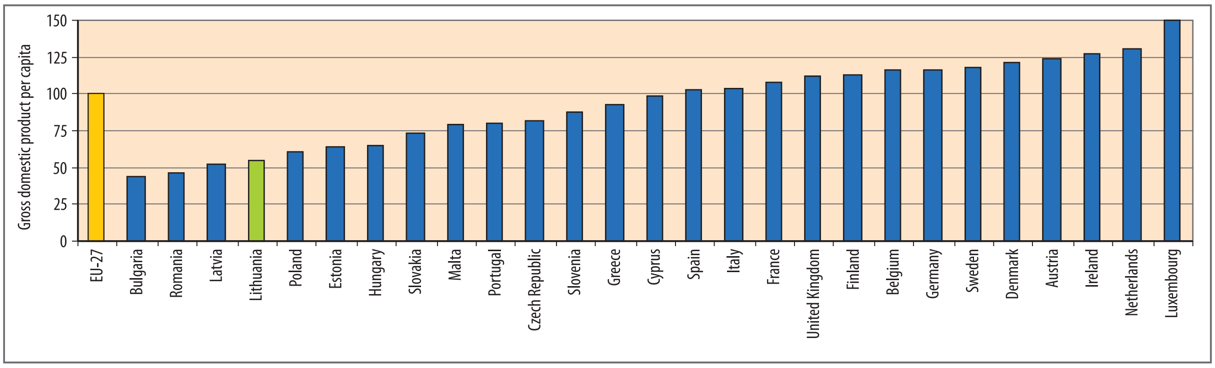


**Fig. 19.** Indices of GDP per capita in real terms expressed in purchasing power standards. *Source: Lithuanian Department of Statistics*

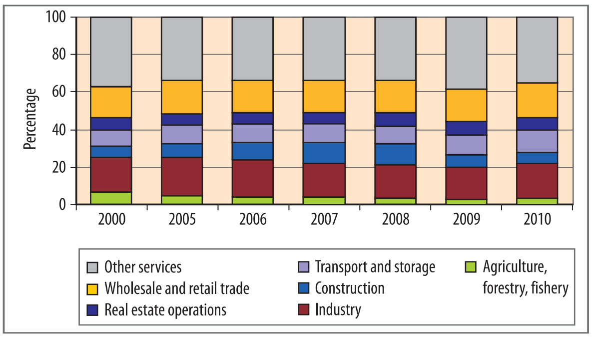


**Fig. 20.** GDP structure in Lithuania. *Source: Lithuanian Department of Statistics*

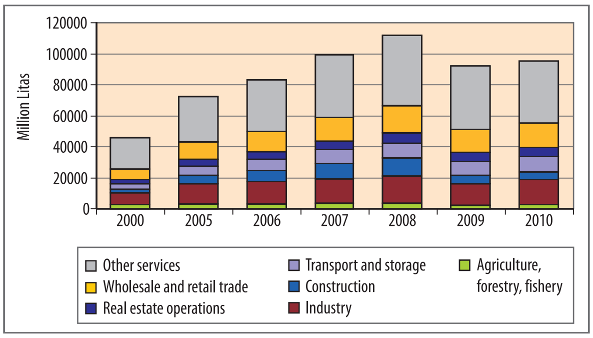


**Fig. 21.** Gross value added and GDP expressed in production method. *Source: Lithuanian Department of Statistics*

Until the end of 2008, the development of economy resulted in the especially rapid growth of the share of GDP generated by the construction sector. As compared with 2008 and 2009, the value of product generated by the construction sector has dropped down more than twice (down to 5,475.5 million Litas at the prices of that time) and despite the fact that sector is reviving is still at the level of 2005.

# Overview of Development of Certain Economic Sectors

One of the most important goals of nowadays is to solve the issues related to the environment protection. In the current phase of civilisation and economy development, emission into the atmosphere and water bodies, pollution of environment from the energy systems and transport of industrial companies are sometimes reaching the scales, when the pollution level significantly exceeds the permissible sanitary norms.

The emission of pollutants from industrial plants and other sources of pollution has a negative impact not only on the environment, but also may negatively affect the performance of the technical means. E.g., the equipment of power stations or electricity transmission systems, which is installed outside, is negatively affected by the products of organic fuel combustion.

Due to its national importance, the energy sector is one of the most significant and having the highest influence on the economic development and environment protection. It includes the interconnected energy sectors: electricity, central heat supply, production, transport, transmission, distribution and consumption of oil, natural gas, coal and local fuel as well as renewable energy sources.

Energy provides comfort to mankind, however, the energy production and consumption causes a number of environmental problems – it contributes to climate change, degradation of ecosystems, and has a negative impact on the public health. Therefore, the balance of the guarantee of energy supply, efficiency of energy consumption and environment protection is also very important in the energy sector.

After the restoration of Lithuania's Independence, the probably greatest changes were made in the energy sector, as it was necessary to reorganise the entire system and adapt it to the changing situation, shift to more economic methods of energy production, transmission and consumption.

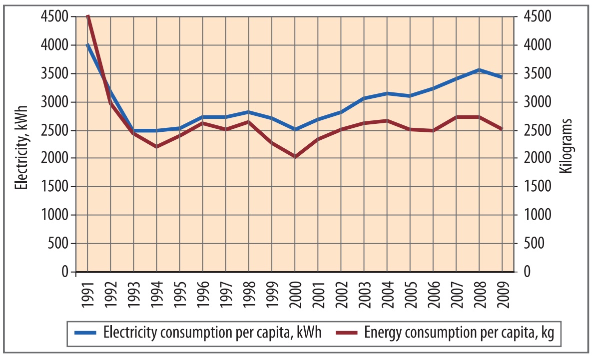


**Fig. 22.** Electricity and energy* consumption in Lithuania. *Source: the World Bank*

*The primary consumption of energy, as equivalent to oil, per capita (prior to transformation to other direct consumption fuels), kg

The majority of these energy transmission networks were outdated, some were using expensive diesel and furnace oil, others were burning coal, peat, sawdust, poisonous slate oil, there were almost no installed at least slightly more advanced air treatment facilities. This inevitably conditioned a higher pollution of the environment air of that time in the cities, settlements and industrial districts.

The economic recession after the restoration of Lithuania's Independence lead to significant decrease of energy costs in all economic fields in 1991. During 1991–1994, the initial and final costs of energy decreased by 2.1 times.

During 1995–2000, the start of the revival of national economy resulted in a further decrease of the final energy costs at an average of 3.8% per year. However, this time is was conditioned by the structural changes in the country's economy, implementation of the new technologies that replaced the energy-intensive ones inherited from the past, as well as other means increasing the effectiveness of energy consumption.

An extremely rapid economic growth started after 2000. From 2000 to 2007, Lithuania's GDP increased 2.1 times, however, the final energy costs used to grow at an average of 4.7% per year and increased only 1.4 times. The initial costs of energy increased 1.3 times.

As compared with the EU-27 average, in 2006, the Lithuania's GDP per capita was lower 1.8 times. Whereas in 2006, one resident consumed 1.5 times less of initial energy on average, 1.7 times less of final energy, and 2.3 times less of final electricity than the EU-27 average.

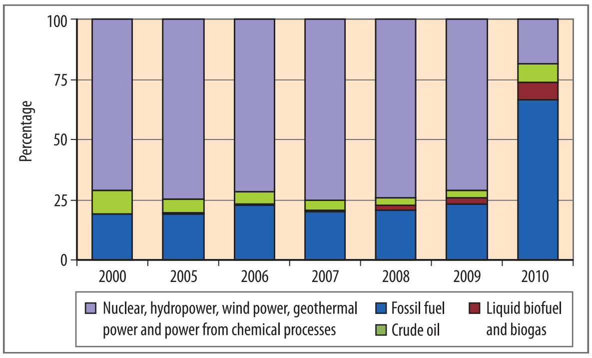


**Fig. 23.** Energy sources and their consumption. *Source: Lithuanian Department of Statistics*

Lithuania is one of 31 countries in the world using a nuclear energy for the generation of electricity. Since the very start of its operation, Ignalina Nuclear Power Plant (NPP) was an important supplier of electricity to Lithuania and its neighbouring countries. Due to significant increase in the price of organic fuel, mostly imported from Russia, the cost price of electricity production in the nuclear plant was nearly twice lower than in other power plants. In 1991, Ignalina NPP generated 60%, and in 1993 – even 88% of the total electricity in the country. Later, this share started to decrease, especially from 2005, when the first NPP unit was decommissioned, whereas after the decommissioning of Ignalina NPP in 2009, the energy balance has changed virtually. The share of energy, which used to be generated by the nuclear energy, lately, is received by using the fossil fuel. Therefore, Lithuania faces the threat of the increased atmospheric emissions (for more information see chapter "Air").

The total balance of generation and consumption of energy has remained stable in Lithuania for the last 15 years. It is likely that the consumption of raw energy remained stable due to increased effectiveness of energy consumption. Energy consumption is one of the largest pollution sources accounting for more than 90% of all emissions of sulphur dioxide, nitrogen dioxide and half of all emissions of organic compounds. Due to installed pollution minimising technologies and consumption of cleaner energy sources, the overall air pollution has not increased.

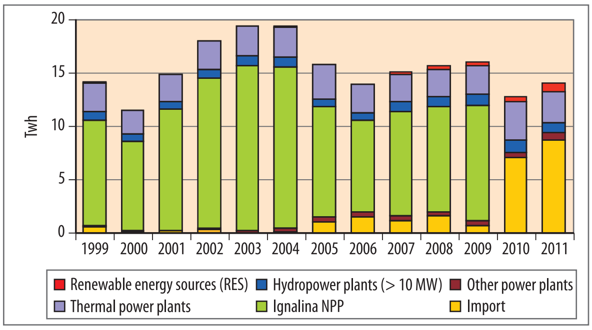


**Fig. 24.** Electricity balance, 1999–2011 (TWh). *Source: National Control Commission for Prices and Energy*

In 2010, as compared with 2009, the total country's fuel and energy costs decreased by 18.9% and amounted to 7,042.7 (in 2009 – 8685.9) thousand tons in oil equivalent. In 2010, the largest share of energy among the total costs was composed by oil products (36.6%) and natural gas (35.4%).

In Lithuania, non-renewable energy sources include only peat (and a relatively small amount of oil). However, only a small share of them is used as fuel and in majority of cases, this fuel is used solely for local heating. Until 1992, the main source of energy for the production of electricity and thermal energy was the imported oil and fuel oil used in large power plants. However, the increased oil prices (Lithuania was forced to pay the global prices for resources) led to the annual increase in the consumption of gas, whereas in majority of power stations fuel oil remains only as alternative fuel in case of breakdown of gas networks or as a compensation fuel in the heat generation when it is necessary to use extra fuel in addition to the established gas consumption limits. After the start of usage of gas, the emission of greenhouse gases and substances causing acidity processes has decreased.

During the past ten years, Lithuania's energy dependence from import, as compared with the EU average, fluctuated by insignificantly exceeding or reducing it. However, in 2010, the Lithuania's dependence on the imported organic fuel increased significantly, i.e. increased from 48.8% in 2009 to 79.4% in 2010 and significantly exceeded the EU average. In principle, the imported fuel and energy sources are currently used to meet the needs of local users. Lithuania imports the main resources of fuel and energy: oil, natural gas and coal.

The structure of final consumers is currently dominated by household and transport sectors, where 33.3% and 32.8% of energy supplied for national economy fields was consumed respectively in 2010. The share of industry sector accounts for 18% in the final energy consumption structure. The transport sector mostly consumed the oil products, whereas the household sector mostly consumed renewable energy sources and centrally supplied thermal energy. In 2010, all modes of road transport consumed 2.6% more fuel than in 2009, however, only the diesel consumption increased (13.7%), meanwhile the share of petrol and liquefied natural gas has decreased (19.5% and 1.6% respectively).

One of the main factors influencing the use of more effective actions for the increase of economic energy consumption is the rising price of oil and other energy sources. In Lithuania, the highest energy saving possibilities are in the building sector (economic saving potential – approx. 30%) by renovating the current buildings and modernising their energy systems. Approx. 40% of country's final energy is used in the buildings.

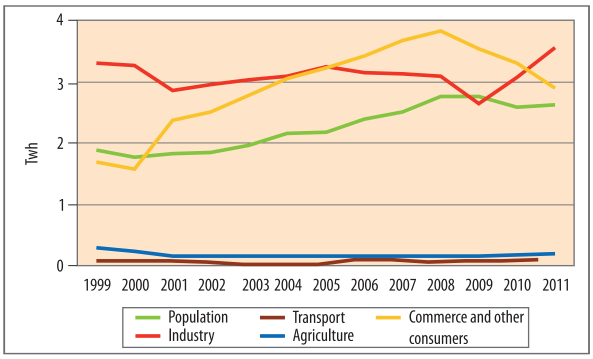


**Fig. 25.** Dynamics of electricity demand structure, 1999–2011. *Source: National Control Commission for Prices and Energy*

In Lithuania, the main consumer of electricity is the industry, which uses more than 1/3 of the total energy and this share has remained stable in the balance for more than ten years. A certain decrease (down to 30% or 3 TWh) was observed during the crisis period in 2008–2009, however, the electricity demand is increasing in this sector again and, in 2011, the highest index of electricity consumption of the past decade was recorded. More and more electricity is consumed in trade and service sector (1/3); however, during the period of economy upraise this sector used to comprise 38% of the total electricity. The decrease in the electricity demand is observed at the moment. The third place is occupied by the residents – they receive approx. 28% of all electricity, and the demands of this segment are constantly increasing – this can be related to the fact that households acquire an increasing number of domestic appliances; electricity is used for domestic heating, etc. Since 1996, electricity costs have increased more than 50%.

The maximum energy saving potential is in the residential and trade and service sectors – total 80% of the overall saving potential. Energy saving potential accounts for 11% in industry and 8% in transport sector.

In order to reduce the dependence on the imported fuel and the impact of organic fuel on the environment, it is very important to use the renewable energy sources as widely as possible. Lithuania has become obliged to increase the production of energy from renewable energy sources at least up to 20% until 2020. A wider usage of renewable energy sources for the production of electricity and thermal energy as well as transport created opportunities to reduce the usage of increasingly more expensive imported fossil fuel, especially natural gas and oil products. As compared with 2009, in 2010, the consumption of renewable energy increased by 1.4% in Lithuania. In 2010, the share of renewable energy sources accounted for 15.2% of the total energy costs.

Currently, Lithuania sees the highest energy potential in biomass, especially firewood and wood waste. The analysis of structure of use of wood fuel and agricultural waste shows that, in 2010, the largest share of this fuel (61.6%) was used in the households. 26.8% of wood fuel and agricultural waste are used in boilers of central heat supply plants and electric power stations.

In Lithuania, one of the most rapidly expanding and most environmentally friendly technologies of use of renewable energy sources is the wind power stations. In 2010, as compared with 2009, wind power stations produced 43% more electricity accounting for 3.9% of all electricity produced in the country.

The climate conditions for solar energy in Lithuania are similar to Germany (European leader in the area of photoelectricity utilisation) – approx. 1,047 kWh/m$^2$, however, only 0.1 GWh was produced in 2011. This area is currently becoming increasingly more popular (and is popularised). Attempts are made to use solar energy as one of the methods of multi-dwelling house renovation and reduction of energy costs. Today it becomes common to use solar energy as an additional method to produce energy in private homes. The main reason of such a small level of use of solar energy is the need for relatively high initial investment.

Lithuania is among a few new EU Member States that still do not use the household waste for the production of thermal energy and that pollute the environment - they rotting waste in dumpsites. Today more than 420 modern waste incineration factories adapted to organic heating and electricity production are successfully operating in Europe. The incineration of household waste, the annual accumulations of which amount to 1.3 million tons in Lithuania, could produce approx. 30% of centrally supplied thermal energy. By using the household waste for production of energy in modern power stations, it would be possible to reduce their quantity in country's landfill sites up to five times.

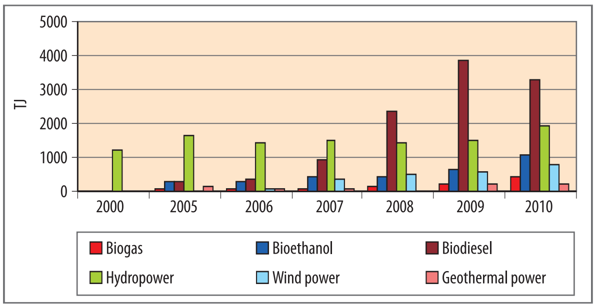


**Fig. 26.** Balances of renewable energy sources (except for firewood). *Source: Lithuanian Department of Statistics*

In Lithuania, biogas energy has been developed for ten years already. At the moment, there are six biogas power stations recycling urban wastewater sludge, pig manure and various organic wastes. Liquefied, easily decomposing organic materials are used for the production of biogas. In the balance of raw materials, the largest share is composed by livestock manure (pig, cow, bird). In the European Union, it accounts for 89% of biomass recycled in biogas power stations. It is conditioned by large concentration of stock-raising and their waste and liquid manure management technologies.

One hydropower station of the installed capacity of 100.8 MW and 82 small hydropower stations of the overall installed power of 26 MW are operating in Lithuania. Based on the effective procedure regulating the construction and operation of hydropower stations, only the construction of small hydropower stations is possible in Lithuania. After the implementation of the prospective construction plans and renewal of the facilities of outdated small hydropower stations, the current capacity and production of electricity in small hydropower stations could be doubled until 2020.

The western part of our country is mostly suitable for the use of geothermal energy for the production of energy.

Klaipėda Geothermal Power Plant, which is the first of its kind (closed circulation system) power plant in the Baltic Sea region, operates here. The total capacity of power plant is 35 MW (13.6 MW heat from geothermal water and 21.4 MW from boiler-house hot water). The use of geothermal energy for heating of buildings by installing heating pumps (usually of the capacity of 15 and 18 kW) is expanding in Lithuania. Over 100 such systems of the total capacity of more than 1 MW are installed.

The main users are private homes (or partnerships), multi-dwelling houses. Meanwhile one may mention that one of the large objects using thermal pumps is the Church of Saint Apostles Peter and Paul in Vilnius. The geothermal energy in Lithuania can also be used for wood drying, food preservation, greenhouses, fish breeding water bodies, soil heating, pools, healing basins. Furthermore, the geothermal water can be used for the extraction of valuable chemical substances.

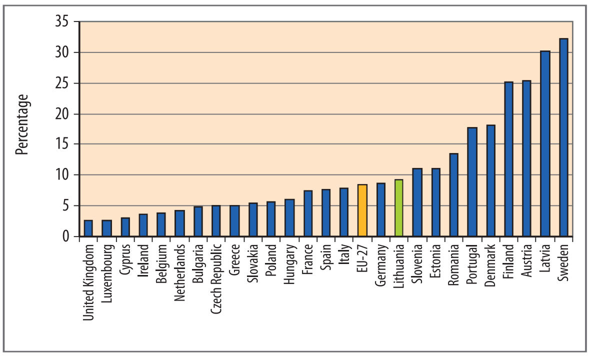


**Fig. 27.** Share of energy generated from renewable energy sources in the European Union, 2008. *Source: Eurostat*

Situation in Lithuania, in the context of the European Union, today is not bad – the share of energy produced by renewable energy sources exceeds the EU average, however. However, almost all this energy is generated by the biomass rather than the methods based on state-of-the-art technologies, which have the least impact on the environment.

## INDUSTRIAL DEVELOPMENT AFTER THE RESTORATION OF LITHUANIA'S INDEPENDENCE

After the restoration of Independence, the industry sector as well as the entire Lithuania's economy saw essential changes – the relations with suppliers, established markets were lost and the conditions of sale changed. Due to high prices of energy and raw materials and uncompetitive production in Lithuania, the entire fields of industry – machine production, electrotechnics and radio electronics – were at the verge of extinction during the Independence period.

However, the new modern fields of industry – packaging, printers, and plastic producers – also emerged. According to the data of the Department of Statistics, the value added, which was generated by one employee, increased more than twice during the last decade – the gross added value generated by one employee amounted to 31 thousand Litas, whereas in 2010 it was 72 thousand Litas.

Nevertheless, the productivity of renewed Lithuanian manufacturing industry able to compete with the EU plants has reached only one third of the EU average so far.

As already mentioned in the previous chapter, the industry sector generates approx. 18% of the overall Lithuania's GDP. This share has not changed for the last ten years (Fig. 20). However, from the broader perspective, the efficiency and solvency of industry is also related to other areas of economy – construction sector, electricity, gas, water supply companies – thus, approximately one third of the total GDP generated in Lithuania is related directly or indirectly to the industry.

Moreover, having included the economic fields servicing the industry, such as transport, warehousing, communications – we get additional at least 15% of GDP. Therefore, industry is a very important pre-requisite for the successful development of all country's economy.

Based on the structure of produced and sold goods, the major share of production is composed of food products and beverages, refined oil products, manufacture of wearing apparel and processing and dying of fur, textile goods and products of chemical industry.

During the last five years, the value of industrial production sold in Lithuania has increased by 12.5% and a constant growth has been observed. However, the structure of sold industrial products has changed: the share of production of refined oil products, food products and textile has increased in the overall balance. Furthermore, the changes have been recorded in the markets of sold industrial production: in 2005, 60.5% of production was exported and in 2011, this share increased to 67.4%. The highest export rate refers to refined oil products, chemicals and chemistry products, food products, furniture, wood and wood products. During the last several years, the largest three exporters were the oil-processing factory "Orlen Lietuva", producers of fertilisers "Lifosa" and "Achema". The title of the largest taxpayer is annually awarded to plant "Orlen Lietuva".

After the restoration of Independence, which was followed by the wave of industrial recession and decrease in the industrial production, the environmental pollution from stationary sources decreased by nearly 70% in 1994–1997. The industrial plants are mostly polluting environment with sulphur dioxide, carbon monoxide and nitrogen oxide, particular matter, heavy metals and benzene. These pollutants are usually related to the incineration of organic fuel in the production process. However, there are also many other pollutants, which are difficult to associate directly with one or another industrial production activity. Although there have been no significant deviations from the established permissible norms of pollutants, and the highest pollution indices are associated with the transport concentration, certain changes recorded in the largest industrial cities (Mažeikiai, Kėdainiai, Panevėžys, Šiauliai, Kaunas and Vilnius) result in presumption that the most active industrial plants have influence on the environment pollution.

In Lithuania, the industrial sector consumes approx. 1/3 of all electric power and remains one of the main sources of environment pollution – air, water and soil. After the restoration of Independence, the fields of industry and separate plants characterised by high consumption of energy and resources lost the competition battle in the long run and had either to retreat or search for new technologies and production methods. Therefore, the growth of industry and environmental pollution are not directly proportional.

Installation of new technologies, decreasing environment pollution, more complex products and conquering of new markets is characteristic to the majority of industrial plants that have survived to this day.

In 2011, 974.3 million Litas were allocated to the research and development (R&D) sector in Lithuania (28.5% more than in 2010). Each year, 28 million Litas go to environmental studies (this amounts to 4% of all funds allocated to R&D), accordingly, production and technologies receive 10% of all funds.

In 2008–2010, 32.5% of all production and service companies in Lithuania were engaged in innovative activity. In 2010, the costs for innovative activity amounted to 1,810.6 million Litas; 1,401.5 million Litas were allocated to the purchase of new machines, facilities or equipment, 248.9 million Litas – to the technology development works performed by the companies. 36.6% of all innovative companies installing technological innovations received support from various institutions (national and foreign), 6.1% received funding from the national budget, and 34.9% were funded by the European Union support programmes.

In 2011, the added value of information technologies (IT) sector increased by 13%, as compared with 2010, and accounted for 2.5% of the total added value (in 2010 – 2.4%). The most significant increase was recorded in the added value of the companies engaged in the computer programming, consultancy and related activity and in the wholesale trade of information and communication technologies (ICT). Day after day, the modern technologies become more ordinary and integral part of our life and work. 71.2% of all production and service companies had a website in 2012 (67.7% in 2011).

The share of sectors attributed to the industry using high-tech as well as high qualification manpower (biotechnologies, pharmacy, radio, television and communication equipment, electronics and computer, machine and equipment, production of flying machines, construction and repair of vessels) is still relatively small in the field of processing industry and does not reach 10%. However, it has a tendency to increase – the attraction of investment to high added-value production, for example, solar elements, medical facilities, has been increasing for several years.

One of the most perspective Lithuania's industry sectors is the laser sector. Its range of sales of production exceeded 100 million Litas in 2010. The average annual growth of the sector is approximately 20%. Besides, the sale of Lithuanian laser industry increased even under the conditions of global crisis. Such long-term growth of the sector is unique and should be stimulated as this area of industry is less susceptible to resources, yet creates a high added value. The Lithuanian laser industry exports 89% of production. With the increase in the demand of laser technologies in the national economy, science and medicine, the sale of sector's production also increased in the Lithuanian market. Approx. 10% of sector's income is annually invested into research and development area. The aim of such investments is to improve production, its technical parameters and creation of new devices for the global laser market. Due to the created added value and efficiency of work, the Lithuanian laser industry is the leader among the national economy sectors.

## TRANSPORT

The contribution of transport and logistics to the Lithuania's GDP showed gradual increase each year and accounted for 11.7% of GDP in 2010 (8.5% in 2000). It is the fourth important sector after industry, trade and agriculture. However, in our neighbour countries Latvia and Estonia the transport sector generates more than 14% of GDP. The major part of added value created in the transport sector in Lithuania is the income from transit. Lithuania has good-quality roads, non-freezing seaport, good traditions of transportation business providing an excellent potential for transit carriages. After joining the European Union, the Lithuania's macroeconomic environment has changed. Favourable conditions for competition, expansion of business contracts and even more rapid development of passenger and cargo transport were created. Balanced and effective transport activity is not only a service that creates high value, but also a precondition for the successful development of other economic fields and the quality of life of people.

Lithuania has a developed network of automobile roads (Fig. 28) – the length of national roads amounts to 21,603 km (308 km of which are occupied by highways), including 1,535 bridges and viaducts of the total length of 49,254 km, and up to 80% of cargoes and passengers are transported via these roads. In order to ensure sustainable development and reduce the negative impact on the environment, today we build special "green" bridges and concrete passes for animals to cross the fenced highways.

The density of highways and freeways is closely related to the density of residents and degree of district urbanisation. In Europe, the most dense highway networks are in Netherlands (77 km/1000 km²), Belgium (58 km/1,000 km²), Germany and Great Britain. The worst developed highway system is in Romania (1 km/1,000 km²), Estonia, Finland and Poland (2 km/1,000 km²). In Lithuania, same as in Bulgaria, Sweden, Ireland and Slovakia, the density of highways is lower than 10 km/1,000 km².

There are 250 high-risk road sections ("black spots") in Lithuania. In the rural territories and suburban roads, where the driving speed is high, 75-80% of all fatal accidents occur. According to the number of road fatalities per 1 million population Lithuania is among the five most disadvantageous countries of the European Union (while in 2005, it was in the most disadvantageous place). 362 people died in road accidents in 2011. It is the lowest number of road fatalities in Lithuania since 1961. We are glad to note that this number is twice lower than in 2000, when 769 road casualties were recorded. The high number of road fatalities remains not only due to insufficient control of traffic participants, condition of roads, but also due to improper behaviour of traffic participants.

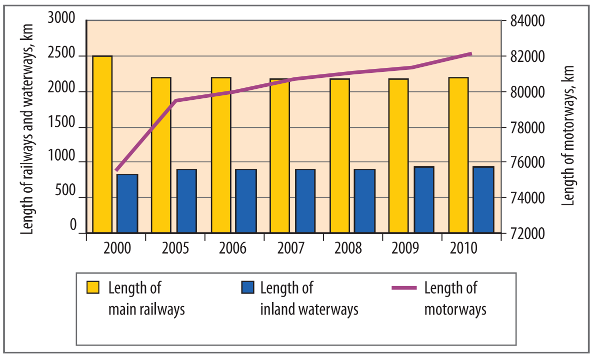


**Fig. 28.** Length of the main roads in Lithuania. *Source: Lithuanian Department of Statistics*

In Lithuania, the operation of railway between Vilnius and Kaunas started in 1861 after the construction of Petersburg-Warsaw railway branch to Konigsberg. The total length of all Lithuanian railways is 2,184 km; some of them are of two pair rails, some – of one pair with passing stations. The best railway network exists in the Western and Central Europe (Netherlands, Belgium, and Germany – approx. 100 km / 1,000 $km^2$). The sparser network exists in peripheral regions – Scandinavia, countries of Iberia peninsular, the Baltic States – up to 60 km / 1,000 $km^2$.

In Lithuania, there are approx. 30,000 rivers that are longer than 250 km and 750 rivers – longer than 10 km. The length of the navigation roads of internal waters – 931 km, however, only Nemunas is used for navigation during the summer season. Gravel and people are transported from Kaunas to Nida and Klaipėda. One should also mention two ferry lines in Klaipėda transporting many cargoes and passengers from Klaipėda to Neringa.

In geographic terms, Lithuania is situated by the Baltic Sea and has a non-freezing Klaipėda seaport and four main airports – in Vilnius, Kaunas, Šiauliai and Palanga. Air corridors and routes are 25% shorter than parallel railways lines and up to 50% shorter than river and marine transport routes. Sometimes this distance of air route can decrease by 2-3 times. Recently, the absolute majority of passengers were transported by road transport (including urban buses and trolleybuses): in 2010, the domestic carriage of passenger by road transport composed 98.6%, railway transport – 0.9%, other transport – less than 1%. When calculating the average distance of carriage of one passenger by road transport, the distance has not changed for several years – 7-8 km on average (as the mean distance for which passengers take a trolleybus is only 3 km). In the past decade, the distance travelled by rail increased by 20% and the distance travelled by air transport – nearly twice. According to the data of 2010, the international carriage of passengers by railway transport composed 34.7% (881 thousand passengers), air transport – 32.6% (828 thousand passengers), road transport – 22.7% (576 thousand passengers) of all international passenger carriage. In 2010, 2.3 million passengers arrived at and departed from country's airports. This number is 58.7% higher than in 2005. The average increase in the number of passengers in airports was 9.2% per year during the period between 2005 and 2010.

During 2005–2010, the cargo transportation decreased at the average of 3.4% per year (Fig. 29). In 2010, 115.2 million tons of cargoes were transported by all kinds of transport (including the transportation through oil pipelines); however, it was 15.9% less than in 2005. Most significant factor, which affected this sector, was the decrease in transportation by oil pipelines.

In 2010, 40.3 million tons of cargoes were loaded in Klaipėda State Seaport and Būtingė oil terminal, i.e., 44.3% more than in 2005. During 2005–2010, the cargo loading in Klaipėda State Seaport and Būtingė oil terminal increased at the average of 7.6% each year.

In 2010, 11.9 thousand tons of cargoes and post were loaded and unloaded in airports – this number is 20% higher than in 2005. In 2010, 387.8 million passengers were carried; however, it was almost 15% less than in 2005. Passenger transportation has decreased because part of international carriers stepped back from the Lithuania airports and the national carrier "flyLAL" ceased its activity.

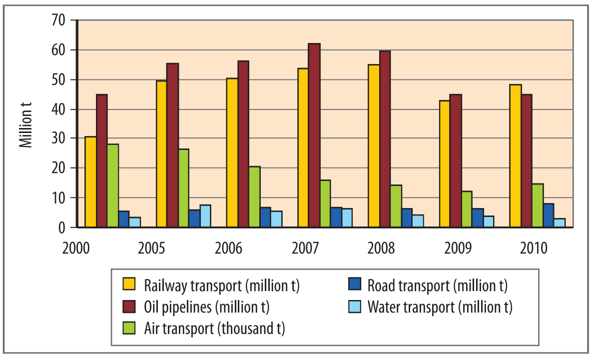


**Fig. 29.** Cargo transportation volumes. *Source: Lithuanian Department of Statistics*

The transport sector is a very important sector not only to the economy and social environment, but also to the quality of environment. Transport, especially car transport, is currently the main source of environmental pollution. Pollution caused by motor transport accounts for one third of the total pollution in the world and more than half in Lithuania, mostly in motorised cities – even up to 70 percent of atmospheric pollutants. The railway pollution mostly manifests by air pollution as the emission of heavy diesels is dominated by sulphur oxides. Heavy diesels emit SOx (calculated per unit of effective work) 5–20 times more than carburettor engines, NOx – 2 times more, whereas CO – on the contrary, 1,000 times less.

During the last decade, the number of vehicles has increased significantly in Lithuania, especially the fleet of motor cars (Fig. 30). In 2010, there were 521 vehicles per 1,000 population (in 2000 – only 333 vehicles per 1,000 population). Based on the number of vehicles per 1,000 population, Lithuania aligns with Germany and France. On one hand, this increasing index shows the improving economic situation in the country and increasing personal income.

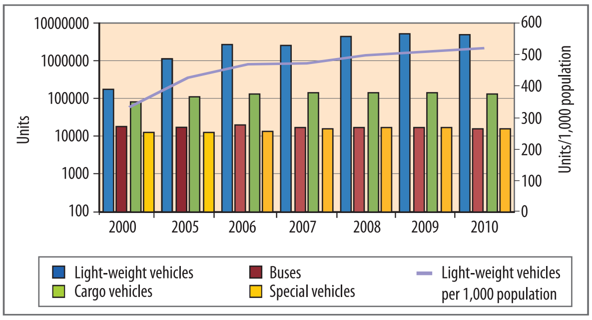


**Fig. 30.** Number of vehicles. *Source: Lithuanian Department of Statistics*

On the other hand, Lithuania is different from the western countries because our population is using much older vehicles. In 2010, there were only 239 new registered vehicles per 100,000 Lithuanian population. This is 3.5 times less than in Poland and 16 times less than in Austria. In 2011, there were total 15,059 new lightweight vehicles registered in Lithuania and, although this is by 69% more than in 2010, this number is 41% less than in 2007. In Lithuania, nearly the entire fleet of motor cars and cargo vehicles increases mostly from used transport means (older than 10 years) resulting in the increase of environmental pollution.

The average age of operated vehicles was 15 years in 2011. This was slightly more than in 2010, when this number reached 14.6 years. It should be noted that such average of age is calculated by eliminating the vehicles included into the register of vehicles, but not actually operated – 455 thousand vehicles have not been delivered to technical inspection. Therefore, such assessment is not quite precise. In fact, the average age of our vehicle fleet can amount to 17 years, and this number has not changed for 11-12 subsequent years. The Lithuanian fleet of vehicles is one of the oldest in Europe, whereas the average age of the fleet of European vehicles is of the age of 8.5 years. Out of 1.7 million of vehicles registered in Lithuania, 58% are produced before 1993. Pursuant to the statistics of State Enterprise "Regitra", the number of new registered vehicles is 15 times lower than that of used ones. In 2011, there were 15.4 used vehicles per one new registered vehicle, in 2010 - 19.2, in 2009 – 16.1, in 2008 – 7.6 and in 2007 – 8.1.

The trend of the annual increase of 2-3% in the share of diesel in the total balance of the consumption of fuel and the respective decrease in the share of petrol and liquefied gas has been observed in the recent years. In 2011, 979 thousand tons of diesel and 255 thousand tons of petrol were used in the transport sector. Under the constant increase in diesel prices, the experts forecast the likely increase in the consumption of liquefied natural gas.

The production and use of biofuel in Lithuania is stimulated by international obligations related to the reduction of greenhouse emissions and increase of biofuel share in the fuel used for vehicles. The influence is also felt from the increasing demand of diesel (as compared with petrol) and increasing prices of oil and mineral fuel. The main types of biofuel used in Lithuania include biodiesel and bioethanol.

In 2011, 20.9 thousand tons of bioethanol were produced in Lithuania, whereas in 2010 this quantity even reached 39.3 thousand tons (by 59.8% more as compared with 2009) and 79.9 thousand tons of biodiesel – the level of 2010 (89.2 thousand tons) has not been achieved as well.

Another solution that is likely to reduce the pollution caused by vehicles – the use of hybrid vehicles that should replace the current ones. According to the data of "Regitra", there are total 800 hybrid vehicles, mostly "Toyota" and "Lexus", registered in Lithuania. The reviving economy and increase in the income of companies and persons are likely to result in the increase of the popularity of new technologies in the transport sector, because the petrol and electricity-powered vehicles are on average 7-49% more expensive than similar petrol or diesel-operated vehicles. However, the experts note that due to lower fuel costs, the price surplus of the hybrid vehicle disappears after driving several thousand kilometres.

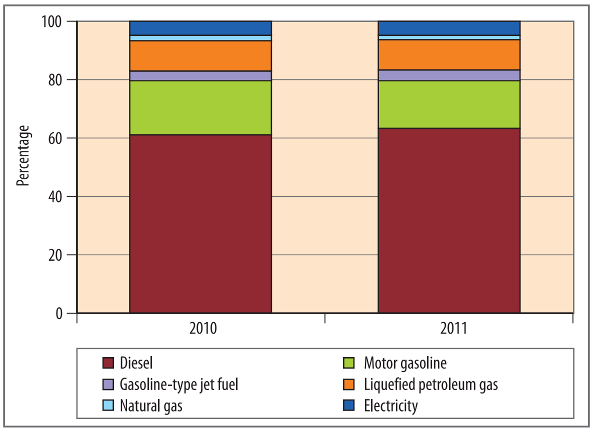


**Fig. 31.** Usage of the main types of fuel in the transport sector. *Source: Lithuanian Department of Statistics*

## AGRICULTURE

During the inter-war period, Lithuania was an agrarian country, the economy of which was based on the agriculture and recycling of it production. During the Soviet times, the importance of agriculture decreased, yet still was the second sector in terms of importance, number of jobs and the generated GDP, and it remained the visit card of our country (the Lithuanian meat and milk products were valued for their exceptional quality in the entire Soviet Union). However, after the restoration of Lithuania's Independence, the general production of agricultural products along with its share in the GDP has decreased – during the recent decade, the agriculture generated 3% of the national GDP. However, as it was already mentioned in the discussion of the number of rural and urban residents, that the Lithuanian agriculture remains one of the priority sectors performing an important economic, social and environmental role, because one third of the overall population lives in rural settlements.

Agriculture is supported almost everywhere in the world due to its specific features (link with biological organisms, traditions, environment). Especially lately, the society started to study in more detail and shifted to the organic production, meaning the decreasing harvest. Other areas of activity – transport, trade, industry – can operatively react to changes and quickly change the number of employees, volume or type of production, meanwhile the agriculture sector is more inert. Since the very restoration of Independence, relying on the experience of other European countries, Lithuania tried to subsidise and support agriculture and its production. When Lithuania was preparing for accession to the European Union, the main priority was to increase the competitiveness of agriculture because of the emergence of new difficulties and challenges – quality policy, animal welfare and higher environmental requirements.

Direct payments to the Lithuanian agriculture are substantially lower than in the old Member States of the European Union. Based on the amount of payments per one hectare of utilised agricultural area, Lithuania was in the next-to-last place – the amounts received hardly reached one third of the EU-27 average. However, even during the period of 2014–2020, the direct payments planned to be paid to the Lithuanian farmers will be twice lower than the subsidies of other EU countries. Such difference reduces the competitiveness of Lithuanian agricultural production and weakens the existing farms.

At the moment, the Lithuanian Land Fund is composed of 65.3 thousand hectares, including 39.51 thousand ha of agricultural land. In 2010, the arable land occupied ¾ of the utilised agricultural area (21.27 thousand ha). Since 2005, the share of arable land has increased due to cultivation of meadows and orchards (Fig. 33).

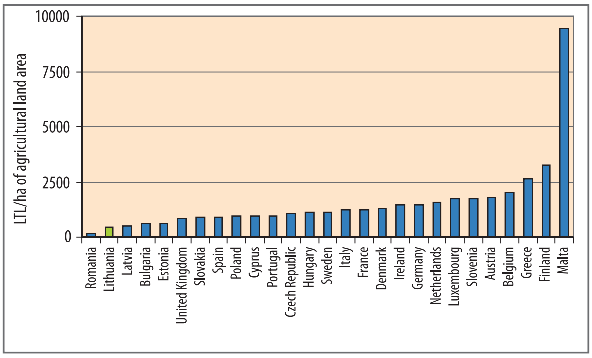


**Fig. 32.** Direct payments in the EU countries, 2010 (LTL/ ha of utilised agricultural area). *Source: Evaluation of the influence of direct payments on the Lithuanian agriculture sector by applying AGMEMOD*

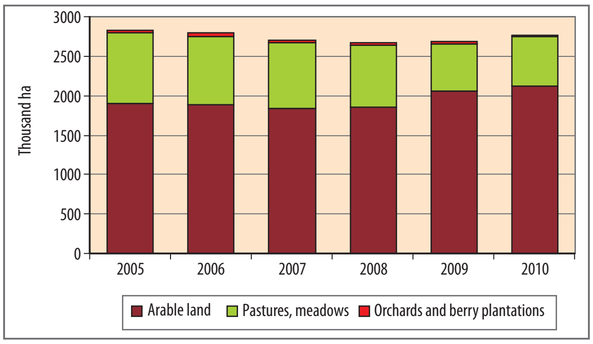


**Fig. 33.** Utilised agricultural areas used by producers of agricultural products. *Source: Lithuanian Department of Statistics*

The initial agricultural level and food industry are directly related not only to the sectors of production of material resources and services. They also directly affect the environmental condition in Lithuania. The agricultural activity influences the landscape and natural variety. Therefore, there is a necessity to coordinate the agricultural activity and preservation of the biodiversity.

According to the data of the national census of 2010, there were 364.4 thousand farms producing agricultural products in Lithuania. Farms occupied 3 million 85.6 thousand ha of land, including 2 million 764.3 thousand ha of the utilised agricultural areas. 199,913 farms were larger than 1 ha, they occupied 3 million 3 thousand ha (97% of all land and 99% of all utilised agricultural area).

In 2010, as compared with 2003, the utilised agricultural area increased by 10% in farms larger than 1 ha. The average size of a farm (based on the utilised agricultural area) increased from 9.3 ha (2003) to 13.8 ha (2010). However, farms in Lithuania remain significantly smaller than in Europe, where the average farm is larger than 22 ha.

Nearly one third of farms were engaged in the field crop cultivation (as the main source of income) – wheat, oil and leguminous plants – and were engaged in general agriculture. The remaining farms were mostly engaged in keeping grazers (cattle, sheep, goats, other grazers for meat and milk) and pursued mixed cropping and animal breeding, i.e., cultivated field crop and kept grazers.

Based on the quantity of fertilisers per one hectare of utilised agricultural area, Lithuania occupied the seventh place in the European Union. Although mineral fertilisers are expensive in Lithuania, they are used in large amounts. Other Baltic States consume approx. 60-70% less of mineral fertilisers, Poland – approx. 10% less.

About half of fertilisers consumed in Lithuania are of nitrogen fertilisers. The fertilisers used in agriculture have the maximum effect upon diffuse source pollution to the surface water bodies.

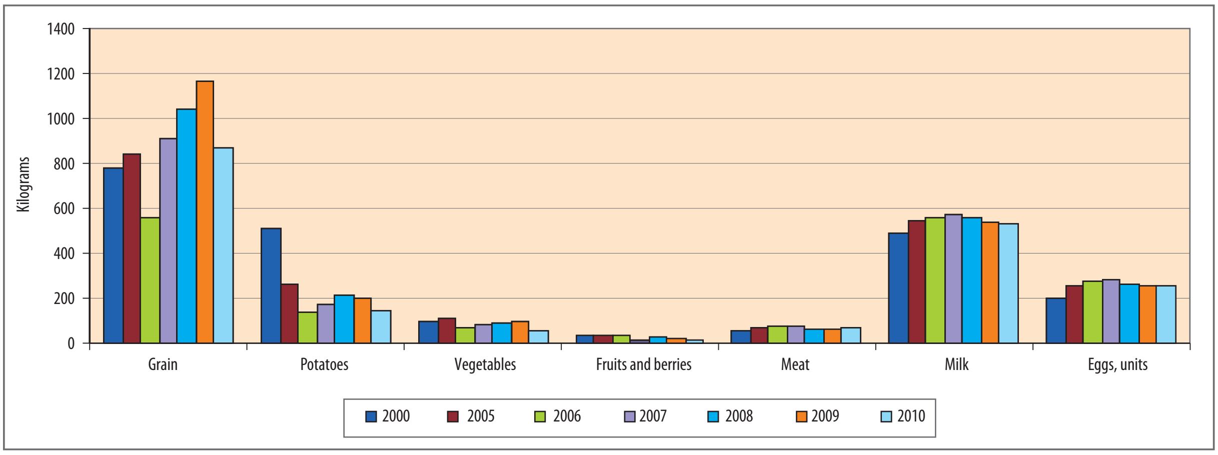


**Fig. 34.** Production of agricultural products per capita. *Source: Lithuanian Department of Statistics*

The number of rape cultivators and the area of rape cultivation have increased recently. Such interest in this culture was partly conditioned by the introduction of biofuel production, i.e., the market was offered to the cultivators to sell their production.

In the inter-war Lithuania, mineral fertilisers were used in relatively small quantities. Approx. 100 thousand tons were used in 1937. During the period of 1938 to 1940, annual consumption amounted to 140 thousand tons. In the Soviet times, the use of fertilisers increased year by year. In 1950, 250 thousand tons were used, in 1955 – 480 thousand tons, in 1965 – 940 thousand tons, in 1968 – 1.2 million tons. The use of fertilisers especially increased in 1965, after construction of the plants of nitrogen fertilisers in Jonava and phosphorus fertilisers in Kėdainiai in 1993 and already in 1980, the use of fertilisers increased up to 5.5 million tons, in 1988 – up to 8.0 million tons.

Diffuse source agricultural pollution can account for 45-80% of all the load of nitrogen pollution washed to water bodies. In Lithuania, due to non-point source pollution 222 surface water bodies out of 1,177 do not meet the criteria of good organic state. This accounts for 19% of the total number of all water bodies.

In 2010, the agricultural production amounted to 6.4 billion Litas at the prices of that time and, as compared with 2009, its scope decreased by 8.6% (crop production – 17.4%, livestock production – increased by 3%). The decrease in the crop production was conditioned by a smaller harvest: 41.4% - of vegetables, 28.0% – of potatoes, 26.5% – of crops. The livestock production increased, because the livestock breeding increased by 7.6%. The prices of agricultural products increased by 16.3%.

The year of 2008 was the most favourable financially for the cultivators of agricultural production, when the sales of production amounted to 7,340.0 million Litas. The prices of all products increased by 20-30%, as compared with the previous years, especially the price of rape. However, the crisis that struck at the end of 2008 also had impact on agriculture – in 2009, the products of agriculture amounted to 5,707.0 million Litas (23% less than in 2008). Later, the volumes started to increase again; however, even the level of 2007 has not been achieved yet.

So far, the intensive agriculture was prevailing in Lithuania. It is characterised by specialisation, concentration and increase of production volumes, mechanisation, and application of chemical and biological measures, in order to produce as much marketable production as possible. At the moment, when an increasing attention is paid to the quality of production and environmental protection, the balanced and organic agricultural systems are more perspective and advanced, especially in respect of environmental protection.

Balanced farming is characterised by the fact that one follows not only the economic effect received after the end of production cycle and sale of production, but also considers the further perspective – the impact of production on the environment.  Therefore, in order to seek the balance, the crop rotation by coordinating leguminous plants, fertilising of fields with organic fertilisers, formation of favourable conditions for the reproduction of earthworms and other organisms, maintenance of proper soil structure and avoidance of mineralisation as well as the expansion of areas of perennial plants are recommended. By developing this type of farming, the crop rotations that stimulate the fertility of soil are applied – areas of pastures, leguminous plants are increased, medium plants are sowed, and this encourages not only the cultivation of plants but also the breeding of livestock. In the area of livestock breeding, it is important to coordinate the usage of organic and mineral fertilisers. Only the quantity of fertilisers that is absorbed by plants is used, therefore, it is necessary to create annual fertilisation plans and set the balanced volumes of nutrient not only for the fields, but also for the entire farm. It is important to conduct the accounting of economic activity. The norms of pesticides are reduced – they are used only in case of risk of decrease in the harvest.

It is necessary to apply widely the prophylactic and biologic measures of plant protection. Therefore, the future agriculture is aimed at organic farming, formation of new markets for organic products, as well as the certification of farms producing organic products, thus, encouraging the farms to shift to organic farming. Furthermore, it is important to care for the cultivation of energy plants as well as to encourage the use of renewable fuel. It is also very important to plant trees in the areas that are not suitable for agriculture and the areas of cut forest.

Organic farming is the farming system, which ensures the production of high quality agricultural products without synthetic fertilisers, pesticides and other technical substances. The soil is improved by organic fertilisers, crop rotation is applied, diseases and pests are exterminated by biologic means. By developing the crop cultivation one strives to maintain the variety of species and ecologic balance in the environment, thus reducing the spurt of pests and diseases. Furthermore, the conditions of keeping of livestock and aspects of feeding are taken into account and special attention is paid to the supply of livestock with sufficient quantity of good-quality organic feed and proper veterinary care. In order to achieve harmonious relation between crop cultivation and livestock breeding, it is important to find a proper relation between the amount of feed grown in the farm and number of kept livestock. It is no surprise that the harvest of organic farm is substantially smaller than of traditional farm and the production is more expensive.

Each year, organic farms become more popular in Lithuania, because a market is formed for their production. It is farm markets, direct trade with purchasers, and supply of production of organic farms to the largest trade networks. The growth of organic farming in Lithuania may be related to the problem of occupation of residents of rural settlements. There are many partly occupied qualified people in rural settlements, whereas organic farming becomes the new lifestyle of some young educated former urban citizens. The operating costs of organic farming are 20-30% higher than in ordinary farms. This could be one of the solutions of unemployment problems in rural settlements. Another reason for the emergence of organic farming in Lithuania – areas of infertile or low-fertile soil, which occupy 360 thousand ha or 11% of all utilised agricultural area in our country.

In 2010, 2,639 organic production farms were certified in Lithuania: 2,541 farmers, family farms, and 98 agricultural enterprises. The area of organic production farms accounted for 5% of all utilised agricultural area. The average size of organic farm reached up to 54.4 ha.

The major part – nearly 50% of all area of organic farm – was occupied by crops. Meadows and pastures occupied approx. 22% of the area of organic plants, leguminous plants – approx. 14%, orchards and berries – approx. 4%, oil plants – approx. 3%, potatoes and field vegetables – less than 1%, other plants – approx. 7%. In 2010, there was an average of 34.7 livestock per one farm keeping certified animals, 14.5 pigs per one farm keeping certified pigs, 153.4 goats and sheep per 1 farm keeping certified goats and sheep, and 90.3 birds per one farm keeping certified birds. Based on the number of kept animals, organic farms are significantly larger than farms engaged in ordinary farming.

# Climate and Its Change in Lithuania

The Earth's climate is a very complex, territorially varied and dynamic system of physical and chemical processes. This climate system covers the entirety of atmosphere, hydrosphere, lithosphere, cryosphere and biosphere as well as the interaction of these spheres. In the light of long-term and slow climate fluctuations caused by changes in chemical composition of the parameters of Earth's orbit and atmosphere, orogeny, drift of lithosphere plates, a number of accidental powers are acting (high frequency pulsation of Solar activity, voltage of geomagnetic field, volcanism, etc.), causing short-term climate fluctuations and variations. The climate change acts on the process of other natural phenomena: landscape formation, soil formation and exogenic geological processes, the organic world of the aquatic and terrestrial environment. The climate change that has become increasingly more obvious in the recent decades causes threat to the environment, economic activity and the development of global economy. The economic activity of mankind increases the atmospheric thermal pollution: the increasing concentration of greenhouse effect causing gas (hereinafter referred to as the greenhouse gas) increases the natural greenhouse effect and conditions the increase of the global air temperature. However, the warming in various areas across the globe manifests in different intensity: in tropical latitudes, the warming phenomenon is slower, whereas in medium and polar latitudes – more intensive.

The global temperature of the lowest troposphere layer has remained higher than the average of 20th century for 36 subsequent years, whereas since the early 20th century it increased by 0.8°C (in Europe – by approx. 1°C). Furthermore, due to intensive water circulation rating and increased atmosphere circulation in central and high latitudes the warming is accompanied by increased average precipitation rate causing the rise of the global sea level, melting of mountain ice, constantly shrinking areas of permafrost and sea ice. The melting of the Arctic sea ice is progressing rapidly: since the end of summer season 2012, its area became even 45% smaller than the one characteristic to that period of the year in 1979–2000 (NSIDC, 2012).

None the less important is other global scale processes having influence on the climate change and being the cause of this change. These include a rapid desertification of periodically dry savannahs and rare forests due to intensive overgrazing, sand drifting or disordered distribution of seasonal showers in the time and space; reduction of stratospheric ozone in high latitudes. From the climatic perspective, the decreasing ozone concentration conditions the decrease in the temperature of lower stratosphere of polar areas in the cold season; however, it is also the main cause of increase of circumpolar whirl. This influences the development of very active cyclones in central latitudes, formation of devastating storms over non-tropic ocean water areas. The rising global temperature of air and water surface forms more favourable conditions for the formation of tropical storms and hurricanes, leads to the development of abnormal atmospheric and water circulation processes, formation of long-term air abnormalities causing a significant damage to nature and economy, increases the risk of negative consequences of climate change. Negative consequences of climate change mean the changes of physical environment and biota caused by climate change having a negative impact on the composition, vitality and productivity of ecosystems as well as functioning of social and economic systems, human health and welfare. Lithuania's climate is an integral part of processes occurring in the entire climatic system around the globe. Thus, Lithuania is potentially open to both the global climate changes and results achieved by reducing the greenhouse gas emissions.

## METEOROLOGICAL PARAMETERS

Reliable meteorological and hydrological information, which is necessary for the national needs of Lithuania and fulfilments of international obligations, is delivered by the Lithuanian Hydrometeorological Service under the Ministry of Environment (hereinafter referred to as the LHS). LHS started its activity on 30 September 1921, when the Prime Minister of the Republic of Lithuania, K. Grinius, signed a legal document legitimising the establishment of the central meteorological station and assigning it all the functions characteristic to the Hydrometeorological Service. This document legalised the national Lithuanian meteorological service.

During the period from 1941 to 1990 (except for the years of World War II), the network of Lithuanian meteorological and hydrological stations belonged to the USSR hydrometeorological system. Observations, forecasts and climate research were conducted according to the unified requirements. In 1945–1955, meteorological measurements started in 89 stations in the territory of Lithuania (9 stations and 80 posts). In 1955, there were 120 meteorological measurement stations – 26 stations and 94 posts – operating in Lithuania. By 1944, meteorological stations conducted monitoring three times per day, from 1945 – four times per day and from 1966 – eight times per day. The Weather Office was established in 1944, civil aviation meteorological station was established and radio-probing of atmosphere and regular agrometeorological observations started in 1945, actinometric (solar radiation) measurements started in 1952, in 1953 agrometeorological forecasts started to be prepared and in 1974–2000 meteorological radiolocation station was put into operation. In 1990, the Hydrometeorological Management Board of the Republic of Lithuania was established (since 1996 – the Lithuanian Hydrometeorological Service under the Ministry of Environment, the LHS). The LHS conducts regular monitoring of hydrometeorological parameters in the national territory, forms the data bank of monitoring results, evaluates the national water sources and climate, forecasts the change of weather, unfavourable and hydrometeorological disasters.

## FACTORS INFLUENCING CLIMATE IN LITHUANIA

The climate in Lithuania is of transitional type between central latitude oceanic and continental climate. In the classification of world climate, the climate of the major part of Lithuania is characterised as medium cold with snowy winter. The rate of precipitation is sufficient during all seasons and is more intensive during the warm season. The mean temperature of the coldest month is below −3°C, whereas of the warmest month does not exceed 22°C. For at least 4 months, the mean temperature is above 10°C. Such climate is characteristic to the region of Eastern Europe. The climate of the western part of Lithuania and Curonian Spit is defined as medium warm because the average air temperature of the coldest month is above −3°C. This type of climate is dominating in the Western Europe. The climate in Lithuania is conditioned by zonal (global) factors and local geographical conditions (azonal factors).

In 1992, Lithuania became the member of the World Meteorological Organisation. In 1993, the measurements of total ozone amount and, in 2000, UV solar radiation started to be taken. Due to insufficient funding, in 1990–2001, the programme of meteorological measurements and observations was narrowed (the meteorological radiolocation and aerology stations were shut down, the network of phenological and agrometeorological monitoring was eliminated). In 2003, the automatic equipment started to be installed in meteorological stations, aerological and phenological monitoring was updated, whereas in 2007, the agrometeorological monitoring has been renewed. In 2006, high-resolution weather forecast model HIRLAM was installed, in 2011 – Doppler-type meteorological radio locator started to operate and in 2011 – the advanced system notifying about natural calamities was installed.

In 2012, the network of meteorological and hydrological monitoring consisted of 26 meteorological stations, 43 automatic agrometeorological stations, 2 hydrometeorological stations, aviation meteorological centre and 2 aviation meteorological stations, 2 hydrometeorological stations, 1 hydrology station and 91 water measurement stations. The LHS cooperates with European Organisation for the Exploitation of Meteorological Satellites (EuMETSAT), European Centre for Medium-Range Weather Forecasts (ECMWF), distant training programme (EuMETCAL) of the European Organisation of National Hydrometeorological Services (EuMETNET). Lithuanian climate and hydrological research has recently been conducted in the Department of Hydrology and Climatology of the Vilnius University, Laboratory of Hydrology of the Lithuanian Energy Institute and the LHS.

Zonal factors include the Lithuania's territorial geographical situation and dominating carriage of air masses from the west covering the entire troposphere and the lower part of stratosphere. Lithuania is situated in the northern part of the medium climate zone between 53°54' and 56°27' of the northern latitude. The distance of territory from the equator (approx. 6,100 km) and the North Pole (approx. 3,900) conditions the height of sun over the horizon, the duration of day and inflow of total solar radiation. The height of sun over the horizon in Kaunas latitude varies in 47° interval. It is in the maximum (58.5°) on the 22nd of June, when the duration of day exceeds 17 hours, and the minimum (11.5°) on the 22nd of December, when the day lasts for barely 7 hours and several minutes. Lithuania receives the average of 3,400 $MJ/m^2$ of total solar radiation to the horizontal surface per year (it is twice less than in the equator areas).

However, this annual amount is distributed very unevenly: in June 17% of solar radiation is received, while in December this number is only 1% of the annual amount. The highest total solar irradiance is characteristic to the south-west region of Lithuania (3,500 $MJ/m^2$), whereas the lowest – to the cloudy western part of Samogitian highlands (approx. 3300 $MJ/m^2$).

The number of annual sunny hours is highest in the Curonian Spit and seaside areas (approx. 2000) and is decreasing towards the east down to 1,750. The most sunny months are May and August (with the average number of 260-300 sunny hours in each), and the least sunny are the months of November-January (with the average number of 30-45 sunny hours in each). Due to cloudiness, the number of sunny hours is much lower than the maximum possible, i.e., duration of day. The actual duration of sunshine usually accounts for 37% in the east and 41% in the seaside areas of the maximum possible. In the past 20 years (1991–2010), as compared with 1961–1990, the number of sunny hours increased by 80–200 hours: mostly 9 in the Curonian Spit, Western and South-West Lithuania, the least – in the East. For example, during the period from 1961 to 1990, the sun was shining at the average of 4.8 hours per day in Kaunas, while in 1991–2010 – 5.3 hours. Having compared both periods, the highest increase in the duration of sun irradiance (16%) was established in April and July: in 1991–2010, sun was shining 27 and 42 hours longer per month, respectively. It is related to more frequent recurrence of anticyclone processes.

The number of sunny hours decreased only in February (8%).

The electromagnetic waves of solar irradiance of the length of 100-400 nm are called the UV irradiance (hereinafter referred to as the UV). It is composed of three parts: UVA – wavelength of 320–400 nm, UVB (280–320 nm) and UVC (100–280 nm). The entire UV irradiance causes a strong photo-biological impact. The most dangerous is the UVC irradiance; however, it is absorbed in the atmosphere and does not reach the Earth's surface. In the total UV amount, that reaches the Earth's surface, UVA accounts for approx. 94% and UVB accounts for 6%. Erythema (redness of skin of unsunned person) is mostly caused by the UV irradiance of the wavelength of 290-340 nm. In Lithuania, only the UVB irradiation is measured. The maximum intensity of UVB irradiance is recorded in June and July (reaches 0.61-0.62 MED/h), whereas in November-February, the medium intensity of UVB does not exceed 0.06 MED/h. In the specific year, the intensity of UVB irradiance depends on the cloudiness, amount of ozone and aerosol. For example, in case of 1% decrease in the ozone amount, UVB irradiance can increase by 2%. The tendency of increase of UVB irradiance has been observed in the recent years. The major increase in the intensity of UVB irradiance was observed in April and July-August. UV irradiance also has a prophylactic and therapeutic impact, because it strengthens the organism's resistance to infections. However, extensive doses of UV irradiance have a cancerogenic impact that may lead to a skin cancer, encourage the development of malign tumours, cause eye inflammations (keratitis, conjunctivitis), etc. UV irradiance has a significant impact on the plants. UVB irradiance is absorbed by proteins, chlorophyll, and other substance of plant cells. Small additional doses of UVB irradiance stimulate the growth and development of plants, kills pests. The limit dose of UVB irradiance is individual for different species and may differ by several hundred times.

In some days, the minimum values of ozone amount dropped down to as little as 211-220 DU. Seasonal fluctuations are typical to the ozone amount, as well. The highest amount of ozone is in March-April (approx. 390 DU) and the least is in October-November (approx. 280 DU). The tendencies of ozone decrease over Lithuania have not been observed during the measurement period from 1993. The total global amount of ozone has not changed since 2000 and remains approx. 4% lower as compared with the average of 1970–1979. However, in the polar areas of both hemispheres, the amount of ozone is decreasing ceaselessly. As compared with 1970–1979, in the entire South Polar area, the amount of ozone remains 50-55% lower in spring, whereas in the Arctic – 25-40% lower (SAOZ, 2012).

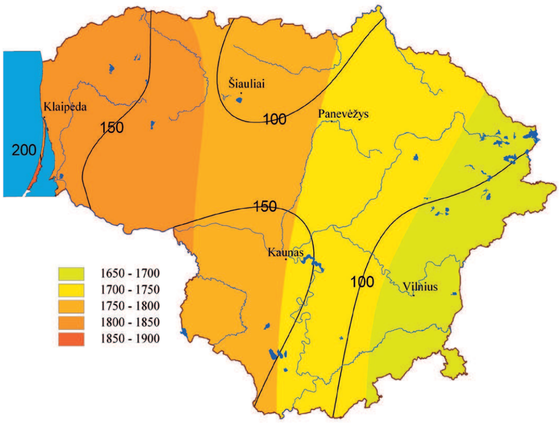


**Fig. 35.** The average number of sunny hours per year, 1961–1990 (colour scale). The isolates indicate the difference (in hours) of the number of sunny between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

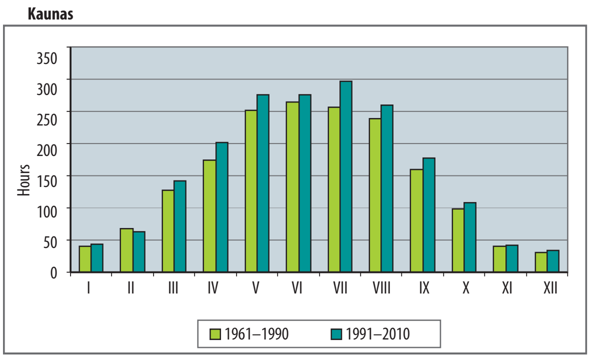


**Fig. 36.** Average duration of sun irradiance per month in Kaunas, in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

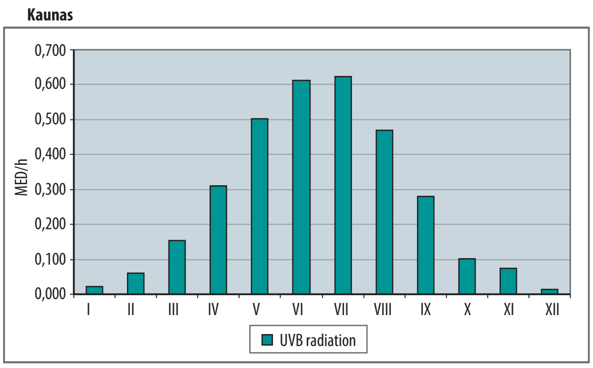


**Fig. 37.** Average intensity of UVB irradiance per month (MED/h). MED – the minimal erythema dose of UV solar irradiance (69.4 mW/m$^2$), causing redness of the skin of unsunned person. *Source: Lithuanian Hydrometeorological Service*

The average annual ozone amount varied between 305 and 357 DU in 1993–2010 (DU – Dobson units, 1 DU = 0.01 mm ozone layer), whereas the average DU during this period was 334.

The features of Lithuania's climate also depend on azonal factors: surrounding areas of land, situation of oceans and seas, absolute altitude of relief, soil characteristics, and cover of bed surface. The Baltic Sea and the Atlantic Ocean water areas and only small areas of land – Scandinavia and Jutland peninsulas with islands – are situated to the west of Lithuania. To the east lies the Eurasian continent stretching for thousands of kilometres. Therefore, although Lithuania is a seaside region, the climate is not typical to oceanic in country's territory. The coat of bed surface is the most important factor Influencing the absorption of solar irradiance. The surface of the Lithuanian territory absorbs 2,600–2,900 MJ/m$^2$ of solar energy (mostly the forestry regions in the south and south-west areas). The major part of absorbed irradiance is in May and July (by 400-500 MJ/m$^2$), the least – in the months of December and January (by 20–25 MJ/m$^2$). The energy sources of absorbed irradiance are further consumed for the evaporation of moist, heating of ground-level air and deeper layers of soil.

The climate in Lithuania depends not only on the geographic situation of territory and inflow of solar irradiance, but also on the atmosphere circulation processes: periodicity of cyclone and anti-cyclone formation, advection of air masses, mixing of vertical air. These processes ensure uninterruptible circulation of heat and moisture between various regions of Earth and between Earth's surface and atmosphere. Furthermore, atmosphere circulation processes condition short-term climate fluctuations, seasonal weather anomalies and all weather changes in general.

The main trajectories of cyclones coming to Lithuania stretch from the eastern shore of North America to Scandinavia, the Barents Sea and Norwegian Sea as well as Northern Russia. The majority of them move from the South Greenland via Iceland towards Northern Scandinavia (these are regenerating cyclones). Other cyclones, moving towards Southern Scandinavia cross the British Isles – it is the group of developed and intensive cyclones. The smallest part is composed of south cyclones developing in the polar front over the Mediterranean or the Black Sea water areas. Upon the formation of strong southern carry, their trajectories turn to north – towards the Central and Eastern Europe.

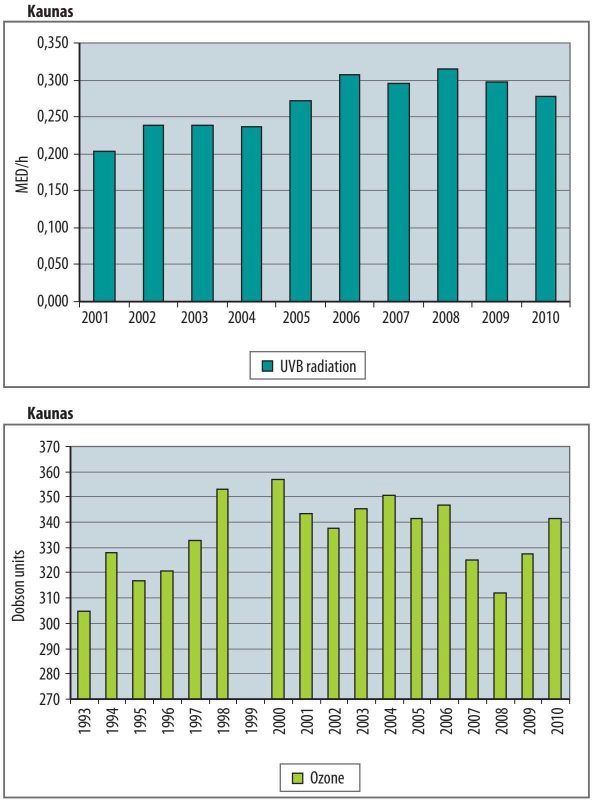


**Fig. 38.** Medium intensity of UVB irradiance (MED/h) per year (a) and medium total amount of ozone (b) in Kaunas (ozone measurement data of 1999 were condemned). *Source: Lithuanian Hydrometeorological Service*

Anticyclones are usually coming from the north-west or the north. The speed of their movement is usually slower than that of cyclones; therefore, by moving to south they suffer various transformations – heating, pressure dropping. Sometimes, during winter seasons, the ultrapolar anticyclones come from northeast, from Central Arctic. Anticyclones from Azores or subtropical Atlantic anticyclones do not reach the territory of Lithuania with their central part; however, their northern periphery brings the Indian summer. The weakening of western carry increases the influence of Siberian and Scandinavian anticyclones: Siberian anticyclone ridge extends to the west and north-west, where the individual closed centre is likely to form; low mobile high-pressure centre quickly develops in Scandinavia, the periphery of which (ridges) can reach the North Sea, the Carpathians, cover the entire region of the Baltic Sea. When the paths of Atlantic cyclones move to northern latitudes, the Siberian anticyclone connects with the high-pressure neck via Central and Eastern Europe with subtropical anticyclone of Azores. This sessile high-pressure strip cools down gradually in winter, whereas, in the clear skies, the temperature can drop down as low as in the Siberian anticyclone ridge.

In Lithuania, the average annual ground-level atmospheric pressure in the sea level is 1,104-1,015 hPa. Since Lithuania also receives deep cyclones and powerful anticyclones, the pressure does not change even in the range of 100 hPa (from 960 to 1,060 hPa). In the past 50 years, the tendency of increase in ground-level atmospheric pressure has been observed: the value of average annual pressure increased by 1.5-2 hPa in Lithuania.

Azonal factors also include local climate factors Influencing the peculiarities of meso- and micro-scale climate elements. The main local climate factors are as follows: relief forms, water bodies, soils, vegetation, urbanisation elements as well as the seasonal variation of their physical status. The degree of impact of local landscape elements (lake, forest, etc.) on climate depends on their area and compactness. Micro- and meso-climate territorial particularities are usually conditioned by several rather than one factor.

Soil impact dominates (together with hydrogeological conditions) – 35% of territory, relief – 24%, forest – 10%. Climatic characteristics in the remaining part of territory occur due to a couple of dominating factors: due to relief and soil – 18% of territory, due to forest and soil – 9%, due to the Baltic Sea, Curonian Lagoon and soil – 4%. The impact of lakes on the climate is characteristic to 10% of the territory; however, it is as the most important in any of the regions.

## AIR TEMPERATURE

In Lithuania, the territorial distribution of air temperature indicators depends on the inflow of solar irradiance, its absorption in the bed surface, on the locations of surrounding oceans and land areas as well as on the nature, cover and energy circulation with atmosphere of the bed surface, on the relief of locality, type of soil and moisture. The characteristics of all these factors condition the fluctuations of temperature indicators and affect characteristics of territorial distribution.

The data of measurements of 18 meteorological stations performed in the altitude of 1.5-2 m were used for temperature analysis (1961–2010).

The average annual air temperature in Lithuania in 1991–2010 (as compared with 1961–1990) increased by 0.7-1°C and indicated the rapid warming of the climate.

Short-term fluctuations are synchronic across the country. Long-term warming tendencies are mostly observed in the seaside areas and Northern Lithuania. Thus, the average annual air temperature of 20 years (1991–2010) in the territory of Lithuania crossed the limit of 6.5°C and reached 6.7–8°C. In 1961–1990, it was between 5.5 and 7.1°C.

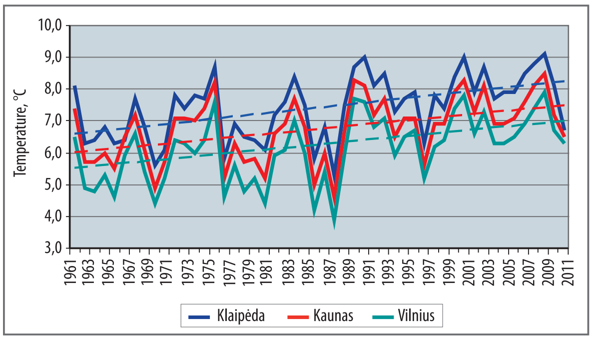


**Fig. 39.** Average annual air temperature and linear trends of its variation (dash lines) in Klaipėda, Kaunas and Vilnius, in 1961–2011. *Source: Lithuanian Hydrometeorological Service*

The analysis of variation of temperature of various months revealed that, in 1991–2010, the average air temperature was higher than in almost all months during the period of 1961–1990.

The most intensive warming (0.8–2.5°C) was recorded in the months of January-April, July and August. Insignificant (0.1–0.4°C) cooling was observed in the Western and Central Lithuania only in October and November and in June in Samogitian highlands.

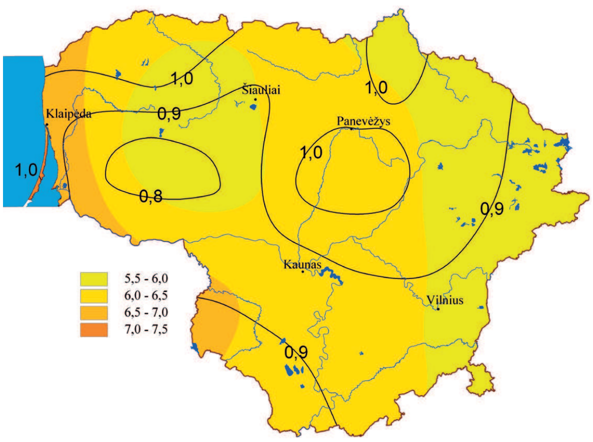


**Fig. 40.** Average annual air temperature, 1961–1990 (colour scale, °C). The isolates indicate the difference (°C) of air temperature between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

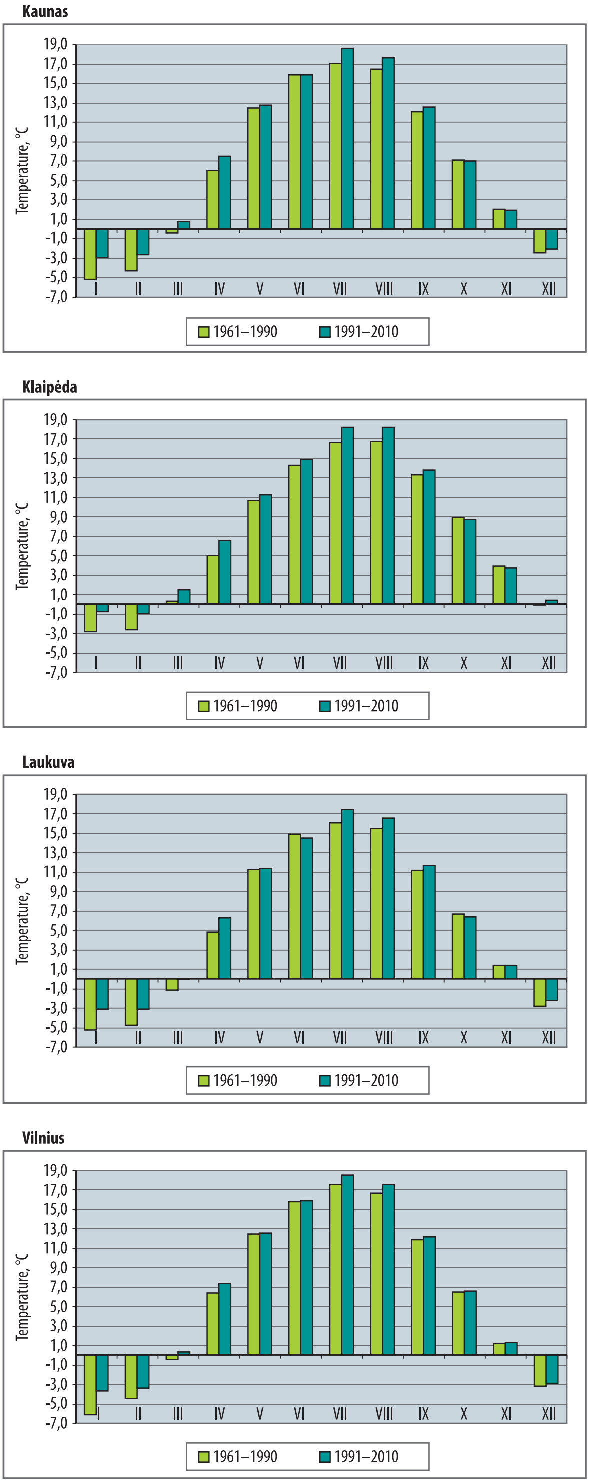


**Fig. 41.** Average monthly air temperature in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

During the analysed period, the changes were observed not only in the average air temperature, but also in its extremities. The absolute maximum (minimum) of air temperature refers to the highest (lowest) temperature of mentioned periods. In the past 20 years (1991–2010), the previous maximums of temperature (1961–1990) were exceeded by 1-3°C in the entire Lithuania's territory. The highest air temperature (+37.5°C) during the entire history of meteorological monitoring was recorded in Zarasai on 30 July 1994.

Same as the temperature maximums, the temperature minimums have also changed in the same trend (i.e., increased): in almost entire Lithuania (except for Šilutė, Kaunas and Lazdijai regions), they increased by 1-6°C. In 1991–2010, the lowest recorded air temperature was as low as –33.44°C, while in the previous years it was even down to –35, –38°C (absolute minimum –42.9°C).

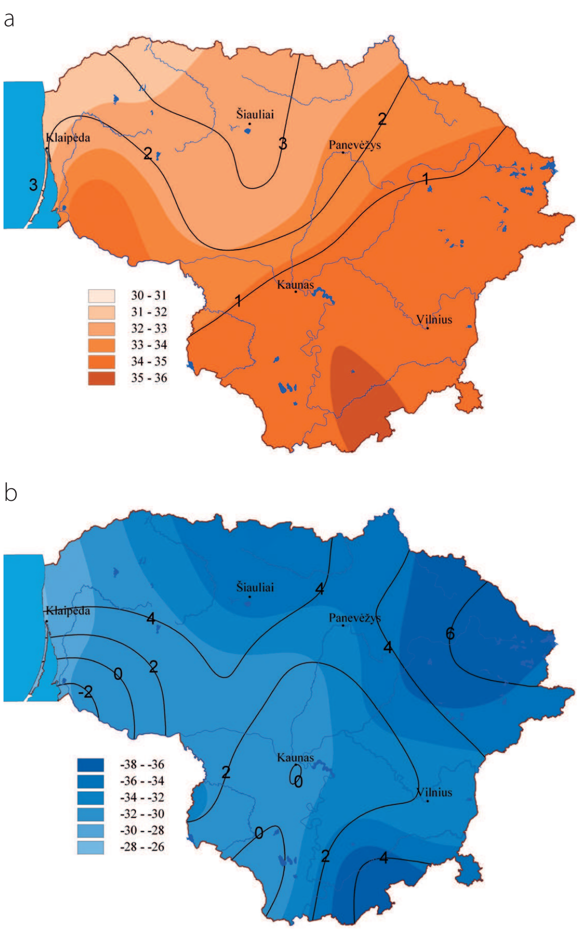


**Fig. 42.** Absolute maximums (a) and minimums (b) of air temperatures, 1961–1990 (colour scale). The isolines indicate the difference (°C) of values of absolute maximum and minimum between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

During the recent decades, the likelihood of temperature extremities changes rapidly, as well. The high temperatures, when the maximum daily air temperature is equal to or exceeds 30°C, and the frosts, when the daily minimum air temperature drops down to –20°C and below, cause danger to human health, damage to nature, transport, agriculture and other sectors. There have also been some cases, when frost caused accidents in heating supply and water supply underground routes. The number of extremely hot days started to increase in the late 20th century. Their likelihood in 1991–2010, compared with 1961–1990, increased by 2-2.6 times and now reaches 2-6 days per year. The maximum likelihood is in Southern and South-West Lithuania – 4-6 days per year. Meanwhile the number of frosty days has showed a noticeable decline in Lithuania: if there were approximately 10-12 frosty days recorded in the Eastern Lithuania in 1961–1990, in the recent years only 6-7 such days were recorded per season. In the seaside areas and North-West Lithuania, the likelihood of frosty days decreased down to 0.5 per winter, i.e., the frost is likely to occur in only every second year, on average. It has been established that these changes of likelihood of heat and frost days are mostly associated with more frequent occurrence of anticyclone processes in summer and rarer occurrence in winter.

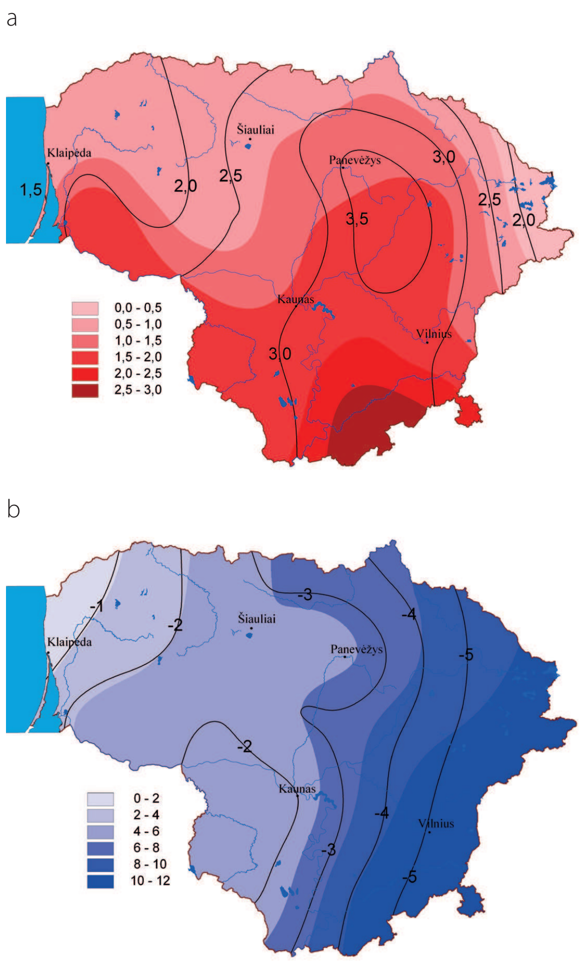


**Fig. 43.** The average annual number of extremely hot days (daily maximum air temperature ≥30°C) (a) and extremely cold days (daily minimum air temperature ≤–20°C) (b), 1961–1990 (colour scale, number of days). The isolines indicate the difference of extremely hot days (a) and extremely cold days (b) between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

In Lithuania's territory, moving from west to east, the continental feature of climate is increasing: the annual and daily amplitudes of temperature are increasing, winters become colder, the snow cover lasts for a longer period of time, and the air becomes drier.

For example, the average annual temperature amplitude is 18.5–19.5°C in the seaside areas, while in the east it increases up to 22°C. In some years (in case of cold winter and hot summer), this temperature amplitude can exceed 30°C.

## PRECIPITATION

In Lithuania, the precipitation patterns are mostly conditioned by the relief, the position of slopes in respect of dominating airflows and distance from the sea. Therefore, the average annual precipitation rate in Lithuania varies from 800-900 mm in windward Samogitian highland slopes to 550-590 mm in the lowlands of the Central Lithuania. The average annual precipitation rate is approx. 675 mm (44 $km^3$). Moist oceanic air masses coming from the west and south-west are forced to climb the slopes of the Samogitian highlands and cool down adiabatically, the cloud formation becomes more active and causes more abundant precipitation trend. The opposite process occurs in the downwind slopes of the Samogitian highlands: here, moving downwards, the air heats up adiabatically. This results in a decline in precipitation. A similar effect is also formed in the northeast Sūduva and eastern Švenčionys highland slopes. The precipitation rate decreases moving from the sea due to additional reason – the water vapour reserves are decreasing in the air. Due to peculiarities of atmospheric circulation in specific year, the precipitation rate can be different from the average value by more than 1.5 times. In Lithuania, 60-66% (this share increases when moving from east to west) of precipitation fall during the warm season of the year (April-October).

In 1991–2010, as compared with 1961–1990, the average annual precipitation rate in the territory between Šilutė and Kėdainiai decreased by 10-42 mm (the changes not exceeding 5%), whereas in the remaining territory of Lithuania – increased. The precipitation rate mostly (60-87 mm) increased in the South-West Lithuania and regions of Jonava, Ukmergė and Molėtai (the changes constitute 10-13%).

The precipitation rates of warm (April-October) and cold (November-March) seasons in 1961–1990 and 1991–2010 are presented in Table 1. It has been established that the precipitation rate of the warm season changed insignificantly by ±5%, whereas of cold season – increased by 5-12%. The maximum changes of precipitation rate have been established in the seaside areas.

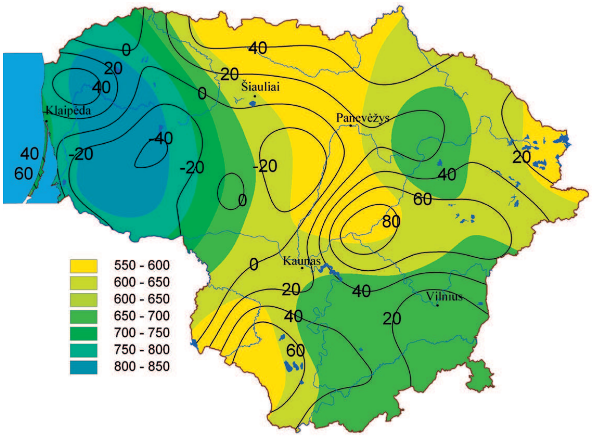


**Fig. 44.** The average annual precipitation rate, 1961–1990 (colour scale, mm). The isolines indicate the difference between the average annual precipitation rate (mm) between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

**Table 1.** Precipitation rates of warm (April-October) and cold (November-March) seasons in 1961–1990 and 1991–2010

| Period | Klaipėda | | Laukuva | | Kaunas | | Vilnius | |
|---|---|---|---|---|---|---|---|---|
| | Warm | Cold | Warm | Cold | Warm | Cold | Warm | Cold |
| 1961–1990 | 458 | 276 | 496 | 324 | 425 | 199 | 454 | 216 |
| 1991–2010 | 440 | 308 | 483 | 297 | 423 | 219 | 460 | 226 |
| Change, percentage | –4 | +12 | –3 | +8 | 0 | +10 | +1 | +5 |

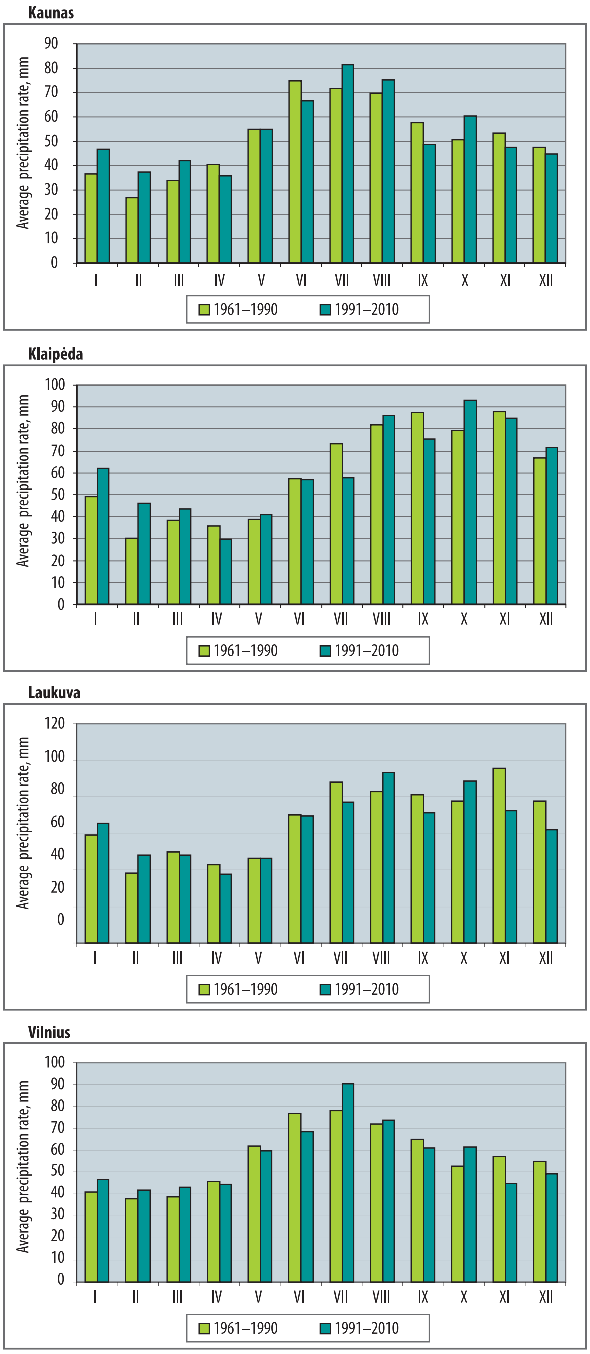


**Fig. 45.** Average monthly precipitation rate in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

The precipitation rate of various months in 1991–2010, as compared with 1961–1990, has changed unevenly: in the entire Lithuania, it decreased in April, September and November and increased in January, February, August and October. Other trends of variation of precipitation rate are characterised by a regional nature. For example, in the seaside areas and Western Lithuania, the precipitation rate in July decreased by even 13-22%, whereas elsewhere in Lithuania – increased by 12-13%.

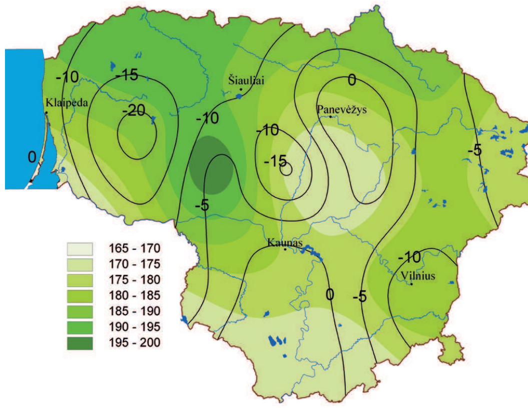


**Fig. 46.** Average number of annual days with daily precipitation rate ≥0.1 mm in 1961 to 1990 (colour scale). Isolines mark the difference of the index in 1991–2010 and 1961–1990 (days). *Source: Lithuanian Hydrometeorological Service*

The average number of annual days with precipitation rate being ≥0.1 mm (these are called the days with precipitation), decreased, and only in some Central and southern districts of Lithuania remained almost the same as in 1961–1990. The number of such days mostly decreased in the Samogitian highlands (15-22 days). In addition, the number of days with precipitation in Lithuania in 1991–2010, same as in previous thirty years, remained the highest in Raseiniai (194 days), and became the lowest in the south-west slopes of the Samogitian highlands (165 days). In the major part of Lithuania's territory, the number of days with precipitation varies from 170 to 180 days. The weather with precipitation is mostly conditioned by the atmosphere fronts of low-pressure barometric formations, passing through the Lithuania's territory in the average amount of 160-170 per year (according to A. Buz). In summer, precipitation also falls from the clouds of convectional origin that form inside a single air mass.

Very strong showers, when the daily precipitation rate reaches 20-30 mm and more, are characteristic to each summer, on average. Strong showers condition high waters in rivers, flood arable fields, cause soil erosion, damage to hydro-technical facilities. So far, the maximum amount of daily precipitation – 250 mm was recorded in Dusetos on 2 July 1980. Heavy rains are usually occurring due to moving south cyclones (in their frontal part or centre), in slowly moving and filling low-pressure areas or quasi-stationary atmospheric fronts. The maxim daily precipitation rate decreased by 1-3 mm in the central and north-west part of Lithuania and increased by 1-9 mm elsewhere. Therefore, in the recent years (1991–2010), the zone of heaviest showers covered not only the Samogitian highlands, but also the Southern and South-Eastern Lithuania – here, the average of annual daily precipitation maximums reached 38-43 mm.

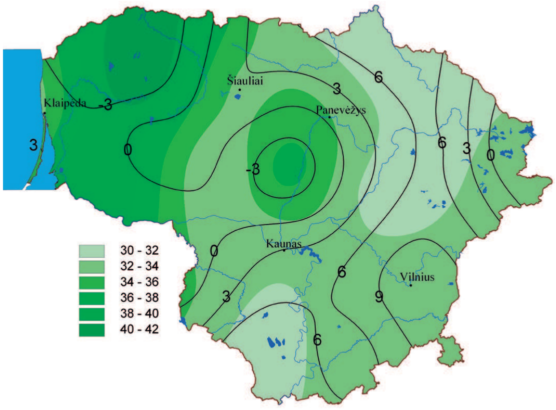


**Fig. 47.** Average of annual daily precipitation maximums, 1961–1990 (colour scale, mm). The isolines indicate the difference (mm) of averages of annual daily precipitation maximums between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

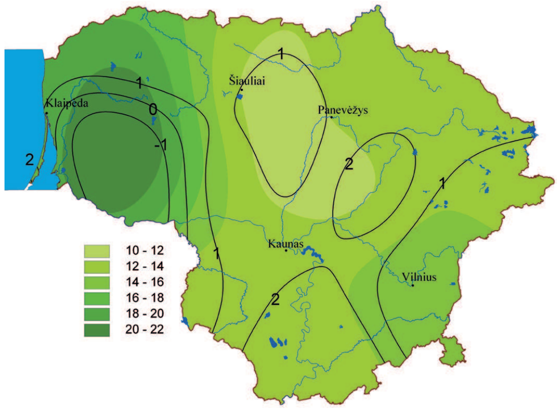


**Fig. 48.** Average number of annual days with daily precipitation rate ≥ 10 mm in 1961–1990 mm (colour scale). The isolines indicate the difference of this index between 1991–2010 and 1961–1990. *Source: Lithuanian Hydrometeorological Service*

Heavy precipitation cases (when daily precipitation rate is ≥10 mm) usually occur in the Western Lithuania, and their lowest likelihood is in the Central Lithuania (respectively, 18-22 and 10-12 days per year). During 1991–2010, as compared with 1961–1991, the cases of heavy precipitation increased by 1-2 days in the major part of Lithuania, except for Šilutė, Šilalė and Tauragė regions: here, the incidence of such precipitation decreased by 1 day.

## SNOW COVER

It is northern and eastern part of Lithuania and the Samogitian highlands, where the snow cover remains for the longest period (90-100 days, on average); in seaside areas, it stays for 60-70 days, and in the remaining territory – 80-90 days. The longest duration of snow cover was recorded in the deep winter of 1995–1996 – 115-146 days, whereas in warm winters of 1974–1975 and 1989–1990 there were, for example, only 11-24 snowy days in the seaside areas. The climate warming in Lithuania results in the decline in the number of days with snow cover and its reduced persistence. When comparing the average number of days with snow cover in 1961–1990 and 1991–2010, the decrease of 4-10 days has been established. However, the maximum thickness of snow cover, which is formed in the Western and Central Lithuania during winter season, increased by 1-2 cm. It is related to the increasing precipitation rate in the cold season and more frequent incidences of heavy snow. The thickest snow cover was recorded in 1996: in February-March, it reached 50 cm in many regions, and even 72 cm in Lazdijai. In 2011, a very thick snow cover was also recorded: in the middle of the first decade of January, its thickness increased up to 60-68 cm in the Samogitia region.

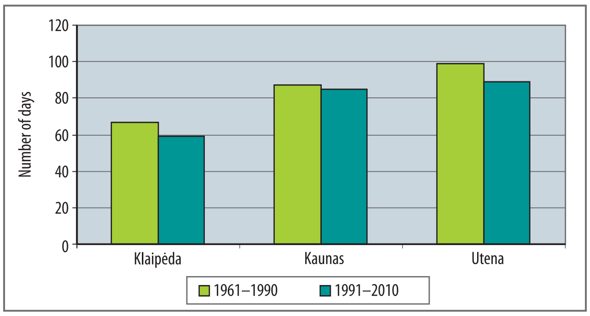


**Fig. 49.** Average number of days (N) with snow cover in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

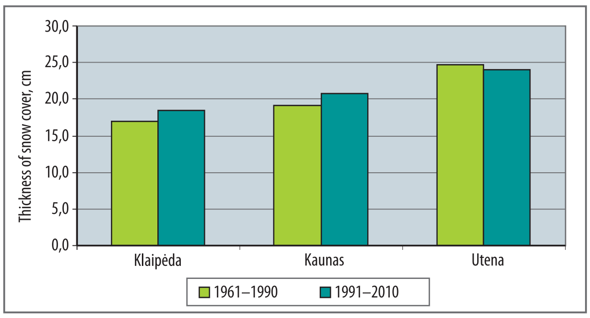


**Fig. 50.** Averages of maximums of snow cover thickness (cm) in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

## WIND DIRECTION AND SPEED

Wind speed and direction depend on the arrangement of climatic pressure centres, activity of cyclogenesis and anticyclogenesis processes and pressure gradients in mobile barometric formations. In Lithuania, the average annual wind speed (in the altitude of 10 m) is strongest in the seaside areas (4.5-5.5 m/s), decreases moving to the east and reaches minimum values (2.7-3 m/s) in forested and hilly district of the East and South-East Lithuania.

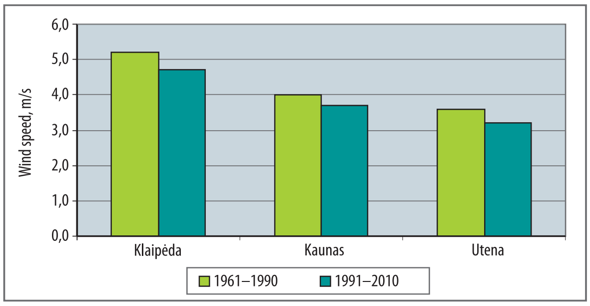


**Fig. 51.** Average wind speeds in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

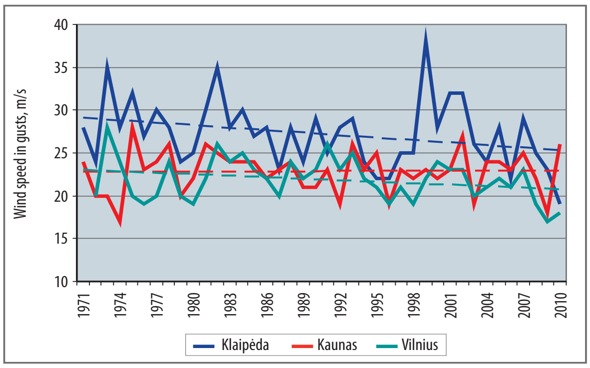


**Fig. 52.** Maximum wind speed in gusts (m/s) and linear trends of its variation (dash lines) in 1971–2010. *Source: Lithuanian Hydrometeorological Service*

During the cold season, wind speeds are 1-2 m/s higher than in summer due to active cyclonic activity. Strongest winds are blowing in November-January (in seaside areas – 5-6 m/s, elsewhere – 3-5 m/s), and the weakest winds are in May-September (in seaside areas – 4-5 m/s, elsewhere – 2-3 m/s). On hill peaks and upper parts of windward slopes, the wind speed is 30-50% higher than in the plains, whereas on the downwind slopes and hollows hardly reached by wind – 20-40% lower, accordingly.

The comparison of the average annual wind speeds in 1971–1990 and 1991–2010 revealed the tendency of wind weakening by 0.3-0.5 m/s (i.e., 7-10%). However, a chance exists that these changes of wind speed could have been influence by the changes of environment of the meteorology stations (overdevelopment, planting, etc.), rather than by the particularities of atmospheric circulation. The winds mostly weakened (by 0.5-1.1 m/s) in Klaipėda at the end of summer and autumn.

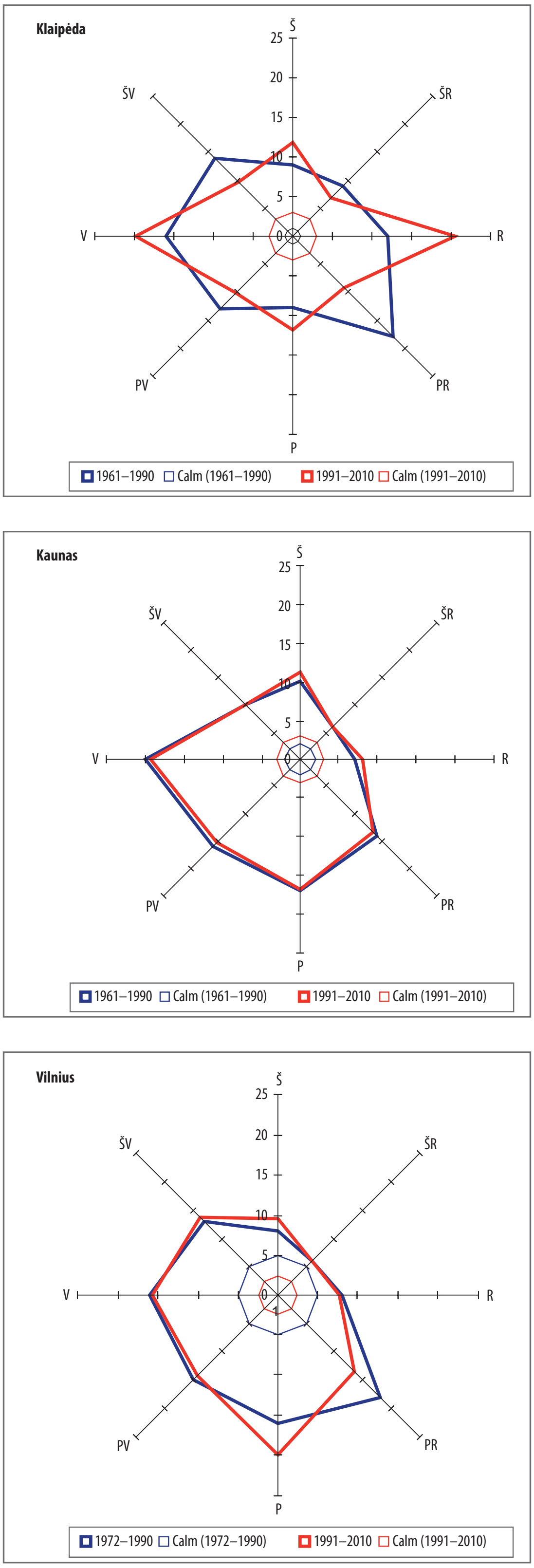


**Fig. 53.** Average repetition of wind directions (percentage) in 1961–1990 and 1991–2010. *Source: Lithuanian Hydrometeorological Service*

The wind increasing up to 15 m/s in gusts becomes a dangerous meteorological phenomenon. It is unfavourable to the constructions works performed in open air, agricultural plants, fishing, etc. The wind speed of 15 m/s and more is typical to the seaside areas 60 days per year, on average, in Central Lithuania – 20-25 days, and in the east and southeast – only 6-10 days.

The highest likelihood of gusts is in October-March. The average number of annual days, when the speed of wind gust reaches 15 m/s and more, decreased by 1-10 days in Lithuania, as compared with 1971–1990 and 1991–2010. However, the meteorology stations cannot record all local squall phenomena, which have been quite often recently. Unfortunately, the precise statistics of such phenomena do not exist; therefore, the conclusions are made based on the data of meteorological stations.

The maximum speed of wind in gusts can reach up to 35-40 m/s near the Baltic Sea, and in other regions of Lithuania – 25-28 m/s. In case of tornadoes, the speed of wind can reach even more than 50 m/s. The usual and strongest storms are ranging in the months of October – January. In autumn and winter, the strongest winds are from southeast, south and south-west directions, in summer – from western and north-west directions. When analysing the maximum wind speeds in 1971–2010, no significant long-term tendency of their change has been observed. During this period, the wind speed of 30 m/s and stronger was recorded in meteorological stations eight times in total. Pursuant to the data of the forecast climate models, the climate warming is accompanied with the likely increase in the incidence of winds gaining the strength of a tornado, especially during the local squalls.

In autumn and winter, usually the south, south-west and west winds are blowing, in summer, the west and north-west winds are dominating. When comparing the repetition of the average wind direction in 1961–1990 and 1991–2010, more changes that are significant were established in the seaside areas only. Here, the incidence of southeast winds deceased even by 9 percentage points, whereas the incidence of south, west and north winds increased by 2-4 percentage points. In the Eastern Lithuania, the southeast winds decreased by 4% and south winds increased as well. The incidence of doldrums (calm) increased by 1-2 percentage points in the seaside areas and Central Lithuania and their current annual likelihood became similar in the entire Lithuania – 2.4-3.1%

## SOIL FROST

The depth, duration and temperature of the soil frost depends on the duration of winter and air temperature, thickness of snow cover, vegetation cover, thermal properties and moisture of soil, its granulometric composition and the depth of stratification of groundwater. In Lithuania, the duration of seasonal frost varies from 24 days (in warm winters) to 171 days (in cold winters) and the usual duration of frost is 123 days. The deepest soil frost (down to 55-64 cm, on average) is usually recorded in north-east, east, south-east and south, where dry sandy soils prevail, groundwater stratifies in great depths and the lowest temperature is recorded in winters. The deepest frost is reached in February. In cold winters, it penetrates down to the depth of 130-145 cm. Since the midst of the 20th century, the duration of soil frost decreased by two weeks, on average, and increased the likelihood of its full melting and refreezing. The frost recurring several times per season causes impact on the processes of pedogenesis (formation of soil) and shortens the service time of artificial coats and other constructions inside the soil. The more frequent incidence of defrosting of soil in the entire country shows that, in the past 50 years, not only the winters have become warmer, but also the infiltration conditions of the cold season water, minimum outflow of rivers and nature of spring flood hydrogram have likely suffered significant changes.

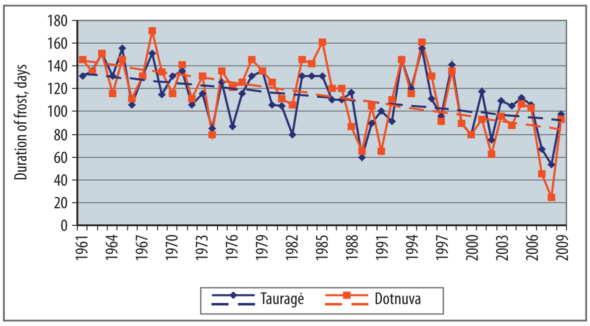


**Fig. 54.** Duration of seasonal frost (in days) and linear trends of its variation (dash lines) in Tauragė and Dotnuva. *Source: Lithuanian Hydrometeorological Service*

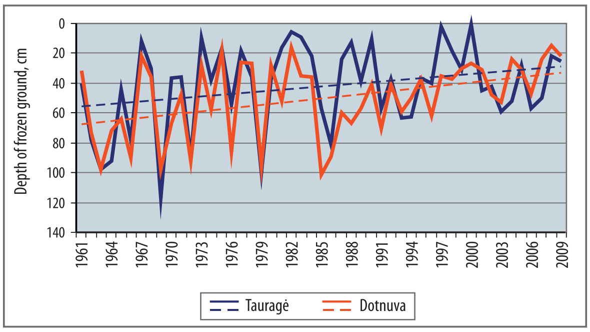


**Fig. 55.** Depth of seasonal frost (cm) and linear trends of its variation (dash lines) in Tauragė and Dotnuva. *Source: Lithuanian Hydrometeorological Service*

## DANGEROUS METEOROLOGICAL PHENOMENA

Some atmospheric phenomena are closely related to human activity and have influence on such economic fields as energy, construction, transport, communications, agriculture and forestry, tourism and recreation. It is not unusual for the atmospheric phenomena to cause negative impact on human health, danger to life, especially when they achieve the intensity and scale of the dangerous, elemental or even catastrophic phenomena. The indicators of dangerous meteorological phenomena are approved by Order No V-28 of the Director of the Lithuanian Hydrometeorological Service under the Ministry of Environment of 15 February 2012, whereas the indicators of elemental catastrophic meteorological and hydrological phenomena are indicated in Order No D1-870 of the Minister of Environment of the Republic of Lithuania of 11 November 2011. Dangerous, elemental or catastrophic meteorological phenomenon can be the mist, heavy rain and snow, freezing rain, thunderstorm, wind, blizzard, etc.

Mist in the Samogitian highlands and the Baltic highlands is formed 90-105 and 60-80 times per year, respectively, elsewhere – 40-50 times, their total duration varies from 200 to 600 hours per year (the maximum is in the coolest part of the Samogitian highlands). The usual and longest mists are characteristic to the period of September-March. In the wintertime, the mist is usually accompanied with the crystal hoarfrost. When the visibility reaches 50 m and less, the mist is considered strong (thick) and is very dangerous. The average duration of one mist is 4-6 hours, whereas the maximum can amount to several days.

There are 19-30 days with thunderstorm per year, on average (in some years, 40-45 days). The majority of such days occur in the southern regions, as they are dominated by the harsh, forested bed surface and sandy soils encouraging the mixing of air turbulence and thermal convection. The total annual duration of thunderstorms varies from 60 hours in the southern regions to 20 hours in the Central Lithuania. Usually, thunderstorms occur in June-July (in seaside areas – in August).

Lithuania has favourable conditions for the formation of freezing rain (high relative air humidity and usual temperature fluctuations, frequent hot atmospheric fronts during cold seasons). Freezing rain occurs 9–19 times per year. Its highest likelihood is in the Samogitian highlands. Here, this dangerous phenomenon lasts for the average number of 100-145 hours (the maximum is in Raseiniai); in southeast and seaside areas, its duration decreases down to 23-40 hours, elsewhere in Lithuania – approx. 60-80 hours per year.

The thickness of layer of glazed frost can be from several millimetres to several centimetres. Freezing rain becomes more dangerous, when a strong wind is blowing at the same time. The heaviest freezing rain occurred on 12-13 April 1974: the thickness of frost on wires amounted even to 123 mm. Freezing rain is usually formed due to strong wind or in case of doldrums. In 70% of all cases, freezing rain starts to form, when the wind speed is up to 4 m/s. Due to climate warming, the favourable conditions for the formation of freezing rain become increasingly rare. Their duration decreased by 1-2.3 days per year, on average (Gečaitė, Rimkus, 2011).

The duration and likelihood of blizzards in the territory of Lithuania is different: their duration in longest in the southern part of Samogitian highlands (100-130 hours) and the Eastern Lithuania (60-70 hours), elsewhere they last for 30-60 hours. The territorial distribution of days with blizzard is similar to the distribution of the duration: 10-25 per year. However, there were some winters, when the blizzards raged for 40 days, whereas in the Samogitian highlands - even 55 days per year. The blizzards mostly occur in January-February (55-60% of the annual number), although they are likely during the entire period from November until March. On the average, a strong blizzard is raging in Lithuania seven times per 10 years (the prevailing average wind speed is 15–20 m/s and duration ≥12 hours).

The warm seasons are accompanies by hails. The ice lumps are usually of 2-5 mm diameter; however, sometimes they may reach 20 mm or more. The occurrence of ice lumps larger than 20 mm in diameter accounts for 36% all hail cases. Hail is a local phenomenon. It usually pours from thick cumulonimbus clouds in the territories of the length and width of several hundred metres/several kilometres, therefore, same as in case of heavy showers, the hail cannot always be recorded by meteorological stations. In the majority of Lithuanian districts, the hail occurs once or twice per season. The largest ice lumps of the diameter of 10-12 cm fell on 10 July 1995, whereas the heaviest ice lump was of the weight of 300 g (on 20 June 1964).

A sudden wind intensification up to 8 m/s and more in a short period of time (<2 min) is called the squall. During the squall, the speed of wind is usually >10 m/s, however, it can reach and exceed 20-30 m/s and the wind direction is also changing. The phenomenon lasts for a short period of time – 1-5 min. The squalls are related to the powerful cumulonimbus rain clouds formed by strong convection, therefore they are accompanied by pelting showers, hails and thunders. In the terrestrial regions, squalls are most likely during summer days, in the afternoon (13:00–20:00), when the conditions for convectional formation of clouds are most favourable. Squalls over the sea are likely during all seasons of the year. The most favourable synoptic conditions for squalls are in the cold atmospheric fronts. Inside these fronts, the convectional cumulonimbus clouds form a long range of the width of 50-75 km, which is called the squall line. The narrow line of squalls is usually also stretching in front of the cold front (within the hot sector of cyclone). When atmospheric fronts pass across the Lithuania's territory, 90% of all squalls are formed. In summer, high atmospheric instability is possible both in front of and behind the front, and inside the front. The remaining part of squalls occurs in the course of formation of convectional clouds. Due to its locality, this phenomenon cannot always be recorded by the meteorology stations; therefore, the price statistics on the incidence of these phenomena is unavailable. However, the tendency of the increase in occurrences of squalls reaching the destroying force (30-40 m/s) has been observed in the recent years.

In view of the climatic conditions, Lithuania belongs to the zone of excessive moisture, i.e., the annual precipitation rate is higher than the evaporation rate, however, our country suffers dry seasons and evens draughts almost each year. There are four types of draughts: meteorological, agro-meteorological, hydrological and socioeconomic (Valiukas, 2011). Meteorological draught depends on the precipitation rate only. Agro-meteorological draught is formed when the rate of soil moisture necessary for the plant during its active vegetation becomes insufficient. It is related not only to the precipitation, but also to the evapotranspiration, air temperature, type of soil and plant species. Hydrological draught is formed when the water level of rivers, lakes, ponds decreases after a long period with absence of precipitation. Socioeconomic draught is recorded when the shortage of water has a serious negative impact on human life and the activity of economic sector. Socioeconomic draught does not have the index of its evaluation; it is the result of consequences caused by one or all other three types of draught. Various indexes of draughtiness are used for the establishment of meteorological, agro-meteorological and hydrological draughts (National Drought Mitigation Center, 2006).

The hydrothermal coefficient (HTK) is used for the evaluation of draught intensity in Lithuania – it is the ration of sums of precipitation rate and air temperature during the period of 30 days, when the mean daily air temperature is higher than 10°C. Draughtiness period is considered to be the condition, when the HTK values are less than 0.5 for 15 days or more. If HTK values remain lower than 0.5 for more than 30 subsequent days, the elemental drought is recognised.

Six droughts covering the territories of various sizes were recorded in Lithuania during the period from 1991 and 2010. In the recent years, droughts have become more frequent in Lithuania. The longest and strongest draught covering the major part of Lithuania's territory, lasting for 110 days and causing the natural calamity on the national-scale was recorded in 1992. More than 1,100 forest fires occurred during that time. Another very strong draught devastated Lithuania in the summer 1994. At that time, the all-time highest index of forest fires was recorded – 20.254°C.

## CLIMATE CHANGE AND GROUNDWATER LEVEL

In Lithuania, the restoration of underground and, first of all, groundwater sources mostly depends on two climate factors – precipitation and its evaporation.

The impact of climate changes on the groundwater and its recourses and changes that they cause may be established only by analysing the constant and long-term data of the measurement of groundwater level. In Lithuania, the data of measurement of groundwater level were accumulated since 1956–1965, when the network of bores for state monitoring was established. In 2005, it was supplemented with 18 bores installed in meteorological and hydrological stations. This supplement is especially valuable as the data received in the new groundwater depth measurement points can be directly related to the data of meteorological observations conducted by the Lithuanian Hydrometeorological Service.

When comparing with the period of long-term level fluctuations, the phase of decrease in the level is still continuing in 2005–2011. Although the values of mean annual level did not show significant fluctuation around the values of multiannual level, however, they were usually lower.

The level of groundwater of neighbouring calendar years was of opposite situation in respect of long-term level. For example, in 2009, the groundwater sunk to such level that the mean level of that year was the lowest in many areas during the entire period of observations, whereas in 2010, the values were much higher than the long-term level (Fig. 56). The high level of groundwater in 2010 was conditioned by especially favourable weather conditions, after the change of which the level of groundwater is also changing. Therefore, it is rather early to state that the turning point in the variation of long-term level occurred and the level of groundwater is starting to increase. However, in respect of the variation of groundwater level in 2005–2011, the tendency of increase in the level appears to become more evident.

The impact of changes of meteorological conditions is mostly manifesting by the fluctuations of the seasonal groundwater level. The comparison of the annual mean groundwater level of the last three decades approves the decrease in the level during the last decade, as well as the fact that, in view of the geological-hydrometeorological conditions, the depth of the annual stratification of groundwater has changed (Fig. 57).

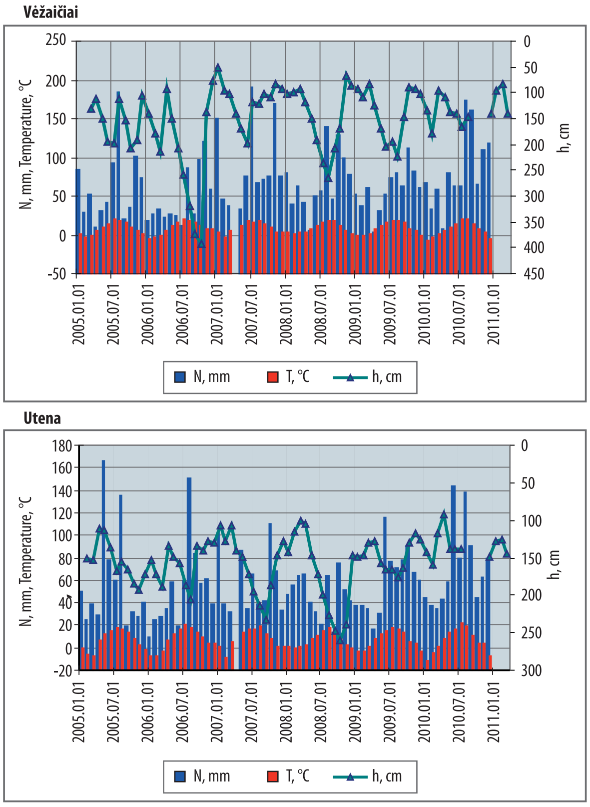


**Fig. 56.** Variation of groundwater level and meteorological conditions (2005–2010). N – average monthly precipitation rate (mm); T °C – average monthly air temperature (°C); H – average monthly groundwater stratification level (cm). *Source: Precipitation and air temperature – Lithuanian Hydrometeorology Service, water level – Lithuanian Geological Survey*

Groundwater is closely related to the meteorological conditions in those location, where the quaternary surface is composed of limnoglacial sediments and ground moraine formations (clayey bedsores), and, in principle, where no direct impact of meteorological conditions on the mode of groundwater stratifying in great depths exists. The monitoring data of the last 5-6 years shows that impact of the unfavourable long-term meteorological phenomena, for example, droughts, on the mode of groundwater level is very important. Increasingly stronger and longer droughts usually repeating every 3.5 years have influence on the rapid decrease in the groundwater level. This decrease usually starts in the spring and ends only in the late autumn. Due to low groundwater level in summer and autumn, the bores are drying in the second part of the summer; the bodies of surface water lose part of their nutrition. There has been an increasing tendency for the minimum groundwater level of summer and autumn rather than the maximum level of spring to condition the average annual level. It is especially noticeable in the regions of clayey bedsores, where the groundwater accumulates in shallow depths.

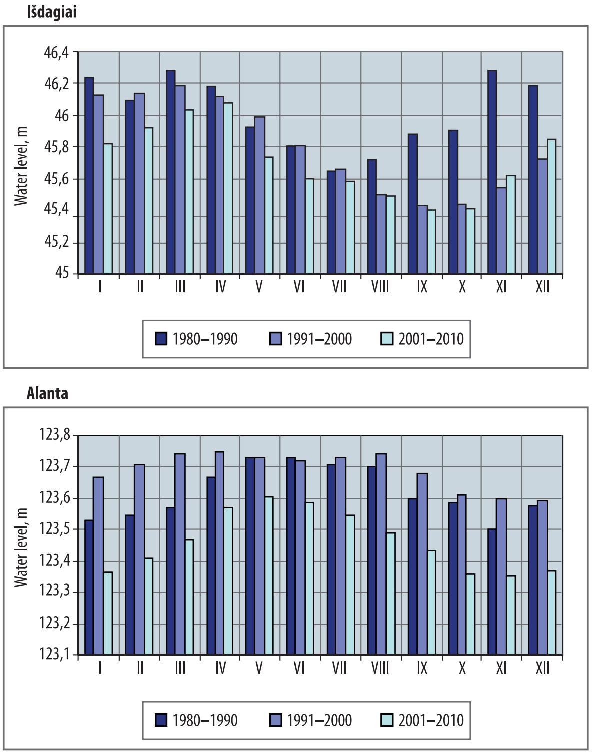


**Fig. 57.** Comparison of average monthly water level distribution in separate decades. *Source: Lithuanian Geological Survey*

The meteorological conditions that directly affect the hydrothermal mode of aeration zone and fluctuations of groundwater level become increasingly diverse. Therefore, it becomes more difficult to evaluate and forecast the status of groundwater resources and only the available constant observations that provide information on the main characteristics of the mode of level and reasonable statistical indicators enable us to assess the differences and deviations from the established regularities.

# SECTORAL ANALYSIS OF THE STATE OF ENVIRONMENT TRENDS AND THEIR CAUSES

# Air

## AIR POLLUTION IMPACT ON CLIMATE CHANGE AND ACIDIFICATION

The solution of environmental problems is highly dependent on the priorities of national economic growth and political activity. It is especially significant in the course of assessment of how the air pollution issues are solved in Lithuania.

After the restoration of Lithuania's Independence and collapse of the Soviet political and economic block, the former Soviet economic system that was characterised by high costs of raw materials and energy and high level of greenhouse emissions and pollutants collapsed as well. Due to the economic crisis of that time, the volumes of industrial production decreased significantly, many factories were shut down and the collective farms were broken. Therefore, a significant decline was observed in the pollution caused by industrial and agricultural sectors and a significant decline in the amount of greenhouse emissions was recorded in the country.

All countries of transitional economy have a common feature of rapid and multidimensional changes. Therefore, Lithuania's economy started to revive soon and separate indices of economic development quickly achieved and even exceeded the Soviet level. Transition to market economy, restructuring of economy, more expensive energy and other natural resources first of all conditioned more effective consumption of energy and other natural resources and favourable changes in respect of sustainable development.

Even under the conditions of economic depression, the consumption of resources and environmental pollution decreased more rapidly than the volumes of production and services. With the increase of economy, these factors increased slower or have not increased at all.

A very important criterion of assessment of effectiveness of the state of environment and applied measures is the ratio of pollution and economic growth. Under the conditions of the current economic development and growth, the increase in the global industry and economic development causes the increase in the environmental and air pollution. The same tendencies have also been observed in Lithuania. The country's economic growth model, under which the increase in GDP would not increase the level of greenhouse emissions, is unreal in current conditions. Therefore, in order to implement the aims of the sustainable development in the ambient air sector, one should strive for a slower increase in the greenhouse gas emissions generated by the economic growth of the country.

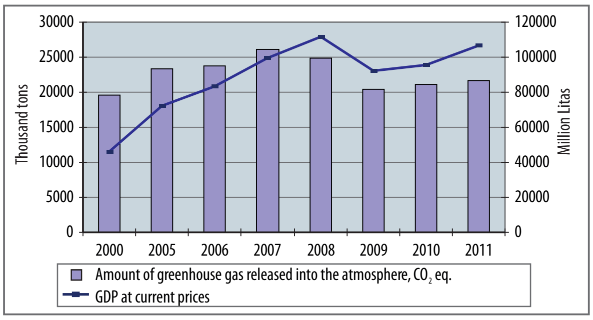


**Fig. 58.** Variation of the level of greenhouse gas emissions and gross domestic product in 2000–2011. *Source: Environmental Protection Agency*

In 2000, in Lithuania the level of greenhouse gas emissions amounted to 19.365 million tons expressed in the $CO_2$ equivalent (excluding the LULUCF sector) and increased to almost 25.5 million tons in 2007, i.e., by almost one third. However, the GDP increased more than twice. In 2010, with the growth of Lithuania's economy after the recession of 2009, the level of greenhouse emissions was approx. 7% higher than in 2000, and the GDP (in terms of prices of that time) started to approach the level of economically very significant period of 2007 and exceeded the GDP level of 2000 more than twice. Since the GDP change is characterised by a certain lag from the change in the volumes of production (and, respectively, the greenhouse gas emissions), the growth in the greenhouse gas emissions is likely to maintain the increasing slower growth compared with the volumes of generated GDP.

The data at hand show that the major long-term objective stipulated in the National Sustainable Development Strategy (to achieve that the level of atmospheric pollutants and greenhouse gas emissions would increase slower than the increase of the production volumes) is being successfully implemented. Although the GDP level increased, the level of greenhouse gas emissions decreased. Fuel burning is currently the main source of greenhouse gas emissions. The decommissioning of the Ignalina Nuclear Power Plant was followed by the increase in the amount of greenhouse gas emissions in the energy sector. The thermal power plants work at higher capacities. The technological facilities of the part of these power plans are outdated; therefore, it is necessary to make the maximum use of the financial support supplied by the European Union for the update of technologies and production of "clean" electricity.

The share of the balance of cost of initial energy on oil products accounts for 26%; however, it is probably the most polluting method of energy production. This share should be reduced in order to diminish the amount of greenhouse gas emissions and improve the quality of the ambient air.

Pursuant to the National Energy Independence Strategy approved by Resolution No XI-2133 of the Seimas of the Republic of Lithuania on 26 June 2012, up until the end of 2009, Lithuania had a good record of greenhouse gas emissions as compared with the average levels of emissions in the EU Member States. However, after the decommissioning of the Ignalina Nuclear Power Plant and the resulting increase in the use of older thermal power plants, Lithuania is facing a major rise in greenhouse gas emissions. In view of the obligations assumed under the Kyoto Protocol, by 2020 Lithuania should cut down the emission of greenhouse gas emissions by 11 million tons (in the $CO_2$ equivalent) by applying diverse means reducing greenhouse gas emissions. This would amount to 46% of the actual greenhouse gas emissions in 2008 or 23% of the greenhouse gas emissions anticipated in 2020. The sectors of industry, agriculture and electricity production have most potential for the reduction – there is a potential to reduce the amount of greenhouse gas emissions by 20–30% in each of these sectors. In transport sector, the amount of greenhouse gas emissions can be reduced by 5–10%.

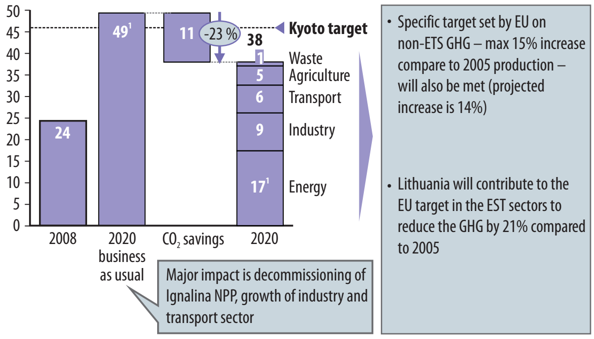


**Fig. 59.** Greenhouse gas emissions, million tons of $CO_2$ equivalent. *Source: National Energy Independence Strategy, Ministry of Energy*

Lithuania is already taking a number of necessary measures to decrease the level of greenhouse gas emissions. In the future, the following initiatives will have the largest impact on the achievement of this objective: construction of the regional Visaginas Nuclear Power Plant (the discussions on the purposiveness of its construction are still on-going); development of energy production from the renewable energy sources; increase in the efficiency of energy consumption. Timely and well-considered implementation of these measures will enable Lithuania to use the full potential of reducing the level of greenhouse gas emissions and significantly limiting the increase in the greenhouse gas emissions by 2020 by implementing the requirements of the EU Energy and Climate Package. In case of failure to implement these initiatives, the reduction of the greenhouse gas emissions would require the application of alternative less economically effective measures. In the period from 2020 to 2030, the level of greenhouse gas emission will further decline due to continuous increase of energy production from renewable energy sources and the increase in the efficiency of energy consumption efficiency (1.3% every year).

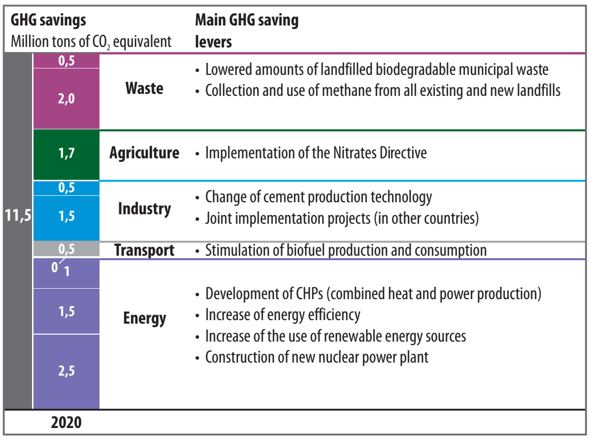


**Fig. 60.** Decrease in pollution, million tons of $CO_2$ equivalent. *Source: National Energy Independence Strategy, Ministry of Energy*

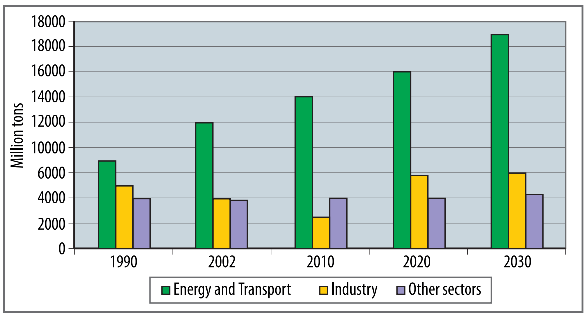


**Fig. 61.** Level of greenhouse gas emissions based on sectors (in the $CO_2$ equivalent). *Source: Ministry of Environment, 2010*

The main gases causing greenhouse effect (greenhouse gas emissions) include carbon dioxide ($CO_2$), methane ($CH_4$), nitrogen suboxide ($N_2O$), perfluorocarbohydrates (PFC), hydrofluorocarbons (HFC) and sulphur hexafluoride ($SF_6$). Their impact is different; therefore, it is recalculated in the $CO_2$ equivalent (greenhouse gas emissions are assessed according to their global warming potential). When evaluating the intensity of the greenhouse gas emissions from separate economy sectors, it becomes obvious that the majority of greenhouse gas emissions are coming from the energy objects in Lithuania. However, the "contribution" (in percent) of this sector is decreasing annually, while the share of transport and industry sectors has been increasing during the recent decade. This indicates that the measures of the reduction of greenhouse gas emissions aimed at the energy sector gave positive results, however, more focus is needed on the transport subsector and industry sector. The largest source of emissions is the energy sector, which generated 12.848 t of $CO_2$ equivalent in 2010, or 61.7% of the total amount of greenhouse gas emissions (Fig. 61). 88.6% of $CO_2$, 14.6% of $CH_4$ and 3.3% of $N_2O$ gases are emitted in the energy sector. Due to recent increase of the energy consumption, as compared with 2009, the amount of $CO_2$ generated by energy sector increased by 1.2%. The largest $CH_4$ emitters are the sectors of agriculture and waste. In 2010, these sectors generated 51.8% and 33.6% of the total amount of $CH_4$ gases, respectively. It should also be noted that the agriculture sector is the largest source of $N_2O$ emissions in Lithuania. In 2010, this sector generated 78.2% of the total amount of $N_2O$ gas which showed minor increase from 2005, has decreased by 4% due to the start of economic crisis in 2009. Meanwhile, the GDP decreased by nearly 22% in 2009, as compared with 2008, but such situation was achieved due to the decrease in the production volumes. It is important to note that the change of the total amount of $N_2O$ gas.

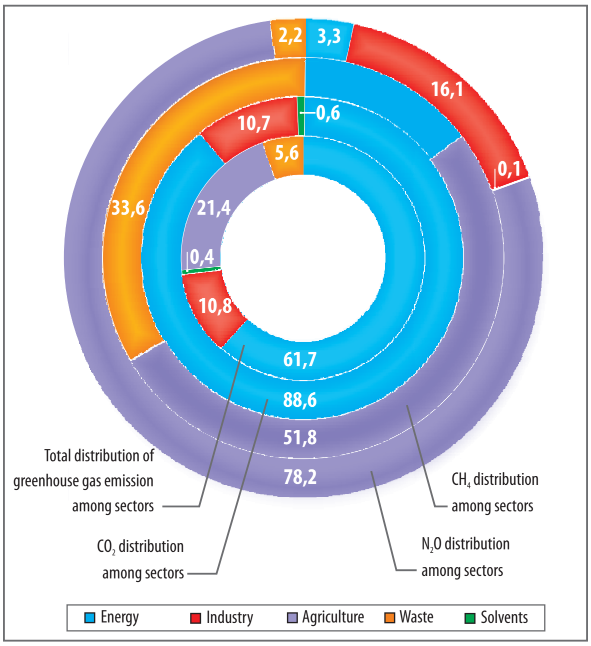


**Fig. 62.** The percentage amount of greenhouse gas emissions based on sectors (in the $CO_2$ equivalent). *Source: Environmental Protection Agency*

In 2007, the European Council decided that the Community should take serious individual measures for the reduction of greenhouse gas emissions at least by 20% by 2020, as compared with 1990. Lithuania also has respective obligations and, therefore, the amounts of greenhouse gas emissions should be compared with basal levels of 1990. The energy sector has a special effect on the greenhouse gas emissions. During the period of the past twenty years total amount of greenhouse gas emissions in the energy sector has decreased by nearly 2.6 times, i.e.

from 33,787.4 tons of the $CO_2$ equivalent in 1990 down to 12,848.4 tons of the $CO_2$ equivalent in 2010 (Fig. 63). The reason of this decrease was the economic recession during the period from 1991 to 1994. The rapid growth of economy in 2000–2008 conditioned the increase in the greenhouse gas emissions in the energy sector by average 2.3% each year, however, the global economy recession in 2009, especially in the energy sector, conditioned the decrease in the emissions by 9%, on the average. After the decommissioning of Ignalina Nuclear Power Plant and start of GDP growth, the level of greenhouse gas emissions increased by 7.3% in the energy sector in 2010.

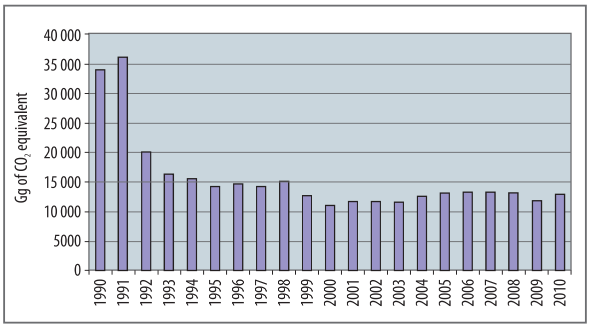


**Fig. 63.** Tendencies of greenhouse gas emissions in the energy sector. *Source: Environmental Protection Agency*

The level of greenhouse gas emissions from non-organised pollution sources were mostly conditioned by the "evaporation" of $CH_4$ in the natural gas distribution networks, which have expanded significantly in the past twenty years. Since 1990, the amount of greenhouse gas emissions has shown the average annual increase of 3% in this subsector. When evaluating the greenhouse gas emissions, the land use, land-use change and forestry (LULUCF) sector is exclusive. It conditions a high-level emission of these gases and based on the definition of the climate control secretary of the United Nations, it is necessary not only to evaluate the emission of greenhouse gas in this sector, but also the absorption of these gases in the vegetation. During the photosynthesis, the carbon dioxide is absorbed (removed) from the atmosphere and accumulated in the trees and other plants.

During the period from 1990 to 2000, the amount of carbon dioxide (excluding the LULUCF sector) emitted to the atmosphere accounted from 60% to 76% of the total amount of greenhouse gas emissions. In 2010, as compared with 1990, the amount of $CO_2$ decreased by 62% (excluding LULUCF sector) and 93% (including LULUCF sector). During the analysed period, a significant decreased in the greenhouse gas emissions occurred due to the decrease in the manufacturing and fuel costs. It has been noted that the growth of economy was accompanied by a respective increase in the amount of greenhouse gas emissions; however, a certain share of it was compensated by increasing the effectiveness of energy consumption and installing the measures of the reduction of greenhouse gas emissions.

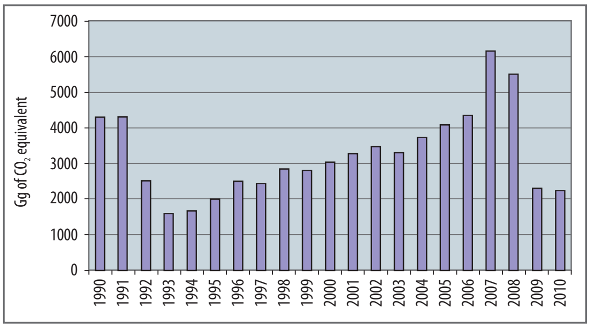


**Fig. 64.** Tendencies of greenhouse gas emissions in industry sector. *Source: Environmental Protection Agency*

In 2010, the amount of greenhouse gas emissions in the industry sector (not related to energy sector) accounted for 10.8% of the total amount of greenhouse gas emissions. This sector mostly generated $CO_2$, $N_2O$ and F-gases. During the period from 1990 to 2010, the greenhouse emissions from the industry sector decreased approx. twice from 4,295.65 Gg $CO_2$ eq. to 2,249.17 Gg $CO_2$ eq. (Fig. 64).

In industry sector, the largest source of greenhouse gas emissions is the production of ammonia (1,150.3 Gg $CO_2$ eq.), accounting for 5.5% of the total amount. Due to significant reduction of ammonia production (53%), the lowest amount of greenhouse gas emissions was recorded in this sector in 1993; however, after the recurring increase in the ammonia production, the maximum amount was recorded in 2007.

The chemistry industry is the main source of $N_2O$ emissions in the industry sector, where 578.04 Gg of $CO_2$ eq. (or 2.8% of the total amount of $N_2O$) was emitted in 2010 in Lithuania. Since 1995, the amount of $N_2O$ showed increase in this sector and achieved the highest value in 2007, however, in 2008, after the installation of the secondary catalysers in the nitrogen acid production, the level of $N_2O$ decreased significantly.

It has been observed that the emissions of F-gases (hydrofluorocarbons and sulphur hexafluorides) increased in the industry sector in 1995–2010. In 2010, they amounted to 0.9% of the total amount of greenhouse gases. The main reason of the increase in the amount of these gases was the replacement of ozone-depleting substances (ODS) with F-gases in various industry sectors.

In Lithuania, the waste sector generated 5.6% of the total amount of greenhouse gas emissions (excluding the LULUCF sector). $CO_2$, $CH_4$ and $N_2O$ emissions showed insignificant changes in the waste sector during the last 20 years, i.e. from 1,165.70 Gg of $CO_2$ eq. in 1990 down to 1,161.25 Gg of $CO_2$ eq. in 2010 (Fig. 65). Approximately one third of the total amount of methane was generated in the waste sector, 29.7% out of which was generated due to decomposition of waste in the landfill sites and 4% was associated with the wastewater treatment. The process of the decomposition of waste in the landfill sites generates the highest amounts of methane, which constitute 82.2% of the average amount of greenhouse gas emissions in this sector.

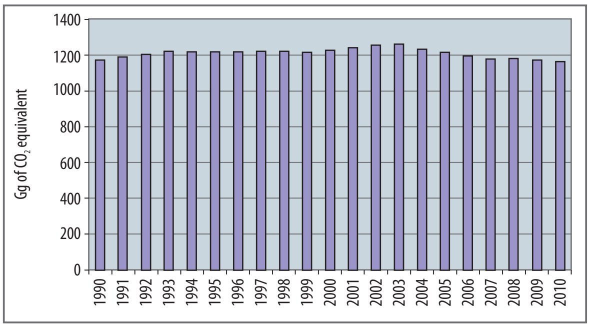


**Fig. 65.** Tendencies of greenhouse gas emissions in the waste sector. *Source: Environmental Protection Agency*

The increase in the amount of greenhouse gas emissions in 2001–2004 was mostly conditioned by a high elimination of the organic waste of sugar production.

Since 2004, sugar producers started to supply these wastes to farmers, who, in turn, used them for feeding livestock. This resulted in the decline of the greenhouse gas emissions in the waste sector.

By implementing the strategy of the development of renewable energy sources (RES) in our country, the aim is to increase the share of final energy consumption of renewable energy sources at least up to 23% by 2020, thus, increase the Lithuania's independence in energy sector, and reduce the amount of greenhouse gas emissions. In 2011, the energy received from RES constituted approx. 20% of the final energy consumption in Lithuania. The major share of this energy is produced by biomass, which will continue to remain the main source of the RES. However, in view of the natural conditions of the country, Lithuania does not utilise the entire potential of wind and biomass energy. Therefore, it is necessary to create technical, economic and regulation measures for the use of economic potential of wind and biomass energy. Lithuania promotes the development of RES by creating clear long-term economic and procedural promotion measures. The priority will be on the most economically useful types of RES.

The energy intensiveness (the amount of energy costs per unit of GDP) showed a slight decrease in the EU Member States, whereas Lithuania is so far facing the negative changes. The most important measure for the decrease of energy intensiveness is to strive for the most efficient use of energy by the final consumers. In Lithuania, the highest energy saving potential is in the final energy consumers in the country – households and transport sector. In households, it is related, first of all, to the renovation of the houses that were built in the Soviet times. This would enable the significant reduction of costs of energy used for the domestic heating.

| Gwh production (net MW) | 1097 (12,6 %)[2] | 3,675 (25 %)[2] | | | |
|---|---|---|---|---|---|
| RES technology | 2011 | 2020 | Additional capacity in 2020, MW | Investment, billion LTL | Effect on final electricity price ct/kWh |
| Hydropower[1] | 480 (128 MW) | 470 (141 MW) | 13 | 0,1–0,2 | Subsidy (0,1–0,2) |
| Wind power | 470 (205 MW) | 1 250 (500 MW) | 295 | 1,0–1,4 | Subsidy + system costs (0,9–1,1) |
| Biomass | 204 (49 MW) | 1 940(355 MW) | 306 | 1,9–2,3 | Subsidy (1,0–1,1) |
| Solar energy | 1 MW | 15 (10 MW) | 9 | 0,2–0,3 | Subsidy (0,1–0,2) |
| Geothermal power | – | – | – | – | |
| | | **1 006 MW** | **623 MW** | **3,2–4,2** | **2,1–2,6** |

**Fig. 66.** The production of electricity from renewable sources. *Source: National Energy Independence Strategy, Ministry of Energy*

In 2010, the electricity generated from the renewable energy sources (excluding Kruonis Hydro Power Plant) accounted for approx. 9.9% (7.5% in 2009) of the total consumed electricity. The goal is that the renewable energy sources constituted 20% of all consumed electricity in 2020, whereas in case of the final electricity consumption – at least 23% (according to the preliminary data, the electricity produced from renewable energy sources constituted approx. 18% of the total final consumed energy in Lithuania in 2010, i.e., 2% more than projected). The amount of electricity produced from renewable energy sources also significantly exceeded the projected amount (7%).

The further development of renewable energy sources should be ensured by Resolution No 789 of the Government of 21 June 2010 approving the National Strategy for the Development of Renewable Energy Sources and Order of the Minister of Energy of 23 June 2010 approving implementing the National Renewable Energy Action Plan as well as the Renewable Energy Action Plan prepared by the European Commission. It is forecasted that, in 2020, the share of energy from renewable energy sources will account for 23.3% of the total consumed final energy. Such results are planned to be achieved by using the available country's potential in respect of renewable energy sources.

The concern is also that, at the moment, among the total EU-27 Member States, Lithuania has the highest energy intensiveness (1,273 kg tne/million LTL GDP), thus, the European average (210 tne/million LTL GDP) is exceeded by 6 times. Furthermore, this fact causes the concern because our GDP per capita, as compared with the EU average, constitutes only 45.7%, whereas one of the national strategic aims is to come closer to the European GDP average.

In order to implement the requirements of the international documents in the area of ambient air protection, a particular attention shall be paid on the energy effectiveness and use of renewable energy sources in the energy and transport sectors.

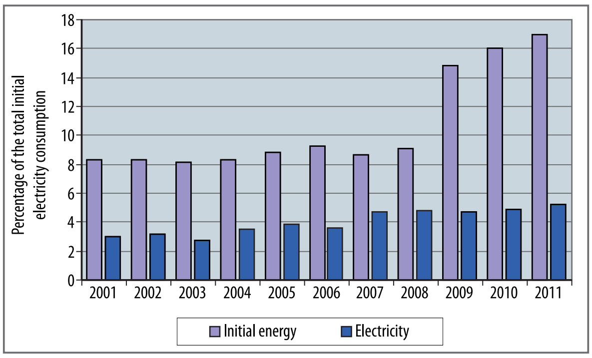


**Fig. 67.** Growth of initial energy and electricity produced from renewable energy sources in 2001–2011. *Source: Ministry of Energy*

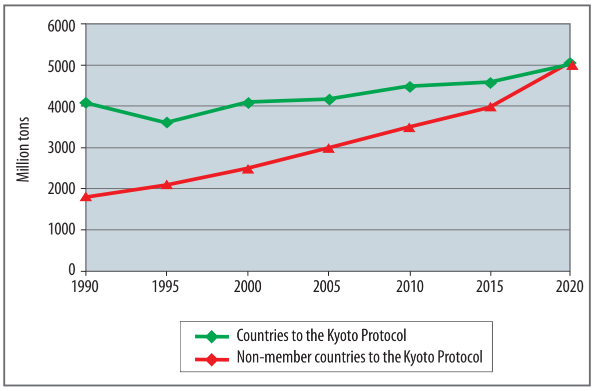


**Fig. 68.** Variation of the greenhouse gas emissions in the member and non-member countries of the Kyoto Protocol (million tons of $CO_2$ eq.). *Source: Ministry of Environment*

Pursuant to the data of the European Environment Agency, the greenhouse gas emission in the European Union decreased in almost all sectors (energy industry, industry, agriculture), however, the emissions in the transport sector increased by nearly 21% during the same time. This was conditioned by the 2.3% decrease in the greenhouse gas emissions in the EU, however, the requirements of the Kyoto Protocol to reduce the amount of greenhouse gas emissions by 8% in 2008–2012 (as compared with basal level of 1990) was implemented by one fourth only.

The illustration (Fig. 68) shows the projected variation of the greenhouse gas emissions, expressed in the carbon dioxide ($CO_2$) equivalent[1], in the countries that ratified the Kyoto Protocol (countries that have become obliged to reduce the greenhouse gas emissions) and countries that did not ratify the Protocol (the countries that have not become obliged to reduce the greenhouse gas emissions – these are mostly the developing countries, including India and China).

Lithuania, together with other advanced countries of the world, is engaged in the solution of global climate change problems. The amount of greenhouse gas emissions (in $CO_2$ eq.) constitutes 4–5 tons per capita in Lithuania and is one of the lowest in the European Member States (3–15 tons per capita).

The index of the emission of pollutants causing the acidification has been used for the monitoring of tendencies of emissions of anthropogenic acidification causing substances, i.e., nitrogen oxide, ammonia and sulphur dioxides, each of which is evaluated according to the acidification potential, since 1990. The index also provides information on the changes of emissions in the main sectors having the largest impact on the pollution. The substances causing acidification have detrimental impact on human health, ecosystems, buildings and materials (corrosion). The impact related to each pollutant depends on its acidification potential and properties of ecosystems and materials. In the majority of European ecosystems, the level of the acidification causing substances is still exceeding the critical impact. This index enables the evaluation of the progress that has been made by evaluating the Convention on Long-range Transboundary Air Pollution (the CLRTAP) of 1979, the Goteborg Protocol and the EU directive on national emission ceilings for certain atmospheric pollutants (the NEC Directive) (2001/81/EC).

The emission of acidification causing gases has been significantly reduced in the majority of the EU Member States. Despite the economic growth (GDP), in 1990–2002, the emissions decreased by 43% in the old Member States (EU-15 Member States), whereas in the new Member States (10 EU Member States) – by 58%. In all Member States of the European Environment Agency, except for Malta, the emission decreased by 44%.

The target limits for $NO_X$, $SO_2$ and $NH_3$ emissions were established in the EU directive on national emission ceilings for certain atmospheric pollutants (NEC) and in the Goteborg Protocol of the Convention on Long-range

1 The equivalent amount any greenhouse gases is calculated based on their global warming potential. The numeric value of this potential is different for each component: $CO_2$ is 1, $N_2O$ – 310, etc. (www.am.lt).

Transboundary Air Pollution (the CLRTAP). The objectives of reduction of emissions based on NEC were established for 10 EU Member States in the EU Treaty of Accession 2003. The NEC Directive provides slightly stricter objectives of the reduction of emission by 2010 than in the objectives of the Goteborg Protocol for the 15 EU Member States.

The emission of acidification causing gases was significantly reduced in the majority of the EU Member States. In 1990–2002, the emission of 15 EU Member States was reduced by 43% mostly because of the decrease in the sulphur dioxide emissions, which accounted for 77% of the total reduction. The emissions were significantly decreased in the energy, industry and transport sectors that managed to reduce the calculated total emission of acidification causing gases by 52%, 16% and 13%, respectively. The decline in the emissions was virtually conditioned by the replacement of fuel with natural gas, economic restructuring in new German lands and desulphication of emissions initiated by certain power plants.

This reduction of emissions means that 15 EU Member States are successfully seeking for a common goal – significant reduction of the emission of substances causing environment acidification. The emission of acidification causing substances was also significantly reduced in the new Member States and candidate states. From 1990 to 2002, the emission is these Member States decreased by 58% mostly due to significant reduction of sulphur dioxide, same as in 15 EU Member States. Emission of nitrogen oxides decreased due to pollution mitigation measures applied in the area of road transport and large fuel burning facilities.

## AMBIENT AIR QUALITY

In Lithuania, same as in the entire world, the atmospheric pollutants remain one of the largest environmental problems. It is conditioned by various reasons: economy development, insufficiently installed environmental technologies, increasing transport flows, etc. The majority of air pollutants are characterised by the fact that they can survive in the ambient air for a long period of time and air masses can carry them far from sources of their origin. Due to atmospheric pollutants (CO, VOC, $NO_X$, $SO_2$, $PM_{10}$), the quality of air is worsening in the cities, the tropospheric ozone is formed, the soil and surface water acidifies and the eutrophication occurs. This first of all causes a negative impact on human health and on the productivity of agriculture, biodiversity, forest condition, etc.

The information on the amounts of atmospheric pollutants and their changes during the Soviet times is restricted in Lithuania. However, according to the available archival and statistic data, it can be concluded that the total volume of pollutants in Lithuania decreased by more than 2.5 times during the last decade of the last century, as compared with the end of the Soviet period. During the Soviet times, the total amount of atmospheric pollutants was increasing gradually and exceeded one million tons in 1990. Same as today, during the last Soviet years, the largest sources of pollutants were the mobile pollution sources in Lithuania (motor transport, agriculture, construction machines, railway, civil aviation, marine and river fleet), the emissions of which extracted more than 60% of all atmospheric pollutants.

According to the collected monitoring data, it is obvious that after the restoration of Lithuania's Independence the level of emission started to decrease rapidly and amounted to 535 thousand tons in 1995. The most sudden changes occurred in 1992, when the total level of emissions decreased by approximately 40% within one year. However, it basically occurred due to sudden changes in the economy sector, when large plants, i.e., the significant sources of atmospheric pollution, were reorganised or shut down. Since 1997, the growth of the economy of Independent Lithuania and extreme development of transport sector resulted in a recurrence of gradual increase in the overall amount of emissions. Due to repetitive economic recession in 1999, the level of pollution showed a noticeable decline, however, since 2000, the tendency of not high but constant growth has been observed.

The current Lithuania's status in the ambient air sector should be evaluated as satisfactory or good (except for the situation due to certain pollutants in the major cities), as the current level of main atmospheric pollutants does not exceed the permitted allowances. However, there is an actual danger that the growth of economy and the standard of living, and especially the sectors of production and transport (these are one of the most important forces acting in the ambient air sector), will be followed by the increasing impact on the environment and, therefore, it will require additional measures for the control of pollution.

The implementation of the aims of the National Sustainable Development Strategy in the area of the ambient air quality (harmonisation of the interests of environment, economy and social development, ensuring of clean and healthy environment, effective consumption of natural resources, overall economic welfare of the public, strong social guarantees) is characterised by the following indicators: the efficiency of energy consumption, use of fossil fuel and nuclear energy, import and export of production, share of economy in the industry, growth of industry sectors, use of renewable energy sources, ratio of growth of pollution from industry sector and consumed resources and industry.

The National Sustainable Development Strategy, which is probably the main national document in the assessment, analysis and forecast of the development of the environmental status in Lithuania, indicates that "due to economic recession and more effective consumption of energy sources, the level of emissions decreased by nearly 3 times in the past decade (until 2008). The most significant decrease (by 5 times) was recorded in the emissions from the stationary sources (industry, energy). Although there was a significant increase in the number of vehicles, their impact on environmental pollution is twice lower. The decrease in the air pollution resulted in the improvement of the quality of the air in the cities and industrial centres. Due to centralised heating, the air of Lithuania's cities has low sulphur dioxide content. After the prohibition of use of petrol with lead additives in Lithuania, the concentration of lead decreased by several times in the air of urban environment and near highways. During the recent five years, the emissions have, principle, stabilised with noticeable tendency of insignificant decrease (due to installation of new air treatment facilities, implementation of pollution prevention measures, etc.).

The National Sustainable Development Strategy also emphasises the main problems related to the protection of atmosphere and improvement of the ambient air quality: "The major energy objects have no emission treatment facilities and the smaller ones use outdated energy production technologies. Due to outdated heat supply system and poor thermal properties of the majority of previously built houses, the thermal energy is used very inefficiently and relatively high amounts of pollutants are emitted into the atmosphere. Although the level of greenhouse gas emissions decreased by several times during the last decade, however, the production energy costs and air pollution per unit of GDP are so far by 1.5–2 times higher than in other EU Member States. Due to outdated and non-effective traffic regulation systems, the increasing number of vehicles in some cities, especially in their central parts, the increase in the concentration of nitrogen oxides and particular matter is rather frequent.

The slow development of infrastructure of engine-free transport means (bicycles, roller-skates, etc.), almost no installation of modern multimodal transport flow regulation systems also does not contributed to the reduction of air pollution in the central parts of the urban areas. The system of monitoring of air quality in the urban areas is not perfect so far, and the air quality of smaller cities is not controlled at all. Therefore, the country's environmental policy is aimed at the solution of the problems mentioned in this strategy.

The reduction of air pollution by increasing the volumes of production is one of the most important objectives of environmental protection. Lithuania has joined the United Nations conventions that strive for the minimisation of atmospheric pollution and have transposed the directives of the EU environment sector regulating the air quality into its legal base. By implementing the provisions of the Convention on Long-range Transboundary Air Pollution and Goteborg Protocol on the mitigation of impact of acidification, eutrophication and ground-level ozone, Lithuania has become obliged to ensure that in 2010 and each subsequent year the level of emitted sulphur dioxide would not exceed 145 thousand tons, nitrogen oxides – 110 thousand tons, volatile organic compounds – 92 thousand tons and ammonia – 84 thousand tons.

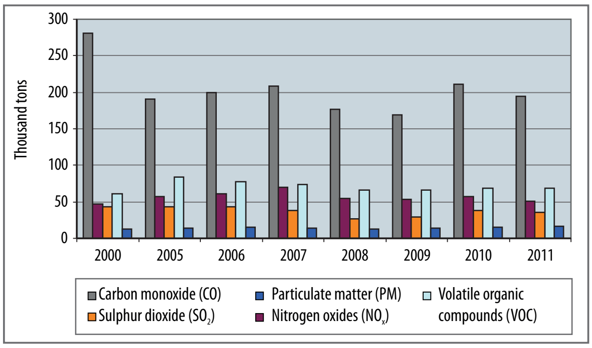


**Fig. 69.** Level of main atmospheric pollutants emissions in 2000–2011. *Source: Environmental Protection Agency*

Pursuant to the available environment research data, the total amount of emitted atmospheric pollutants, which started to increase since 2006 and exceeded the level of 2005 by nearly 4.6% in 2008, decreased by 3.9% in 2009, as compared with 2008. In such way, based on the indicators of the main atmospheric emissions, Lithuanian returned to the level of 2005.

The pollution of ambient air depends on how many pollutants are emitted into the atmosphere and on the conditions available for their dispersion. The pollutants are usually emitted into the ambient air during the manufacture and burning processes; therefore, the main sources of pollution include industry, energy plants and other smaller fuel burning facilities used for domestic heating, as well as transport vehicles. The pollution caused by transport includes not only the pollutants emitted into the air from exhaust pipes, but also road dust re-suspension. The dust is generated in the roads due to attrition of tyres or other aggregates, attrition of asphalt, especially due to the thorny tyres used in the cold season, accumulation of impurities due to covering of roads with salt and sand mixture, in order to reduce slippage.

Air pollution can be increased by massive burning of old grass or garbage in suburban or more distant areas in spring or autumn. The Law on Protection of Ambient Air prohibits the burning of dry grass, stubble; however, such prohibition is infringed quite often. Furthermore, the atmosphere is usually polluted by natural origin pollutants formed due to heavy forest or peat bog fires that occur due to reasons other than the fault of people, farina, dust blown by the wind in desert regions, substances ejected from volcanic eruptions. Although there are no deserts or volcanoes in Lithuania, our country is influenced by intercontinental transport of air pollutants, when certain amounts of pollutants are transported with air masses in hundreds or even thousands of kilometres.

As indicated by the data presented in Fig. 70, the level of atmospheric pollutants (CO, $NO_X$, $SO_2$, LOJ, $PM_{10}$) from stationary (industry and energy plants, households) and transport is one of the most important factors affecting the quality of ambient air. The total amount of atmospheric pollution, amount of atmospheric pollution from separate sectors of economy was not equal. It mostly decreased (by almost 6.8%) in the transport sector – the highest anthropogenic source of atmospheric air pollution in Lithuania, however, in the industry sector the decrease of only 0.8% was recorded. Several factors should be considered in this case: the assessment is made pursuant to the indicators of the crisis period, the industry pollution accounts for only 20% in the overall emissions, and their treatment amounts to almost 100% in the plants. Therefore, the thermal energy production (including domestic heating) and transport remain the largest sources of the ambient air pollution. They should increase the effectiveness of the processes of pollution minimisation and reduce the amount of secondary gas products formed during the energy production processes.

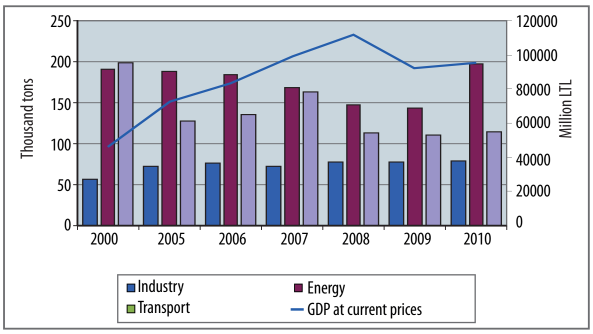


**Fig. 70.** Variation of the level of total pollution from industry, energy and transport sectors and GDP in 2000–2010. *Source: Environmental Protection Agency*

In the Lithuania's cities, air pollution is usually lower than in the major cities of its closest neighbouring countries and many other European cities. There are no million-population cities with concentration of industry and energy plants in our country, the density of population and transport flows are smaller than in European major cities, whereas the geographic situation conditions unstable weather, which is usually favourable for the dispersion of pollutants.

The data of the Lithuania's air quality research show that the most topical air pollution problems are related to the concentration of particulate matter $PM_{10}$. Despite the fact that during the recent years the average annual concentration of this pollutant has not exceeded the annual limit values in the ambient air of urban areas of our country. There are days or longer periods each year, when a significant increase in the level of this pollutant is recorded in the air and its concentration exceeds the daily limit value. According to the requirements of legal acts, the $PM_{10}$ daily mean concentration should not exceed the limit value (50 µg/m$^3$) for more than 35 days per year. In 2010, in Vilnius, Kaunas, Šiauliai and Panevėžys, this criterion was exceeded. However, in 2011, partly due to dominating more favourable air conditions for the dispersion of pollutants, partly due to applied air quality improvement measures of certain municipalities, the quality of ambient air showed some improvement. The usual reasons of increase in the air pollution include the intensive burning in domestic heating and the increase of emissions during cold season; transport pollution and road dust re-suspension in spring, when it is not enough time to clean and take away the impurities accumulated during winter; after long-term settling of dry, calm air, long-range transport of air pollutants contributing to local pollution sources. In 2012, the daily mean concentration of coarse particulate matter $PM_{10}$ in different areas of Vilnius varied from 16 to 32 µg/m$^3$, whereas in Kaunas – from 17 to 29 µg/m$^3$. The daily limit value was exceeded for 9 to 31 days in Vilnius and for 3 to 30 days in Kaunas, i.e., the 35-days limit was not exceeded in either station. The same situation was recorded in other major cities, in 2012, the annual mean concentration of particulate matter $PM_{10}$ varied between 24–31 µg/m$^3$ and did not exceed the annual limit value in either station (40 µg/m$^3$). The average daily concentration of particulate matter $PM_{10}$ in other cities exceeded the limit value for 10 to 35 days in all stations, thus, the annual limit value of 35 days was not exceeded in any place. The reasons of air pollution remained the same as in the previous year.

The concentration of nitrogen dioxide and sulphur dioxide does not exceed the established norms in Lithuanian cities and is lower than in many other European cities.

In 2012, the annual mean benzo(a)pyrene concentration exceeded the target value in air quality research stations in Vilnius, Kaunas, Klaipėda and Šiauliai. Benzo(a)pyrene is a secondary product of incomplete combustion, which can be emitted into the ambient air from thermal power plants, households for domestic heating, and transport. The maximum concentration of this pollutant is recorded during the cold season of the year, especially in February (this month was the coldest in 2012). Such trend proves that the main source of benzo(a)pyrene is the burning of fuel in households for domestic heating. The major level of benzo(a)pyrene is emitted during the burning of solid fuel – wood, coal, peat, waste.

According to the environment monitoring and statistical data, it is possible to state that the main levels of emissions emitted into the ambient air are decreased as compared with the end of the Soviet period or the first year of Independence period. The level of $SO_2$ emissions has especially decreased. The improvement of air quality is significantly affected by properly executed environmental policy and its strategic implementation. The positive tendencies were conditioned by the country's economic restructuring, installation of equipment for treatment of emissions and more favourable environmentally friendly technological solutions, selected by the industry.

The environmental specialists have long known that where the majority of people live, more domestic and industrial waste is accumulated and the level of environmental pollution is higher. Currently, the cities of the European Union are inhabited by three fourths of all population; therefore, the quality of urban air conditions the health of the major part of the EU population. The air pollution has a negative impact not only on population, but also on the environment of urban areas – the plantation of cities is perishing, the buildings and other engineering constructions suffer more intensive wearing.

Even a short-term increase in the concentration of air pollutants can cause acute health disorders, whereas the long-term impact of pollution can become the cause of chronic disorders. Based on the recommendations of the Wold Health Organisation, the main pollutants are subject to limit or target concentration values, which do not cause harmful impact on human health and should not be exceeded.

In the largest European cities, approx. three fourths of all pollutants are emitted into the atmosphere by motor transport. Along with the emissions of the vehicles, carbon monoxide, nitrogen oxide, volatile organic compounds, heavy metals, particulate matter are emitted into the air. Motor transport also conditions the road dust resuspension, air pollution with particulate matter is one of the main issues in many European cities. The Lithuanian air monitoring data show that concentration of particulate matter $PM_{10}$ in the bigger cities and industrial centres exceeds daily limit value during some days or periods.

The researches of the World Health Organisation established that more than half of the population of Central and Eastern European cities is suffering from the increased concentration of $PM_{10}$, which causes the exacerbation of the airway as well as heart and vascular diseases.

Until 2001, the concentration of pollutants was determined in the laboratory, by analysing the manually taken air samples (by absorbing air for 20–30 minutes 3 times per day). Since 2003, the concentration of sulphur dioxide, nitrogen dioxide, carbon monoxide, benzene and particulate matter $PM_{10}$ in the ambient air has been measured incessantly by using automatic measurement devices. The concentration of lead and, since 2007, other heavy metals (arsenic, cadmium, nickel) and polycyclic aromatic carbon hydroxides (B(a)P, etc.) in the ambient air are measured by semi-automatic devices. I.e., samples are taken uninterruptedly, 3 days per week, and analysed in the laboratory every month, by establishing the mean monthly concentration from the fraction of overall dust (since 2007 – from particulate matter $PM_{10}$).

It was back in 2000, when two agglomerations (Vilnius and Kaunas) and one zone were distinguished in order to ensure a more precise air quality assessment and its better management in Lithuania. Air quality researches are carried out in Vilnius and Kaunas agglomerations and largest cities of the territorial stations (Klaipėda, Šiauliai and Panevėžys) as well as industrial centres (Jonava, Kėdainiai, Mažeikiai and Naujoji Akmenė). In order to establish the background air pollution and evaluate the influence of the atmospheric transport of air pollutants on the air quality in Lithuania, concentration of certain pollutants is measured in 4 rural background stations, installed within a larger distance from any pollution sources. According to current environmental monitoring data and by evaluating industrial infrastructure in these listed cities, it is possible to presume that due to anthropogenic impact the air pollution can be the highest in here.

The urban air quality stations are measuring the concentration of pollutants that are mostly emitted to the atmosphere due to economic activity performed by people and the assessment of which in the ambient air is regulated by the legal acts valid in the entire European Union. According to the fact that the ambient air is a very dynamic system, the concentration of the main pollutants in the atmosphere is measured uninterruptedly; the results of measurement are delivered to the society by applying information technologies in the time, which is close to real-time.

The summarised information on the main air quality indicators and their assessment is expediently delivered and regularly updated on the website of Environmental Protection Agency.

The National Sustainable Development Strategy stipulates the improvement of the ambient air quality assessment and management system in order to ensure the air quality, which is non-harmful to human health and ecosystems across the country. To achieve an effective restriction of the amount of pollutants emitted into the environment, one should possess a reliable and complete information on the dynamics of level and concentration of sulphur dioxide, nitrogen oxide, durable organic pollutants, greenhouse gases and ozone-depleting substance emitted into the atmosphere and other factors having influence on the climate change, environment acidification and eutrophication.

Fluctuations of the main concentration of polluting substances in the air during the Independence period indicate that the mean annual concentration of the majority of pollutants, the main sources of which are industry and energy and transportation, decreased in the major Lithuanian cities and industrial centres.

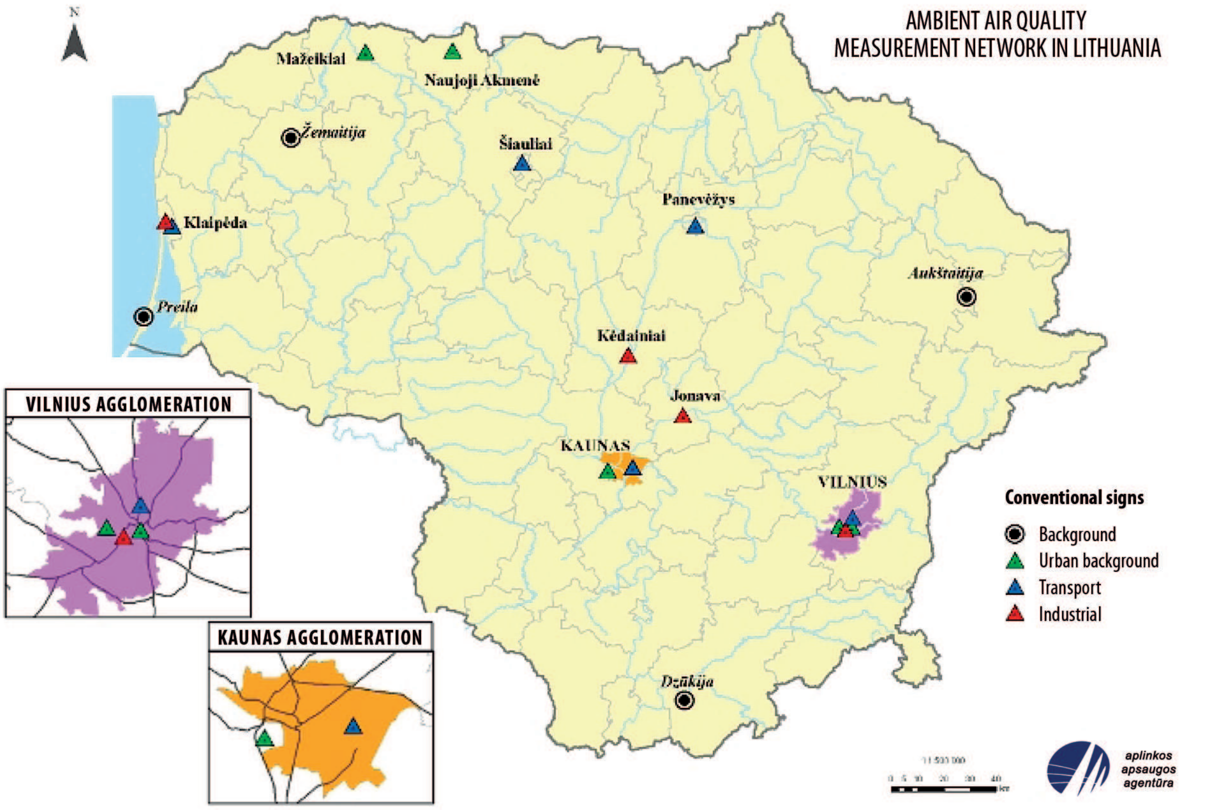


**Fig. 71.** Air quality monitoring network in Lithuania and in agglomerations of Vilnius and Kaunas. *Source: Environmental Protection Agency*

The amount of sulphur dioxide emitted into the atmosphere has decreased significantly in the majority of European cities during the recent two decades, after replacement of crude oil and stone coal with lower sulphur content having fuel – natural gas – in energy production. Since the very period from 1992 to 1993, the concentration of sulphur dioxide in the Western European cities has not exceeded the standards of the ambient air quality established by the European Union. The concentration of sulphur dioxide in the ambient air is characterised by seasonality in the majority of cities. It is related to the burning of fossil fuel during the cold season. When evaluating the mean annual concentration, it has been observed that due to centralised heating Lithuanian cities are characterised by especially low concentration of sulphur dioxide in the ambient air. In the past decade, it has shown a further decrease. Based on the EU criteria, the $SO_2$ level in the ambient air is restricted by daily limit values: 1-hour limit value is 350 µg/m$^3$, while the daily limit value – 125 µg/m$^3$. In 2012, low concentration of $SO_2$ was recorded in Vilnius: the mean annual concentration did not exceed 3 µg/m$^3$, the maximum daily value did not exceed 17 µg/m$^3$, and the maximum 1-hour value did not exceed 30 µg/m$^3$. In Kaunas and other major cities, the recorded concentration of sulphur dioxide was approximately 2 times higher than in Vilnius. This might be caused by more decentralised heating systems, as compared with the situation in the capital city. However, according to the presented data, the limit value was not exceeded anywhere.

The group of extremely dominant and dangerous atmospheric pollutants is composed of nitrogen oxides. According to the data of the World Health Organisation, high concentration of nitrogen oxides leads to the increase in the sensitivity of lungs to other pollutants and allergens. The exceeded limit values of $NO_2$ concentration show, in which territories the increase in air pollution with nitrogen dioxide can have a negative impact on the population.

The main atmospheric pollutants include carbon monoxide (CO), nitrogen oxide ($NO_X$), sulphur dioxide ($SO_2$), volatile organic compounds (VOC) and particulate matter (PM). The total level of emissions decreased by 15–18% during the economic crisis period (2008–2009), as compared with the level of 2006–2007. However, it is obvious that this decrease was conditioned by the slowdown in the economic activity. For example, the economic recession has almost no influence on the level of particulate matter, which mostly depends on the contribution of energy sector during the heating season and transport emissions. With the revival of country's economy, already in 2010, the total level of emissions exceeded 391 thousand tons and, again, nearly achieved the values of pre-crisis period, whereas the levels of the separate emissions even exceeded the emission values of 2006–2007. Only the level of volatile organic compounds, the major share of which is composed of emission from the industrial plants, increased slightly slower, because the revival of the activity of industrial plants is characterised by certain inertia and because nitrogen oxides still lag behind the former values: the slower increase of the latter pollutants, the main source of which is transport, could also be influenced by the intensively increasing price of fuel.

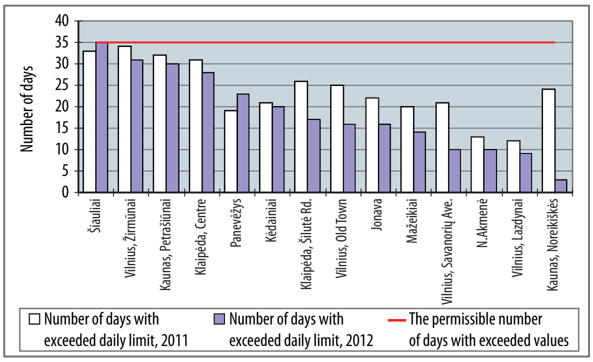


**Fig. 72.** Number of days with the exceeded limit daily value of concentration of particulate matter ($PM_{10}$) in 2011–2012. *Source: Environmental Protection Agency*

The mean annual concentration of nitrogen dioxide also showed significant decrease in the Lithuanian cities after the restoration of Independence. The measured $NO_2$ concentration is compared with the limit values approved by the EU and Lithuanian legal acts established by the recommendations of the World Health Organisation. The concentration of the nitrogen dioxide is subject to the annual (40 μg/m$^3$) and hourly (200 μg/m$^3$) limit values. Until the coming into force on 1 January 2010, the permissible deviations were applied with gradual decrease each year. As stipulated by the legal acts, the hourly norm shall not be exceeded more than 18 times during the calendar year.

The analysis of environment air monitoring shows that the maximum concentration of nitrogen dioxide ($NO_2$) is recorded in those measurement sites, where the impact of transport pollution on the quality of ambient air is observed. For example, in 2011, the maximum hourly values of nitrogen dioxide varied from 70 to 205 μg/m$^3$ in the air of Lithuanian cities. The latter value was registered in February at the air quality research station in Dainava (Kaunas) – in this case, the concentration of nitrogen dioxide exceeded the limit hourly concentration value by a minimum (200 μg/m$^3$). In 2010, the limit value was also exceeded in only one station located in Klaipėda, Šilutė road (at that time, the $NO_2$ concentration reached 258 μg/m$^3$ for one day). Pursuant to the requirements of legal acts, this limit value shall not be exceeded more than 18 times per year. The increase in the dioxide concentration in Kaunas might have been caused by the increase in the emission from energy plants and households for domestic heating during heating season as well as prevailing favourable meteorological conditions for the accumulation of pollutants. When comparing it with the data of 2010, in 2011, the maximum $NO_2$ concentration was higher in Vilnius, Kaunas, Šiauliai, Panevėžys and Kėdainiai, and lower in other cities.

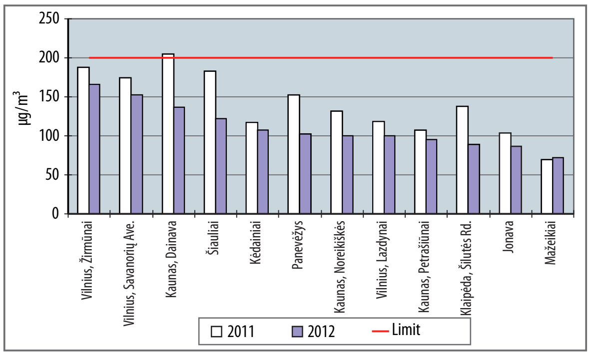


**Fig. 73.** Maximum 1-hour $NO_2$ concentration in 2011 and 2012. *Source: Environmental Protection Agency*

The results of modelling show that near the sections of streets of very intensive traffic the mean annual concentration of nitrogen dioxide can amount to 45–50 μg/m$^3$.

The data of the Vilnius map of pollution with nitrogen dioxide developed by the specialists of the Environmental Protection Agency by means of modelling show that the maximum concentration of this pollutant should be in the central part of the city near large transport arteries.

The ozone ($O_3$) present in the ambient air is one of the most prevailing secondary atmospheric pollutants, i.e., the pollutants, which are not emitted directly into the atmosphere. Ozone is not emitted directly into the atmosphere, but is formed from other compounds during the photochemical reactions – so-called ozone precursors (usually, nitrogen oxides and volatile organic compounds). Their higher concentration in the ambient air can have a negative impact on all living organisms – plants, animals, and people.

This is so-called "bad" ozone. Due to the peculiarities of formation of ozone in the ambient air and meteorological conditions, the maximum concentration of this pollutant, otherwise than in case of particulate matter, is usually observed within a longer distance from intensive pollution formation places (for example, large urban road transport crossings) – suburban or rural localities, during hot and sunny days in spring and summer.

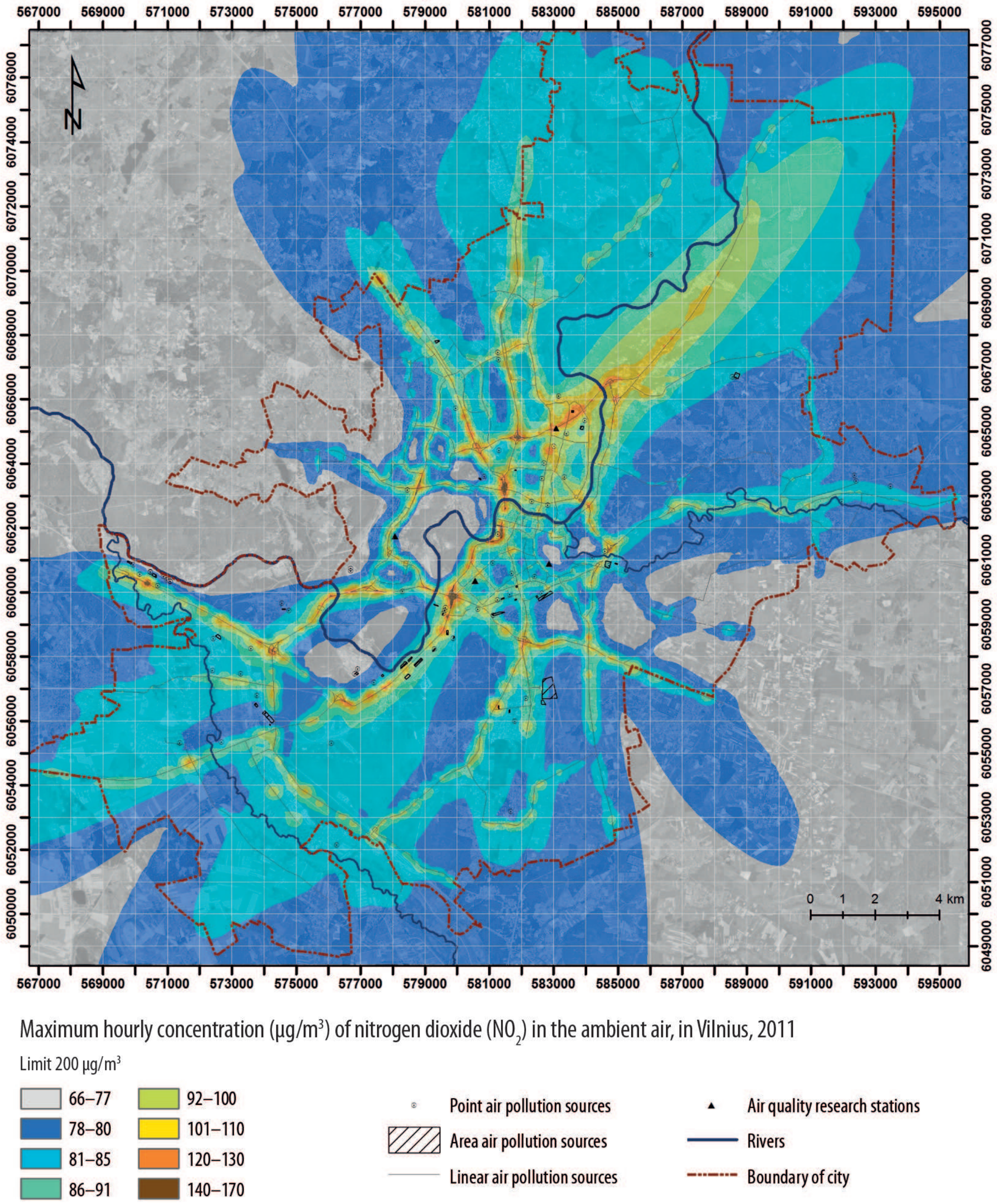


**Fig. 74.** Maximum 1-hour $NO_2$ concentration in Vilnius, in 2011. *Source: Environmental Protection Agency*

In 2011, the level of ozone concentration in Lithuania was similar to that of the previous year. In different measurement sites, the mean 8-hour concentration of this pollutant exceeded the target value (120 μg/m$^3$) for 1–8 days per year (the value was exceeded for 8 days in Kaunas suburban area, 5–7 days – in the background air quality monitoring stations in rural settlements). In the majority of stations, the increase in the concentration of this pollutant was observed in the third decade of April and on some days in May and June.

The annual number of exceeding of the target value established for the protection of human health shall not be higher than 25 days in the average of 3 years. Whereas during the recent three years (2009–2011), the mean annual number of days, when the target value was exceeded in different stations, amounted to 1–10 days, thus, this index was not exceeded in any station.

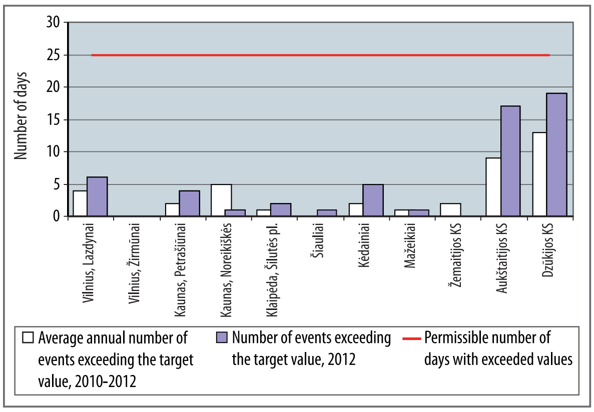


**Fig. 75.** Exceeding of the target values of 8-hour ozone concentrations. *Source: Environmental Protection Agency*

Despite the positive tendencies of air quality changes, the infringements are still frequently recorded in the atmosphere sector. For example, in 2010 alone, more than 14 thousand infringements of the legal acts regulating the environmental protection and usage of nature resources have been recorded, approx. 7% of these infringements (1,032) were recorded in the field of atmosphere. As it is shown in Fig. 19, the decrease in the offences conducted in the atmosphere area has been observed during the period from 2002 to 2010. Only in 2009, the insignificant increase in the recorded offences was recorded, which is related to the more frequent inspection of larger and more potentially pollutant economic entities.

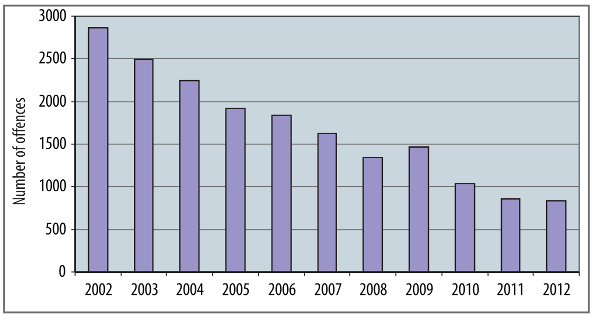


**Fig. 76.** Variation of recorded offences of environmental requirements in the atmosphere sector, in 2002–2012. *Source: Environmental Protection Agency*

The majority of infringements of environmental requirements were recorded in the regions, where the majority of economic entities are concentrated. The greatest share of infringements were noticed in the territories of Šiauliai Regional Environmental Protection Department (REPD), Kaunas REPD and Vilnius REPD. The least number of these offences was recorded in the territory of Utena REPD. The minimum decrease in the recorded infringements has been observed in all regions. It is likely for the number of recorded offences to stabilise in the future with only an insignificant tendency of decrease.

# Water

## RESOURCES AND QUALITY OF SURFACE INLAND WATERS

Until 2004, the issues of management of water bodies were solved in view of the Environmental Protection Strategy of Lithuanian of 1996. As indicated in this Strategy, the main aims of water protection include the reduction of water pollution with wastewater from urban and settlement areas, reduction of the pollution of water bodies from utilised agricultural lands and reduction of the pollution from run-off water, etc. These provisions were stipulated in the Law on Water of the Republic of Lithuania of 1997. When implementing this policy, the construction of urban wastewater treatment facilities, centralised water supply and wastewater networks as well as other engineering facilities were brought into focus.

According to the EU Water Framework Directive 2000/60/EC (hereinafter referred to as the WFD) a decision was made to consider the river basins to be the most important objects of the management of the status of water bodies instead of individual polluters or other sources of pollution. The basins are natural hydrological-geographic systems; therefore, their management should be based on a complex approach. In Lithuania, this policy was consolidated in the Law Amending to the Law on Water of the Republic of Lithuania, which was harmonised with WFD. Based on the WFD, the main aim of water policy is to ensure "the good status of water bodies".

In 2004, when Lithuania joined the European Union, same as other EU Member States, it obligated to prepare river basin districts management plans and determine the measures enabling the achievement of good ecological and chemical status of the national water bodies.

For the purposes of management of water bodies, the basins of Lithuanian rivers were divided into four river basin districts – Nemunas, Venta, Lielupė and Dauguva – that were thoroughly described, the main natural, social and economic conditions were indicated and the water bodies were grouped according to the natural characteristics.

The implementation of river basin districts management plans and programmes of measures according to WFD and assessment of the effectiveness of used measures requires the effective observation (monitoring) of the status of water bodies. Until 2005, the monitoring of surface water bodies was mostly aimed at assessment of transboundary water pollutant transport and influence of pollution from point sources on water bodies. The status of smaller rivers remained almost unexamined. Tests were conducted in a small number of lakes only and the researches of indicators of physical and chemical quality elements were mostly in focus. Since 2005, the status of Lithuanian surface water bodies is being observed in accordance with the National Environmental Monitoring Programme, which was drafted on the basis of the WFD requirements, i.e., the monitoring is performed in singled out water bodies significant in terms of management, influenced by different anthropogenic impacts, mostly focusing on the research of indicators of biological quality elements. Subsequent to the aforementioned monitoring programme, during the period from 2005 to 2010, the status of water bodies was observed annually in approximately 200–400 river sites and 30–70 lakes and reservoirs. The monitoring network was divided into surveillance, operational and investigative monitoring sections by applying intensive (annual examination of approx. 50 river sites and 9 lakes/reservoirs) and extensive (rotational examinations once per 3 or 6 years) monitoring frequency.

In 2007, the society was introduced with the main water protection issues in Nemunas, Venta, Lielupė and Dauguva River basin districts. Later the management plans and action programmes of measures were prepared for the aforementioned river basin districts. These documents were approved by the resolutions of the Government of the Republic of Lithuania in 2010. The river basin districts management plans are updated every six years. The first management plan will be implemented during the period from 2010 to 2015.

In Lithuania, the processes of eutrophications of water bodies (visually manifesting by water blooming, swamping of shores, overgrowth of macrophytes in coastal zone) have been observed for several decades. The main nutrients stimulating the eutrophication of water bodies include total phosphorus and total nitrogen; whereas the main sources of pollution include agricultural activity, municipal and industrial wastewater. Nitrogen and phosphorus compounds are present in the composition of mineral fertilisers used in agriculture and quite a significant part of them remains in the natural environment. The main factors Influencing the washout of nitrogen and phosphorus compounds from soil and their passage to the surface water bodies include fertilisation intensiveness, soil composition and precipitation rate. Quite a significant amount of nitrogen compounds passes to the surface water bodies with groundwater, while the major part of phosphorus compounds – with snow melt and rain water. Significant amounts of phosphorus and nitrogen compounds pass to water bodies with chemical substances used in households and industry and containing phosphorus or nitrogen compounds. Some nutrients passing to water bodies are accumulated in bottom sediments; therefore, in case of intensive mixing of water, the concentration of these substances can increase in the surface water layer and result in the increased eutrophication of water bodies and deterioration of their ecological status.

The ecological status of rivers is assessed based on physico-chemical, biological and hydromorphological quality elements. The indicators of physico-chemical quality elements include total nitrogen (Nt), total phosphorus (Pt), phosphate phosphorus ($PO_4$-P), nitrate nitrogen ($NO_3$-N), ammonium nitrogen ($NH_4$-N), 7-day biochemical oxygen demand ($BOD_7$) and amount of dissolved oxygen in water ($O_2$). The indicator of biological quality elements (taxonomic composition, abundance, age structure of ichthyofauna, as well as taxonomic composition and abundance of zoobenthos) are the Lithuanian fish index (LFI) and the Danish Stream Fauna Index (DSFI). The indicators of hydromorphological quality elements – hydrological regime (quantity and dynamics of water flow), river continuity and morphological conditions (structure of shores) are: amount of flow, river continuity, structure of river bed. Based on the average annual value of each index of physico-chemical quality elements, description of average annual value of biological quality indicators of ecological relations (ER) and description of indicators of hydromorphological quality elements, the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

Based on the information submitted in the first river basin districts management plans during the period from 2005 to 2009, 17% of 832 river waters bodies were of high ecological status, 24% – of good, 50% – of moderate status, 8% – of poor and 1% of bad ecological status. In 2015, the second of Nemunas, Venta, Lielupė and Dauguva River basin districts management plant will be finally drafted and it will include the assessment of the ecological status of rivers and its change during the period from 2010 to 2014.

The ecological status of lakes and rivers is evaluated according to the values of indicators of physico-chemical, biological and hydromorphological quality elements. The indicators of physico-chemical quality elements include total nitrogen and total phosphorus. The index of biological quality element – taxonomic composition, abundance and biomass of phytoplankton – is chlorophyll a. The indicators of hydromorphological quality elements – hydrological mode (quantity and dynamics of water flow) and morphological conditions (structure of lakeshore) – are water level changes and shore line changes. Based on the average annual value of each indicator of physico-chemical quality elements of surface water layer, the average rate of the ER of the average annual value of chlorophyll *a* and of the ER of the maximum annual value and description of indicators of hydromorphological quality elements, the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad. Based on the information submitted in the first river basin districts management plans during the period from 2005 to 2009, 28% out of 345 lakes and reservoirs significant in terms of management were of good ecological status, 26% – of moderate, 6% – of poor ecological status, and there were no water bodies of bad ecological status recorded. In 2014, the second Nemunas, Venta, Lielupė and Dauguva river basin districts management plans will be prepared and will include the assessment of the ecological status of the lakes and reservoirs and its change during the period from 2010 to 2014.

When preparing this overview, the data of the national monitoring of indicators of physico-chemical and biological quality elements of surface water bodies of 2004–2011 were evaluated.

The overview also presents results of the monitoring of hazardous substances in rivers, lakes and reservoirs of 2004–2011. The chemical status of surface waters is divided into two classes: good and below good. When the concentration of hazardous substances at issue in water body meets the standards of environment quality established by the respective EU and national legal acts, it is classified as being of good chemical status. In case one founds non-compliance with the environment quality standards, the water body is classified as not meeting the requirements of the good chemical status.

## COMPLIANCE OF THE RIVER WATER QUALITY WITH THE QUALITY NORMS IN THE STATE MONITORING STATIONS BASED ON THE AVERAGE ANNUAL VALUES OF TOTAL NITROGEN, AMMONIUM NITROGEN, NITRATE NITROGEN, TOTAL PHOSPHORUS, PHOSPHATE PHOSPHORUS, $BOD_7$ AND $O_2$

This chapter presents the indicators of physico-chemical quality elements of national monitoring of rivers in 2004–2011: total nitrogen (Nt), total phosphorus (Pt), phosphate phosphorus ($PO_4$-P), nitrate nitrogen ($NO_3$-N), ammonium nitrogen ($NH_4$-N), 7-day biochemical oxygen demand ($BOD_7$) and amount of dissolved oxygen in water ($O_2$). Based on the annual average of each indicator, the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

Having evaluated the ecological status of rivers based on the nitrate nitrogen, it has been recorded that during the period between 2004 and 2011, approx. 76% of all examined river stations have met the requirements of high and good ecological status. The group of high ecological status is the largest (approx. 55% of all examined river stations). In 2006, the highest number of river stations of high ($NO_3$-N concentration <1.3 mg N/l) and good ($NO_3$-N concentration varied from 1.3 to 2.3 mg N/l) ecological status were recorded, i.e., they amounted to 86% of all examined river stations. In 2005 and 2007–2010, approx. 79% of all examined river stations were recognised as high and good ecological status, whereas in 2004 this ecological status was attributed to 64% of all examined river stations. In 2005–2010, bad ($NO_3$-N concentration >10 mg N/l) and poor ($NO_3$-N concentration varied from 4.51 to 10.00 mg N/l) ecological status of river stations was recorded for 3% to 14% of all examined river stations. In 2011, the lowest number of very good and good status (66%) was determined and the highest number of the river stations with bad or poor ecological status.

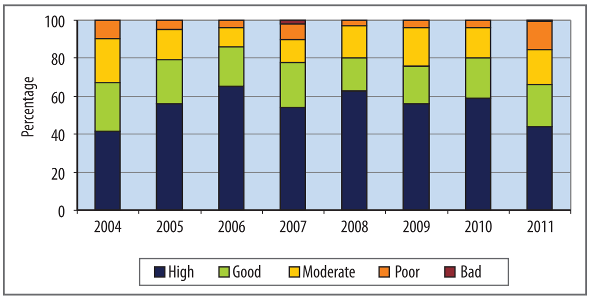


**Fig. 77.** Number (percentage) of river examination stations by average annual values of $NO_3$-N, 2004–2011. *Source: Environmental Protection Agency*

Based on the average annual concentration of ammonium nitrogen ($NH_4$-N), in 2004–2011, the requirements of high ($NH_4$-N <0.10 mg N/l) and good ($NH_4$-N varied from 0.10 to 0.20 mg N/l) ecological status were met by approx. 89% of the examined river stations. The highest number of river stations of high and good ecological status were recorded in 2008 (96% of all examined river stations), whereas the lowest number – in 2004 (79% of all examined river stations).

In 2004, the highest number of river stations of bad ($NH_4$-N concentration >1.50 mg N/l) and poor ($NH_4$-N concentration varied from 0.61 to 1.50 mg N/l) ecological status was recorded (13%). Whereas in 2005, 2008 and 2010, there were approx. 3% of river examination areas, where the river stations of bad and poor ecological status was recorded. In 2011, such status was recorded in only 2% of all examined river stations. However, the best situation was observed in 2007, when there were no stations of rivers of bad or poor ecological status recorded.

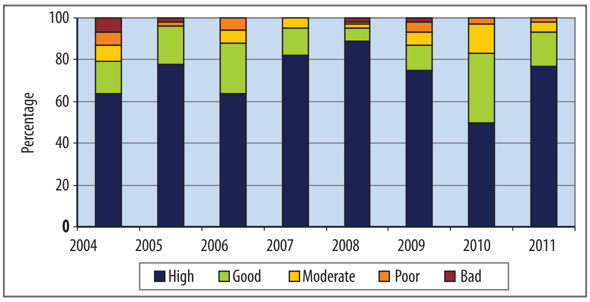


**Fig. 78.** Number (percentage) of river examination stations by average annual values of $NH_4$-N, 2004–2011. *Source: Environmental Protection Agency*

During the period from 2004 to 2011, based on the average annual concentration of total nitrogen (Nt), high (Nt concentration <2.0 mg/l) and good (Nt concentration varied from 2.00 and 3.00 mg/l) ecological status was met by approx. more than 68% of all examined river stations. In 2006, high and good ecological status was recorded for 76% of all river stations, whereas in 2004 – only 56% of all examined river stations. The lowest number of river stations of bad (Nt concentration >12.00 mg/l) and poor (Nt concentration varied from 6.01 to 12.00 mg/l) ecological status were recorded in 2008 (3% of all examined river stations), whereas the highest number – in 2004 and 2011 (16% and 17% of all examined river stations, respectively).

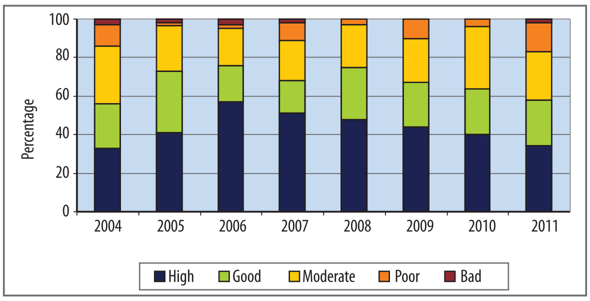


**Fig. 79.** Number (percentage) of river examination stations by average annual values of Nt, 2004–2011. *Source: Environmental Protection Agency*

Based on the average annual concentration of phosphate phosphorus ($PO_4$-P), in 2004–2011, high ($PO_4$-P concentration <0.05 mg P/l) and good ($PO_4$-P concentration varied from 0.05 to 0.09 mg P/l) ecological status was recorded for approx. 85% of all examined river stations. The best situation was observed in 2007–2011, when 90% of all examined river stations met the criteria of high and good ecological status, while the worst situation was in 2004 (70% of all examined river stations). The lowest number of river stations of bad ($PO_4$-P concentration >0.40 mg P/l) and poor ($PO_4$-P concentration varied from 0.181 to 0.40 mg P/l) ecological status was recorded in 2011 (3% of all examined river stations), whereas the highest number – in 2004 and 2006 (17% and 10% of all examined river stations, respectively).

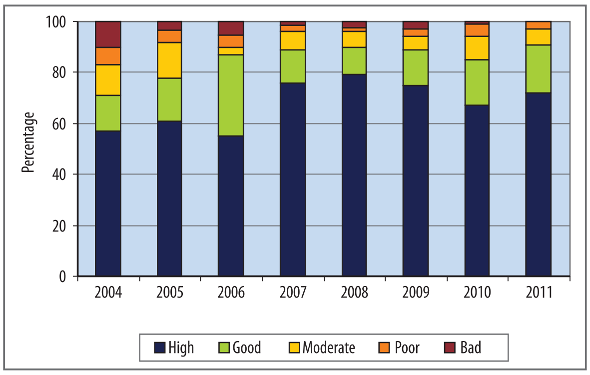


**Fig. 80.** Number (percentage) of river examination stations by average annual values of $PO_4$-P, 2004–2011. *Source: Environmental Protection Agency*

Having evaluated the ecological status of rivers during the period from 2004 to 2011 based on the average annual concentration of total phosphorus (Pt), the criteria of high (Pt concentration <0.10 mg/l) and good (Pt concentration varied from 0.10 to 0.14 mg/l) ecological status were met by approx. 82% of all examined river stations. The best situation was recorded in 2011, when the criteria of high or good status were met by 91% of all examined river stations, whereas the worst – in 2004 (62% of all examined river stations). The lowest number of river stations of bad (Pt concentration >0.47 g/l) and poor (Pt concentration varied from 0.231 and 0.47 mg/l) ecological status was established in 2007 and 2011 (only 3%), while the largest – in 2004 (20% of all examined river stations).

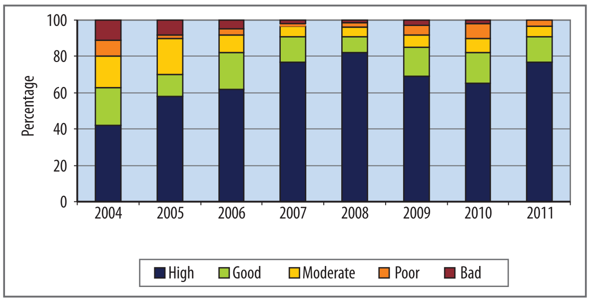


**Fig. 81.** Number (percentage) of river examination stations by average annual values of Pt, 2004–2011. *Source: Environmental Protection Agency*

Based on the average annual values of 7-day biochemical oxygen demand ($BOD_7$), during the period from 2004 to 2011, high ($BOD_7$ concentration <2.30 mg $O_2$/l) and good ($BOD_7$ concentration varied from 2.30 to 3.30 mg $O_2$/l) ecological status was recorded for approx. 75% of all examined river stations. The best ecological status was observed in 2011, when approx. 90% of all examined river stations met the requirements of high or good ecological status. Meanwhile the worst situation was in 2004 and 2005 (64% of all examined river stations). The lowest number of river stations of bad ($BOD_7$ concentration >7.00 mg

$O_2$/l) and poor ($BOD_7$ concentration varied from 5.01 to 7.00 mg 02/l) ecological status was recorded in 2011 (only 0.56%), whereas the highest number – in 2005, 2006 and 2009 (9% of all examined river stations).

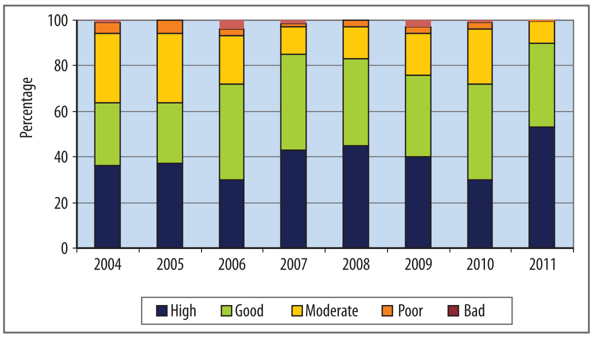


**Fig. 82.** Number (percentage) of river examination stations by average annual values of BOD7, 2004–2011. *Source: Environmental Protection Agency*

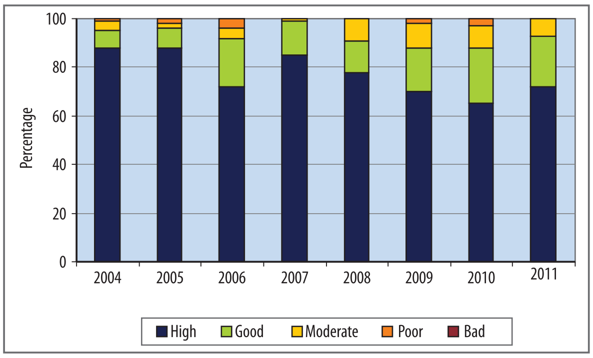


**Fig. 83.** Number (percentage) of river examination stations by average annual values of $O_2$, 2004–2011. *Source: Environmental Protection Agency*

Based on the data of 2004–2011, in approx. 92% of examined river stations, the amount of dissolved oxygen in the water ($O_2$) met the requirements of the high ($O_2$ concentration should be higher than 8.50 mg $O_2$/l for 1, 3, 4, 5 river types; for 2 type rivers – higher than 7.50 mg $O_2$/l) and good ecological status ($O_2$ concentration varies from 8.50 to 7.50 mg $O_2$/l in 1, 3, 4, 5 river types; for 8 type river – from 7.50 to 6.50 mg $O_2$/l). The best ecological situation was observed in 2007, when 99% of all examined river stations were of high or good ecological status, whereas the worst situation was in 2010 (88% of all examined river stations).

The lowest number of river stations of bad ($O_2$ concentration <3.00 mg $O_2$/l for 1, 3, 4, 5 type rivers; for 2 type river – <2.00 mg $O_2$/l) and poor ($O_2$ concentration varies from 5.99 to 3.00 mg $O_2$/l for 1, 3, 4, 5 type rivers; 2 type river – from 4.99 to 2.00 mg $O_2$/l) ecological status was recorded in 2004, 2005 and 2007–2009 (up to 2% of all examined river stations), whereas in 2008 and 2011, no such river stations were recorded at all. The largest number of river stations of bad and poor ecological status based on the examined indicators was recorded in 2006 (4% of all examined river stations).

In summary of the period from 2004 to 2011, the maximum values of nitrates, ammonium nitrogen, total nitrogen, phosphate and total phosphorus and organic substances (based on $BOD_7$ indicator) were recorded in river stations below cities and low wateriness streams, where urban wastewater that is generated in intensive agricultural territories is discharged.

## CHEMICAL STATUS OF RIVERS DURING THE PERIOD FROM 2004 TO 2011

In 2004, the monitoring of hazardous substances in rivers was performed based on the State Environmental Monitoring Programme for 1997–2004. The following groups of hazardous substances were examined: heavy metals (cadmium (Cd), mercury (Hg), lead (Pb), nickel (Ni) copper (Cu), zinc (Zn), and chrome (Cr)), phenols (pentachlorophenol) and pesticides (DDT, polychlorobiphenyl, hexachlorocyclohexane (gama)). Bottom sediments were examined for the traces of heavy metals and pesticides.

From 2005, the monitoring of hazardous substances was performed pursuant to the State Environmental Monitoring Programme for the period of 2005–2010, which was prepared in view of the requirements of the Water Framework Directive (2000/60/EC). From 2005, the following groups of substances were examined: heavy metals (cadmium, mercury, lead, nickel, copper, zinc, chrome, tin, vanadium, aluminium, arsenic), phenols, pesticides (polychlorobiphenyl, hexachlorocyclohexane, endosulfan, aldrin, dieldrin, endrin, hexachlorobenzene, simazin, atrazin, diuron, isoproturon), volatile organic compounds (tetrachloromethane, tetrachloroethylene, trichloroethylene, trichloromethane, 1,2-dichloroethane, dichloromethane, benzene), polycyclic aromatic hydrocarbons (anthracene, fluoranthene, naphthalene, benzo(a)pyrene, benzo(b) fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene). In 2010, the list of examined materials was supplemented with the following substances and groups of substances: phthalates (dibutylphthalate, di(2-ethylhexyl)phthalate), phenols and their ethoxylates (nonylphenols, 4-(para)-nonylphenol, 4-octylphenol, 4(tert)-octylphenol), hexachlorobutadiene and tributyltin. Bottom sediments were examined for traces of heavy metals and pesticides and polycyclic aromatic hydrocarbons. In 2011, the following hazardous substances and their groups were examined: heavy metals, pesticides, polychlorinated biphenyls, volatile organic compounds, polycyclic aromatic hydrocarbons, alkylphenols, phthalates, pentachlorophenol and tributyltin.

*Research of river waters.* In 2004, the monitoring of hazardous substances was performed in 50 river monitoring stations, in 2005 – 51 stations, in 2006 – 25 stations, in 2007 – 18 stations, in 2008 – 21 stations, in 2009 – 23 stations, in 2010 – 16 stations, in 2011 – 18 stations.

Based on the data of national monitoring of 2004, in many cases the concentration of found heavy metals was insignificant, while the traces of pentachlorophenol and pesticides were not found at all. Out of 50 examined river stations, the chemical status was good in 42 stations, i.e., the concentration of found hazardous substances was below the concentration established by the Environmental Quality Standard (EQS). In 8 river stations, the chemical status did not meet the requirements of good status in terms of the established lead and mercury concentration. The one-time concentration of lead (Nevėžis River below Panevėžys) and mercury (Nemunas River above Rusnė, Šešupė River in the frontier area and Šelmenta River in the frontier area), the average concentration of mercury (Mūša River below Šaločiai, Lėvuo River mouth, Skirvytė River above Rusnė and Šešupė River in the frontier area) exceeded the EQS limit values.

In 2005, the concentration of heavy metals was very low, and in some stations it was not found at all. The traces of examined pesticides were observed in several cases, the concentrations of which were below the limit of quantification, whereas in other cases – not found at all. Pentachlorophenol was found, whereas polycyclic aromatic hydrocarbons were found in many stations, however, in low concentrations and below the limit of quantification. Out of 51 examined river stations, the chemical status was good in 45 stations. In 6 river stations, the chemical condition did not meet the requirements of good status: the average annual concentration of trichloromethane (chloroform) exceeded the EQS in Šušvė mouth, Venta River below Mažeikiai, Varduva River near Griežė, Ašva River in the frontier area, Bartuva River above Skuodas and Šventoji River near road No 1502.

In 2006, the concentration of heavy metals and polycyclic aromatic hydrocarbons was low and usually below the limit of quantification. Pentachlorophenol was not found. In many cases, the examined pesticides and volatile organic compounds were not found or their concentrations were below the limit of quantification. Out of 25 examined river stations, the chemical status was good in 20 stations. In 5 river stations, the chemical condition did not meet the requirements of good status: the average annual concentration of trichloromethane (chloroform) exceeded the EQS limit in Venta River below Mažeikiai, the average annual concentration of aldrin exceeded the EQS limit by 14 times in Šventoji mouth, the average annual concentration of endrin exceeded the EQS limit by respectively 7 and 8 times in Akmena-Danė mouth and Minija River near Suvernai, the average annual concentration of DDT exceeded the EQS limit in Nemunas River near Pagėgiai near road No A12.

In 2007, heavy metals and polycyclic aromatic hydrocarbons were found in all examined stations; however, their concentration was very low or below the limit of quantification. Pesticides, volatile organic compounds and pentachlorophenol were detected only in several cases and their concentration was very low or below the limit of quantification. Out of 18 examined river stations, the chemical status was good in 16 stations. In 2 river stations, the chemical condition did not meet the requirements of good status: the average annual concentration of lead exceeded the EQS limit in Nevėžis River above Raudondvaris and Neris River above Kaunas.

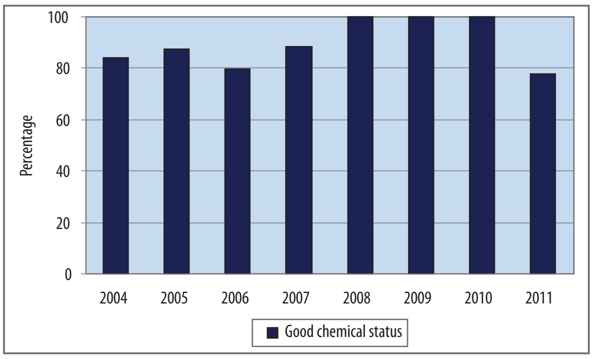


**Fig. 84.** Chemical status of river monitoring stations (percentage). *Source: Environmental Protection Agency*

In total, pursuant to the data of research of 2008–2010, the chemical status of examined river stations was considered as good. The concentrations of heavy metals were low or below the limit of quantification. The traces of pesticides, volatile organic compounds and pentachlorophenol were observed only in several cases and their concentration was low or below the limit of quantification. Polycyclic aromatic hydrocarbons were observed in many examined stations, however their concentration was very low or below the limit of quantification. In 2010, the traces of phthalates and phenols and their ethoxylates and tributyltin were not found. However, in 2011, the chemical status was evaluated as not meeting the good status in 4 stations out of 18 examined river stations: the average annual concentration of di(2-ethylhexyl)phthalates slightly exceeded the EQS limit in Skirvytė River near Rusnė and Nemunas River above Rusnė; the one-time concentration of pentachlorophenol exceeded the EQS limit by three times in Nemunas River above Rusnė and Nemunas near Pagėgiai, whereas the average annual concentration of pentachlorophenol slightly exceeded the EQS limit in Nemunas River above Rusnė; the one-time and average annual concentration of tributyltin exceeded the EQS limit by 6 times in Neris River above Paneriai.

*The research of river bottom sediments.* The EQS for bottom deposit is not established therefore it is impossible to evaluate the pollution of bottom sediments, whereas the data analysis was performed only by comparing the variations of separate concentrations in the areas of examination.

Based on the data of national monitoring of 2004, the pesticides were observed in bottom sediments only in several examined stations, whereas higher concentration of heavy metals was found in 8 examined areas out of total 43. In 2005, the researches of bottom sediments were performed in 19 locations, in 4 locations of which (Neris River above Kaunas, Šventoji River near road No 150, Birvėta River in the frontier area and Sidabra River in the frontier area) higher concentrations of metals were found. In 2006, larger metal concentrations were found only in 2 stations out of total 24 examined stations (Obelė River near Voskoniai and Nevėžis River above Raudondvaris). In 2007, the recorded heavy metal concentration in bottom sediments was lower than in 2004–2006. In 2008, out of 12 examined areas, the metal concentration was higher in 3 stations (Venta River below Mažeikiai, Nemunėlis River near Tabokinė and Mūša River below Saločiai).

Based on the results of research of bottom sediments of 2009, same as in 2007, the concentration of heavy metals was low and very high concentration of heavy metals was not found in any place. In 2010, the research of river bottom sediments was not performed.

*The results of projects of hazardous substances.* The project "Establishment of Substances Hazardous to Water Environment in Lithuania" was performed in 2005–2007, in order to establish the actual situation on the concentration of hazardous substances in the main sources of pollution (wastewater treatment facilities of 25 cities) and environment (15 transboundary river stations and 4 areas of the Curonian Lagoon). The project was implemented by the Environmental Protection Agency in cooperation with the Finnish Environment Institute, Baltic Environmental Forum and Environment Protection Policy Centre. In the course of this project, the following hazardous substances and their groups were examined: metals, phenols and their ethoxylates, phthalates, organic tin compounds, brominated diphenylethers, chlorinated paraffins, polycyclic aromatic hydrocarbons, volatile organic compounds, chlororganic pesticides, pentachlorophenol, chlorpyrifos, cyanides and absorbed organic halogens.

The results of research of hazardous substances revealed that phthalates and organic tin compounds were detected in all examined mediums (wastewater, wastewater sludge, surface waters and bottom sediments), and their concentration usually exceeded the EQS limit. Nonylphenols, octylphenols, and their ethoxylates were detected in many examined wastewater and sludge samples. In many cases, the metal concentration did not exceed the EQS limit in surface waters and wastewater, except for zinc and copper, large concentration of which was recorded in wastewater. The concentration of polycyclic aromatic hydrocarbons was usually significantly below the EQS limit in all tested mediums, except for anthracene, the concentration of which in one case exceeded the EQS limit in the wastewater. Volatile organic compounds were usually not found at all or their concentration was very low. Chlorinated pesticides were not found except for one-time detection of hexachlorobenzene in sediments. Pentachlorophenol was detected in sludge only in one case, whereas absorbed organic halogens were found once in surface waters and sediments. Chloroalkanes, chlorpyrifos and cyanides were not found in any monitoring station. Brominated diphenyl ethers could not be evaluated, because the limits of establishment of applied research method were above the EQS limit.

The Project on Control of Hazardous Substances in the Baltic Sea region (COHIBA) was run in 2009–2011, in order to identify the sources of substances hazardous to the Baltic Sea and establish the limit values of such substances in the wastewater. The project was implemented by the Environmental Safety Agency, the Institute of Botanic and the Baltic Environmental Forum. In the course of project, research was performed in 6 places located in Western Lithuania: in two urban wastewater treatment facilities, two industrial wastewater treatment facilities and one discharger of run-off water and one leachate of landfill site. During this project, 11 Baltic Sea-relevant hazardous substances and their groups were analysed: organic tin compounds, brominated diphenyl ethers, perfluorinated compounds, hexabromocyclododecane isomers (HBDC), phenols and their ethoxylates, cadmium, mercury, endosulfan, chloroalkanes, dioxins.

The results of research of samples taken under the project showed that concentration of cadmium in the samples of wastewater and landfill leachate, and the concentration of mercury in wastewater, landfill site leachate and rainwater was low in the majority of cases. Out of 8 examined organic tin compounds, monobutyltin (MBT) was detected in all samples, dibutyltin (DBT) – in wastewater, monooctyltin (MOT) – once in landfill site leachate, concentration of other organic tin compounds were below the limit of quantification. Nonylphenols and their ethoxylates were detected in all examined mediums, whereas octylphenols were found only in two samples of wastewater. Perfluorinated compounds were detected in many examined areas. Short-chain (SCCP) and medium-chain (MCCP) chloroalkanes were detected in all samples. Pesticides (endosulfan and HBDC), majority of dioxins and their compounds, brominated diphenyl ethers were found below the limit of quantification. In the course of project, the majority of examined substances were found in the wastewater; however, their concentration did not exceed the EQS limit.

The project "Baltic Actions for the Reduction of Pollution of the Baltic Sea from Priority Hazardous Substances" was conducted in 2009–2011, in order to examine the spread of hazardous substances included in the WFD and Helsinki Convention in the environment and to establish the sources of pollution, in order to take respective actions further to the obtained results. The Project was performed by the Environmental Protection Agency in cooperation with the Baltic Environmental Forum and Environment Engineering Institute of the Kaunas University of Technology. In the course of project, the samples were taken from 86 various industrial, commercial objects, landfill filtrate, domestic wastewater in residential areas. 321 samples of industrial and manufacturing wastewater, 15 samples of surface wastewater and 15 samples of sludge were taken, the following hazardous substances and their groups were analysed: phenols and their ethoxylates, phthalates, organic tin compounds, brominated diphenyl ethers, perfluorinated compounds, hexabromocyclododecane and chloroalkanes.

The results of researches showed that organic tin compounds were detected in wastewater of various fields of industry, and the exceeding of the EQS limit was recorded in some samples. Phenols and their ethoxylates were detected in the wastewater of various fields of industry and wastewater treatment facilities, landfill site filtrate, households, wastewater of shopping centres and surface wastewater; however, their concentration did not exceed the EQS limit. Phthalates were mostly found in various wastewater discharged by various fields of industry, and, in certain cases, the exceeding of the EQS limit was recorded. Brominated diphenyl ether and hexabromocyclododecane were found in the wastewater of many fields of industry; however, the concentration did not exceed the established EQS limit. Short-chain 10-13 chloroalkanes were detected in several locations and their concentration exceeded the ESQ limit. The medium-chain 14-17 chloroalkanes were detected in the samples of nearly all industry fields. Perfluorinated compounds were found only in individual cases – in industrial wastewater and landfill sites filtrate.

By summarising the results of research of hazardous substances based on both the State Monitoring Surface Waters for 2004–2011 and projects, one may status that the most relevant hazardous substances the concentration of which exceeded the EQS limit in surface waters and wastewater discharged into the natural environment and/or wastewater supply were the following: tributyltin compounds (TBT), phthalates (DEHP), c10-13 chloroalkanes (SCCP). Furthermore, nonylphenols and their ethoxylates, octylphenols and their ethoxylates, brominated diphenyl ethers and organic tin compounds (MBT, DBT, MOT, DOT) are commonly found in the surface waters, industrial and municipal wastewater, however, their concentrations do not exceed the EQS limit.

## ECOLOGICAL STATUS OF RIVERS BASED ON THE INDICATORS OF BIOLOGICAL QUALITY ELEMENTS IN THE STATE MONITORING STATIONS

The ecological status of river is evaluated according to these biological quality elements: taxonomic composition, abundance and age structure of ichthyofauna and taxonomic composition and abundance of zoobenthos.

The index of assessment of ecological status of rivers based on the taxonomic composition, abundance and age structure of ichthyofauna is the Lithuanian Fish Index (hereinafter referred to as the LFI). Further to the annual average value of the LFI, a certain water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

Based on the State Environmental Monitoring Programme, the researches of ichthyofauna commenced in 2005. The ecological status of rivers based on the LFI index started to be evaluated from 2007, after the entry into force of the Lithuanian Environmental Protection Normative Document LAND-85–2007 "Methodology of Calculation of Lithuanian Fish Index" (Official Gazette, 2007, No 47-1812, 2011, No 16-760) and the Methodology of Establishment of the Status of Surface Water Bodies (Official Gazette, 2007, No 47-1814, 2010, No 29-1363), and from 2010, the criteria of establishment of the ecological status by LFI have changed. Since the requirements of legal acts regulating the evaluation system according to the fish indicators have changed during the discussed period, the criteria of the classes of ecological status of river also changed. Therefore, the overview does not include the assessment of ecological status of rivers and trends of its variation in terms of LFI index during the period from 2004 to 2011.

The index of assessment of the ecological status of river based on the taxonomic composition and abundance of zoobenthos is the Danish Steam Fauna Index (hereinafter referred to as the DSFI). Based on the average annual value of the ecological quality ratio of the DSFI (hereinafter referred to as the EQR), the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

Assessment of the ecological status of rivers based on the DSFI index commenced on 2006. In 2004–2005, the status of rivers based on zoobenthos was evaluated according to the biotic (Trent) index, and also the RAO (relative amount of oligochaete) was used as an additional index.

In 2006, the national monitoring, which included the research of zoobenthos, was performed in 394 river monitoring stations. It has been recorded that based on the DSFI EQR 22% of examined river stations were of high ecological status, 21% – of good, 44% – of moderate, 10% – of poor and 3% of bad ecological status. In 2007, 391 river stations were examined, 15% of which were of high ecological status, 17% – of good, 46% – of moderate, 18% – of poor and 4% of bad ecological status.

In 2008, out of 181 examined river stations 32% were of high ecological status, 28% – of good, 35% – of moderate, 4% – of poor and 1% of bad ecological status. Bad status was determined in only one monitoring area – Nemunas River near Pagėgiai.

In 2009, out of 183 examined river stations, 41% were of high ecological status, 24% – of good, 27% – of moderate, 6% – of poor and 2% of bad ecological status.

In 2010, 172 river stations were examined. It was recorded that 30% of monitoring stations were of high ecological status, 34% – of good, 31% – of moderate, 5% – of poor ecological status. There were no river stations of bad ecological status recorded in 2010.

In 2011, a higher percentage of examined river stations (as compared with 2010) with high and good ecological status was recorded and the number of rivers of bad and poor status did not change – accounted for 5% both in 2010 and in 2011.

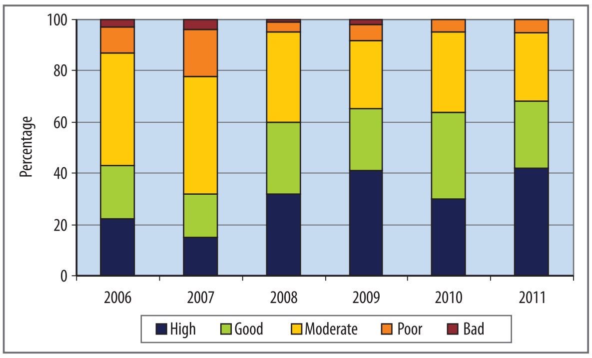


**Fig. 85.** Number (percentage) of river monitoring stations by DSFI EQR values, 2006–2011. *Source: Environmental Protection Agency*

## COMPLIANCE OF THE QUALITY OF LAKE WATERS WITH THE QUALITY NORMS IN THE STATE MONITORING STATIONS BASED ON THE AVERAGE ANNUAL VALUES OF TOTAL PHOSPHORUS AND TOTAL NITROGEN

The ecological status of lakes and reservoirs is evaluated by the indicators of physico-chemical quality elements: total nitrogen (Nt) and total phosphorus (Pt). Based on the annual average value of each indicator of surface water layer, the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

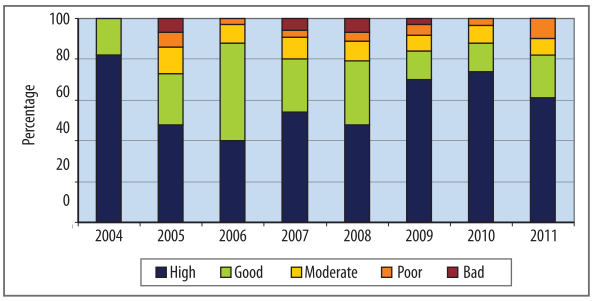


**Fig. 86.** Compliance of the quality of lake and reservoir waters with the requirements of quality in state monitoring stations based on the average annual concentrations of total phosphorus, 2004–2011. *Source: Environmental Protection Agency*

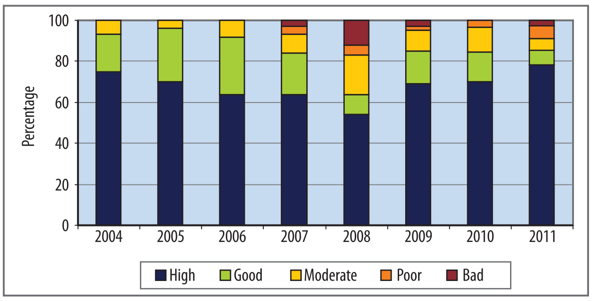


**Fig. 87.** Compliance of the quality of lakes and reservoir waters with the requirements of quality in state monitoring stations based on the average annual concentrations of total nitrogen, 2004–2011. *Source: Environmental Protection Agency*

During the period from 2004 to 2011, in terms of total phosphorus (Pt), approx. 84% of examined lakes and reservoirs met the requirements of high and good ecological status. In 2004, all examined lakes and reservoirs met the requirements of high and good status, however, one should note that, in 2004, the national monitoring of lakes was performed in 16 water bodies only. The majority of lakes not meeting the requirements of high and good ecological status were recorded in 2005, when even 26% of all examined water bodies were of moderate, poor or bad ecological status. In 2006–2011, high and good ecological status was determined for 79–89% of all examined water bodies.

Based on the total nitrogen (Nt), approx. 82% of lakes and reservoirs that were examined during the period from 2004 to 2011 have met the requirements of high or good ecological status. In 2004–2006, no water bodies of bad or poor ecological status were recorded. The majority of lakes and reservoirs of bad or poor ecological status were recorded in 2008 (15% of all examined water bodies). In the recent years, such lakes account for 3–4% of the overall number of examined lakes.

## ECOLOGICAL STATUS OF LAKE AND RESERVOIR WATERS BASED ON THE INDICATORS OF BIOLOGICAL QUALITY ELEMENTS IN STATE MONITORING STATIONS

Ecological status of lakes and reservoirs is evaluated according to the biological quality element – indicator describing the taxonomic composition, abundance and biomass of phytoplankton – the average annual value and maximum value of chlorophyll a. Based on the average of ecological quality relation (hereinafter referred to as the EQR) of the average annual value and the EQR of the maximum value of this indicator, the water body is attributed to one of the five classes of ecological status: high, good, moderate, poor and bad.

In 2005, in the course of performance of the National Environmental Monitoring, 27 lakes and reservoirs were examined. In terms of chlorophyll *a* 18% of them were of high, 30% – of good and moderate, 11% – of poor and bad ecological status.

25 water bodies were measured in 2006, 12% of which were of high ecological status, 44% – of good, 28% – of moderate, 16% – of bad ecological status.

In 2007, out of 70 examined river stations, 18% were of high ecological status, 33% – of good, 37% – of moderate, 9% – of poor and 3% of bad ecological status.

73 water bodies were measured in 2008, 14% of which were of high, 29% – of good, 40% – of moderate, 12% – of poor and 5% of bad ecological status.

70 water bodies were examined in 2009, 35% of which were of high, 27% – of good, 24% – of moderate, 8% of poor and 6% of bad ecological status. Bad ecological status was recorded in Grūdas, Širvys, Spenglas lakes and Paupys reservoir, whereas poor ecological status was recorded in Alsakis, Lielukas, Paežerys, Paršežerys lakes and Jurbarkai reservoir.

In 2010, during the national monitoring, chlorophyll *a* was examined in 61 water bodies, 18% of which were of high ecological status based on chlorophyll a, 29% – of good, 25% – of moderate, 10% – of poor and as much as 18% – of bad ecological status.

In 2011, chlorophyll *a* was examined in 70 water bodies, 17% of which were of high ecological status, 31% – of good, 26% – of moderate, 16% – of poor and 10% – of bad ecological status.

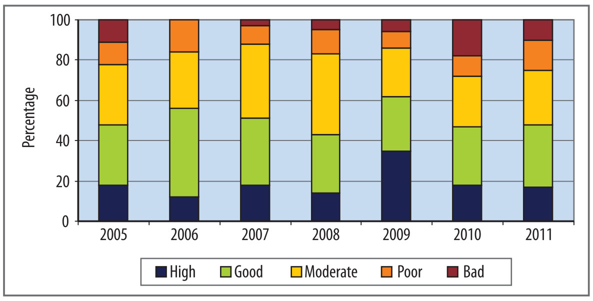


**Fig. 88.** Number (percentage) of lake and reservoir monitoring stations by the average of the EQR of the average annual value and EQR of the maximum value of chlorophyll a, 2005–2011. *Source: Environmental Protection Agency*

When summarising the results of researches of the status of lakes and reservoirs by the indicator of taxonomic composition, abundance and biomass of phytoplankton, it was recorded that, in 2005–2011, the values of chlorophyll *a* met the criteria of good status in approx. half of examined lakes and reservoirs.

Since the Lithuania's accession to the European Union, the environmental attention on the improvement of the status of surface water bodies has increased significantly. The data of annual monitoring of Lithuanian surface water bodies shows that the ecological status of national water bodies has not been deteriorating since 2004 and in many cases it was even improving. It is associated with the environmental measures implemented in agriculture, industry and management of urban wastewater treatment facilities. Although the status of the majority of Lithuanian surface water bodies is considered as good and high, in order to achieve this status in all national rivers and lakes, heavily modified and artificial water bodies and related ecosystems, one should continue the reduction of point and diffuse pollution of water bodies.

## ABSTRACTION AND USE OF SURFACE WATER

In Lithuania, the use of surface water mostly is strongly influenced by the energy needs of the state, which use 97-98% of the total abstracted surface water. Fisheries sector uses up to 2% and industry – only up to 1% of the overall amount of abstracted surface water.

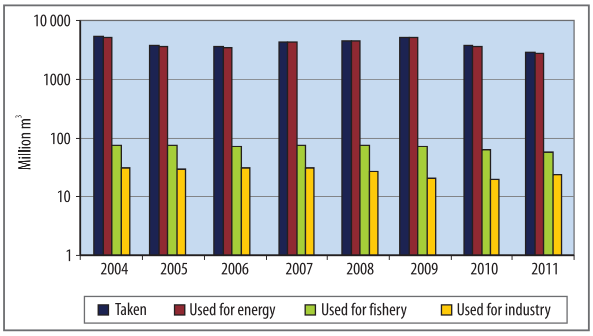


**Fig. 89.** Abstraction and use of surface water, 2004–2011. *Source: Environmental Protection Agency*

In 2004, the total amount of abstracted surface water was 5,293.1 million $m^3$. The energy sector used 5,183.8 million $m^3$ of water, 58% of which was used for the cooling needs of Ignalina NPP and nearly 42% used by Kruonis HPP. Fisheries sector used 74.5 million $m^3$, industry – 30 million $m^3$ of water in 2004. In 2005, 3,759.1 million $m^3$ of surface water was abstracted from the environment, i.e., 1,534 million $m^3$ less than in 2004 (State of Environment, 2005). The decrease of the amount of abstracted surface water was conditioned by the decommissioning of the 1st energy block of Ignalina Nuclear Power Plant, however, in 2005, same as in 2004, Ignalina NPP remained the largest user of surface water, using 49% of the total amount of abstracted surface water. In 2006, 3,611 million $m^3$ of surface water was abstracted from the environment, i.e., 148.1 million $m^3$ less than in 2005 (State of Environment, 2006). In 2006, the repair works were performed in Ignalina NPP; therefore, it required a lower amount of surface water. The highest amount of water was used by Kruonis HPP – more than 47% of the total abstracted surface water. During the period from 2007 to 2009, due to the increased volume of production by Kruonis HPP, Ignalina NPP and Lithuanian Electric Power Plant, the use of the surface water increased annually and reached 5,219.8 million $m^3$ in 2009, i.e., increased by 45%.

Statistically, in 2004–2009, there were two leaders in the area of water use in Lithuania: Ignalina NPP and Kruonis HPP. The amount of surface water used for the needs of fisheries sector was varying only minimally in 2004–2009. In the industry sector, the use of surface water did not change from 2004 to 2007 and only during the years of 2008–2009, it decreased by as much as 33.4% as a consequence of the economic recession which has brought substantial decrease in production volumes of the industry sector.

In 2010, 3,721.7 million $m^3$ of surface water was abstracted from the environment, i.e., by 1,498.1 million $m^3$ less than in 2009 (State of Environment, 2010). The decrease in the amount of abstracted surface water by 29% was conditioned by the decommissioning of Ignalina NPP. The amount of surface water used by fisheries sector decreased by 15% (as compared with 2009). In the industry sector, the amount of used surface water showed almost no changes (as compared with 2009) and reached approx. 20 million $m^3$. In 2011, due to reduced electricity production by Kruonis HPP and Lithuanian EPP, the use of surface water decreased by only 2863.7 million $m^3$.

When summarising the results of 2004–2011, the trend of reduction in abstraction of surface water became more obvious. When comparing 2004 with 2011, the abstraction of surface water decreased by 46%. The amount of surface water used for energy needs also decreased by 46%, for fisheries sector – by 21% and for the industry sector – by 21%. When forecasting the future needs of surface water, it is necessary to assess the possible construction of new nuclear power plant and it operation for the next decade.

## AMOUNTS OF POLLUTANTS DISCHARGED TO WATER BODIES FROM THE POINT POLLUTION SOURCES

The data on amounts of substances which are polluting water bodies are collected by the annual statistical reports submitted by companies. The information is evaluated only according to those economic entities, which must provide the reports of statistical data on the pollutants discharged into surface water bodies. The amount of pollutants discharged into surface waters with wastewater was gradually decreasing during the entire 2004–2011 period.

In the years of 2009–2011, the main pollutants reached their lowest values since 2004 (see figure). Comparing data of 2011 and 2004, it was recorded that $BOD_7$ decreased by 48%, suspended solids – by 25%, total nitrogen – by 33%, total phosphorus – by 59%, oil and its products – by 36%. The decrease of the amount of discharged pollutants was by large part attributed to the increased effectiveness of wastewater treatment facilities.

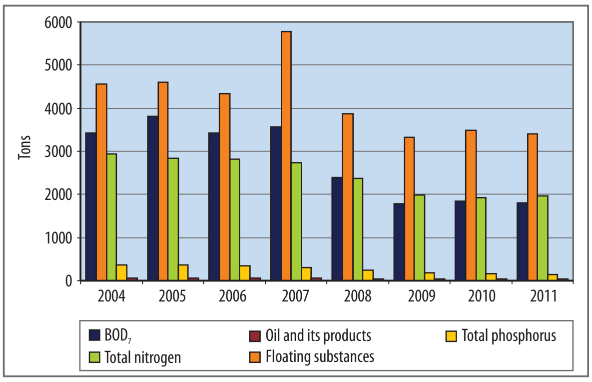


**Fig. 90.** Annual amounts of discharge pollutants to water bodies from point pollution sources, 2004–2011. *Source: Environmental Protection Agency*

## IMPACT OF DIFFUSE POLLUTION ON SURFACE WATER BODIES

Fertilisers, pesticides, livestock manure used in agriculture, as well as rain and snow melt water not passing to treatment facilities are attributed to the sources of diffuse pollution. Diffuse pollution is mostly relevant to the Central and North Lithuania, where the largest agricultural lands are located. After the Republic of Lithuania joined the European Union, the agricultural production decreased in Lithuania, less fertilisers; pesticides were used as well as the number of livestock reduced. In 2004, when comparing the sources of diffuse and point pollution, it was recorded that nitrogen compounds and suspended solid usually pass from diffuse pollution sources, whereas larger amounts of phosphorus, organic substances ($BOD_7$) – from point pollution sources (State of Environment, 2004).

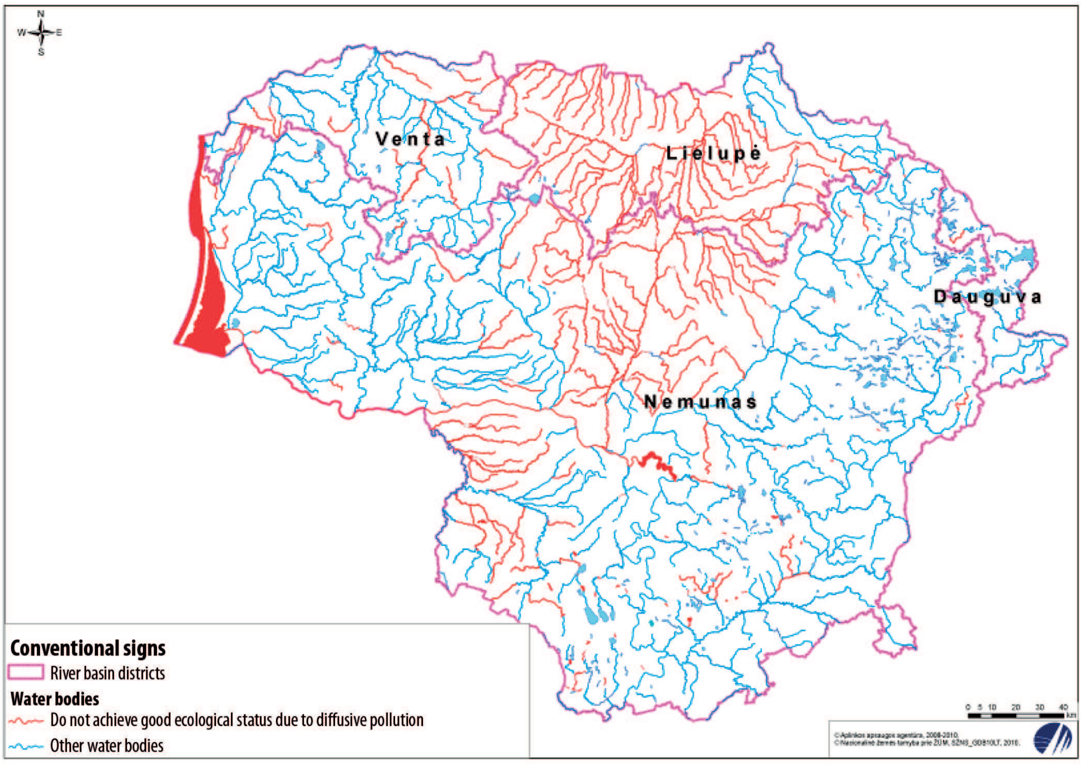


**Fig. 91.** Areas of impact of diffuse pollution on water bodies. *Source: Environmental Protection Agency*

The water from 75% of Lithuania's territory inflows into the Curonian Lagoon. In the recent decades, the increase in the diffuse pollution was conditioned by large amounts of nutrients (nitrogen, phosphorus) flowing to Nemunas and other rivers with precipitation from various sources of pollution (Lithuania's Natural Environment, State, Processes and Development, 2008).

The assessment of the diffuse pollution is facilitated by the data of long-term researches of nitrogen and phosphorus in rivers, transitional and coastal waters, tendencies of long-term variation. In 2004–2011, the maximum concentration of nutrients was recorded in the central area of the Curonian Lagoon (Nemunas Delta), indicating that the majority of them are carried by rivers. When summarising the results of researches of 2004–2011, it is possible to status that diffuse pollutions appear in transitional and coastal waters due to economic activity performed in the water body itself (marine transport, landfilling of soil excavated in the port, etc.) and due to pollution brought from terrestrial rivers by water/atmosphere. Polluting substances that pass by Nemunas River from the diffuse pollution sources to the Curonian Lagoon are the main reason of eutrophication of the Curonian Lagoon. Approx. 98% of all waters are brought to the Lagoon by Nemunas; therefore, the quality of the water of the Curonian Lagoon directly depends on the quality of water of Nemunas River basin. Approx. 60% of the territory of Nemunas River basin is used for agriculture, and approx. 30% of the area is composed of arable land. The agriculture sector is not developed in the seaside and Minija River basins in the shortest distance to the transitional and coastal waters, because tourism and recreation has much higher potential here. The agrarian farming is most intensive in Šilutė region. The amount of pollutants passing to the Lagoon from the Kaliningrad region is unknown; however, pursuant to the amounts of basin and population, it can be evaluated as 5–20% of the load from Lithuania. The results of the long-term research show that not all amounts of nitrogen and phosphorus discharged to the Curonian Lagoon pass to the coastal area of the Baltic Sea. A certain share of the passing amount is consumed by algae, fauna; another share passes to the bottom of the Lagoon. Furthermore, a lower amount of nitrogen passes from the lagoon to the coastal area due to denitrification process (reduction of nitrates into free atmospheric nitrogen in case of low amount of oxygen).

The report submitted by the Environmental Protection Agency (12/08/2011, Section "Management of River Basins") indicates that the major part of the diffuse pollution or pollution from unspecified sources is composed by the load from the agricultural activity. This includes the loads of the organic substances passing to the soil with livestock manure and mineral fertilisers, nitrogen and phosphorus compounds. The impact of agricultural activity on water bodies is different. The majority of water quality issues in surface water bodies are recorded in north, central and south-west basins of Mūša, Lielupė small inflows, Nevėžis, Dubysa and Šešupė rivers. Diffuse pollution from agricultural can account for 45–80% of the overall load of nitrogen pollution washed to water bodies. In Lithuania, out of 222 surface water bodies 1,177 do not meet the criteria of good ecological status due to diffuse pollution. This accounts for 19% of the total number of all water bodies.

## TREATMENT OF SURFACE RUNOFF WATER

In Lithuania, the focus was and continues to be the management of urban and industrial wastewater, whereas the quality of surface runoff water is not considered so relevant. For this reason the situation in this sector was changing insignificantly during the period from 2004 to 2011. When comparing data of 2011 and 2004, it was recorded that only 11% of wastewater was treated up to the established standards and discharged into environment, whereas as much as 88% of the discharged wastewater was untreated. In 2007 and 2010, due to high precipitation rate at the time, the total amount of discharged surface runoff water increased by 57 million $m^3$ in 2007 and 65.2 million $m^3$ in 2010.

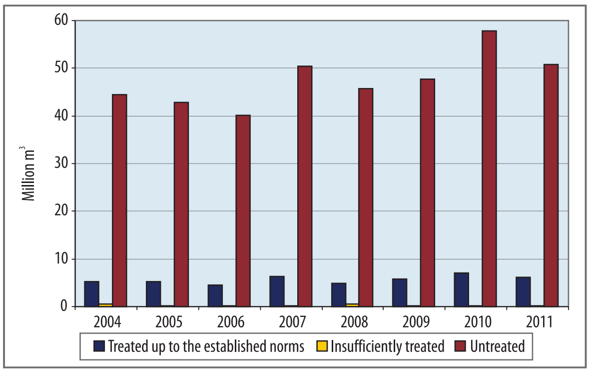


**Fig. 92.** Management of surface runoff water, 2004–2011. *Source: Environmental Protection Agency*

## TREATMENT OF URBAN AND INDUSTRIAL WASTEWATER

In 2004, the urban and industrial wastewater was treated in 713 treatment facilities in the Republic of Lithuania, 106.4 million $m^3$ of wastewater treated up to the established standards was discharged into surface water bodies, 64.8 million $m^3$ – insufficiently treated and 0.4 million $m^3$ – were discharged without treatment.

In 2005, 115.5 million $m^3$ of urban and industrial wastewater treated up to the established standards was discharged into surface waters – 8% more than in 2004, insufficiently treated – 56 million $m^3$, i.e., 14% less than in 2004, untreated – 0.7 million $m^3$, i.e., 85% more than in 2004. The latter indicator increased due to accidents in wastewater collection systems, increased amount of wastewater in cities, where it was discharged untreated.

In 2006, approx. 164.9 million $m^3$ of urban and industrial wastewater was discharged into surface water bodies – approx. 6.8 million $m^3$ less than in 2005. 110.7 million $m^3$ of wastewater was treated up to the established standards (4.4 million $m^3$ less than in 2005), insufficiently treated – 53.6 million $m^3$ (2.3 million $m^3$ less than in 2005), untreated – 0.6 million $m^3$ (0.1 million $m^3$ less than in 2005). In 2008, approx. 175 million $m^3$ of treated urban and industrial wastewater were discharged into surface water bodies (State of Environment, 2008) - approx. 7% less than in 2007. In 2008, the ratio of wastewater treated up to the established standards, insufficiently treated and untreated wastewater amounted to respectively 72.4%, 27.3% and 0.3%. In 2008, as compared with 2007, the share of wastewater treated up to the established standards increased by 3.2% and the share of insufficiently treated wastewater decreased by the same amount. The improvement of the quality of wastewater was mostly conditioned by the new urban wastewater treatment facility in Kaunas, which was built in 2008. In 2010, 181.5 million $m^3$ of treated municipal and industrial wastewater was discharged into surface water bodies – 11.8 million $m^3$ more than in 2009 (State of Environment, 2010). The indicators of wastewater treatment were gradually improving in 2011 as well. The amount of wastewater treated up to the established standards reached 92.66%. The amount of insufficiently treated wastewater decreased, amounting to only 7.31% in 2011, and the amount of untreated urban and industrial wastewater remained – was as low as 0.03%.

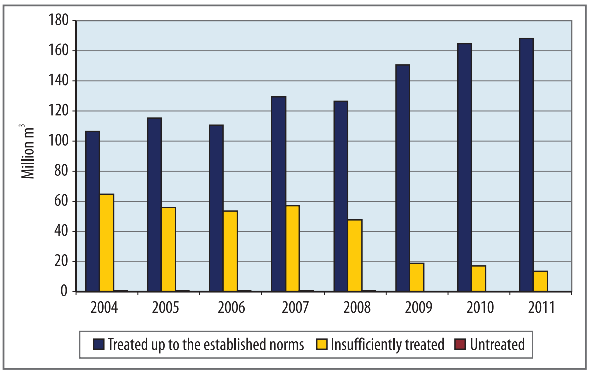


**Fig. 93.** Management of urban and industrial wastewater, 2004–2011. *Source: Environmental Protection Agency*

During the 2004–2011 period, the amount of untreated and insufficiently treated wastewater discharged into surface waters decreased, whereas the amount of wastewater treated up to the established standards increased. These improvements were made possible with the construction of new wastewater treatment facilities and the reconstruction of outdated systems.

## POLLUTION OF THE WATERS OF THE CURONIAN LAGOON AND THE BALTIC COASTAL WATERS

The share of the Curonian Lagoon and the area of spread of the Curonian Lagoon waters in the Baltic Sea falling into the territory of Lithuania are attributed to the category of transitional waters. The ecological status of transitional waters is evaluated according to the physico-chemical quality elements – total nitrogen and total phosphorus. Based on the annual average value of each indicator of surface water layer during the summer season (June-September), the water body is attributed to one of five classes of ecological status. Furthermore, the indicator of assessment of the ecological status of transitional water bodies based on the taxonomic composition, abundance and biomass of phytoplankton is the average summer value of chlorophyll a.

Lithuania has approx. 100 km of the coastline, its territorial and economic area waters account for 1.5% of the total area of the Baltic Sea. Lithuania owns 413 $km^2$ of the water area of the Curonian Lagoon – share of the central and northern part of the Curonian Lagoon with the state seaport established in the Klaipėda channel. In these waters, water pollution and eutrophication are usually observed. The water from 75% of Lithuania's territory inflows into the Curonian Lagoon. This is an eutrophied water body influencing the status of waters of the Baltic coastal area (Lithuania's Natural Environment, State, Processes and Development, 2008). The increasing biological productiveness is conditioned by large amounts of nutrients (nitrogen, phosphorus) passing with urban and settlement wastewater by Nemunas and other rivers from the atmospheric and other sources of pollution. Other specific pollution substances such as oil hydrocarbons and heavy metals enter the Curonian Lagoon and the Baltic Sea from various sources of pollution. The highest amount of such pollutants is recorded in the areas of technogenic impact: in Klaipėda Channel, where inevitable pollution occurs due to seaport activity, in waters of small ports, in sites, where the quality of water is conditioned by the discharged wastewater, etc. The very low concentrations of organochlorine pesticides, such as DDT and HCH accumulating in water and bottom sediments, in biota are recorded due to prohibition of use of these substances several decades ago, the tendencies of the decrease in their amounts are observed. This indicates the elimination of these substances from the natural environment.

After analysis of the water salinity change, variation in water salinity in the Curonian Lagoon was identified; it was proved by the results of the biological researches. The discovery of plant *Chara baltica* of semi-saline waters near Bulvikas cape and Juodkrantė shows that high-salinity water has influence on the community of macrophytes in these areas.

Other changes of hydrobiocenoses that reflect the increase in salinity of the Lagoon can be recorded after longer period of time, therefore, the further observation and assessment of the flow of saline water to the Curonian lagoon and its influence on the status of Lagoon are necessary. The status of Lithuanian seaside area depends on the interaction of natural and anthropogenic factors.

## CONCENTRATION OF CHLOROPHYLL *a* IN THE CURONIAN LAGOON

The water quality of the Curonian Lagoon is conditioned by the municipal, industrial, surface (rain) wastewater, agriculture, navigation and other type of pollution as well as natural conditions. The water from 75% of the Lithuania's territory inflows into the Curonian Lagoon, draining 5.8% of the area of the Baltic Sea river basin (Lithuania's Natural Environment, State, Processes and Development, 2008). The nutrients passing to the Curonian Lagoon are used for the production of algae, while some parts of nutrients deposit to the bottom, therefore, the water passing from the Lagoon to the sea is of cleaner status. However, the Curonian Lagoon has a significant influence to the quality of the Baltic Sea coastal area, conditions the changes of ordinary natural background. Water blooming is observed in almost all territory of the Baltic Sea, mostly in the coastal areas, especially in lagoons, estuaries and districts within the closest distance to the sources of pollution. The amount of chlorophyll *a*, as the main pigment of the photosynthesis process, allows the evaluation of photosynthetic activity of algae and, thus, assessment of the trophicity level of the water body.

By the assessment based on the dynamics of chlorophyll *a*, in 2004–2010, the eutrophication processes of the Curonian Lagoon were unstable (State of Environment, 2005; State of Environment, 2006; State of Environment, 2008; State of Environment, 2010). In view of the obtained research results, from 2005, the decrease in the hypertrophic values was observed in the entire area of the Curonian Lagoon.

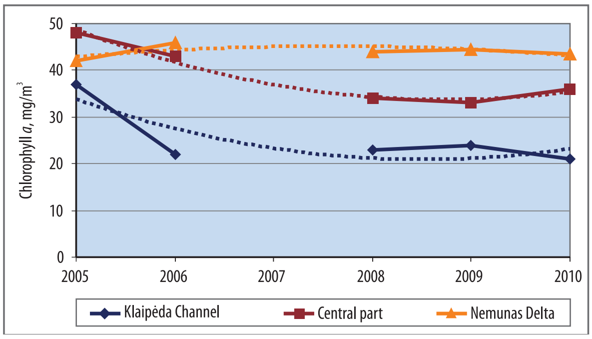


**Fig. 94.** Changes of chlorophyll *a* in the Curonian Lagoon, 2005–2010. *Source: Environmental Protection Agency*

In the Water Quality Improvement Programme of the Curonian Lagoon for 2006–2015, which was approved by the Government, the measures for the reduction of eutrophication of this water body have been implemented. In 2006, the largest amount of chlorophyll *a* was recorded in the Nemunas Delta (State of Environment, 2006). In July, it reached a level that is typical to the hypertrophic water bodies – 244.05 mg/m$^3$. Having compared the average amount of chlorophyll *a* in 2005 and 2006, it was recorded that it has decreased in the entire area of the Curonian Lagoon, mostly – in the Klaipėda channel water area (State of Environment, 2006). When comparing it with the previous year, it was noted that hyper-eutrophication has decreased in the overall area of the Curonian Lagoon from 2003. When comparing the average values of the amount of chlorophyll *a* of 2008 with the long-term averages (1994–2007), an insignificant increase of the amount of chlorophyll *a* was observed in the central part of the lagoon, whereas in the Klaipėda channel and northern part the decrease of the amount of chlorophyll *a* was observed. In 2008, the highest values of chlorophyll *a* were measured during the autumn season – in September (State of Environment, 2008). The maximum amount of chlorophyll *a* was recorded in the northern part of the Curonian Lagoon. Unlike in 2009, when the maximum concentration of chlorophyll *a* was measured in the Curonian Lagoon during the autumn season, in 2010, the maximum concentration of chlorophyll *a* was recorded during the summer season, in July, i.e., when the water is warmest in the lagoon and calm weather is prevailed (State of Environment, 2010). In early autumn, when the water temperature starts to decrease, the concentration of chlorophyll *a* is gradually decreasing in the lagoon water as well. When comparing the average value of concentration of chlorophyll *a* in 2010 with the long-term average (1994–2009) it becomes obvious that, in 2010, the concentration of chlorophyll *a* increased insignificantly.

## AMOUNT AND BIOMASS OF PHYTOPLANKTON IN THE CURONIAN LAGOON

Phytoplankton – microscopic algae and cyanobacteria – is one of the main components of water ecosystems. Based on the intensity of development of phytoplankton, it is possible to evaluate the ecological status of the water body. The intensive development of microalgae is usually observed in the Curonian Lagoon during summer (Lithuania's Natural Environment, State, Processes and Development, 2008). The summer species of phytoplankton usually vegetate in plankton from June to September, therefore, during these months "the water blooming" – the process related to the high biomass of these species – is observed in the Curonian Lagoon.

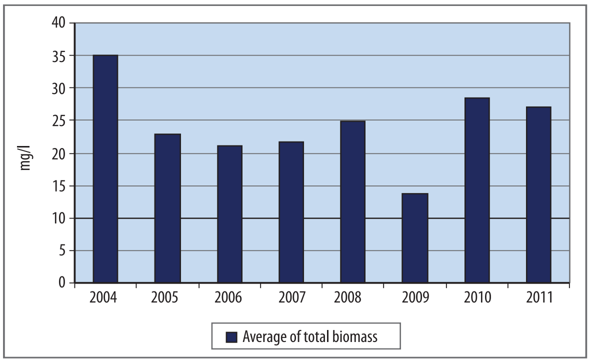


**Fig. 95.** Changes of the total biomass of summer phytoplankton in the Curonian Lagoon, 2004–2011. *Source: Environmental Protection Agency*

The ongoing eutrophication and related water blooming observed in the waters of the Curonian Lagoon indicate the intensive development of microscopic algae (phytoplankton).

Intensive development of algae usually starts in the August and continues until the early autumn. During the intensive vegetation period, more than 50% of the average biomass of phytoplankton composed potentially toxic species of blue algae Aphanizomenon flos-aquae. The long-term tendency of changes of the abundance of this species is decreasing, same as the total biomass of phytoplankton. The results of research performed during the period from 2004 to 2008 showed that the composition of phytoplankton is characterised by the abundance of toxic cyanobacteria species *Planktothrix agardhii*, the amount of which consists approx. 20% of the total biomass.

When summarising the changes of the total biomass of summer phytoplankton in the Curonian Lagoon recorded for 2004–2011, the significant decrease in the mass of phytoplankton from 2005 to 2007 was observed, the mass increased in 2008, and decreased again in 2009. When comparing the data of 2011 and 2004, it was recorded that the average of the total biomass of phytoplankton has decreased by 32.5% in 2011.

## CONCENTRATIONS OF NUTRIENTS IN THE BALTIC SEA AND THE CURONIAN LAGOON

The Baltic Sea is one of the most eutrophied seas; therefore, the assessment of the amount of biogenic substances (nitrogen and phosphorus compounds) is one of the most important parameters of quality (Lithuania's Natural Environment, State, Processes and Development, 2008). The coastal waters of the Baltic Sea are characterised by higher eutrophication because they are constantly supplemented with nutrients from the Curonian Lagoon, where the content of these substances is several times higher than in the sea. The annual amounts of biogenic substances depend on the weather conditions: in case of higher precipitation and more intense outflow of rivers, the higher amounts of these substances are eluted from the soil. In the publication "State of Environment, 2004", it is indicated that the majority of biogenic (nutrient) substances into Lithuanian coastal area pass with the water from Curonian Lagoon and by Šventoji River; therefore, the highest concentrations of nitrogen and phosphorus compounds were recorded near Klaipėda (the highest concentration of total phosphorus) and Šventoji (the highest concentration of total nitrogen). In 2004, the average annual value of total phosphorus in the Baltic Sea coastal water was 3.5 times lower than in the Curonian Lagoon, whereas in the winter of 2005 (State of Environment, 2005), the average concentration of total phosphorus exceeded the maximum permissible concentration (MAC) (0.1 mg/l) in the Curonian Lagoon near Nida. In the Baltic Sea coastal area, the concentration of total phosphorus was low – approx. three times lower than in the Curonian Lagoon, where, in the winter of 2005, it was the same as the average concentration of the recent decade. The average long-term concentration of total nitrogen in the Curonian Lagoon during the winter is 1.7 mg/l. The average concentration of the total nitrogen in the Baltic Sea coastal area in the winter of 2006 was 0.29 mg/l – by 5 times lower than in the Curonian Lagoon (State of Environment, 2006).

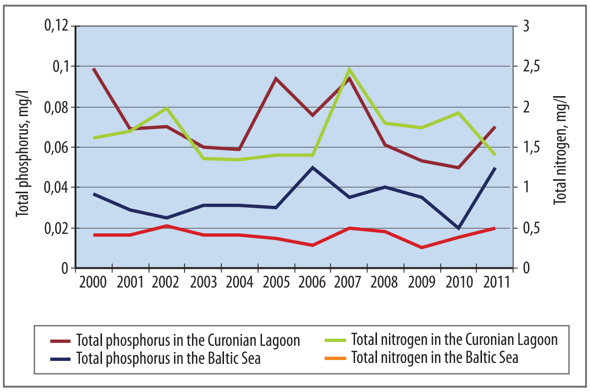


**Fig. 96.** Changes of the average concentrations of total phosphorus and total nitrogen in the Curonian Lagoon and the Baltic Sea, 2000–2011. *Source: Environmental Protection Agency*

The average long-term concentration of the total phosphorus in the Curonian Lagoon in winter is 0.086 mg/l, whereas in 2006 it was 0.076 mg/l. In the Baltic Sea coastal area, the concentration of the total phosphorus is low – by 2–3 times lower than in the Curonian Lagoon. In winter of 2006, in the course of the performed tests because of the impact of meteorological conditions (the thickness of water mixed by heavy winds), the average concentration of total phosphorus was 0.05 mg/l in the coastal areas – by approx. 1.5 times higher than the average concentration in the recent decade (0.033 mg/l). In winter of 2008, the average total nitrogen concentration (1.8 mg/l) in the Curonian Lagoon was equal to the average long-term winter concentration (State of Environment, 2008).

During the winter season, the average concentration of total nitrogen (0.45 mg/l) was 4 times lower in the Baltic Sea coastal area than in the Curonian Lagoon and close to the average annual (0.47 mg/l). The dynamics of variation of concentration of total nitrogen in the Curonian Lagoon shows that the amount of nitrogen compounds is decreasing and the quality of water is improving. As already mentioned, the average long-term concentration of total phosphorus amounts to 0.086 mg/l in the Curonian Lagoon in winter, however, in 2008, it amounted to only 0.061 mg/l. In the Baltic Sea coastal area, the concentration of total phosphorus was lower than in the Curonian Lagoon – during the research performed in winters of 2007 and 2008, in the Baltic Sea coastal area, the average concentration of total phosphorus was 0.035 and 0.04 mg/l, respectively, i.e., close to the average concentration of the past decade (0.033 mg/l).

In 2010 (State of Environment, 2010), during the period of later autumn, the concentration of total phosphorus amounted to 0.046 mg/l in the Curonian Lagoon, i.e., it was slightly lower than the average concentration of winter of the last 10 years (0.075 mg/l). At the same time, the concentration of the total phosphorus (0.018 mg/l) was by 2.5 times lower in the Baltic Sea coastal area than in the Curonian Lagoon and 1.6 times lower than the average long-term concentration of the winter period. In late autumn of 2010, the concentration of total nitrogen amounted to 1.92 mg/l in the Curonian Lagoon and was close to the average long-term winter concentration of the past decade (1.7 mg/l). At the same time, the average concentration of total nitrogen amounted to 0.38 mg/l in the Baltic Sea coastal area, i.e., was approx. 5 times lower than in the Curonian Lagoon, but close to the average long-term winter concentration of the past decade (0.42 mg/l). As compared with winter 2009, in 2010, the concentration of total phosphorus was decreasing in the Curonian Lagoon and the Baltic Sea coastal area, whereas the concentration of total nitrogen was slightly increasing. In 2010, the concentration of total nitrogen recorded in the Baltic Sea was higher than in 2009. It shows that the impact of diffuse pollution on the status of water bodies remains significant still.

When summarising the results obtained in 2004–2011, it is possible to status that no essential tendencies of the changes of average concentrations of total phosphorus and total nitrogen were observed.

## POLLUTION INFLOW INTO THE CURONIAN LAGOON

The maximum accumulations of nutrients are usually recorded in the central area of the Curonian Lagoon (Nemunas Delta), indicating that the majority of them are carried by rivers. The data of researches of 2004–2011 shows the gradual tendency of decrease in the BOD7 level. A clear decrease in the phosphorus inflow was observed during the period from 2004 to 2005, whereas during the period from 2005 to 2011 the situation remained stable. The decrease of the amount of phosphorus can be associated with the newly built or updated current wastewater treatment facilities in the cities that discharge their waste to the Nemunas River basin (State of Environment, 2005). The inflow of total nitrogen used to vary without any clear trend during the period from 2004 to 2011. Since the major part of pollution with nitrogen is composed by the agricultural pollution, these changes can show the insufficiently effective applied measures of reduction of diffuse pollution and agriculture.

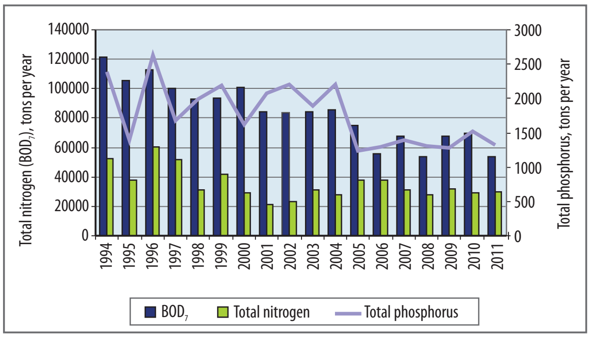


**Fig. 97.** Pollution inflow into the Curonian Lagoon (tons/year), 1994–2011 (loads are normalised in accordance with the method recommended by HELCOM). *Source: Environmental Protection Agency*

## WATER SALINITY IN THE CURONIAN LAGOON AND THE BALTIC SEA

Each year, the impact of the fresh waters flowing from the Curonian Lagoon on the Baltic coastal zone coastal area is usually observed in Klaipėda Channel and near Palanga due to dominating carriage of water masses from south to north. In the Baltic Sea coastal area near Nida the impact of fresh water has not been recorded during the period of researches (State of Environment, 2004).

In 2005, as compared with the previous year, the average annual salinity was lower in Klaipėda Channel and the Curonian Lagoon, and higher in the Baltic Sea coastal area near Nida and Palanga (State of Environment, 2005). In spring, as usual, the salinity of water decreased in the Curonian Lagoon and the Baltic coastal area due to increased load of fresh river waters. The hydrometeorological conditions with domination of still and low-windy weathers conditioned lower water level as compared with the lagoon. Therefore, there were no favourable conditions for the seawater to pass to the lagoon. The sea water having considerable influence on the salinity of water of the Curonian Lagoon was observed near Juodkrantė in May and August, 2006 (State of Environment, 2006). Due to prolonged warm weather and decrease in the precipitation rate, the water level of the lagoon has dropped; therefore, saline water was coming from the Baltic Sea during the entire warm season. In 2006, in the Curonian Lagoon near Nida, the changes of water salinity were not observed, because still and low-windy weathers did not form favourable conditions for the passage of saline water deep to the lagoon towards Nida. The impact of the fresh water coming from the Curonian Lagoon on the coastal area was mostly observed near Klaipėda and near Palanga due to dominating water carriage from south to north. In the Baltic coastal area near Nida, the impact of fresh waters was not recorded. Here, the changes of water salinity were minimum in the recent years. In 2008, the values of salinity in the Baltic Sea were not different from the former ones and were characterised by low variation in the recent years (State of Environment, 2008). In the coastal area, in spring (March, April), when outflow of lagoon water to the sea is dominating, fresh water is mixed with sea water and this results in the increase of salinity. However, during other seasons, the saline sea water usually passes through the Klaipėda Channel into the Lagoon and usually reaches Juodkrantė. In July, August and November, the average value of salinity varied from 3 to more than 4 parts per thousand near Juodkrantė. Values of salinity above 5 parts per thousand were observed near Juodkrantė for 62 days. In 2007, there were 27 such days. Low salinity water (0.5-5 part per thousand) was observed for 94 days in 2008 and for 54 days in 2007. Changes of salinity were not observed near Nida and Ventė. In 2009, in the northern part of the Curonian Lagoon, the values lower than the water salinity of 2008 were observed. According to the data of the Juodkrantė hydrometeorological station of 2009, the values of salinity exceeded 0.5 parts per thousand for 113 days per year, for 26 days the salinity was exceeding 5 parts per thousand. In 2008, the number of days with salinity being >0.5 parts per thousand amounted to 156, where 62 days were characterised by saline water >5 parts per thousand. In 2009, the salinity of the Baltic Sea water was the same as long-term variations. Near Nida, the annual average value of water salinity was 7.0 parts per thousand.

The maximum salinity was observed in September and amounted to 7.4 parts per thousand, whereas the least – in March – 6.0 parts per thousand. In 2010, in the Curonian Lagoon, the average values of water salinity by 32-68% lower than the long-term ones were observed (State of Environment, 2010). The maximum change of salinity was recorded in Juodkrantė. In 2010, the average annual salinity amounted to 0.38 parts per thousand in Juodkrantė, whereas the average long-term value amounted to 1.2 parts per thousand. According to the data of Juodkrantė hydrometeorological station of 2010, the values of salinity were lower than 0.5 part per thousand for 293 days per year, whereas in 2009, the number of such days amounted to 113. As compared with the long-term variations, in 2011, the salinity of the Baltic Sea water was not characterised by any changes. Heavy impact of fresh waters coming from the Curonian Lagoon was not recorded in Klaipėda Channel or near Palanga in 2011. The salinity was significantly lower than in previous year only in the Curonian Lagoon near Nida.

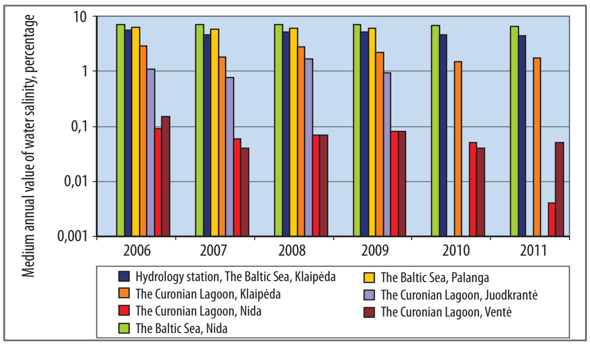


**Fig. 98.** Changes of water salinity in the Curonian Lagoon and the Baltic Sea coastal area, 2006–2011. *Source: Environmental Protection Agency*

When summarising the results of 2004–2011, one may state that the salinity was varying insignificantly in each area of researches, therefore, it is too early to make unequivocal statements that the changes have a significant influence on the euryhaline processes in the Curonian Lagoon.

## CONCENTRATIONS OF OIL HYDROCARBONS IN THE BALTIC SEA

Transportation of oil and its products in the Klaipėda seaport and Būtingė terminal, intensive navigation and accidental spill-out of oil-contaminated waters absorbed with oil to the open sea, seaport deepening works and sinking of contaminated soils in the coastal waters, oil extraction performed by the neighbouring country in the frontier zone of the Lithuanian territorial waters and accidents – the complex of these sources of pollution can cause a threat to the entire sea environment from plankton to any larger living organism. In 2004, the Melnragė-Smiltynė district located in the area of influence of seaport gate and heap water area was characterised by the maximum concentration of oil hydrocarbons (State of Environment, 2004).

The concentrations that episodically exceeded the MAC were recorded in the northern part of coastal area near Palanga and Būtingė. In 2004, Nida and Juodkrantė were the least contaminated areas, as well as the waters of districts located in the open sea. In 2005, the average concentrations of oil hydrocarbons varied from below the limit of quantification to above the MAC (State of Environment, 2005). The concentration of oil hydrocarbons exceeding the MAC was recorded in the waters of Būtingė terminal and heap water area. In 2005, unlike previously, the increased concentration of oil hydrocarbons was recorded in the open sea. The concentration of oil hydrocarbons exceeding the maximum permitted concentration was episodically recorded in the entire water area of the Baltic Sea falling into the territory of Lithuania in 2006 (State of Environment, 2006). The average concentration of oil hydrocarbons was moderate and did not reach the MAC. In 2006, the pollution with oil products was lower in the entire water area of the Baltic Sea as compared with 2005. The concentration of oil hydrocarbons varied insignificantly in the Baltic Sea waters in the past several years, however, the pollution with oil products was increasing in soil sinking area. In 2007, as compared with 2006, the pollution with oil products was higher in the entire Baltic Sea water area.

After the changes made to the methodology of measurement of concentration of oil hydrocarbons in the water in 2009, the concentration of oil hydrocarbons was, in many cases, below the limit of quantification in the Baltic Sea water (State of Environment, 2010). The concentration above the limit of quantification was observed in the Baltic Sea coastal area and soil sinking area during the winter season, as well as in autumn – in the Curonian Lagoon water spread area to the Baltic Sea coastal area. However, the average concentration of 2009 did not exceed the limit of quantification, while the current pollution is calculated according to the approved EU methodologies. When evaluating the long-term variation of concentration of oil hydrocarbons in the Baltic Sea, one may state that the variation was low in the recent years. In 2010, the concentration of oil hydrocarbons was below the limit of quantification in the Baltic Sea water. Pursuant to the data of monitoring, in 2011, the situation did not change as well.

When summarising the period from 2004 to 2011, the data of monitoring did not show any significant long-term changes, the concentrations of the majority of oil hydrocarbons did not exceed the limit of quantification, therefore, from the environmental perspective, the situation was stable and no significant possible sources of pollution with oil products were recorded so far.

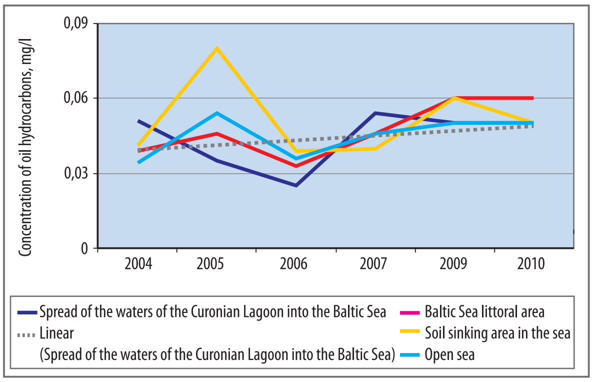


**Fig. 99.** Concentration of oil hydrocarbons in the Baltic Sea water in the research area, 2004–2010. *Source: Environmental Protection Agency*

## AVERAGE CONCENTRATIONS OF OIL HYDROCARBONS AND HEAVY METALS IN THE BOTTOM SEDIMENTS OF THE BALTIC SEA

The variation of concentrations of oil hydrocarbons in the Baltic Sea bottom sediments and its tendencies were monitoring in the surface layer of bottom sediments (1-2 cm) three times per year, during the period from 2004 to 2005 (State of Environment, 2005). The amount of oil hydrocarbons was stable in the Baltic Sea in the past decade. In 2005, its concentration in the bottom sediments was low – usually below the limit of quantification (5 mg/kg of dry weight). The amounts of oil hydrocarbons recorded in all regions did not exceed 20 mg/kg of dry weight, therefore, in terms of this indicator, such bottom sediments are attributed to the first (cleanest) class. The long-term research show that the pollution of Baltic Sea bottom sediments with mercury was decreasing in the entire water area. The pollution of bottom sediments of the Baltic Sea water area with mercury was very insignificant and close to the long-term concentration of mercury, which is typical to these water bodies, the mercury concentration did not exceed 0.1 mg/kg of dry weight in all samples, therefore in terms of this indicator the bottom sediments are also attributed to the first (cleanest) class.

In 2006, the pollution of the Baltic Sea bottom sediments with heavy metals (Pb, Ni, Cu, Zn, Cd, Hg, and Cr) was insignificant (State of Environment, 2006). Slightly higher concentrations of heavy metals were recorded in deap area; however, when examining the bottom sediments, none of the metal's concentration exceeded the limit values of the cleanest first class. In 2006, their concentration slightly increased, however, in all examined water areas the average concentration of oil hydrocarbons did not exceed 20 mg/kg of dry weight, therefore, such bottom sediments corresponded the cleanest – first class.

As mentioned before, the concentrations of oil hydrocarbons were rather stable in the Baltic Sea bottom sediments, however, in August of 2007, their concentration increased up to the level that was higher than the first class of contamination (20 mg/kg of dry weight). The limit value of the first class contamination was exceeded in the dredged material dumping area – the average concentration of oil hydrocarbons reached 30 mg/kg of dry weight in this area.

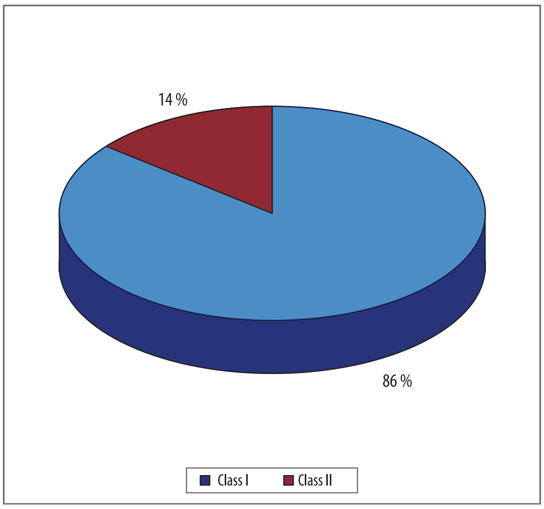


**Fig. 100.** Compliance of medium concentrations of oil hydrocarbons and heavy metals in the Baltic Sea water area bottom sediments with the classes, 2004–2010. *Source: Environmental Protection Agency*

In 2008, the pollution of the Baltic Sea bottom sediments with heavy metals (Hg, Pb, Cu, Cd, Zn, Ni, and Cr) were insignificant. Slightly higher concentration of heavy metals was recorded in the dumping area and open sea; however, when examining the bottom sediments, none of the metals had concentration that exceeded the limit value of contamination of soil of the cleanest first class. In 2010, the concentrations of oil hydrocarbons were below the limit of quantification in the bottom sediments of the Baltic Sea (State of Environment, 2010). Same as every year, the higher concentration of heavy metals in the bottom sediments was recorded in the dumping area in the sea. The amounts of copper (Cu), nickel (Ni) and zinc (Zn) were by several times higher in the bottom sediments of the latter water area than in other investigation sites.

## GROUNDWATER

In Lithuania, only the groundwater from watery layers of different age and lithological composition is used for the supply of drinking water. The layers of fresh groundwater used for the individual and central supply of drinking water to the residents are located in the depth from several meters (groundwater) to several hundred metres (confined). The layer of groundwater that stratifies in shallow depths is mostly used in rural settlements by extracting it in shaft (dug) wells. The confined (artesian) water stratifies in greater depths; therefore, it is usually of good quality and is used for the supply of water by extracting with individual bored wells (bores) and installing public water supply sites.

## BALANCE OF GROUNDWATER RESOURCES

Under the Lithuanian conditions, the main source of formation of fresh groundwater resources is precipitation, which passes to the groundwatery layer and then – to confined watery layers. Together with side load this accounts for a positive part of balance and refers to the dynamic resources of groundwater. This amount of water passing to the system is constantly outflowing – by a layer from the system margins, flows to rivers by filtrating through low permeable beds in outflow area and flows into the groundwatery layer. Under the natural conditions, both parts of the long-term balance of the groundwater resources are equal. When maintaining the groundwater, the natural hydrodynamic system is distorted. The share of outflowing stream is decreased, however, additional sources of groundwater emerge – usually the flow from watery layer of groundwater and surface water bodies' increases and flexible resources are formed in the system upon the decrease of pressure.

The analysis of situation of groundwater shows that the last decade was not characterised by favourable conditions for the replenishment of groundwater resources. From 2000, the level of groundwater was above the average long-term level only in some years. The level of natural "programmed" level of groundwater of dry (non-watery) year was additionally affected by extreme weather conditions, which were extremely unfavourable for the nutrition in 2007–2009, especially the changes of air temperature. Hot and dry summers, reoccurring droughts, very uneven distribution of precipitation per year had a negative influence on the resources of groundwater and caused higher consumption than accumulation in the recent years.

The most unfavourable conditions for the replenishment of groundwater resources were recorded in low drained clayey bed areas, where groundwater accumulates in the depth of down to 5 meters. Here, during the last decade, the consuming part of balance was dominating – an increasing amount of water was lost due to evaporation, plant transpiration, as well as ground run-off. In certain periods, the sun-off of groundwater could not ensure the environmental rates and the minimum river rate was lower than the environmental. In drained regions, where the water is in shallow depths (>5 m), these losses were not that significant, because here the majority of groundwater was lost due to ground run-off and not due to evaporation.

In 2009–2011, the tendency of rise of groundwater level was more evident; however, its intensiveness was uneven. The most significant tendencies of rise were observed in the eastern and southeast regions of country, where groundwater stratifies in shallow depths (>5 m). 2011 yr. was optimistic and favourable to the replenishment of groundwater resource and their balance was positive.

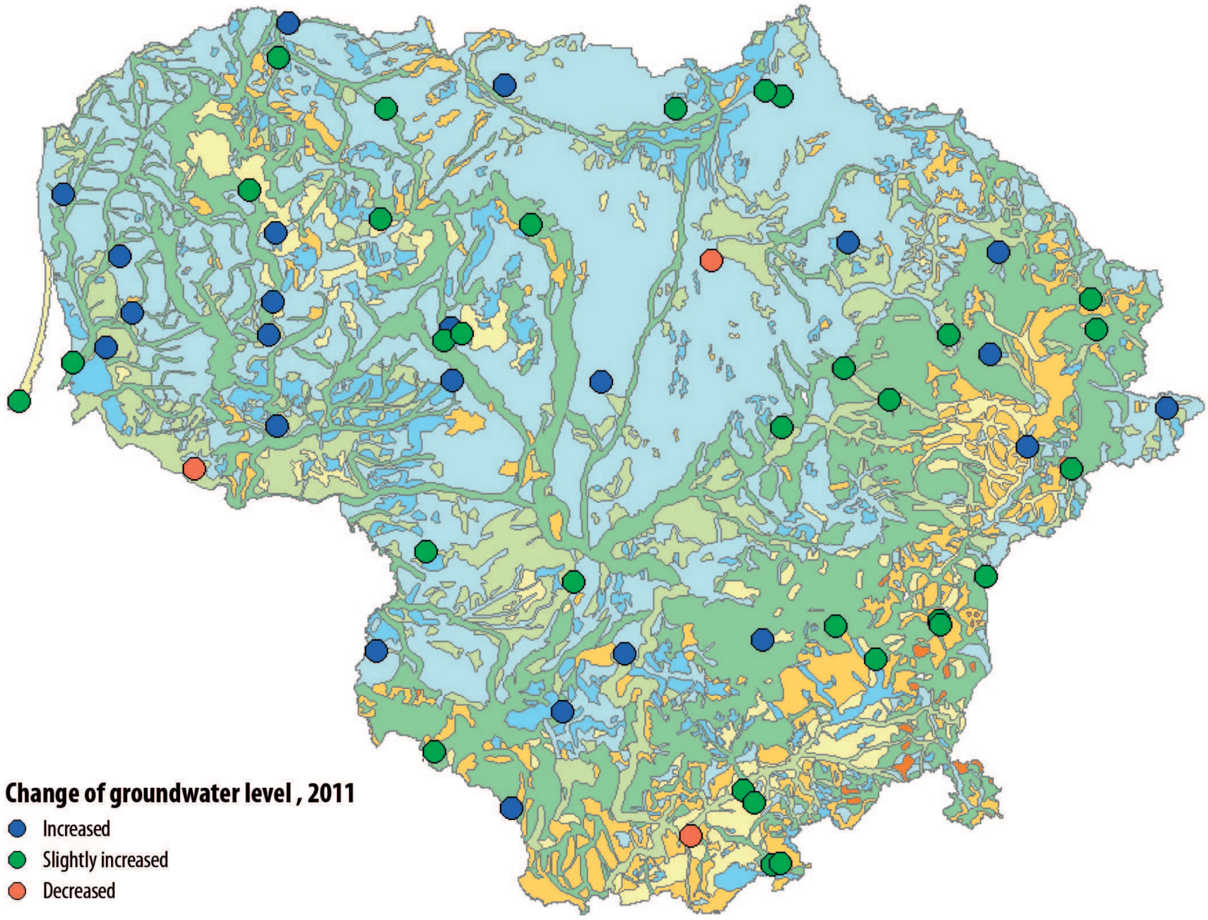


**Fig. 101.** The average position of depth of stratifying groundwater in 2011, as compared with the average of 2005–2011. *Source: Lithuanian Geological Survey*

## GROUNDWATER RESOURCES

According to the data of the register of ground resources, the fresh groundwater is used in 24,000 bores. Since 2011, upon the increase in the demands of shallow individual bores, 7,394 bores were installed, while before the aforementioned year, the number of installed bores was only 1,790. The most active installation of bores was recorded in 2007 and 2008. Meanwhile the demand of operational bores in water extraction sites decreased and 1,582 bores were installed for the production of fresh groundwater from 2001.

A common practice in Lithuania exists that long-term target programmes are developed for the assessment of resources of fresh groundwater, which is used for the supply of drinking water. Pursuant to the EU water directives (98/83/EC and 2000/60/EC), in 2002, the Strategy for the Use and Protection of Groundwater for 2002–2010 (Official Gazette, 2002, No 10-362) was prepared, and in 2006, the Programme on the Evaluation of Groundwater Resources and Use for the Supply of Drinking Water for 2007–2025 (Official Gazette, 2006, No 66-2436), was approved and launched in the midst of 2007. The goals raised by this programme include the specification of the amount of available groundwater resources in view of the requirements of the EU directives, i.e., possible changes of the quality of groundwater or negative impact on nearby ecosystems.

The available usable resources of groundwater – the amount of water which could be taken from the watery layer by using the best available method of production and it would be ensured that the hydrodynamic mode of water body and water extraction site and its influence on the environment will not exceed the recorded level, while the quality of extracted water would meet the requirements of normative documents during the entire period of maintenance of water extraction site.

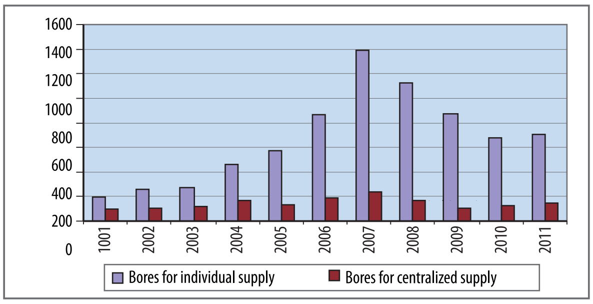


**Fig. 102.** Operated bores installed for the supply of water (2001–2011). *Source: Lithuanian Geological Survey*

The regional available resources of groundwater evaluated and specified in the course of the aforementioned programme amount to 3.5 million m³ of water per day. The approved (i.e., approved for use) resources of groundwater amount for 1.92 million m³ of water per day. The amount of water taken in the Lithuanian water extraction sites amounts to approx. 20% of the approved or confirmed resources of fresh water. The largest resources of ground fresh water, both approved and actually extracted, are in Vilnius, Kaunas and Klaipėda regions.

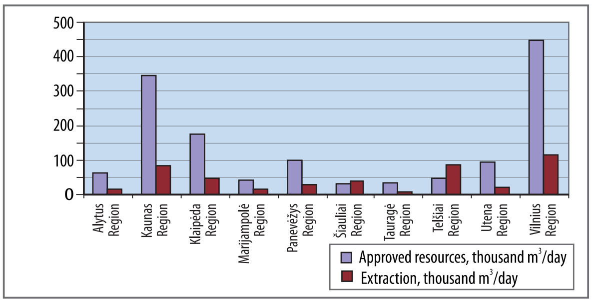


**Fig. 103.** The approved resources of fresh groundwater and extraction in the Lithuanian regions. *Source: Lithuanian Geological Survey*

## ABSTRACTION AND LOSSES OF GROUNDWATER

The abstraction of groundwater showed a diverse variation in the major cities and resorts in 2005–2011. Table 2 proves that the change of rate was hardly noticeable in Kaunas, Alytus, Klaipėda, Panevėžys water extraction sites, while, in Druskininkai, the extraction increased by approx. 78%. In Vilnius, Palanga, Birštonas, Neringa and Visaginas, the water extraction decreased from 14% to 21% When comparing the amount of water extracted in 2011 with the previous year, one may note that the extraction increased significantly only in water sites of Panevėžys, Marijampolė and Druskininkai.

**Table 2.** Abstraction of groundwater in the cities and resorts and tendencies of variation of rate. *Source: Lithuanian Geological Survey*

| Name of the city | The amount of extracted groundwater (thousand m³/day) | | | | | | | | Variation of rate in 2011, as compared with the average of 2005–2011 (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Average of 2005–2011 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
| Vilnius | 88.0 | 106.2 | 106.9 | 107.5 | 78.2 | 73.3 | 74.6 | 69.3 | -21.2 |
| Kaunas | 62.7 | 62.9 | 65.9 | 63.5 | 63.2 | 60.5 | 62.8 | 60.1 | -2.5 |
| Klaipėda | 27.8 | 33.9 | 11.5 | 30.2 | 31.6 | 30.1 | 29.1 | 28.3 | 1.8 |
| Panevėžys | 17.8 | 18.9 | 15.9 | 18.6 | 19.4 | 16.9 | 16.9 | 18.1 | 1.7 |
| Alytus | 8.8 | 9.3 | 9.0 | 8.1 | 10.1 | 8.2 | 8.7 | 8.8 | 0 |
| Marijampolė | 8.3 | 8.0 | 8.0 | 8.0 | 9.2 | 8.6 | 8.1 | 8.6 | 3.6 |
| Visaginas | 7.4 | 8.7 | 7.9 | 7.3 | 8.2 | 7.1 | 6.1 | 6.3 | -14.9 |
| Palanga | 3.9 | 5.1 | 4.0 | 4.2 | 4.0 | 3.7 | 4.0 | 3.5 | -10.2 |
| Neringa | 0.7 | 0.6 | 0.7 | 0.6 | 0.8 | 0.7 | 0.7 | 0.6 | -14.3 |
| Birštonas | 0.7 | 0.7 | 0.7 | 0.6 | 0.7 | 0.6 | 0.9 | 0.6 | -14.3 |
| Druskininkai | 3.0 | 0.4 | 0.3 | 3.9 | 4.3 | 3.6 | 3.8 | 5.3 | 78.0 |

The amount of extracted groundwater was very different in water extraction sites. The majority of registered water extraction sites (approx. 65%) are of low capacity (water extraction – up to 100 m³ per day); however, only 10% of all consumed amount of groundwater is extracted in them.

In Lithuania, the groundwater is mostly used for the population needs. In the cities, high amount of water is used for the public objects; therefore, the highest amount of groundwater is taken in the regions, where the largest cities are located. In 2011, Vilnius region extracted 31%, Kaunas – 24% of the total amount of groundwater per year, whereas Marijampolė, Utena and Alytus regions – only 4–5% of the total amount. In 2011 (as well as in the entire decade), the maximum amount of groundwater was extracted for the economic and domestic needs (68%) and approx. 11% – for industry/production.

In all Lithuanian regions, the consumption of water in the economic and municipal sector is proportional to the extraction of water. In 2011, in economic and municipal sector, the highest amount of groundwater was used in Vilnius region – 37% of the total amount of groundwater used in economic and municipal sector, the least amount – in Utena region (4%). In industry sector, the highest amount of water was consumed in Klaipėda region – 23% of the total amount of groundwater used for industry annually, the least amount – in Alytus region (3%).

According to the statistical data, approx. 2.2 million or 75% of Lithuanian population currently use the centrally supplied water services. After the restoration of Lithuania's independence, the consumption of fresh groundwater was constantly decreasing – from 1.2–1.4 million m$^3$ to 0.4 million m$^3$ per day. Accordingly, the amount of consumed groundwater per capita also decreased: from 300–400 l/day to 150–170 l/day.

The reason of this phenomenon is the significant decline in water consumption in industry and agricultural sectors and increasing prices of water encouraging the residents to save.

In case of decrease in the use of groundwater and insufficient water resources in Lithuania (the amount of groundwater resources significantly exceeds the current or projected extraction level), the negative impact of the use of groundwater is not manifesting at the moment.

The water losses in water supply system remain the most relevant and important problem in the water management area, which involves the technical, economic and social aspects. The reasons of water loss are diverse – the main include technical-operational, run-offs, accidents. Water supply companies usually seek to reduce the losses by technical methods in their supply networks and eliminate various factors causing the run-off.

In Lithuanian water distribution enterprises, the water loss today accounts for 20–40% of the total amount of extracted water. In Vilnius region, the water loss is increasing annually. In 2011, it amounted to 1.3% of the total amount of taken water. In Jurbarkas, the water loss accounted for 13%, whereas in the rural water area of Jurbarkas region it was as much as 75%. The water loss in the water extraction site operated by UAB "Mažeikių vandenys" accounts for 31.3%, in Letvaris – 31% (information of water supply companies). In Lithuania, the water loss comprises 19%.

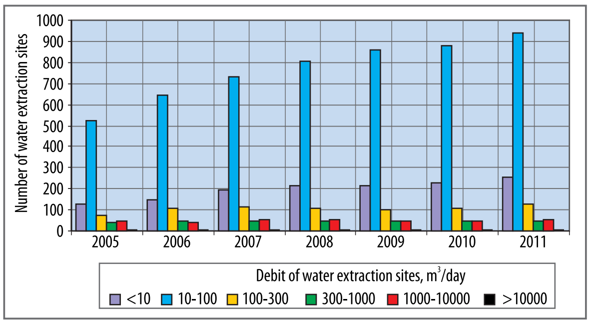


**Fig. 104.** Distribution of water extraction sites based on the amount of extracted water, 2005–2011. *Source: Lithuanian Geological Survey*

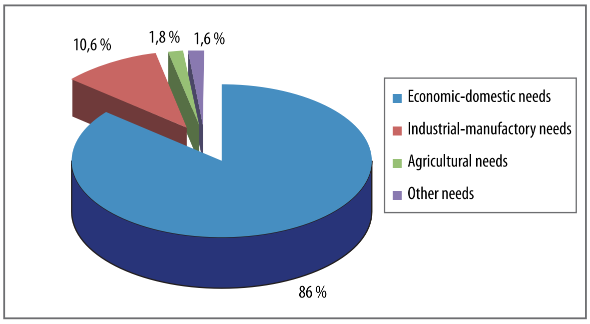


**Fig. 105.** Use of groundwater for various needs (2011). *Source: Lithuanian Geological Survey*

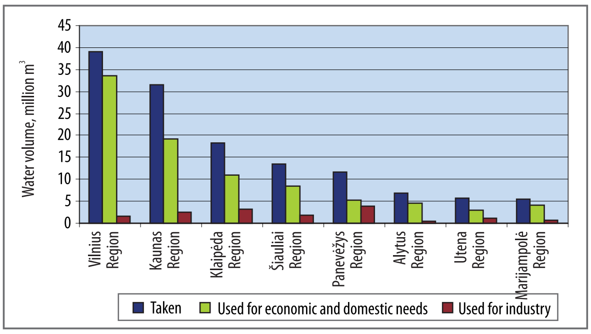


**Fig. 106.** Abstraction and use of groundwater in separate regions, 2004–2011. *Source: Environmental Protection Agency*

## QUALITY OF GROUNDWATER

In terms conditions of formation of chemical composition and anthropogenic impact under Lithuanian conditions, the ground and confined watery layers are distinguished.

The groundwater is not only poorly protected from the surface pollution, but also sensitive to climate changes. However it is still used as drinking water in rural areas, whereas in the areas of regional nutrition flows to deeper layers. The groundwater also forms from several to dozens percentage of river run-off (the rate depends upon the hydrological and hydrogeological conditions). The chemical composition of groundwater together with its quality mostly depends on the lithology of beds, where it is accumulated, and depth of water stratification and intensiveness of anthropogenic load (land use).

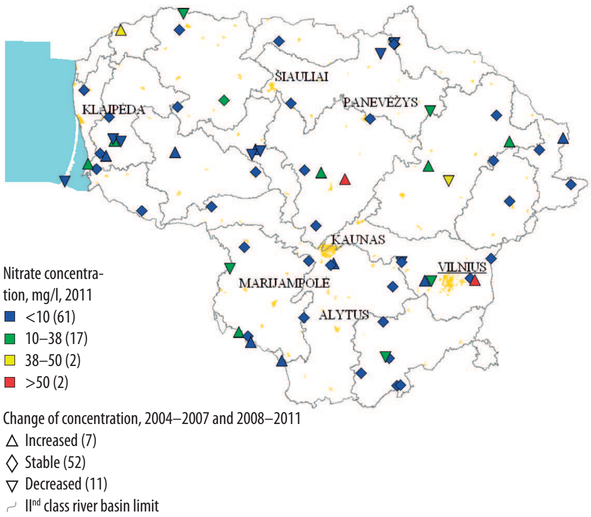


**Fig. 107.** Concentration of nitrates and their variation in groundwater. *Source: Lithuanian Geological Survey*

The concentration of nitrates, which is very low in groundwater under natural conditions, is well suited for the evaluation of groundwater. Their increase is usually associated with the human-induced economic activity and its intensiveness. The maximum allowable concentration (MAC) of nitrates established for groundwater is 50 mg/l, however, environmental measures necessary even if the concentration of nitrates is gradually increasing and reaches 75% of the MAC (37 mg/l).

In 2008–2011, the monitoring of nitrates in groundwater was continued in groundwater subsequent to the State Groundwater Monitoring Programme in 70 sites of monitoring that reflect the impact of varied anthropogenic load on the groundwater. The major part of observation focused on the diffuse pollution from agricultural sources (62 sites). The average annual concentration of nitrates exceeded 50 mg/l in groundwater only in separate cases. The sites, where the average annual concentration of nitrates was lower than 37 mg/l, amounted to approx. 95%, whereas the maximum concentrations – approx. 90% of cases.

Having compared the average concentration of nitrates of 2004–2007 and 2008–2011, an insignificant variation of them was observed in many places, the significant decrease in nitrates is characteristic to 14%, and the increase – in 8% of cases. The variation of nitrate concentration in groundwater is associated with the changed intensiveness of land use; however, the changes in the ground are occurring slowly and they reflect the changes that occurred 5-10 years ago.

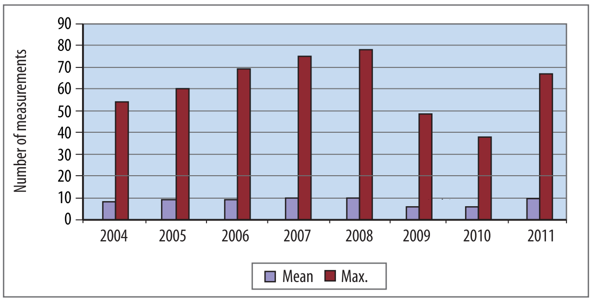


**Fig. 108.** Variation of concentration of nitrates in the groundwater. *Source: Lithuanian Geological Survey*

Assessment of the maximum values revealed a worse situation – a significant increase was observed in ~18%, while a significant decrease – in 13% of cases. The period from 2008 to 2011 was characterised by instability of concentration of nitrates – the average concentration varied from 5.2 to 10 mg/l, while the maximum concentration – from 38 to 78 mg/l. In some cases, due to the changes in the hydrochemical situation, the nitrates transformed into ammonium, however, the total amount of nitrogen changed insignificantly.

**Table 3.** The state of groundwater in the environment of subjects of agricultural activity. *Source: Lithuanian Geological Survey*

| Type of agricultural object | Number of observed objects | State (2006–2011) | | | | |
|---|---|---|---|---|---|---|
| | | Clean | Exceeds LV | Exceeds LV | Exceeds LV | Exceeds LV |
| | | | 1 indicator | 2 indicator | 3 indicator | 4 indicator |
| Livestock farm | 44 | 11 | 2 | 2 | 4 | 25 |
| Pig complex | 21 | 10 | 1 | 4 | 2 | 3 |
| Poultry farm | 24 | 2 | 0 | 1 | 5 | 0 |
| Fertilised fields | 80 | 34 | 25 | 14 | 7 | 0 |

LV- limit value based on the Description of Procedure of Evaluation and Monitoring of the Impact of Agricultural Entities (Official Gazette, 2011, No 2-63)

For the monitoring of the impact of pollution of separate agricultural entities on the groundwater, the monitoring programmes for 2006–2011 were prepared for 73 economic entities, covering 69 individual sites. The monitoring of impact on the groundwater was performed in the territories of livestock and pig farms and complexes, poultry farm territories and fields of spread of manure, liquid manure and slurry (fertilised fields). Having evaluated the results of monitoring of 2006–2011, one may state that in the larger part of territories of farms (62%), a certain negative impact on groundwater was observed. The pollution exceeding the limit value is usually observed in the territories of livestock farms, in rare occasions – in poultry territories. Significant pollution is observed in individual parts of industrial territory, usually near manure and slurry accumulation sites. Even after the elimination or management of pollution sources, their impact remains in the groundwater for next several years.

The chemical composition of confined watery layers, the water of which is usually used for the public supply, is formed under the influence of many various factors and processes. However, the main include the hydrodynamic, lithological and geochemical factors. The load of atmospheric precipitation and surface water to deeper layers is regulated by the thickness and permeability of covering rocks. Based on these features, the different "closing zones" are distinguished in the groundwater basins – from semi-open to relatively closed. The closing of systems restricts the influence of economic activity on the quality of groundwater, affects its oxidation-reduction conditions and biochemical processes. The load of groundwater forms hydro-chemical anomalies of deeper layers in active tectonic zones, and in some cases, the overall fauna.

**Table 4.** Criteria of evaluation of groundwater quality

| Water quality classes | PS, mg/l $O_2$ | $NH_4$ | Cl | $SO_4$ | Na | $NO_3$ | F |
|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | |
| High | <5 | <0.5 | <70 | <70 | <70 | <5 | <1,5 |
| Good | 5–7.5 | 0.5–2.0 | 70–250 | 70–250 | 70–200 | 20–50 | |
| Poor | >7.5 | >2.0 | >250 | >250 | >200 | >50 | >1,5 |

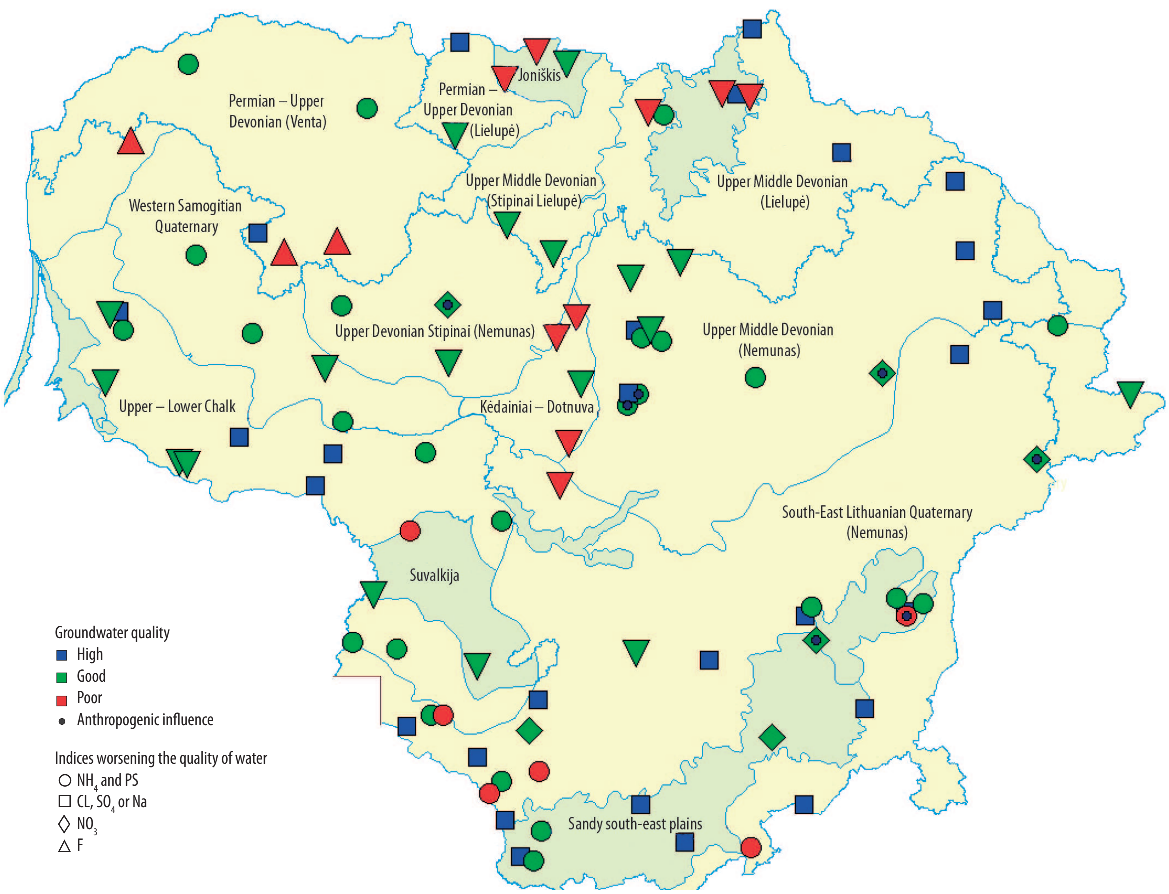


**Fig. 109.** Quality of confined water. *Source: Lithuanian Geological Survey*

When evaluating the quality of groundwater, the specified values of indicators established to the drinking water are usually assessed (hereinafter – the MAC) (HN 24:2003, Official Gazette, 2003 No 79-3606). However, for more informative picture of the situation, three classes of the quality of groundwater were set: high, good and poor (Table 4). When determining the classes of quality, the hydrochemical background of separate watery layers was taken into account.

When evaluating the quality of water, the values of toxic indicators ($NO_3$ and F-) were of critical importance and the groups of indicatory indicators worsening the quality of water were marked in the submitted map.

Having summarised the data of 2011 and assessed the quality of groundwater in terms of the selected criteria, one may state that high and good quality water dominates in Lithuania – it is characteristic to 80% of the monitored bores. The best groundwater quality is characteristic to the water of the quaternary confined layers – the water of 92% of examined bores is of high and good quality, whereas of pre-quaternary confined layers – water of this quality is found in 72% of examined bores.

The quality of groundwater is conditioned by natural and anthropogenic factors. The quality of groundwater is reduced by natural organic compounds, sulphates in the areas of gypseous beds, chlorides and sodium ions in mineralised water discharge areas, fluorides in North-West Lithuania. However, in the bores located in urbanised territories and near arable land, the values of organic compounds, chlorides, sulphates, nitrogen compounds exceeding the MAC are caused by anthropogenic pollution. The anthropogenic influence in the groundwater is observed in ~30% of bores, while the quaternary confined layers are better protected against the surface pollution. The anthropogenic influence on them is less obvious (~16% of bores) and the poor quality water was recorded in only one monitored bore. Anthropogenic influence is manifesting in those areas, where the quaternary intermoraine layers are more open, whereas the influence is more intensive in – Lančiūva, Lentvaris, Mickūnai, Švenčionys. The pollution can pass to pre-quaternary layers only where it stratifies near to the earth surface. For example, the anthropogenic pollution is associated with the increased concentration of nitrates (23 mg/l) in the groundwater of upper Devonian layer in Karajimiškis station.

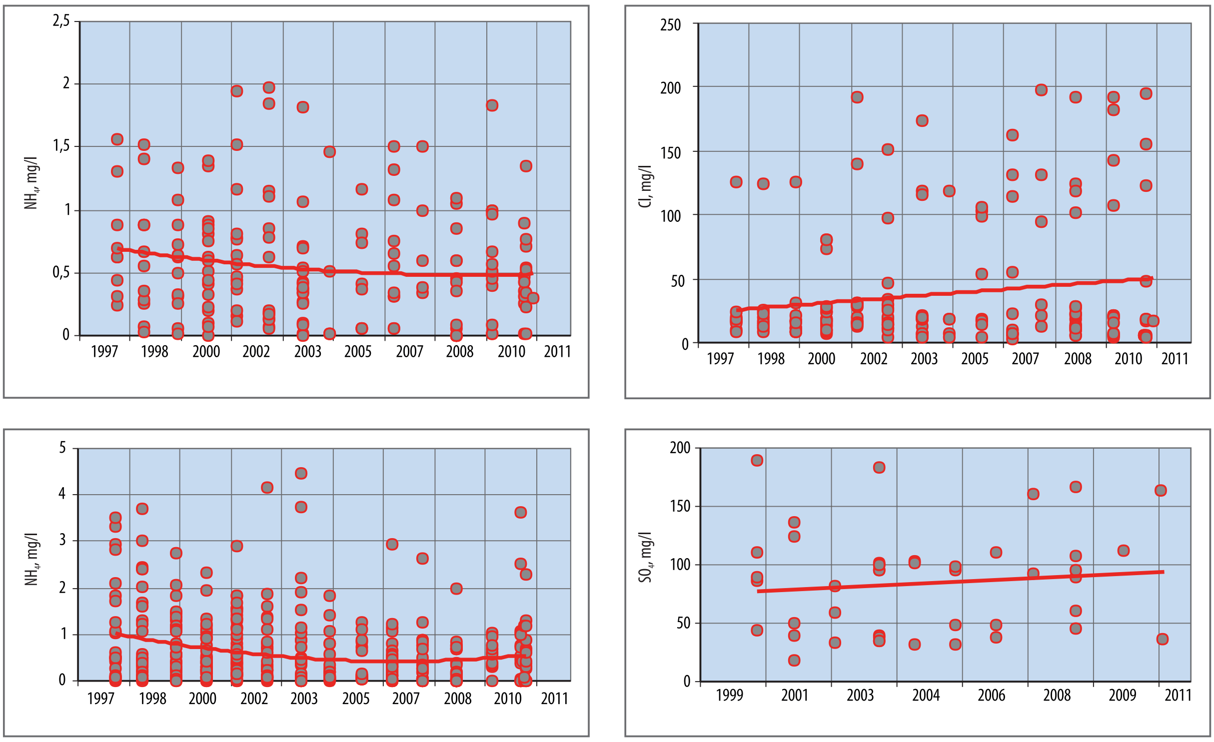


**Fig. 110.** Long-term (1997–2011) variation of groundwater composition in groundwater basins: ammonium – in groundwater basins of (a) Quaternary and (b) Upper-Lower Chalk; chlorides – in groundwater basins of (c) Upper-Lower Chalk and sulphates – in groundwater basins of (d) Permian-Upper Devonian. *Source: Lithuanian Geological Survey*

It is sometimes difficult to distinguish the natural pollution from anthropogenic, especially in case of observation of the increased concentration of ammonium ions. In six groundwater basins out of 10, the average background concentration of ammonium ions is higher than the specified value of 0.5 mg/l recorded for the drinking water. Usually, it is the ammonium formed from natural origin nitrogen in confined water with low amount or almost no amount of oxygen.

The variation of ionic composition and mineralisation of confined water (dry residues) in groundwater basins is characterised by cyclicality and absence of clear tendencies of increase or decrease. It is necessary to consider the variation of ammonium ion concentration – the tendency of their decrease is observed in the water of the majority of groundwater basins. In groundwater basins, which are marked in the areas of natural anomalies of chlorides and sulphates, certain tendencies of increase in the concentrations of these compounds were observed. However, today we don't have enough data to assess the changes conditioned by the maintenance of groundwater. The monitoring of problematic water extraction sites, which commenced in 2013, should facilitate the detection of causes of water quality variation.

## CONTAMINATED SITES AND THEIR MANAGEMENT

The quality of groundwater is conditioned not only by the natural phenomena, but also by the economic activity on the surface of land, especially the existence of pollution sources. The inventory of sources of pollution started in Lithuania back in 1990–1995. At that time, the main focus was on the inventory and examination of landfill sites and former Soviet Union military bases. In 1995, the former warehouses of pesticides were inventoried in Lithuania. In certain territories, the recording of sources of pollution of geological environment was performed by conducting the large-scale geological cartography while investigating the ecological state of geological environment of urbanised territories and performing other works.

In 1997, the Law on Environmental Monitoring was adopted. It regulates not only the state environmental monitoring, but also the requirement applicable to economic entities (the potential polluters) to carry out the monitoring of the impact on the environment as well as groundwater. This encouraged the researches of potential pollution sources (PPS). Upon the initiative of the Lithuanian Geological Survey, the programme was prepared in 1997 aiming at the creation of the methodology of inventory of sources of pollution. The information system of geological environment pollution sources was created in 1998 based on programme, where the data of previously inventoried sources of pollution were stored and the data of newly inventoried PPS started to be accumulated by successfully performing the inventory of sources of pollution in administrative districts.

Upon the entry into force of the Regulation on Ecogeological Researches in 2007, environmental requirements of the management of areas contaminated with chemical substances (2008) and other normative documents and legal acts, the new stage of PPS researches – the ecogeological researches of potentially contaminated areas and management of areas of contaminated with chemical substances – commenced.

Since 1998, the PPS data have been collected in the subsystem of potential pollution sources of the State Geology Information System pursuant to certain principles of classification of sources of pollution. At the end of 2011, there were 11,150 potential pollution sources registered in the information system. From 2000 to 2008, the Lithuanian Geological Survey performed a long-term project of PPS inventory and filling of information system, in the course of which the sources of pollution were inventoried in 21 municipalities. During this period, the information system was annually supplemented with approx. 700 new PPS. In 2009, the Lithuanian Geological Survey performed the project "Assessment of Impact of Contaminated Areas" funded by the EU. One of the activities under this project was the inventory of the PPS in 39 Lithuanian municipalities, therefore, the number of inventoried PPS increased significantly in 2009 (Fig. 111).

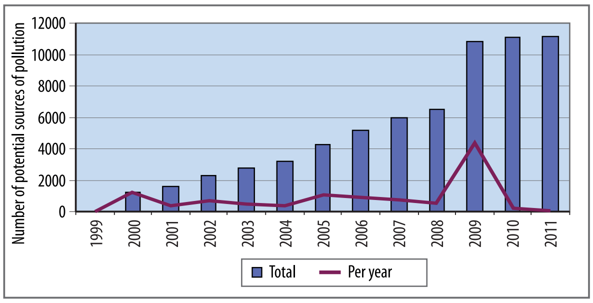


**Fig. 111.** Inventory of potential pollution sources. *Source: Lithuanian Geological Survey*

According to the types of activity, PPS are divided into 4 types: 1) industry, energy, transport and service objects; 2) objects of accumulation and regeneration of polluting substances; 3) objects of livestock farming; 4) sites of accidental discharge of polluting substances. The major part of inventoried PPS includes industry, energy, and transport and service objects (41% of all sources of pollution of geological environment). These are mostly the technical villages that used to operate in the times of collective farms, as well as still operating or already closed oil bases and filling stations. The objects of accumulation and regeneration of polluting substances covering the former storage facilities of pesticides and mineral fertilizers, domestic waste landfill sites account for 36%, whereas the objects of agricultural activity – 23% of inventoried objects (Fig. 112).

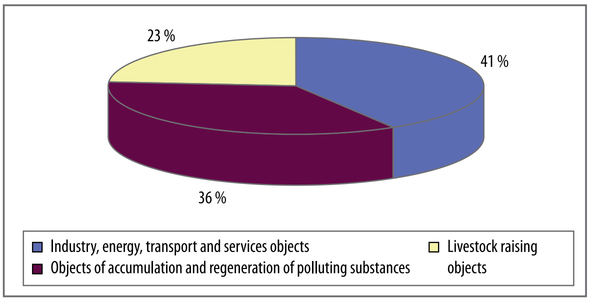


**Fig. 112.** Distribution of inventoried sources of pollution of geological environment by types. *Source: Lithuanian Geological Survey*

By using the methodology of preliminary assessment of hazardousness of potential pollution sources prepared by the Lithuanian Geology Survey (hereinafter – the methodology of assessment of the PPS), the hazardousness of all – more than 11 thousand PPS – was evaluated. The results of assessment showed that every third inventoried PPS is likely to cause harmful effect on the environment, whereas one tenth of them can be very harmful to the environment, Based on the data available in the information system, it was calculated that the area of territories likely to be contaminated with chemical substances can reach approx. 280 $km^2$ or 0.43% of Lithuania's territory. The likelihood of fertilisation with hazardous chemical substances is high or very high in the area of approx. 115 $km^2$. The main polluting substances include oil hydrocarbons. More than 40% of all PPS areas are likely to be contaminated with these substances. The likelihood of pollution with pesticides, heavy metals and other specific compounds – polycyclic aromatic hydrocarbons, halogenated hydrocarbons, detergents, phenols, etc. is present in approx. every fifth object.

Based on the methodology of assessment of PPS, the number of objects of high and very high likelihood of hazardousness can amount to approx. 4.5 thousand in Lithuania (Fig. 113).

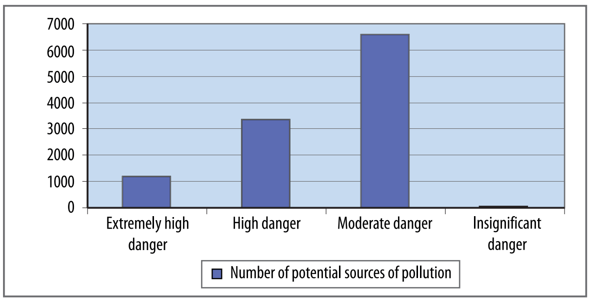


**Fig. 113.** Distribution of potential pollution sources based on the hazardousness to the environment. *Source: Lithuanian Geological Survey*

One of the most significant threats to the environment and ground resources is caused by the objects that are no longer active, but according to the available information, tended to use hazardous substances before the closure. Such objects amount to almost half of objects registered in the information system – approx. 5,000. These include the fire sites, destroyed former technical yards of collective farms and storage facilities of pesticides, the information on the environment pollution of which does not exist. The information system of the Lithuanian Geological Survey contains more than 1,300 former pesticide storage sites, however, only a small share of them has been examined (approx. 120 objects).

The performed researches of territories of warehouses of pesticide showed that although the pesticides were eliminated from former warehouses, the environment is still contaminated with pesticides and especially durable organic pollutants (DOP) due to longevity of these chemical substances. The results of the performed researches allow for the assumption that the pollution of soil and/or groundwater exceeding the permissible concentration of pesticides established by the legal acts is likely to occur in approx. 40-50% of yet unexamined former territories of pesticide warehouses.

After the entry into force (in 2008) of the new procedure of ecogeological research, according to the data of the Lithuanian Geological Survey, approx. 600 ecogeological researches and 30 territorial management works were performed (Fig. 114).

The majority of examined objects were the areas contaminated with oil products, warehouses of pesticides, quite a significant part of ecogeological researches were performed in closed landfill sites (Fig. 115). The ecogeological researches are sometimes performed in the areas, where the activity related to hazardous chemical substances was not performed previously. When building residential or commercial objects, many customers wish to know the current ecogeological status of the area parcel.

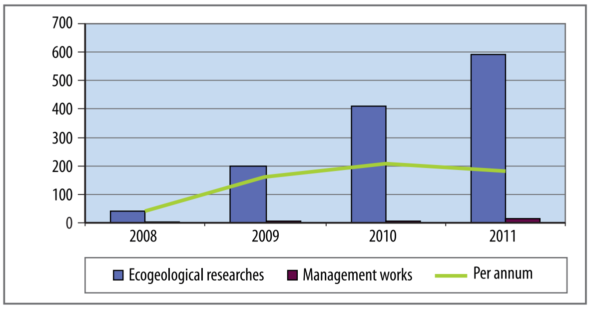


**Fig. 114.** Ecogeological researches, 2008–2011 (accumulated data). *Source: Lithuanian Geological Survey*

The information system of geological environmental pollution sources contains the information on more than 11,000 PPS and this number of not finite. Each year, the database is supplemented with information on 100–200 new objects. However, only an insignificant part of territories is examined (from 1980 – approx. 1,700 examined territories, including the programmes of monitoring of the impact of economic entities on the groundwater) and even smaller part of territories is managed. Of course, not all PPS areas should be researched; however, in order to receive actual information on the impact of PPS on the quality of groundwater, it is necessary to apply certain measures.

One of such measures is the Plan of Management of Contaminated Areas for 2013–2020. In the draft of this legal act, which is submitted for approval (2012), a particular attention is paid to the establishment of priorities of management of areas, safe management of objects contaminated with hazardous chemical substances, increase of environmental consciousness of society and especially of the owners of contaminated areas.

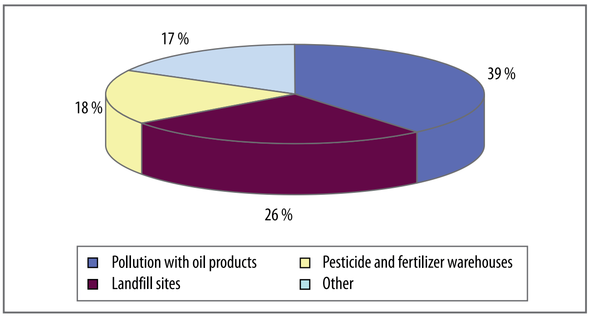


**Fig. 115.** Distribution of ecogeological researches by the activities performed in the territories. *Source: Lithuanian Geological Survey*

## CONCLUSION

The past decade was not favourable for the replenishment of groundwater resources, however, the period from 2010 to 2011 sets optimistic sense – it was favourable for the replenishing of groundwater resources and their balance was positive.

Lithuania has rich resources of fresh groundwater – approx. 3.5 million m$^3$ of water per day, whereas the current extraction accounts for 10% of the available resources. The majority of operating water extraction sites (approx. 65%) is of low capacity (water extraction – up to 100 m$^3$ per day); however, only 10% of the overall consumed amount of groundwater is received in them. The maximum amount of extracted groundwater, same as throughout the entire past decade, was used for the economic and municipal needs (68%) and approx. 11% – for industry/production. Water losses are slightly decreasing and account from 20% of 40% of the overall extracted amount of water.

The water of high and good quality is dominating in Lithuania on regional scale and the quality showed no signs of worsening during the period of monitoring (2005-2011). However, we still lack data for the assessment of influence of the water usage on the groundwater basins distinguished in the areas of natural anomalies of chlorides and sulphates. The diffuse agricultural pollution is not intensive, however, in the larger area of territories of livestock farms (62%) a certain negative impact on the groundwater is observed. The pollution exceeding the limit value is usually recorded in the territories of livestock farms, in rare occasions – in poultry territories. Significant pollution is observed in individual parts of industrial territory, usually near manure and slurry accumulation sites.

There are more than 11,000 potential geological environment pollution sources inventoried in the country at the moment. Having evaluated their hazardousness on the environment, it was recorded that the number of objects of high and very high likelihood of hazardousness in Lithuania can amount to 4.5 thousand, whereas the area of territories that are likely to be contaminated amounts to 280 km$^2$ or 0.43% of Lithuania's territory.

Approx. 1,700 territories have been examined in various levels of particularity in Lithuania. Ecological researches were performed in approx. 600 areas; the monitoring of the impact on groundwater is performed in the remaining territories.

The state of environment will improve only upon the examination and management of contaminated areas.

# Waste

Generation and management of waste is one of greatest environmental problems in the world. After Lithuania joint the European Union, Lithuania started to reorganise the national waste collection and management system in order to meet the requirements applied by the European Union. For this purpose, the reform of the control of municipal waste management was actively conducted – the bases for the regional waste treatment systems were developed (ten regional waste treatment centres were established, the construction of regional non-hazardous waste landfill sites and other regional waste treatment infrastructure (large waste collection sites, "green waste" composting sites, reloading stations, and other) commenced, the pricing of regional waste treatment was determined). The European-level waste management legal base has already been developed. Provisions of the legal acts regulating the waste management in the European Union are timely transposed into the national law of the Republic of Lithuania. For several years already, the municipal waste of all cities, many townships and larger villages has been collected in a centralised way, by intensively developing the infrastructure of collection of these wastes. A modern infrastructure of the management of non-hazardous waste is developed, the landfill sites that fail to meet the requirements of environmental protection and public health safety are closed by using partial funding of the EU Cohesion Fund. The EU-level hazardous waste management system is developed and the network of collection and recycling of hazardous waste is expanded in Lithuania. Development of the system of regional urban waste treatment, management of sludge and other biodegradable waste has already commenced.

In order to achieve the state, where waste management meets the European standards, the improvement of the waste management system in Lithuania is extensively financed from the EU funds. In the recent years, 612 old landfill sites/locations polluted with waste were managed by using the funds of ISPA (Instrument for Structural Policies for Pre-Accession) and Cohesion Fund and funds of the structural aid for 2007–2013. The remaining 189 sites were expected to be organised by the end of 2013.

The long-term environmental objectives of Lithuania include the creation of the proper (in social, environmental and cost-effective terms) management system of waste generated in households, industry and other economic sectors, reduction of the generation of waste and their negative impact on the environment and human health, ensuring of the rational use of waste energy resources, as well as information and education on the issues of waste management.

According to the data of waste accounting, in the year of accession to the European Union, the amount of generated waste reached 5.4 million tons in Lithuania, and this number used to increase every year. The maximum amount of generated waste was recorded in 2008 – it was 5.9 million tons of waste (mostly chemical substances and products generated in production companies (including the production of rubber and plastic products and main drug industry product and pharmacy preparation production) – approx. 1.9 million tons). In 2009, due to the recession in the production and consumption caused by the global economic crisis, 5 million tons of waste where generated, whereas after the revival of Lithuania's economy in 2010, this index started to increase gradually and reached 5.3 million tons (Fig. 116).

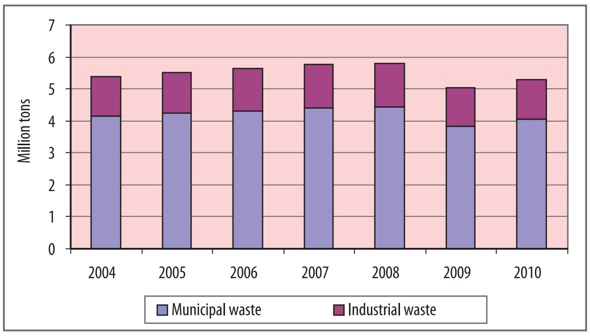


**Fig. 116.** Waste generation dynamics in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

Figure 117 shows a principal waste management hierarchy scheme, which, in principal, meets the hierarchy of priorities established in the State Strategic Plan for Waste Management. By following this hierarchy, first at all, it is necessary to avoid the generation of waste and apply other prevention measures, whereas waste that cannot be avoided should be recycled or used in any other ways to achieve the minimum possible amount of waste disposal in landfill sites and other waste disposal facilities. Waste prevention is the main goal of waste management policy; however, the progress that has been made so far in implementing this goal is not sufficient.

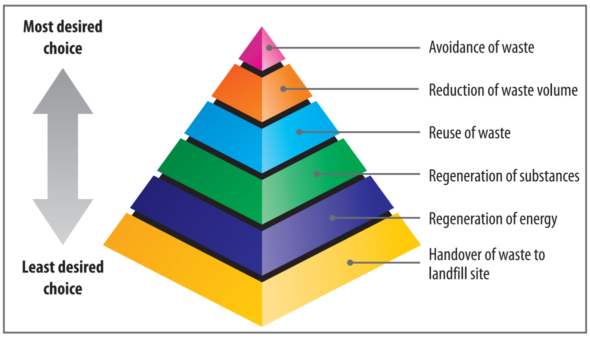


**Fig. 117.** Waste management hierarchy scheme. *Source: the Ministry of Environment*

Lithuania has not yet been among the EU Member States having the best practices of waste management. Unfortunately, we have to admit that the mentality of people has a certain impact in this case. However, the situation has been improving, especially since the accession to the European Union. A huge progress has been made in the past 10 years: all landfill sites that failed to meet the environmental protection requirements have been closed, 11 new regional non-hazardous waste landfill sites have been opened. The residents started to sort the waste. The Ministry of Environment supports many educational projects aimed at educating people on the reasons of waste sorting and the ways to do it. Even at schools, the pupils receive information on proper waste management.

## MUNICIPAL WASTE COLLECTION AND MANAGEMENT

Municipal waste means households waste (generated by housholds) and similar waste, which is comparable to household waste by its nature and composition. Municipal waste includes not only the waste generated by households, but also waste similar to household waste by its nature and composition and generated at companies, institution and organisations, excluding production waste and waste from agriculture and forestry. According to the evaluation of experts, municipal waste of residents accounts for 75–85% of all municipal waste.

It is considered that one of the main forces affecting the generation of municipal waste is the national economic growth, which is probably best evaluated by the increase in the gross domestic product (GDP). It has been acknowledged that both the amount of generated waste and GDP have been constantly increasing during the independence years. Therefore, the increase of economy and consumption leads to the increase in the volumes of municipal waste in Lithuania. This tendency is characteristic to all economically developed countries. To the same purpose, in its 6th Community Environment Action Programme (2002–2012), the European Union set the target to separate the growth of generation of waste from the economic growth.

The generation of municipal waste is significantly conditioned by the number of population in the country. Since the Lithuanian Department of Statistics does not have an opportunity to calculate the number of emigrants per year, therefore, according to the evaluation of experts, the officially presented number of residents is likely to be higher than the number of population actually generating waste in Lithuania. In the opinion of specialists, due to intensive rates of emigration in the recent years, the actual volume of waste per capita should be higher and increase more rapidly.

The improvement of collection of municipal waste is one of the priorities of the Lithuanian environmental protection. By implementing this aim one strives to optimise and improve the collection of this type of waste. In the early 2009, there were 104 companies providing municipal waste collection services, 47 systems supplementing the municipal waste treatment systems in 22 municipalities. The majority of these systems was created for the collection of electric and electronic equipment. Since 16 July 2009, the municipal waste has been disposed of in landfill sites meeting the requirements of the European Union.

In order to improve the collection and management of municipal waste, the Ministry of Environment bought 19,667 units of secondary waste collection containers for municipalities in 2006–2011. During the recent years, the secondary waste collection sites are built in Lithuania and already in 2008 there was one secondary waste collection site per 456 residents.

According to the data of the Ministry of Environment, in 2008, 85.2% of municipal waste were collected to containers, 7.4% – by making a tour to waste generators, 0.9% – in large waste collection sites. Municipal waste management supplementing systems were used to collect more than 6% of municipal waste (mostly electricity and electronic equipment waste).

Pursuant to the data gathered by the Environmental Protection Agency, in Lithuania, the amount of municipal waste per capita collected showed some variation in the recent years (Fig. 118). Since 2004, when Lithuania joined the European Union, this volume was increasing annually until 2008 and amounted to nearly 408 kg per capita in 2008. This can be explained by the growth of the living standard of national population. Although this index does to reflect the purchasing power of population, however, it is obvious that the increase in income is also accompanied by the increase of consumption and also by the generation of more waste. To answer the question why there was more waste generated per capita in 2003 than in 2004, based on data provided in Fig. 118, it is necessary to state that it is related to the changes made in waste accounting system in 2004.

However, the economic crisis that started in 2008 corrected this tendency for a short period of time and, in 2009, the collection of municipal waste per capita amounted to 361 kg in Lithuania. The direction of this index was a short-term phenomenon: as far back as in 2003, the amount of municipal waste per capita increased and amounted to 381 kg. As compared with the year of accession to the European Union, this index increased by nearly 4%. Therefore, it is possible to state that Lithuania recedes from the European environmental aim – to stabilise the generation of waste at 300 kg per capita. However, as compared with other European Member States, this amount remains very low. In the Western European countries, the amount of municipal waste exceeded 500 kg per capita. Even comparing with the Central and Eastern European countries, the amount of waste per capita generated in Lithuania is one of the lowest.

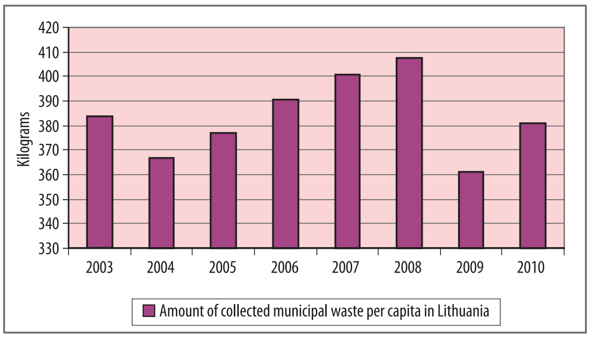


**Fig. 118.** Dynamics of variation of collected municipal waste per capita, 2003–2010. *Source: Environmental Protection Agency, European Environment Agency*

According to the opinion of various Lithuanian and foreign scientists and experts, the increasing standard of living is the main factor influencing the increase in the amount of municipal waste. And this is clearly confirmed by the comparison of the speed of growth of the amount of collected waste per capita in Lithuania presented in Fig. 119. As it is shown by data in Fig. 119, the tendencies of the increase and decrease of these two indicators are clearly related in time. Therefore, it can be stated that although the increase in the amount of generated waste is a normal economic phenomenon, however, in view of the environmental perspective, it is a bad situation, and it is necessary to seek that the growth of GDP would surpass the increase in the amount of generated waste as further as possible.

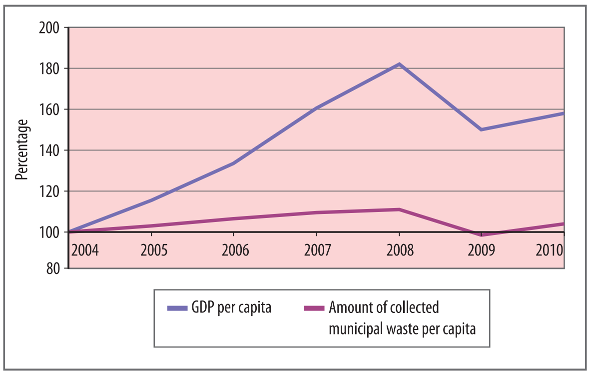


**Fig. 119.** Comparison of the speeds of growth of GDP per capita and amount of collected waste per capita in Lithuania (2004 – 100%). *Source: Environmental Protection Agency*

Fig. 119 presents the dynamics of the ratio of speeds of the growth of Lithuania's GDP per capita and amount of collected municipal waste per capita, expressed in percentage and compared with the previous year. Obvious is the positive fact that the GDP growth per capita has recently surpassed the rate in the increase in the amount of collected waste by nearly 1.5 times and these tendencies have not been deviated even by the global economic crisis that struck at the end of the last decade.

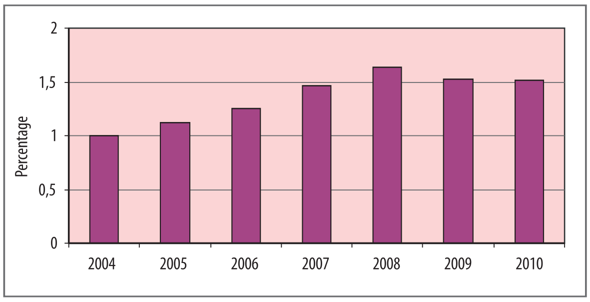


**Fig. 120.** The ratio of the speeds of growth of GDP per capita and amount of collected waste per capita in Lithuania (2004–2010). *Source: Environmental Protection Agency*

As it was already mentioned earlier, the Committee on the Environment, Public Health and Food Safety Policy together with the European Environment Agency has set the ambitious environmental target to reduce the amount of municipal waste per capital down to 300 kg. Unfortunately, according to the specialists, this objective is very difficult to implement in reality.

In recent years, the amount of municipal waste per capita exceeded 500 kg in the Western European Member States. Although these amounts are lower in the Eastern European countries, according to the pessimistic forecasts, the amount of 500 kg will be reached in Lithuania in a decade, whereas in 2020 it can amount even to 640 kg. However, it is also calculated that in case of timely employment of necessary environmental political-preventive measures, this scenario could be avoided especially because there are no completed studies forecasting the tendencies of generation of municipal waste in view of the fulfilment or non-fulfilment of the tasks of the Sustainable Development Strategy.

As it was already mentioned, when evaluating the indicators of the amount of Lithuanian municipal waste per capita in the context of the European Union, in our country, this index remains one of the lowest among all EU-27 Member States. Such differences are mostly conditioned by the inequality of the economic development of countries and it is best revealed by the comparison of the municipal waste generation results in the new EU Member States having a lower standard of living with the wealthiest Member States of the Western Europe. The data provided in Fig. 120 show that the amount of municipal waste per capita collected in our country is nearly twice lower than in economically strong and environmentally advantageous countries, such as Denmark, Luxembourg or Cyprus. The positive achievement of our country in the context of the European Union is the fact that Lithuania is among those Member States of the European Union, which managed to reduce this amount during the period between 2003 and 2010.


**Fig. 121.** Comparison of the collected amount of municipal waste (kg) per capita in the EU Member States in 2003 and 2010. *Source: European Environment Agency*

It should be noted that, although it is sought to establish a unified waste accounting system in Europe in order to compare data, at the moment, the European statistics does not actually reflect the exact generation of waste by Member States, because the principles of waste accounting have been different so far. On the other hand, it should also be noted that, during the period between 2004 and 2008, the volumes of waste generated per capita increased more than the EU average and only after the start of the economic crisis, the volumes decreased more than in the European Union (Fig. 122).

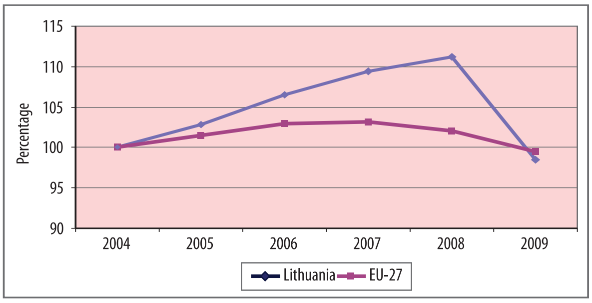


**Fig. 122.** Comparison of growth of collection of municipal waste in Lithuania (kg/per capita) with the tendency in the European Union (2004 – 100%). *Source: Eurostat, Environmental Protection Agency*

In 2009, the amount of generated waste per capita decreased by 12.73% in Lithuania, as compared with the results of 2008, whereas in the European Union, the average decrease amounted to 2.5% only.

When evaluating the contribution of society (population) to the waste management in Lithuania, first of all, it is necessary to state that the majority of collected waste is mixed domestic waste (Fig. 123), i.e., the waste, which is disposed by residents without sorting. Although the amount of collected secondary waste showed some increase in the recent years, however, it is necessary to recognise that Lithuania's population is not yet sufficiently conscious, unmotivated, therefore, is unwilling to collect and sort its domestic waste. It has been observed that, although plastic and glass is recycled more intensively by our population, however, only a very small part of population separate food waste. The change in this situation, in order to encourage the major part of waste to be sorted, is one of the most topical goals of the recent years in the Lithuanian waste sector.

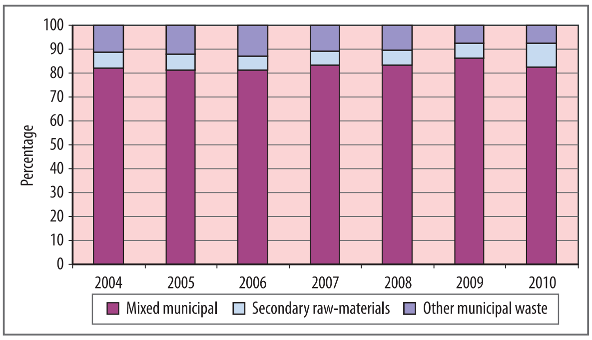


**Fig. 123.** Structure of municipal waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

Worrying is the fact that, although the change in the amount of municipal waste has not been significant in Lithuania, however, when planning municipal waste treatment systems, it is necessary to consider the perspective of increase in the amount of municipal waste in other European countries and countries in the world. According to the evaluation of experts, the amount of municipal waste in the countries of Organisation for Economic Co-operation and Development will increase by 43% during the period between 1995 and 2020 and will amount to 640 kg per capita per year. It encourages consideration of other possibilities of usage of additional political or economic measures in this environmental protection sector.

One of the planned methods of management of biodegradable waste in Lithuania is the mechanical biological processing of waste. The mixed municipal waste remaining after the first recycling will pass to the mechanical-biological processing facilities and will be further recycled by applying respective technologies. Everything that can be recycled will be handed over for recycling, whereas non-recyclable waste having energetic efficiency will be used for the production of energy. Such system of waste treatment is comfortable, because it can be installed both in the landfill sites and in other places.

## INDUSTRIAL WASTE COLLECTION AND MANAGEMENT

Industrial waste is the residual of materials (raw materials), semi-products and other material resources generated in the process of the manufacture of production (performance of works, provision of services) that fully or partly lost their initial consumption properties (chemical or physical). Industrial waste does not include secondary production generated in the course of technological process.

When evaluating the dynamics of the amount of collected industrial waste at the time of Lithuania's accession to the EU (Fig. 124), it is seen that the same tendencies as in the municipal waste sector are dominating here. The experts have determined that the amount of generated industrial waste is directly proportional to the tendencies of economic growth. It is acknowledged that in case of modern scientific and technological potential of the society, increase in the national and regional industry and economy, the amount of generated industrial waste also increases inevitably. However, in the economically and technologically advantageous countries, including Lithuania, this increase has been lower as compared with the GDP growth in the recent years. This corresponds to the national and EU aims in the waste sector, where one of the main objectives and goals is the sorting of the generated industrial waste from the GDP growth. Among the main long-term objectives in the waste sector stipulated in the National Sustainable Development Strategy, is also the objective to achieve that the amount of waste would increase much slower than the increase of production, whereas the amount of waste per unit of generated GDP would not exceed the EU average amount of waste of respective production fields. Of course, this aim could be easily realised during the first decade of independence, when essential processes of transformation of industry and economy occurred. That time was characterised by the most rapid rate of decrease in the amount of industrial waste per unit of GDP. This process became slower in the recent years, however, the tendencies remained and this is confirmed by the high-scoring of implementation of environmental protection policy in this area.

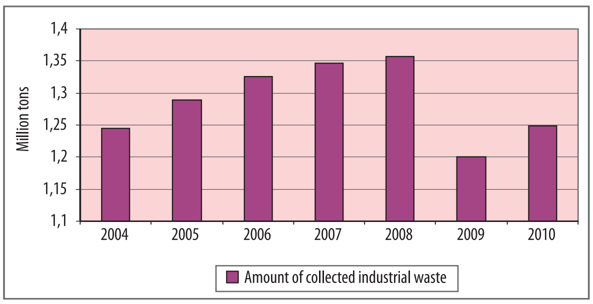


**Fig. 124.** Collection of industrial waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

The biodegradable waste remaining after mechanical recycling will be rotted anaerobically or composted. In the first case, the methane gas is generated that can be used for the production of energy, whereas in other case, compost is produced. The only minus of such compost is that it is not of high quality, whereas the waste not sorted in the initial way are "contaminated". However, such compost is well suited for building roads and renovating roadsides. This system should soon be installed in 9 regional waste management centres. The implementation is planned to be financed by the Cohesion Fund of the amount of 450 million Litas. The projects are implemented in accordance with the measure "Development of Waste Management System" of the Cohesion Promotion Action Programme for 2007–2013.

The generation of industrial waste and collection directly depends on the growth of national economy; therefore, in order to evaluate properly the meaning of the amounts of collected industrial waste in Lithuania, it is best to compare them with the national GDP growth indices (Fig. 125).

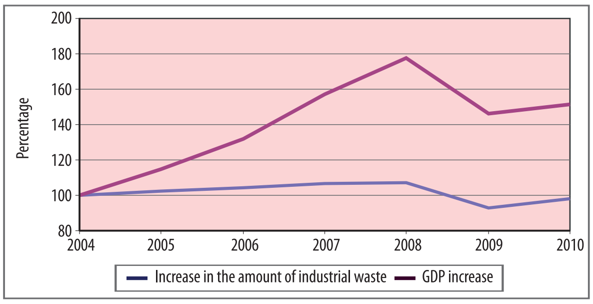


**Fig. 125.** Comparison of the collected industrial waste and growth of Lithuanian GDP in 2004–2010 (2004 – 100%). *Source: Environmental Protection Agency, Lithuanian Department of Statistics*

When comparing the tendencies of growth of collected industrial waste and Lithuania's GDP in 2004–2010, it is obvious that they are directly interrelated and reflect the state of the national economic development.

Since the accession to the European Union, Lithuania's GDP and also the amount of collected industrial waste increased annually until the economic crisis that started in the late 2008. As a result of it, a significant decrease in both evaluated indicators was noticeable in 2009. The collection of industrial waste decreased even below the level of 2004. However, already in 2010, when the national economy started to revive, it started to increase again, although failed to achieve the level of the year of accession to the European Union. It is believed that this tendency of economic growth and industrial waste should also remain in the nearest future.

For more clarity, when analysing the tendencies of generation of industrial waste in Lithuania, it is purposeful to compare difference of the speeds of the growth of the two said parameters. Such evaluation is presented in Fig. 126. As it is shown by the data of Fig. 126, during the period between 2004 and 2008, the speed of growth of Lithuania's GDP increasingly surpassed the speed of the generation of industrial waste each year: If in 2004, this ratio was only 1.04, then in 2008, it already amounted to 1.66 – i.e., GDP increased by 1.66 times faster than the generated amounts of industrial waste. Such tendencies of index variation completely corresponded with Lithuania's environmental aims in the waste sector.

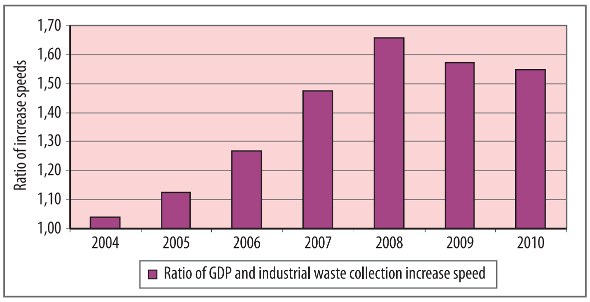


**Fig. 126.** Comparison of the ratio of speed of growth of Lithuania's GDP and collection of industrial waste in 2004–2010. *Source: Environmental Protection Agency, Lithuanian Department of Statistics*

However, in 2009–2010, when the national economy was in deep economic crisis, the tendency of variation of this index changed and it started to decrease slowly. According to the scientists, this was a short-term phenomenon influenced by the economic crisis and in the nearest future the ratio of growth of GDP and the situation of generation of industrial waste should already improve. By summarising the value of this index for 7 years (2004–2010), it is possible to state that, during this period, the national GDP increased by 1.38 times faster than the composition of industrial waste, on average.

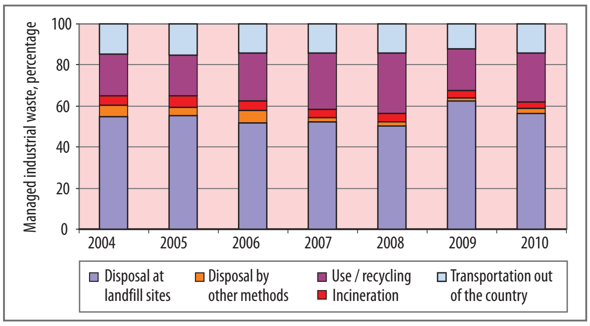


**Fig. 127.** Industrial waste management by methods in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

When analysing the development of industrial waste management by their management methods during the period from the accession to the European Union until 2010 (Fig. 127), it can be seen that so far the largest share of industrial waste was disposed in the landfill sites. Although (evaluating in tons) the amounts of landfilled industrial waste showed almost no increase despite the economic growth, the share of waste disposed in such way, which decreased during the period from 2004 to 2008, has showed some increase recently (event if insignificant).

## PACKAGING WASTE MANAGEMENT

Packaging waste management is another relevant and topical environmental problem. Packaging is a product produced of any kind of materials and used for packaging, protection, transportation and delivery of products to consumers or users of these products. Packaging waste mean any packaging or packaging material covered by the definition of waste excluding production residues. Packaging waste usually constitute a large share of waste (including municipal waste), whereas under the conditions of economic growth, the amount is only increasing.

When evaluating the tendencies of generation of packaging waste from the period of accession to the EU, it is observed that the start of the economic recession in Lithuania, same as in many other EU countries (Fig. 128), lead to the decrease of the constantly increasing amount of packaging placed on the internal market by 3.7% in 2008 and even 21% in 2009.

However, in 2009–2010, when the national economy was in deep economic crisis, the tendency of variation of this index changed and it started to decrease slowly. According to the scientists, this was a short-term phenomenon influenced by the economic crisis and in the nearest future the ratio of growth of GDP and the situation of generation of industrial waste should already improve. By summarising the value of this index for 7 years (2004–2010), it is possible to state that, during this period, the national GDP increased by 1.38 times faster than the composition of industrial waste, on average.

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As compared with 2008, there were even by 20 thousand tons less of paper/cardboard and glass packaging filled with products and by 10 thousand tons less of plastic and wooden packaging placed on the market in 2009. The main reason was the decrease in the consumption influenced by the crisis as well as the fact that due to established economic situation a certain part of market moved to a "shadow".

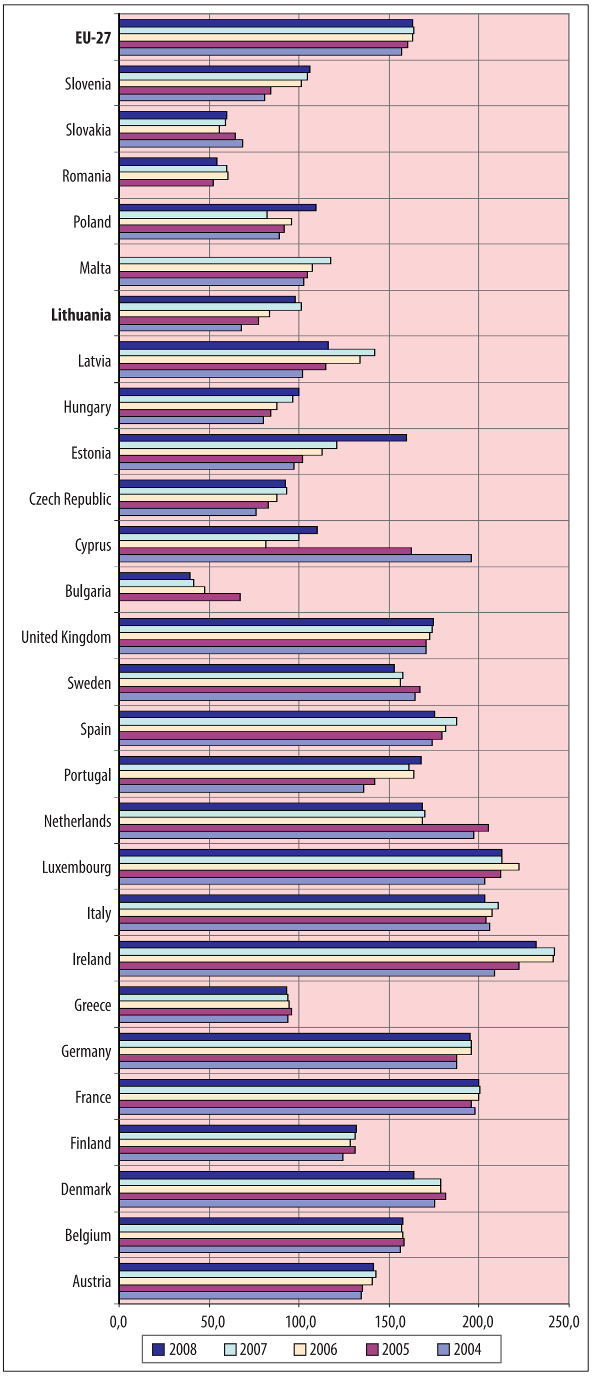



**Fig. 128.** Tendency of generation of packaging waste in the European Union, 2004–2008. *Source: European Environment Agency*

However, the rising from the economic crisis lead to the increase in the overall number of generated packages (launched into internal market) by 4.5% in Lithuania in 2010, as compared with 2009, and amounted to 272.4 thousand tons. Packaging waste can also be used as secondary raw materials or as the source of energy generation, especially in view of the structure of this type of waste. It is sought to reduce the amount of landfilled packaging waste in the European Union. This aim leads to an environmental objective to reduce the amount of landfilled waste down to 55% of the 2000 level in 2008.

The results of the implementation of this objective are presented in Fig. 130. In 2008, there were 52% of packaging waste disposed of in landfill sites in our country and this is the 10th position among the EU-27 Member States. Positive indicator is that our results are better than of the absolute majority of the old EU Member States.

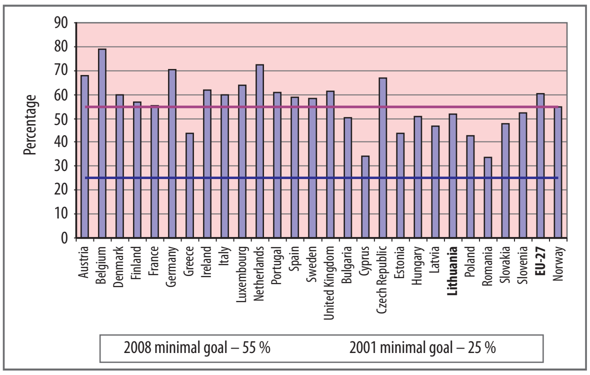



**Fig. 129.** Percentage of landfilled packaging waste of all managed waste in the EU-27 Member States. *Source: European Environment Agency*

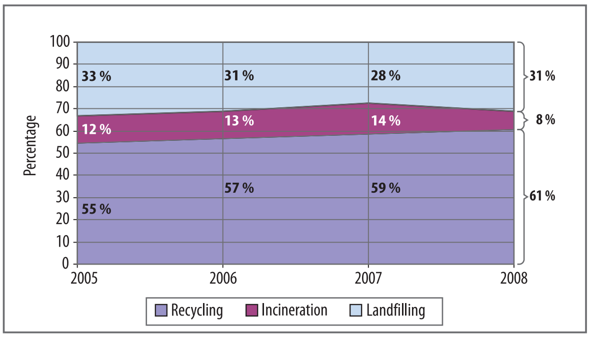



**Fig. 130.** Management of packaging waste by methods in the EU-27 Member States, 2005–2008. *Source: European Environment Agency*

Acording to the data of the European Environment Agency, in the recent years, the majority of packaging waste was recycled in the European Union and the amount of waste managed in such method increased annually during the period from 2005 to 2008 (Fig. 130). During this period, the analogous tendencies were also observed in Lithuania (Fig. 131). Based on the data of statistical reports of waste mangers, in 2010, more than 60% of all packaging supplied to the internal market were used/exported in our country.

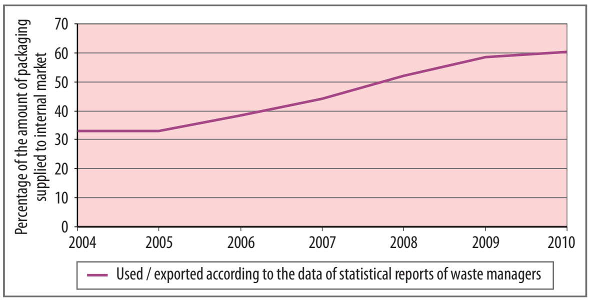



**Fig. 131.** Management of packaging waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

The major share of packaging waste collected in Lithuania was composed of easily recyclable waste, such as paper, glass, metal. Such waste should not occur in the landfill sites at all, however, the major share of them is still delivered there, and therefore, this problem should be solved.

The positive achievement is that namely this waste was managed in increasing numbers in the recent years (Fig. 132). As it is seen in the data of Fig. 132, the volumes of management of all main categories packaging increased in Lithuania from 2004 (after Lithuania joint the European Union). Interesting is the fact that, compared with the tendencies of variation of indices of other waste sector, the economic crisis had practically no negative impact on this index in 2008–2009, because, as shown by the data of the Environmental Protection Agency, even during the period of crisis, the volumes of the management of major categories of packaging increased. This is a clear result of the positive application of environmental, legal and economic measures.

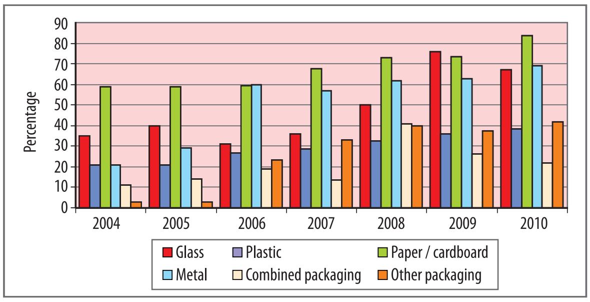



**Fig. 132.** Management of packaging waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

## MANAGEMENT OF BIODEGRADABLE WASTE

Biodegradable waste is a type of waste that can decompose or be decomposed by aerobic or anaerobic way, for example: food and kitchen waste (fruit, vegetable, meat, fish and similar residues), "green waste" (branches, leaves, grass, and garden (olericulture) waste). This type of waste also include paper and cardboard, wood, natural fabric waste as well as sewage sludge, biodegradable industrial waste.

According to the data of the Environmental Protection Agency, approx. 1 million 208 thousand tons of municipal waste were disposed of in landfill sites in 2000. Whereas biodegradable waste constituted approx. 60% of the mixed municipal waste. Thus, in 2000, there were 725.5 thousand tons of municipal biodegradable waste disposed of in landfill sites.

According to the data of environmental specialists, more than 700 thousand biodegradable waste is generated in Lithuania each year, approx. 320 thousand tons of which is from the sugar industry, and approx. 170 thousand tons – are alcohol production waste. When biodegradable waste pass to landfill sites, they start to break down (decompose). When oxygen does not participate in the decomposition process, methane and other gases are released as well as volatile organic compounds that have influence on the climate warming.

If the biodegradable waste is managed properly, it is possible to decrease not only their negative impact on the environment, but also to extract biogas or produce compost. By burning biogas, it is possible to produce electricity and thermal energy, and use it to heat water or use as bio-fuel for vehicles, and compost for the improvement of soil properties.

The construction of composting sites has been supported in Lithuania since 2000. Currently, there are 21 such sites installed by using the funds of the ISPA Programme for 2000–2006 and Cohesion Fund. By 2013, it is planned to install another 32 such sites by using the financing of the Cohesion Fund for 2007–2013.

People can deliver all green garden and olericulture waste to these sites free of charge. The received compost is later used for the city plantation works. Although the number of green sites is still insufficient in the country, not all municipalities find locations for the installation of such sites. On the other hand, the capacities of the current sites are used insufficiently.

The regional waste treatment centres operating in Lithuania (10 such centres in total) distribute special containers-boxes for residents of individual homes for composting biodegradable waste. Thus, the residents are encouraged to manage the aforesaid waste; however, the process of management of such waste does not happen smoothly.

The design capacities of the installed sites are currently reaching more than 34 thousand tons per year. In view of the fact that, in 2010, there were approx. 12.4 thousand tons of organic waste composted in these sites, it is possible to state that even now the sufficient capacities are formed for the development of system of collection of such waste.

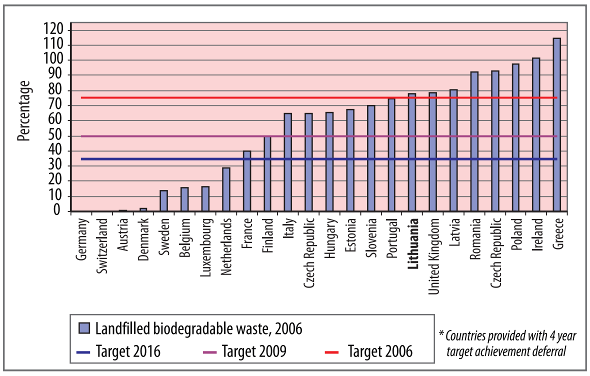



**Fig. 133.** Disposal of biodegradable municipal waste in landfill sites in the EU Member States in 2006 and the environmental aims. *Source: European Environment Agency*

According to the data of specialists, a small amount of biodegradable waste is composed in individual farms. The experts evaluated that approx. 7,400 tons of municipal biodegradable waste were composted individually. Green waste is used as a structural material to compost sewerage sludge; there were approx. 5,400 tons of green waste composted in such way in 2010.

According to the data of the Ministry of Environment, in 2010, there were 621,300 tons of municipal biodegradable waste landfilled. This index does not meet the environmental goals. In Lithuania and across the entire European Union, a particular focus is on the reduction of the amount of landfilled biodegradable waste (Fig. 133). Pursuant to the EU directives, the maximum amount of landfilled municipal biodegradable waste is established in the State Strategic Plan for Waste Management.

It should have been achieved by 2010, that no more than 75% of the amount of municipal biodegradable waste of 2000 were landfilled, no more than 50% of such waste should be landfilled by 2013 as compared with the amount of municipal biodegradable waste of 2000, i.e., no more than 362,600 tons, and by 2020 – no more than 35% of the amount of municipal biodegradable waste of 2000. Although we have not reached the indices established by the European Union, it is obvious that the situation is gradually improving.

When analysing the situation of the management of biodegradable waste in Lithuania in the context of other EU

Member States, it is obvious that the waste of such type are best managed in the mostly developed countries having the strongest economies. Nine old EU Member States already have the system of management reaching the targets of the management of biodegradable waste set for them. Whereas the majority of the new EU Member States, including Lithuania, are among the countries that need to put extensive efforts in improving the management of biodegradable waste.

## SECONDARY WASTE RECYCLING

Secondary waste recycling is not only one of the priority waste management methods, but also a serious economic measure raising the national economy. According to the data of the European Environment Agency, the turnover of the recycling of seven main secondary raw materials in the European Union alone, exceeding 32 billion euro in 2004 (Fig. 134), increased almost twice in 2008 and only the global economic crisis of 2008 that influenced the economy of the entire European Union conditioned the decrease of this index in 2009, however, the situation is believed to return to the former level in the nearest future. When evaluating the data submitted by the European Environment Agency, it is seen that the recycling of iron, steel, copper, aluminium, nickel and other metals constitute the highest turnover in the European Union. In Lithuania, metals also comprise the largest share of recycled secondary waste.

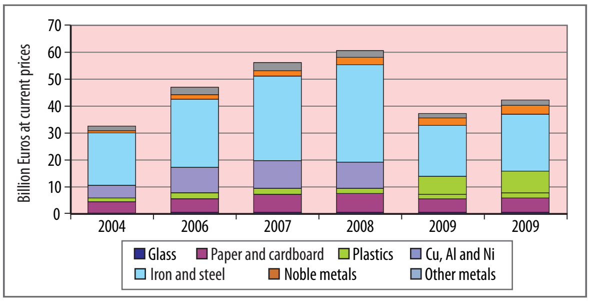



**Fig. 134.** Overall turnover of recycling of seven secondary waste groups in the European Union (billion euro) at current prices in 2004 and 2006–2009. *Source: European Environment Agency*

waste dumped by residents) pass unsorted to landfill sites together with other municipal waste. A particular focus was paid on the solution of this problem in recent years. Millions of Litas from the EU funds and Lithuanian budget were allocated to the education of residents and cultivation of the environmental consciousness in the area of waste management and sorting.

When analysing the tendencies of secondary waste recycling, it has been observed that they are similar in Lithuania as in the entire European Union. In our country, the collection and use of secondary waste increased from 2004 to 2007 and approx. 837 thousand of secondary waste were recycled / used during that period (Fig. 135). The occurrence of economic crisis conditioned a short-term yet significant decrease of this index in 2009, whereas in 2010, the situation started to improve again.

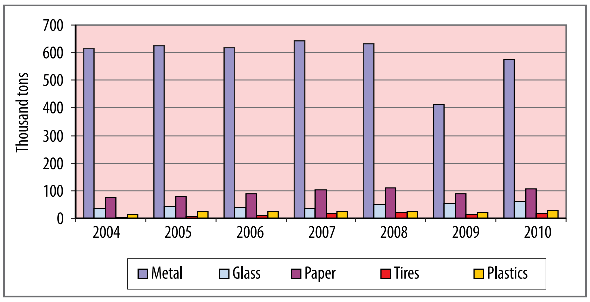



**Fig. 135.** Variation of volumes of use of secondary waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

The reduction of the amount of generated waste, by extracting and reusing secondary raw materials of waste is one of the environmental priorities in Lithuania. For this purpose, in 2006–2011 alone, 19,667 units of secondary raw material collection containers were installed in the municipalities. Such activity gives direct positive results. According to the data of the Ministry of Environment, in 2010 alone, in the sites of collection of large-scale waste, in waste acceptance posts as well as by using secondary raw material collection containers, approx. 100 thousand tons of paper and cardboard waste were collected. However, as it was already mentioned, it is necessary to acknowledge that a large share of waste than can be called the "secondary waste" (mostly paper and plastic packaging

In view of environmental protection, the increase in the collection and use of secondary waste is a good sign. The use of all secondary raw materials increased significantly in 2010, as compared with 2009, although failed to reach the level of use during pre-crisis period in 2007–2008 (31.7%).

In total, 784 thousand tons of secondary raw materials were used in 2010, same as in 2006, therefore, it is possible that the record level of 2008 will be reached and exceeded in the nearest future. The increase in the consumption of secondary waste of all categories has been observed, mostly – metal (39.7%), paper and plastic (17%). Among secondary raw materials, it is necessary to note glass the usage of which has been increasing annually since 2007.

The increasing use of secondary raw materials is related to several main reasons: the revival of economy leads to the use and more generation of potential secondary raw materials in households; residents and economic entities select and sort secondary waste more actively; the producers become increasingly more interested in the technologies and production made by using cheap secondary raw materials.

## MANAGEMENT OF HAZARDOUS WASTE

A separate group of waste is composed of hazardous waste. According to the evaluation of experts, the absolute majority of such waste is composed in the production and business companies and only an insignificant part in the households. The management of generated hazardous waste is a very relevant problem. In view of the management specifics, there are three main flows of hazardous waste:

- oil product waste,
- waste contaminated with oil products,
- hazardous transport waste,
- waste contaminated with heavy metals,
- chemical substance waste,
- medical waste.

Pursuant to the developed legal base, all hazardous waste flows should be managed by strictly following the requirements established by the legal acts and regulation of the management of such waste and also strictly controlled. It is planned that the infrastructure of management of hazardous waste should be composed of the entire complex of measures, including the equipment of disposal of such waste that would be efficient if installed in one base of current regional hazardous waste treatment company, however, first of all, it is necessary to build modern hazardous waste incineration and stabilisation facilities using state funds and international investments.

In Lithuania, hazardous waste is managed by licensed hazardous waste treatment companies. In 2006, hazardous waste was used by 34 companies, in 2007 – 23, in 2008 – 19, in 2009 – 18 companies. Such decreasing number of companies managing hazardous waste was conditioned by the fact that the companies engaged in such activity became larger, the weakest and accidental "players" were eliminated from the market. In this area, it is much easier for the large hazardous waste treatment companies to adapt to established high environmental requirements.

The capacities of hazardous waste treatment meeting the European requirements are currently intensively created in the country. At the moment there is a hazardous waste treatment company in Vilnius with branches in Alytus, Klaipėda and Šiauliai. 92.5% of shares of this company owned by the state are controlled by the Ministry of Economy by the right of trust. The treatment of oil and soil, sludge and water contaminated with oil products is performed in special companies.

With regard to the management of oil product waste, it should be noted that, according to the data of the register of companies engaged in waste treatment, in 2006, 17 companies used oil waste in Lithuania, in 2007 – 10, in 2008 – 9, in 2009 – 8. So far, Lithuania does not have used oil waste regeneration facilities, however, the facilities of oil recycling to fuel are operating.

When analysing the tendencies of collection and management of hazardous waste in Lithuania, although there have been certain variations of amounts in certain years, the decrease in the level of generation and management of this type of waste has been recorded since 2004 (Fig. 136). This tendency could be related to the fact that a significant share of hazardous waste managed in this period was accumulated in earlier years, whereas the generation of new waste of this category showed a certain decrease. From the environmental perspective, this is a positive phenomenon, as the negative influence on environment is reduced.

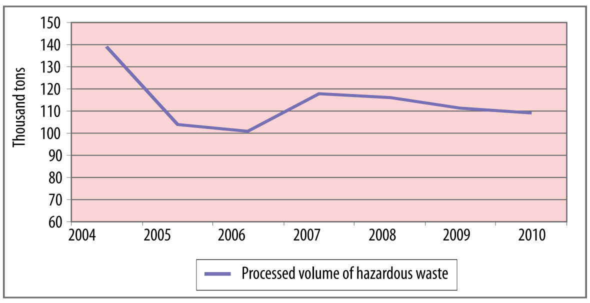



**Fig. 136.** Tendencies of management of hazardous waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

Management of medical waste still remains an unsolved problem. The solution of this problem requires the development of medical waste elimination infrastructure. Chemical disinfection, thermal or microwave sterilisation of such waste are only intermediate methods, assisting their storage and carriage, however, do not solve the problems of safe elimination of such waste.

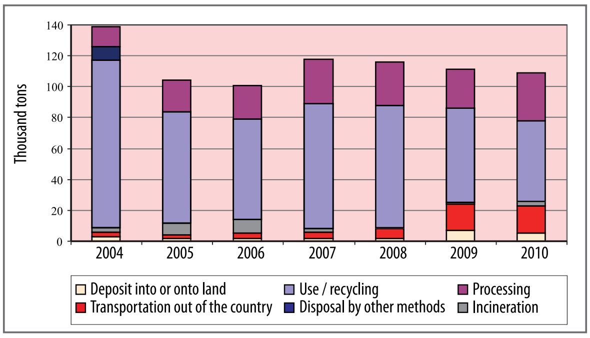



**Fig. 137.** Management of hazardous waste in Lithuania by different methods, 2004–2010. *Source: Environmental Protection Agency*

When seeking for maximum environmental results in the area of management of hazardous waste, the technological capacities of their management are intensively expanded. In the near future, it is planned to start the operation of hazardous waste incineration facility, which is already built and the design capacity of which should amount to 8 thousand tons per year. Furthermore, the installation of the landfill site of hazardous waste is in the finishing stage in Lithuania, the design capacity of which would be 45 thousand tons. These capacities should be sufficient for Lithuania and the problems of collection and management of hazardous waste generated in the country would be successfully solved.

When evaluating the tendencies of hazardous waste management in Lithuania from 2004 to 2010 (Fig. 137), it can be seen that the majority of hazardous waste is recycled or used in other ways. As compared with the year of accession to the European Union, the amount of hazardous waste transported from the country increased and more and more hazardous waste is disposed in Lithuania by other environment-friendly ways. It is likely that after the start of operation of waste incineration facilities and construction of a special landfill site for deposition of hazardous waste, such waste treatment method would become less harmful to the environment.

## TYRE WASTE MANAGEMENT

Management of used tyres is the problem of the majority of developed countries around the world. The recycling of used tyres is not only of high ecological, but also economic significance, first of all, related to the opportunities of reuse of polymeric raw material contained in tyres. Tyre collection volumes have increased since Lithuanian joined the European Union. If there were less than 3 thousand tons of tyres collected in 2004, the amount of used tyres collected in 2010 exceeded 16.5 thousand tons (Fig. 138). On one hand it is related to the increasing number of vehicles and higher attention of drivers and responsible institutions on the auto-transport safety and the state of used tyres. However, in this case, a high influence is made by the Ministry of Environment and its subordinate institution in improvement of the legal base, strengthening of control and expanding the system of collection of improper tyres in Lithuania.

According to the evaluation of experts, approx. 15–16 thousand tons of unused tyres are generated in Lithuania annually, a similar amount should be properly managed in order to avoid danger to the environment. Positive indicator is that the amount of properly managed tyres increases is increasing in the country, and this index increased more than 5 times from 2004 to 2010 (Fig. 139), whereas the amount of waste of stored tyres is decreasing.

This was conditioned by the improving collection of unserviceable tyres in Lithuania and increase in the capacity of their management, especially considering the fact that tyres started to be crushed and used for the production of energy.

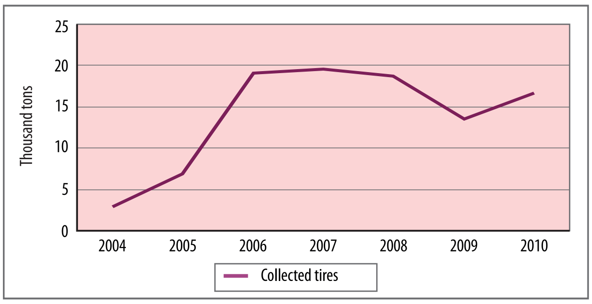



**Fig. 138.** Tyre collection dynamics in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

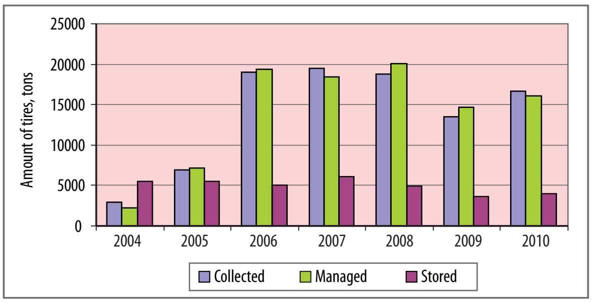



**Fig. 139.** Management of tyre waste in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

It was calculated that there is approx. 5 kg of tyre waste per capita generated on average in our country each year. In more economically developed countries the number is higher – approx. 9 kg per capita per year. According to the opinion of environment specialists, in Lithuania, the growth of economy and increase in the standard of living will lead to the annual generation of 30 thousand tons of used tyres in the future, i.e., up to 10 kg per one statistical resident.

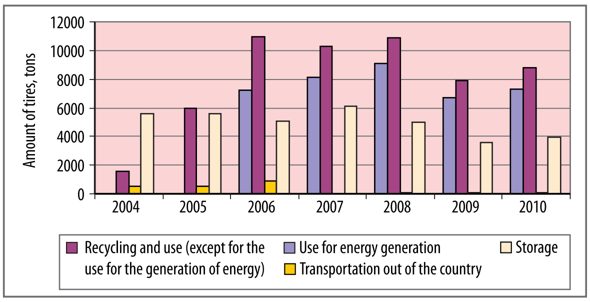



**Fig. 140.** Tyre waste management tendencies in Lithuania, 2004–2010.
*Source: Environmental Protection Agency*

After joining the European Union, the sufficient capacities for the modern management of such waste were created in the country. The recycling of tyre waste started in Lithuania in 2004. 1,234 tons of waste was crushed mechanically at that time and granules were produced. In 2006, tyre waste was started to be used to receive energy by burning them in furnaces (Fig. 140). As far back as in 2006, the available capacities allowed for the management of more than 18 thousand tons of tyres annually, whereas pursuant to the experimental calculations based on the analysis of Lithuanian vehicle fleet they can increase up to 70 thousand tons per year in the nearest future. In this way it is possible to state that there are sufficient capacities in Lithuania for successful utilisation and recycling of the entire amount of generated tyre waste, but also it is necessary to improve their collection from residents.

When analysing the tendencies of tyre waste management after Lithuania joined the EU, it can be seen, that two main methods of their management have formed recently: use for the production of energy and recycling and reuse. Approx. 80% of tyre waste was managed by these two methods in the recent years. Also, from the environmental perspective, positive indicator is that the amount of stored tyre decreased from more than 70% in 2004 to less than 20% in 2010. These tendencies meet the environmental priorities of Lithuania and the European Union.

## MANAGEMENT OF RADIOACTIVE WASTE

Radioactive waste is the used nuclear fuel and other materials contaminated with or containing radionuclides, which are not planned to be used in the future. Radioactive waste is usually different from other industrial waste by their nature. These can be equipment, dismantled devices, protective clothing, filters and liquids contaminated with or containing radionuclides and not planned to be used in the future. However, radioactive waste is specific because of ionising irradiance, i.e., radiation, therefore are dangerous to mankind and environment. Radiation spreads because of the decay of radionuclides contained in waste.

In Lithuania, which has a private nuclear power plant, the problems of radiation safety, management of radioactive waste and prevention of radiation are relevant. These dangers can be caused both by the natural and anthropogenic origin sources of radiation. The problem of radioactive materials of natural origin is complex and multifaceted. One of the observed areas of potential risk is the discharge of natural radionuclides to environment from the companies producing cement and ceramic tiles. For the production of such products, these companies use raw materials containing natural radionuclides and the technological process occurs in high temperature.

Due to high temperature, natural radioactive 238U chain decay elements 210Pb and 210Po turn into gas and pass to the atmosphere through chimneys. The minimisation of discharge of radionuclides to the environment is sought by applying certain technologies, for example, part of 210Pb is retained by filters, however, due to particularities of technological processes, there is not enough time for 210Po to condense in filters, therefore, a small quantity of them are released into the environment.

Having tested the amounts of radionuclides in raw materials used in the production of cement and ceramic tiles, and the products itself, the specialists evaluate the annual amount of 210Po passing to the environment from factories. By applying TATENA universally accepted models, the average annual irradiance to be received by the residents living near factories due to inhaled 210Po contained in the environment air is calculated. It has been established that this irradiance should not exceed 8 µSv.

Not all radioactive waste is equally dangerous. The hazardousness of radioactive waste is conditioned by the intensity of ionising irradiance, which depends from the type and amount of radionuclides present in the waste. The radiance of certain radionuclides is retained by simple protection barriers, and some require the usage of concrete or lead barriers. Therefore, such waste is classified based of dangerousness. The classification allows not only the easier selection of suitable processing methods and measures, but also the method of disposal.

In view of the category of radioactive waste and the danger to environment and human health, strict safety requirements, accounting and control are applied for the management of radioactive waste. Such waste should be sorted, processed and transported to radioactive waste sites and storage places. In order to ensure the safety of environment and people, first of all, it is necessary to seek that the amount of generated radioactive waste would be as minimal as possible. The generated waste should be sorted so that it would be more facilitated and simplified to manage such waste and deposit to waste sites.

Radioactive waste is, first of all, managed pursuant to the principle "Concentrate and contain, prevent from dispersing". It is based on the fact that waste (radionuclides present in waste) are concentrated and kept isolated in order to prevent from spreading into the environment and causing damage to people and environment. Waste is concentrated by using various methods seeking to reduce their volume and isolate them. This principle is applied on solid and liquid waste. The waste should also be kept isolated for a rather long period of time until the major part of contained radionuclides decay (turn into stable nuclei) and cause no harm.

Another potentially dangerous source of irradiance is the radioactive waste. Therefore, it is important to ensure that the residents would not suffer potentially harmful impact of ionising irradiance by operating radioactive waste storage facilities. In order to evaluate whether radionuclides are not passing to the environment and whether they cannot condition additional irradiance of population due to possible release into the drinking water and food products, the radiological status of the closed Maišiagala radioactive waste storage unit and its territory has been observed for a decade already. The evaluation of the radiological status is measured by the dose rate; the samples of soil, fungi and water are taken from the bores located in the territory of storage unit. For this purpose, the quality and reliability of pile sealing works performed as far back as in 2006 were showed by the certain decrease of tritium volume activity observed in the recent years in the water of bores installed near the pile. As it was revealed by the data presented by the SE Radioactive Waste Management Agency, since 2006, after the modernisation of the Maišiagala storage unit, the volume activity of tritium has constantly decreased in the groundwater. This tendency is best illustrated by the diagram of variation of tritium volume activity data observation in 41p bore located within a distance of 0.5 m from the wall of the radioactive waste vault (Fig. 141).

According to the evaluation of experts, approx. 60 thousand m$^3$ of low-radioactivity waste, 100 thousand m$^3$ of low- and medium-radioactivity waste, 2.5 thousand tons of used nuclear fuel and 10 thousand m$^3$ of other long-term radioactive waste should be generated during the period of termination of operation of Ignalina Nuclear Power Plant (NPP). All waste generated since the start of operation of Ignalina NPP are currently stored in the storage units installed in the power plant. This is only a temporary solution.

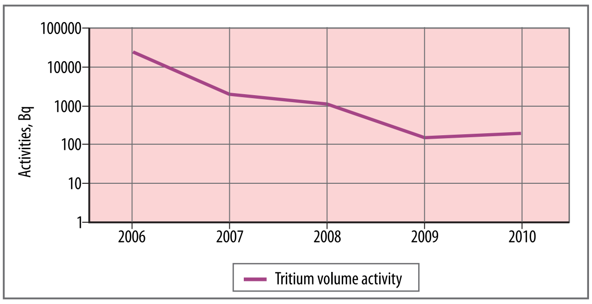



**Fig. 141.** Diagram of variation of tritium volume activity, 2006–2010. *Source: SE Radioactive Waste Management Agency*

Radioactive waste storage unit is a management facility, where waste is temporary isolated with the intension to move them to the waste site in the future. Waste sites of radioactive waste are engineering facilities with special safety barriers that are installed to protect the environment from the harmful impact of ionising radiation during the entire period of dangerousness of radioactive waste (here, the waste is place without planning to take them away). It has been identified that waste sites are the safest and most reliable facilities for the storage of radioactive waste. Each country that had benefit from the activity, which generated waste, must take care of the proper management of such waste by itself. The ditch-type and surface-type designs of radioactive waste disposal facilities are currently in the progress in Lithuania and their construction is included in the plans.

By implementing the State Radiology Monitoring Programme and seeking to ensure the protection of population safety against harmful impact of ionising radiation, the Radiation Protection Centre performs the monitoring of radiation received by population from all possible sources of radiation. The data on the amounts of radionuclides in the surrounding and working environment are required for the implementation of this objective. Radionuclides contained in food products, their raw material, drinking water and air condition the internal irradiance on the residents, whereas the external irradiance is conditioned by the ionising radiation reaching the person from cosmos and depths of the Earth, buildings. For reliable evaluation of the influence of these indicated components containing radiation on all radiation received by population, the constant monitoring of the radiation received by the persons is performed.

By summarising the results of the researches of 2010, it is possible to state that in 2010, higher food contamination with radionuclides 90Sr and 137Cs was recorded, as compared with previous year. In the samples of food taken within 50 km range around the likely influence region of Ignalina AE, higher 90Sr and 137Cs activity have not been observed, as compared with the samples taken in other regions. The results of researches performed in 2010 showed that the activity of 90Sr and 137Cs radionuclides in unprocessed local origin food products and their raw materials is very low and has not changed for the recent decade.

In order to evaluate and forecast the impact of termination of Ignalina NPP operation on people and environment, in 2010, there were additional 160 researches performed in the range of 15 km around Ignalina NPP.

The established medium annual environment dose was not different from the doses measured in other monitoring points. The performed tests show that the works performed in the currently dismantled Ignalina NPP do not cause additional radiation on Lithuania's population. In the future, seeking to evaluate the possible additional radiation on population and their separate groups from newly built nuclear power plants, it is planned to expand the monitoring of environment doses in the territories of Lithuania and neighbouring countries.

As it was already mentioned, radioactive waste is generated not only in the activity related to nuclear energy. Each year, radioactive waste is collected from small waste producers and managed. In 2010, such waste was delivered by nine organisations. These included 1,548 devices with 1,665 used closed ionising radiation sources. The total weight of radioactive waste – 11,016 kg, volume 26.23 m$^3$, activity – 4.89 x 1013 Bq.

After performing the processing of radioactive waste, reducing their volume and packaging, such waste was delivered to the temporary storage unit in Ignalina NPP. The tendencies of variation of the number of managed used devices with closed sources of ionising radiation in 2004–2010 are presented in Fig. 142. In the same 2010, 20 companies and organisation, seeking to import ionising radiation sources to the Republic of Lithuania, applied to SE Radioactive Waste Management Agency regarding the conclusion of agreements on management of radioactive waste covered by suretyship insurance.

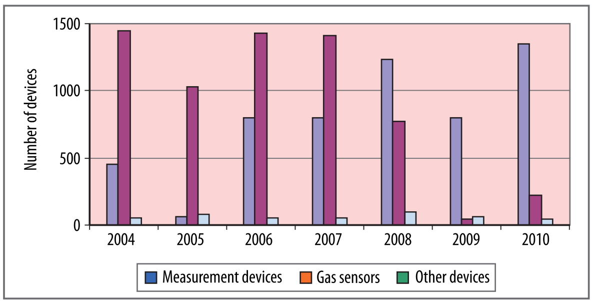



**Fig. 142.** Management of used devises with closed sources of ionising radiation, 2004–2010. *Source: SE Radioactive Waste Management Agency*

In the recent years, the increase in the number of found illegal sources of ionising radiation and objects contaminated with radionuclides was recorded in Lithuania. The tendencies of variation of their collection in 2006–2010 are presented in Fig. 143. Such radioactive waste is collected, processed and handed over for storage in the storage units of Ignalina NPP.

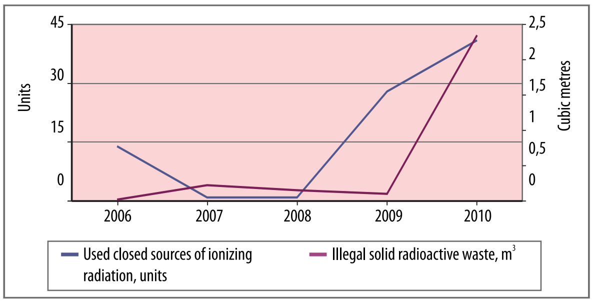



**Fig. 143.** Variation of number of illegal sources of ionising radiation and collection of objects contaminated with radionuclides, 2006–2010. *Source: SE Radioactive Waste Management Agency*

## ENVIRONMENT PROTECTION OFFENCES IN THE WASTE SECTOR

When analysing the dynamics of the variation of recorded environmental offences in the waste sector, it can be seen, that the number of such offences increased during the first three years after Lithuania's accession to the European Union, however, the tendency of decrease in the number of offences has already been observed during the recent years (Fig. 144). It is related to the tightened control of environmental offences in the waste sector during the recent years and more strict liability of offenders for the made offences in the waste sector.

The offences of environment protection requirements in the waste sector amounted to 20% of all solved offences of environmental requirements. It should be noted that since 2008, when 2,650 such offences of environmental requirements were recorded, the tendency of decrease in the number of recorded offences of environment protection requirements in the waste sector has been recorded. It has been conditioned by especially increased focus of environmental institutions on the waste sector (improved legal acts, more intensive and efficient control, increasing waste treatment volumes).

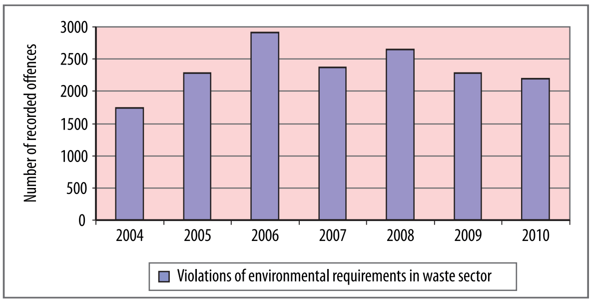



**Fig. 144.** Dynamics of offences of environmental requirements in waste sector in Lithuania, 2004–2010. *Source: Environmental Protection Agency*

## CONCLUSION

By summarising the tendencies in the waste sector, the progress made by Lithuania in the environmental protection waste sector since the accession to the EU until 2010 is clearly noticeable, especially in the area of management of municipal waste. One of the most difficult tasks yet remaining is the insufficient consciousness of our population in the management and sorting of municipal waste, undeveloped system of medical waste treatment, problematic absorption of capacities of dangerous waste incineration within the established terms.

# Landscape

## CHANGE OF LANDSCAPE STRUCTURE

Human activity makes a huge impact on the functioning, dynamics and evolution of landscape. Due to increasingly intensive anthropogenic impact on the landscape, there is increasingly less time for the system to react and adapt. The majority of natural processes forming landscape (biogenic, littoral, geochemical, karst, slope) are actually influenced by and transformed by anthropogenic economic activity (agriculture, industry, construction, transport).

This is the manifestation of indirect anthropogenic impact on the living environment. Direct human influence on the landscape is mostly manifesting by changing its structure, by supplementing, "growing" technosphere, by pushing out such natural components as soil, vegetation and fauna, by changing relief and climate.

The variation of landscape structure due to anthropogenic activity is mostly reflected on the land cover, in the upper layer of the solid Earth's membrane and manifests as the changes of utilised land, urbanised territories and transport lines.

Technogenic elements of landscape are characterised by regular arrangement in the Lithuania's territory. The road network becomes denser and its created landscape fragmentation is increasing closer to the settlements. Furthermore, certain peculiarities of arrangement of urbanised, agrarian and natural (forest and swamp) areas exist. Settlements are usually surrounded by the aureole of agrarian fields of the width of 1.5–2 km, and natural territories stretching behind them in a ring of the width of 2–3 km (Fig. 145).

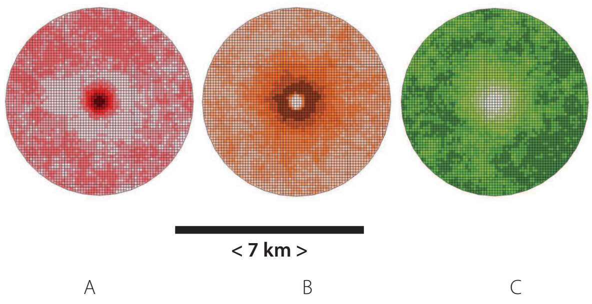



**Fig. 145.** Frequency of occurrence of urbanised (A), agrarian (B) and natural areas (C) moving away from the settlement located in the centre. The more intensive the colour, the higher the frequency of occurrence *(D. Veteikis, M, Jankauskaitė, 2009)*

A significant work has already been done in order to evaluate the changes of landscape structure, however, some works were based on rather highly generalised material (for example, database of 1:100 000 scale CORINE land cover), other, although in more detail (for example, in scale of 1:10 000 of aerial photography images and larger), but examine individual ranges.

During the Independence period and until the accession to the European Union, Lithuania's land cover was cartographed or photographed in 1995 (the first Lithuania CORINE land cover GIS database was prepared), in 1995–1999 (the first b/w aerial photograph was created, hereinafter referred to as the aerial photograph of 1995) and in 2000 (the second CORINE land cover database was created). After joining the European Union, the surface structure of the Lithuania's landscape was also cartographed for three times: in 2005–2006, the colour aerial photograph was created (hereinafter – the aerial photograph of 2005), in 2006, the CORINE land cover GIS database was created and, in 2009–2010, the aerial photograph was created (hereinafter – the aerial photograph of 2009).

From the aforementioned sources, the direct information on the landscape structure can be received from the CORINE database; however, due to the fineness of scale, its particularity is relatively lower. However, pursuant to this database, it is possible to analyse the technogenic landscape structure, especially by adding additional detailed information from other databases. The districting of Lithuania's technosphere created by using namely these data revealed the cultivation differences in Lithuania in a rather expressive way (Fig. 146).

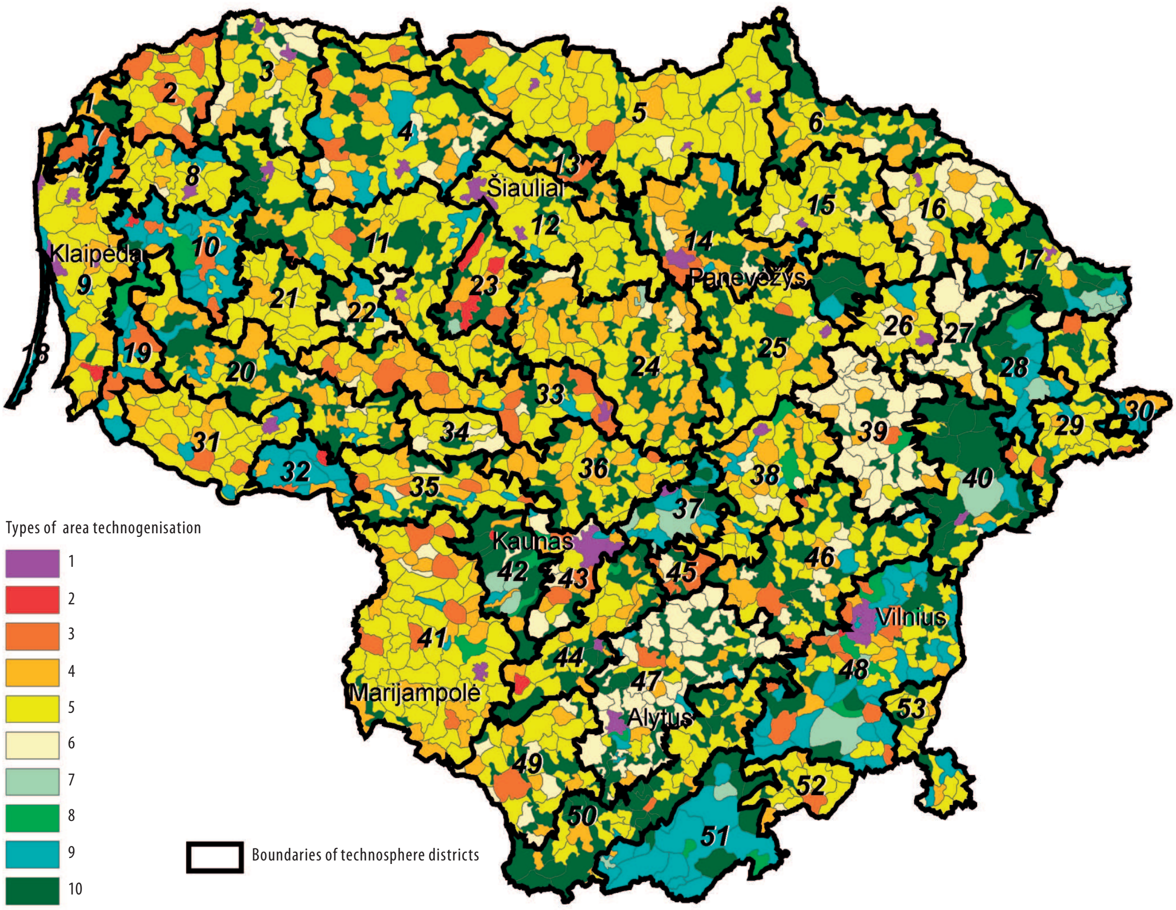



**Fig. 146.** Lithuania's landscape technosphere (cultivation) districts. In the map, the numbers of districts are marked by black numbers, boundaries – by thick black line. The types of areal technogenisation: 1 – industrial and residential development; 2 – industry–mining; 3 – large-scale urbanisation agrarian; 4 – medium urbanisation agrarian; 5 – rural agrarian; 6 – farm-stead agrarian; 7 – large-scale urbanisation in natural areas; 8 – medium urbanisation in natural areas; 9 – rural natural areas; 10 – farm-stead in natural areas *(D. Veteikis, M. Jankauskaitė, 2009)*

Based on the Lithuanian CORINE land cover report (Vaitkuvienė, Dagys, 2008), 1.53% of the entire land cover of Lithuania's territory changed in 2000–2006 (99.7 thousand ha). The major changes have been observed in forest and other natural territories (79% of all changes). They mostly occurred in forest class, where even 50.8 thousand ha were composed of forest cuttings, whereas reforestation covered 26.9 thousand ha. The area of swamps and water bodies decreased by 0.5 thousand ha. Approx. 18% of all changes were comprised by internal changes in agricultural territories, part of which turned into grazing areas (2.8 thousand ha), and part – into bushes (2.1 thousand ha), whereas 7.7 ha of grazed territories were turned into arable land. The area of developed territories increased by 1.9 thousand ha.

It is also necessary to add 2.0 thousand ha of constructions, which will have to turn into developed territories in the perspective. 2.7 thousand ha of area were taken from agricultural areas together with land for roads and railways and urbanised spaces (artificial covers). The area occupied by mineral excavation sites increased by 0.7 thousand ha. The CORINE land cover data of later periods does not exist, therefore the summaries on further changes of Lithuanian landscape that occurred after 2006 can be made by using the databases of larger scale, based on the material of orthophoto images (the most recent one reflects the situation of 2010).

The changes of agrarian land that occurred in 1995–2000 and 2000–2006, obtained by CORINE land cover analysing, show the turning-point in the structure of land utilisation after 2000. Its date should be specified from indirect non-cartographic sources only. Pursuant to the CORINE data, in 1995–2000, two main processes of Lithuanian landscape were dominating: 1) forest cutting and 2) increasing intensiveness of agriculture (by turning pastures into arable land and significantly increasing the areas of complex agriculture).

During the following 6 years (2000–2006), the tendencies of changes remained practically identical, however, more intensive – forest cutting and large scale conversions of agrarian land types, when pastures were turned into arable land more intensively. As it was already mentioned, many agricultural areas were abandoned and turned into transitional bushes. However, in general, the areas of agrarian lands have a tendency to shrink as more of them are lost than created (Table 5).

**Table 5.** Types of land cover turned into the agrarian lands (left column) and the types of land cover formed from agrarian lands (right column). Source: Lithuanian CORINE land cover database (1995, 2000 and 2006). Data are provided in hectares for the entire territory of Lithuania; the changes occurring inside the agriculture territories have been ignored *(Mačiulytė at al., 2012)*

<table>
<tr><td colspan="3">1995–2000</td></tr>
<tr><td>Natural meadows<br>(147.7 ha)</td><td rowspan="5">⇨ Agricultural territorie ⇨</td><td>Urbanised territories (continuous development, road and railway network, construction areas, etc.)<br>(307.7 ha)</td></tr>
<tr><td>Transitional forest stages and bushes<br>(66.4 ha)</td><td>Water bodies<br>(283.0 ha)</td></tr>
<tr><td>Water bodies<br>(61.1 ha)</td><td>Mineral excavation sites<br>(281.9 ha)</td></tr>
<tr><td rowspan="2">Forests<br>(61.2 ha)</td><td>Transitional forest stages and bushes<br>(229.2 ha)</td></tr>
<tr><td>Coniferous forests<br>(6.6 ha)</td></tr>
<tr><td colspan="3">2000–2006</td></tr>
<tr><td>Water bodies<br>(588.5 ha)</td><td rowspan="5">⇨ Agricultural territories ⇨</td><td>Urbanised territories (continuous development, road and railway network, construction areas, etc.)<br>(2720.6 ha)</td></tr>
<tr><td rowspan="4">Other various types of land cover<br>(43.1 ha)</td><td>Transitional forest stages and bushes<br>(2,466.4 ha)</td></tr>
<tr><td>Mineral excavation sites<br>(582.2 ha)</td></tr>
<tr><td>Water bodies<br>(114.5 ha)</td></tr>
<tr><td>Other various types of land cover<br>(57.6 ha)</td></tr>
</table>

* 588.5 ha of water bodies turned into agrarian areas – re drained bodies to the north of Musteika village in Varėna region.

This overall statistics received after comparing different periods of CORINE land cover databases (1995, 2000 and 2006) can be supplemented by territorial analysis of changes showing the territorial differences of change of land cover. Fig. 147 shows the main dominating transformation processes in morphologic landscape units, having evaluated the changes of land cover that occurred in 1995–2006 and their sequences. However, it is necessary to keep in mind, that the precision of CORINE cartography is 20–25 ha, i.e., finer ranges are generalised.

As it is seen, until 2006, the process of loss of mature forest areas occurred in the major part of physio-morphotopes (occupying about two thirds of Lithuania's territory), generally showing the scale of cutting of Lithuanian forests. Most intensive process occurred in the Central and North-East Samogitia, Central Lithuanian and East and South-East Lithuania.

In one fourth of Lithuania's territory, the second main process was the increase in natural areas. The increasing areas of natural territories related to natural and instantaneous reforestation in abandoned agrarian ranges and planting of new forests. The most intensive increase in natural areas was observed in the south-west part of Lithuania and Klaipėda region as well as Eastern Samogitia, some isolated ranges in North-West Lithuania, Šventoji middle river and low river valley and near valleys, lakes of Aukštaitija highlands and laky pools, in large part of Dzūkija highlands (Fig. 147).

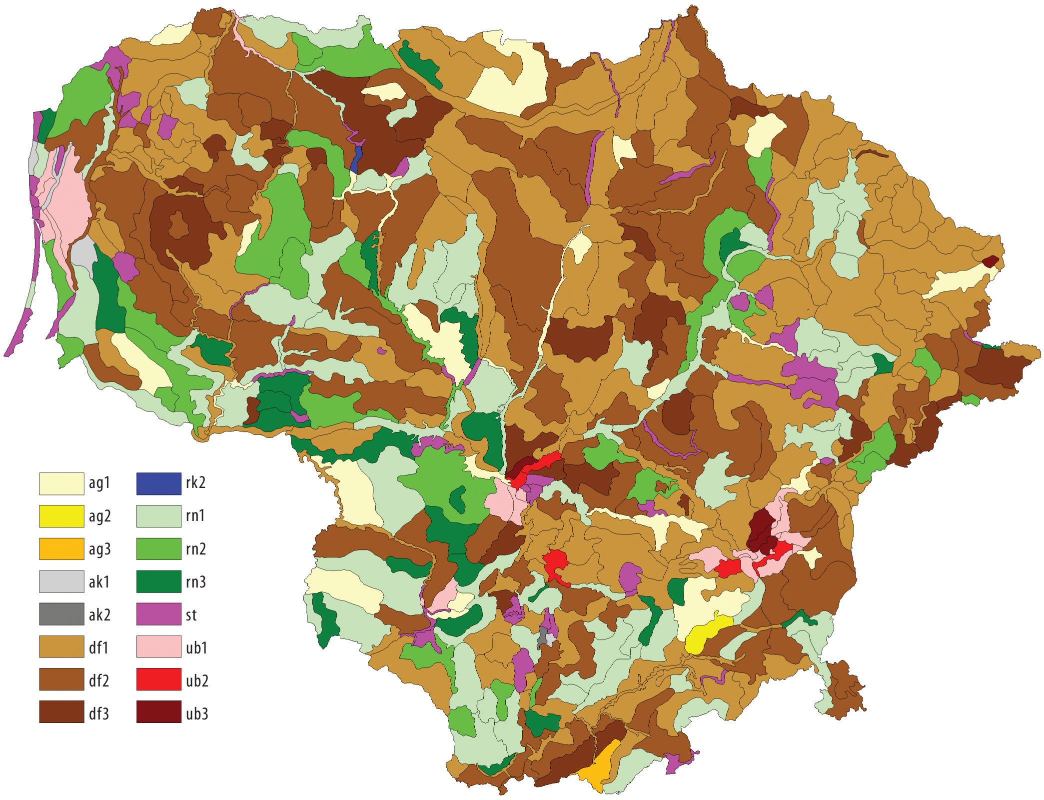



**Fig. 147.** Dominating processes of landscape change in landscape physio-morphotopes in 1995–2006, according to CORINE data (land cover fixation in 1995, 2000 and 2006) (*Source: Veteikis and Kavaliauskas, 2006*): ag1 – insignificant increase in agrarian areas; ag2 – medium increase in agrarian areas; ag3 – significant increase in agrarian areas; ak1 – insignificant processes of landscape degradation; ak2 – noticeable processes of landscape degradation; df1- insignificant decrease in mature forest areas; df2 – medium decrease in mature forest areas; df3 – significant decrease in mature forest areas; rk2 – medium-scale recultivation or territory or decrease in construction areas (finished constructions); m1 – insignificant increase in natural areas; m2 – medium increase in natural areas; m3 – significant increase in natural areas; st – new constructions; ub1 – insignificant urbanisation processes; ub2 – medium-scale urbanisation processes; ub3 – intensive urbanisation processes. *Source of physio-morphotope margins: Landscape strategy of the Republic of Lithuania, 2006*

**Table 6.** Distribution of the number of benchmarks by main landscape types in view of landscape monitoring sites *(according to M. Jankauskaitė, D. Veteikis, 2009)*

| Item No | Summarised types of landscape | | | Number of etalons (gradual proportionality) |
|---|---|---|---|---|
| | Type | Area covered (thousand km$^2$) | Share of Lithuania's area (%) | |
| 1. | Clayey wavy plateaus | 11.0 | 16.6 | 17 |
| 2. | Delta valley and delta | 0.2 | 0.4 | 4 |
| 3. | Lakes | 2.5 | 3.8 | 9 |
| 4. | Moraine hills | 10.0 | 15.1 | 16 |
| 5. | Sandy plains | 5.5 | 8.4 | 13 |
| 6. | Clayey plains | 23.9 | 36.1 | 22 |
| 7. | Curonian Spit | 0.1 | 0.2 | 5 |
| 8. | Sandy seaside plain | 0.2 | 0.3 | 3 |
| 9. | Valleys | 4.0 | 6.0 | 11 |
| | In total | 57.4 | 86.8 | 100 |

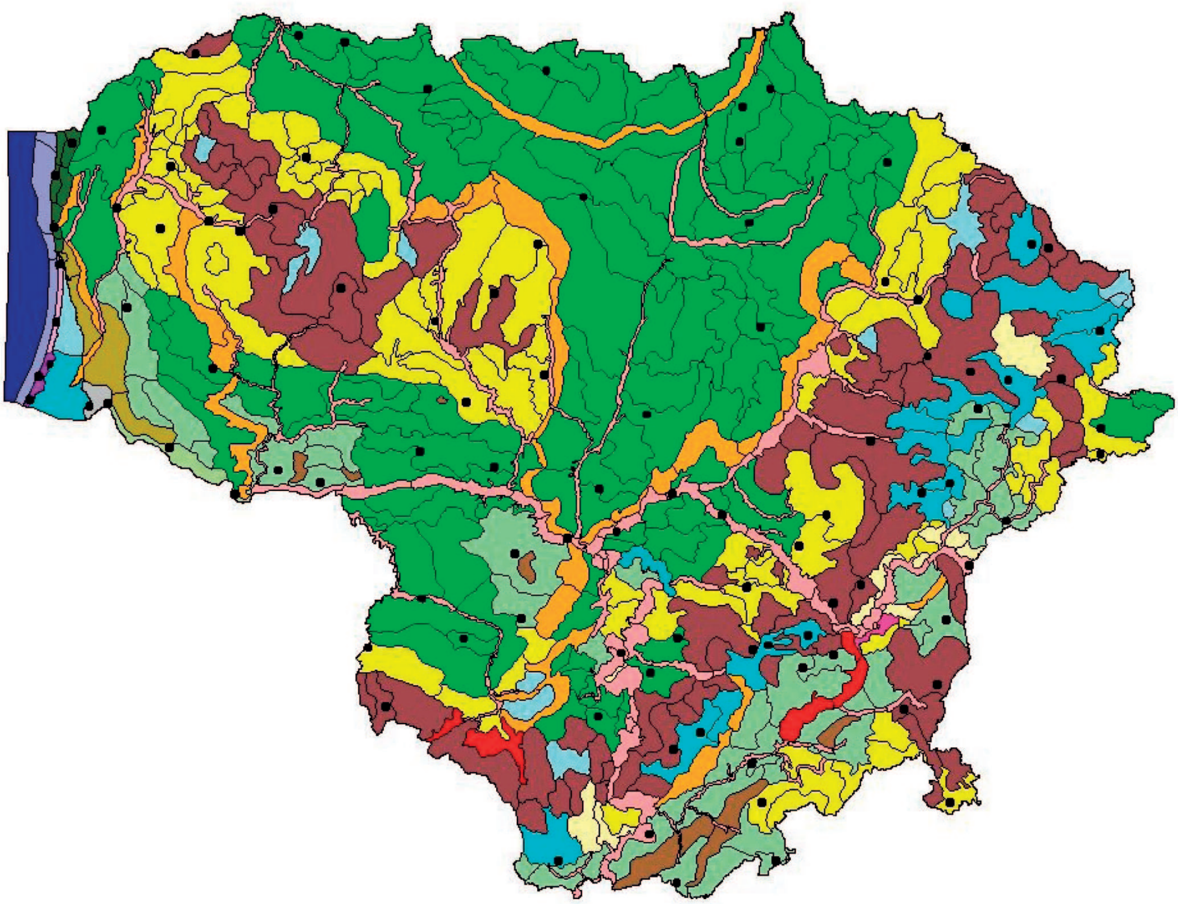


**Fig. 148.** Situation of landscape monitoring benchmarks (black squares) on local site level in landscape physio-morphotopes *(Jankauskaitė, Veteikis, 2010)*. For more brightness, the benchmarks are increased by approximately twice. *Source of map of landscape physio-morphotopes: Landscape strategy of the Republic of Lithuania, 2006*

Landscape units, which were dominated by urbanisation (together with construction) and agrarisation processes in 1995–2006, are occupying Lithuania's territory almost equally (by 5%). There was an increase in developed areas and construction in the territories of major cities (Vilnius, Kaunas, Klaipėda, and Alytus) and their surrounding areas. Urbanisation processes surpassed the forest cutting and renaturalisation processes in certain physio-morphotopes of lakes of the Baltic highlands, certain valleys and in the western part of Northern Lithuania. The increase in agrarian areas, which was more intensive in the South-East Lithuania, was noticed in sporadically scattered different physio-morphotopes. Other landscape processes are dominating in less than 1% of all physio-morphotopes by area (Fig. 148).

Due to already mentioned generalisation of CORINE data, the landscape changes covering small objects or fine territories can be missed, although they would be noticed by terrain observer in nearly all Lithuania's territory. Therefore, by using aerial photographs, the changes of utilised land were observed in separate ranges (of the size of 1.5x1.5 km), gradually listed in various landscape types (Table 6, Fig. 148).

The analysis of land use structure variation was performed in the aforementioned ranges from 1974–1986 (the land use situation recorded in the Soviet topographic maps) until 2005–2006 (colour aerial photograph). Significant changes of the landscape land use structure were recorded: during the analysed period they accounted to even 17.4% excluding the interconversions of meadows, pastures and arable land, by connecting these types of land use to one category (land uses). If the changes between mentioned categories were recorded, the percentage of change would amount to 30–50%. In 1974–2006, the major changes of Lithuanian landscape occurred in fine areas (Table 7), i.e., the share of areas that suffered changes and were smaller than 5 ha accounted for 74%. It is likely that namely these changes have been dominating in our country thus far.

From the second half of the Soviet period until 2005–2006, the major changes of landscape land uses were landscape renaturalisation and development of urbanised territories. Renaturalisation occurred by abandoning the land, which later turned into forest, swamp and bushes, as well as by turning the arable land into meadows and pastures. Although the process of turning of forests, bushes and other categories of land uses into utilised agricultural area occurred at the same time, it was less intensive.

To sum up, it is possible to state that, during the discussed period, the share of forests, bushes and swamps increased by 3.7% in the land use structure, whereas the share of utilised land decreased by 4.9%.

The area of developed territories and land uses nearby (gardens, ponds, streets and roads) increased by more than double during the discussed period (from 1.2% to 2.8%).

**Table 7.** The structure of land use changes in landscape monitoring etalons occupying the total area of 250 km$^2$ in 1974–1986 and 2005–2006, *(Landscape structure…, 2008)*

| The size of ranges of changes (ha) | Number of ranges of changes | Area of ranges of changes (ha) | Total area of changes, % |
|---|---|---|---|
| Up to 0.1 ha | 3933 | 129.8 | 3.0 |
| From 0.1 to 0.5 ha | 2975 | 717.1 | 16.5 |
| From 0.5 to 1 ha | 813 | 570.5 | 13.1 |
| From 1 to 5 ha | 870 | 1798.8 | 41.3 |
| From 5 to 10 ha | 71 | 502.3 | 11.5 |
| More than 10 ha | 40 | 634.9 | 14.6 |
| In total | 8702 | 4353.3 | 100.0 |

After the emergence of aerial photographs of 2009–2010, due to high volume of works for their analysis, only partial researches were performed by using these photographs – or for a small share of territory, or only for a share of land use types. After summarising them, the certain changes of land use of rural landscape were recorded in clayey plains, clayey wavy plateaus and moraine hills mostly dominating in Lithuania and mostly in agricultural landscape types. In 1995–2009, agricultural areas were gradually decreasing in all three types of landscape, however, in different intensity. The most rapid decrease in agricultural areas was noticed in moraine hills, the most stable remained the type of clayey plateau landscape (Fig. 149).

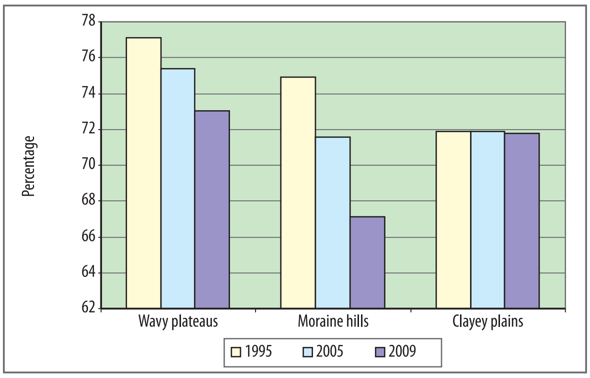



**Fig. 149.** Variation of share (%) of agrarian lands of different landscape types in research territories (percentage share from the area of benchmarking) *(Mačiulytė et al., 2012)*

During the period from 1995 to 2009, the number of parcels in agrarian lands was constantly decreasing. On one hand, it can be related to an overall decrease in agrarian areas. However, it has been observed that the plots decreased not so rapidly as the size of the total arable land plot, meaning that the average size of plots increased. During the entire researched period, the gradual increase in the average size of land plot was observed in wavy plateaus.

The same yet not that intensive process occurred in moraine hills, characterised by the finest land parcels (0.57–0.63 ha), as compared with other two landscape types. The size of parcels of moraine plains characterised by the largest distribution of land uses, showed some variation – first of all, became finer (1995–2005), and later started to increase rapidly (2005–2009) (Fig. 150).

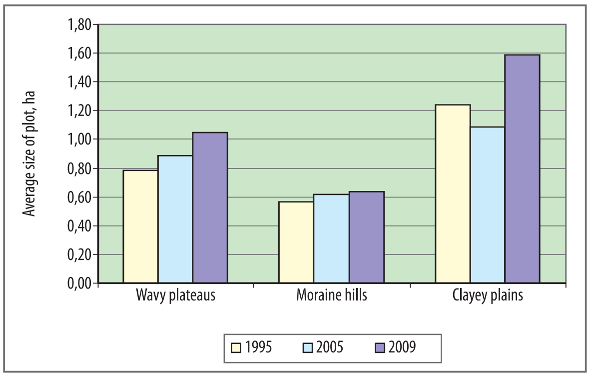



**Fig. 150.** Size of average land parcel (ha) in different natural landscape types (according to data of landscape monitoring benchmarks) *(Mačiulytė et al., 2012)*

On the other hand, the Lithuanian General Programming Document for 2004–2006 (Official Gazette, 2004, No 123-4486) in agricultural sector, indicate small farms and large number of small-scale uncompetitive farms as the problem. During the mentioned period, the process of natural urbanisation occurred in suburban areas, the farms were divided artificially into the plots of 10–20 are, where instead of the agricultural activity the blocks of residential houses were formed. When solving this problem, the changes of the Law on Farmer's Farm and the Law on Territorial Planning entered into force on 1 March 2008, which established the requirement to build farmer's cottage or other buildings in the agriculture land parcel of at least 0.5 ha by preparing rural development land management projects instead of detailed plans.

The change of agricultural territories is closely related to the renaturalisation or instantaneous reforestation (foresting) processes occurring in Lithuania. In the landscape of sandy planes covering 8.36% of Lithuania's territory, the share of territory covered by renaturalisation increased from 5% in 1995 to 15% in 2009.

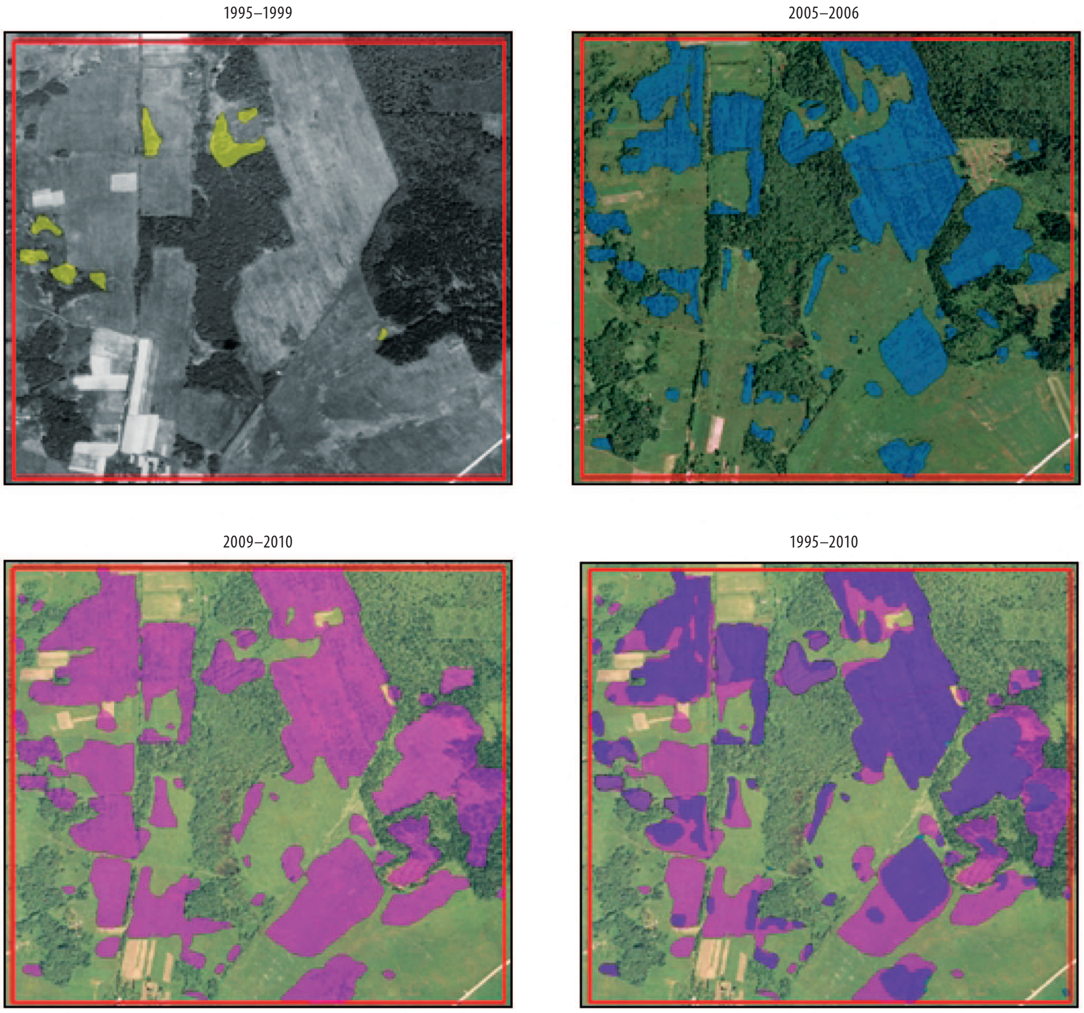



**Fig. 151.** Renaturalisation examples in the landscape of moraine hills in different periods. *Source: National Land Service, Balevičiūtė and Veteikis, 2012*

In this most forested type of Lithuanian landscape, renaturalisation becomes more intensive not only in forest peripheries, where non-arable land is abandoned, but also in the increasing areas of cuttings, where the cut forest is not yet replanted. In the landscape of fertile clayey plains covering the major part of Lithuania (36.10%), more favourable conditions for farming influence the situation that until 2005 slightly strengthened processes of spontaneous reforestation (from 2% in 1995 to 6% in 2005) reached only 8% of the total area during the second period until 2009 and were by half less spread than in sandy plains.

The relief of seaside plain and the Curonian Spit is still currently formed (in part) by modern geomorphologic processes (littoral, aeolian). The surface of deflated dunes is constantly changing; therefore, the spontaneous reforestation processes are irregular there. The landscape of sandy seaside plain occupies 0.29%, whereas the landscape of Curonian Spit – only 0.15% of Lithuania's territory. With almost no agricultural areas in the Curonian Spit and due to special protection mode, renaturalisation does not occur, whereas the main self-contained reforestation processes occur in the seaside sandy plain, in narrow north-south stripes in forests, in former cutting areas or abandoned fields, along melioration ditches.

The analysis of aerial photographs of 1998, 2005 and 2009 showed that, during 11 years, the landscape of seaside plain suffered rather significant changes of land use structure covering 6.72% of the researched area (18.7 thousand ha). The nature of land use changes before and after 2005, when the medium aerial photograph was made, are very different.

The most important structural changes of land cover that occurred during 1998–2005 include the abandonment of agrarian areas and spontaneous growth of natural vegetation (forests, young stands, bushy meadows, etc.) in it. At that time, a small share of agrarian territory was developed. During 2005–2009, in the seaside sandy plain, the major share of changes of landscape structure was composed of the turn of forests into cutting and reforesting cutting areas.

The agrarian areas are developed in larger scales than in previous stage. However, during this period, the number of conversion variants decreased in general. Therefore, during the first period (1998–2005), the trend of changes of land uses towards naturalisation became more obvious, however, after 2005, a sudden turn towards anthropogenisation occurred leading to the general anthropogenic factor during the entire period, which, same as in the entire Lithuania, was distinguished by three main processes of landscape: spontaneous reforestation in abandoned agricultural lands, urbanisation and cutting of mature forests.

The landscape of Nemunas delta valley and delta occupies approx. 0.36% of Lithuania's territory. Here, naturalisation processes occur slowly and only in certain places, because it is conditioned by the watering conditions caused by flooding mode, which are, in principle, unfavourable for the reforestation. In delta, renaturalisation occurs in the periphery of water bodies, the expression of renaturalisation – growing isolated bushes. The islands of alluvial drifts are quite rapidly overgrown with bushes. Nevertheless, renaturalisation processes were expanding in delta valley and delta in 1995, 2005 and 2009, reaching level 2, 4 and 5, respectively.

In the second largest landscape of clayey wavy plateaus in Lithuania (17% of territory), the renaturalisation areas showed a stable increase: 3% – in 1995, 7% – in 2005, 9% – in 2009. Renaturalisation mostly occurred in forest outskirts and abandoned arable fields.

The landscape of moraine hills occupies 15% of Lithuania's territory. Here, renaturalisation areas increased in 1995, 2005 and 2009, accounting for 5%, 10% and 13%, respectively. Due to high distribution of relief, high diversity of growing conditions and complex land use, the ranges of mosaic spontaneous reforestation are of extremely various sizes and stages (Fig. 151). This type of landscape shows the most intensive naturalisation, i.e., the major part of covered cultivated types of land use turn into relatively natural territories.

In the landscape of lakes, occupying approx. 4% of Lithuania's territory, renaturalisation mostly covers the outskirts of lakes and other lower, more irrigated territories. Same as in the majority of landscape types, renaturalisation scales showed some increase: 3% – in 1995, 7.5% – in 2005 and 10% – in 2009. In valley landscape (6% of Lithuania's territory), the areas covered by renaturalisation are mostly characterised by bushes spreading by the rivers. These areas are relatively small, although the percentage part of them increased in 1995, 2005 and 2009 by 2%, 6% and 8%, respectively.

By summarising the processes of renaturalisation that occurred in Lithuania's territory during 1995–2009, it is possible to state that processes showed a stable increase from 3% in 1995, reaching 7% in 2005 to nearly 10% in 2009 (Table 8). Renaturalisation is mostly characteristic to the sandy plains, least – to the seaside plains and landscape of the Curonian Spit (Fig. 152).

**Table 8.** Description of the main types of natural landscapes based on the inherent renaturalisation process *(Balevičiūtė and Veteikis, 2012)*

| Landscape types | Share of areas covered by renaturalisation in benchmarks (%) | | |
|---|---|---|---|
| | 1995 | 2005 | 2009 |
| Seaside plain and the Curonian Spit | 1.70 | 3.13 | 2.85 |
| Delta and delta valley | 2.12 | 4.20 | 5.10 |
| Sandy plains | 5.26 | 11.67 | 15.12 |
| Valleys | 2.07 | 5.71 | 8.16 |
| Lakes | 3.29 | 7.49 | 10.31 |
| Clayey wavy plateaus | 3.29 | 6.99 | 9.27 |
| Moraine hills | 5.00 | 10.22 | 13.35 |
| Clayey plains | 1.97 | 6.14 | 8.08 |
| In total | 3.19 | 7.40 | 9.72 |

By summarising the process of landscape variation, after Lithuania joined the European Union, it is suggested that the main current processes changing the structure of Lithuania's landscape include forest cutting (together with performed restoration of forests by planting and spontaneous reforestation, creating the effect of young forests), urbanisation (mainly focused near the major cities with tendency to move near water bodies) and renaturalisation in unused agricultural areas.

The latter process is so far insignificantly (in 2007–2009, only 716 ha, according the data of General Forest Directorate) supplemented also by the forestation of agricultural land funded by the European Union, in general, oriented to the planting of leafy forest due to larger pay-outs. The analysis of cartographic material covering the period from 1995 to 2010 shows that between 2000 and 2006 (the period with includes the date of Lithuania's accession to the European Union – 2004), the main turning point of the landscape development process was a significantly increased tendency of urbanisation.

Some processes without recording their nature in cartographic material before the accession to the European Union, i.e., 2003, form the impression of gradual progress, for example, constantly increasing areas of spontaneous reforestation in agrarian territories, forest cuttings with restored forests, increasing size of average plots in rural landscape, etc. In general, landscape anthropogenesis increased, and more intensively in 2005–2010 than in 1995–2005.

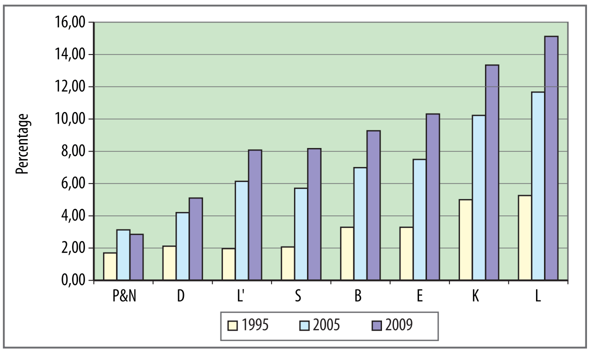



**Fig. 152.** Scale of landscape renaturalisation processes in different types of landscape in 1995–2009, according the data of analysis of aerial photography images in benchmarks: P&N – landscape of seaside plain and Curonian Spit; D – delta and delta valley; L' – clayey plains; S – valleys; B – clayey wavy plateaus; E – lakes; K – moraine hills; L – sandy plains *(D. Veteikis, 2010)*

An important information on the changes of landscape after 2005 is revealed by the analysis of the change of urbanised areas, performed pursuant to the Lithuanian georeference database GDB10LT reflecting the situation of 2005–2006 and 2009–2010. The cartoscheme (Fig. 153) presents the summarised data on the growing part of developed territory. The densification of development is mostly characteristic to Klaipėda and its surroundings, development progress to peripheral ranges – to Vilnius and its surroundings, the most intensive growth of urbanised areas is also around regional centres – Šiauliai, Panevėžys, Alytus, Utena, Telšiai, Tauragė. Increasing development is also characteristic to lake habitats, not passing to protected areas and it is obvious in Molėtai, Utena, Trakai, Elektrėnai and Lazdijai regional municipalities.

Increasingly intensive anthropogenisation of landscape is approved by the increasing general density of roads (together with streets and all local roads (even of lowest category) included into the georeference database GDB10LT). From medium density of 2.12 km/km$^2$ in 2005, it increased to 2.17 km/km$^2$ in 2009, i.e., each square kilometre of Lithuania was supplemented by approximately 50 metres of new roads, on average. The density of roads mostly increased around the major cities (Vilnius, Kaunas, Klaipėda, Šiauliai) – mostly due to urbanisation of suburban areas and building of bypasses. In other regions, the density of roads increased only slightly (due to built new cottages in agrarian territories or new forest roads) or decreased (due to reorganised land use plots (usually their increase), outworn steadings or abandoned lands).

In view of increasing urbanised areas, densifying network of roads, increasing number and areas of cuttings (even if under reforestation), it is possible to assume that the fragmentation of landscape is increasing. The distribution of landscape due to decollectivisation increased by more than 50% during the period from the Soviet times until 2006, whereas having evaluated the finer areas of agrarian territories, the percentage could be doubled. On the other hand, it was already mentioned that the areas of arable land became larger by 10–30% from 1995 until 2009. According to the data of CORINE land cover database, the biggest landscape fragmentation was in 1995, lowest – in 2000, whereas in 2006, the fragmentation increased only insignificantly (0.4%). With the increasing number of abandoned agrarian lands, as well as in less comfortable places for farming, the restoring small areas of forests or swamps also contribute to landscape fragmentation; however, in order to restore the ecological functions of landscape, it is a positive phenomenon increasing the variety of landscape. By summarising, it follows that the current processes also cause destructive changes to the landscape (urbanisation causing fragmentation and weakening of ecological functions, road building), as well as stabilising and restoring changes (establishment of agrarian micro-carcass, growth of natural vegetation habitats).

According to the data of the Lithuanian Department of Statistics, from 2003, when the National Sustainable Development Strategy was approved, until 2012, the Lithuanian forest index increased from 31.3% to 33.3%, respectively (the aim stipulated in the strategy was to increase the forest index by 3–5%). The area of forests is mostly increasing due to agricultural land conversion – by spontaneous overgrowing or purposive planting. This leads to the increase in the percentage share of young forest. However, the area of young forest increases more intensively due to expanding forest cuttings. According to cartographic data, during the entire period of Lithuania's independence, no other wide-scale phenomenon as forest cuttings occurred in the landscape. CORINE land cover database shows that transitional forest stages and bushes are expanding annually and this usually occurs inside the forest areas (i.e., in former cutting areas). In 1995, they accounted for 8.6% of the total area of forest, in 2000 – 11.9%, in 2006 – 12.3%, later data are not available; however, such areas are likely to increase in view of the tendency. Thus, the statistic growth of the total area of forestlands leads to the constant increase in immature forests of transitional succession, and this causes uncertainties in actual evaluation of the Lithuanian forest index.

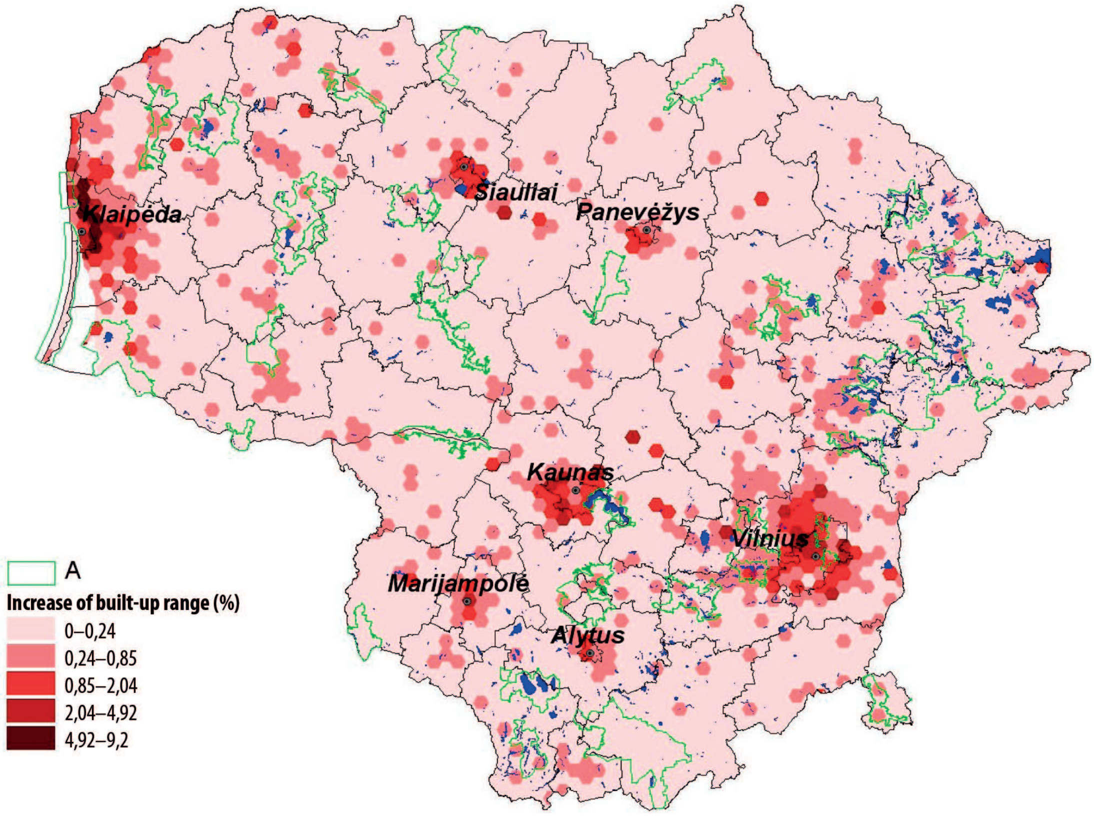



**Fig. 153.** Increased share of developed territory (percentage) in landscape from 2005–2006 to 2009–2010. A – boundaries of regional and national parks (*D. Veteikis, 2010*)

## PROTECTED AREAS IN LITHUANIA

Protected areas are not spontaneous formations existing in the nature. Based on the Law on Protected Areas (1993, 2001) protected areas mean "the land and/or water areas which have clearly defined boundaries, an acknowledged scientific, ecological, cultural and other value and for which a special protection and use regime (procedure) has been introduced". Protected areas are certain storages of the most important priceless natural and cultural values. Protected areas are established in Lithuania in order to:

- protect both the territorial complexes and objects of natural and cultural heritage (values), landscape and biodiversity, genetic stock,
- ensure ecological harmony of landscape as well as balanced use and restoration of natural resources,
- establish proper conditions for the cognitive tourism, scientific researches and further observations of the state of environment,

- propagate territorial complexes and objects (values) of natural and cultural heritage, landscape protection ideas and traditional lifestyle, ethnocultural customs.

In Lithuania, protected areas are established not only for the protection of values, landscape and biodiversity, but also for organisation of recreation, first of all, cognitive tourism, implementation of applied scientific research and observations, propagation of landscape protection ideas and traditional lifestyle, ethnocultural customs.

Until the restoration of independence, the protected areas covered 4.5% of Lithuania's territory. The establishment of protected areas increased after the restoration of Lithuania's independence until the start of land reform. If protected areas once covered 5% of country's territory, now they account for 15.6% of the total area. In the course creation and development of the environmental system of restored independent country, the area of territories increased by three times. Thirty regional parks – Anykščiai, Asveja, Aukštadvaris, Biržai, Dubysa, Dieveniškės Historical, Gražutė, Kaunas Lagoon, Krekenava, Kurtuvėnai, Labanoras, Meteliai, Nemunas Delta, Nemunas Loops, Neris, Pagramantis, Pajūris, Panemuniai, Pavilniai, Rambynas, Salantai, Sartai, Sirvėta, Tytuvėnai, Varniai, Veisiejai, Venta, Verkiai, Vištytis and Žagarė – cover more than half of all protected areas.

Protected areas are selected and represent certain exceptional values of our region and total unique natural environment features, becoming the share of the overall system. In order to select these territories objectively, the criteria of complex evaluation of such territories were approved.

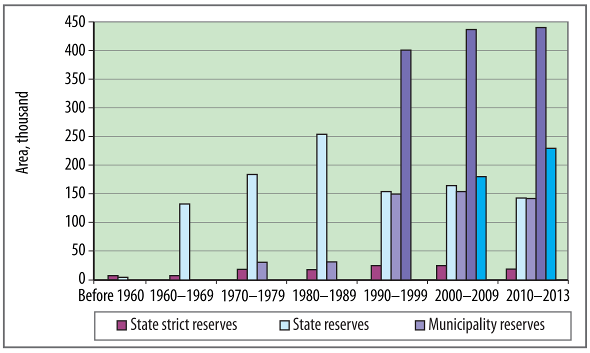



**Fig. 154.** Variation of the area of protected areas. *Source: State Service for Protected Areas*

The late Soviet period and current period, when the network of protected areas was started to be formed scientifically based on a special systematic concept, are critically important on the current system of Lithuania's protected areas and its further development. The most important features of the current period include the following:

- completed formation of the network of Lithuania's national parks (1991), developed system of regional parks and generally expanded network of state nature reserves (1992),
- adopted Law on Protected Areas (1993) and legal acts implementing this Law,
- developed administration system of protected areas, established directorates of all newly established national and regional parks,
- developed system of planning of protected territories – prepared and approved planning schemes for all national and regional parks,
- establishment of the first biosphere reserve (2002);
- start of establishment of the network of Natura 2000 sites, approved first important bird areas (2004), selected and established protected territories for the conservation of natural habitats,
- legally and territorially established natural carcass;
- developed state cadastre for protected areas.

The system of protected areas was established not only territorially, but also legally and institutionally. The move from quantity to quality can be suggested. The specific protection and management measures were implemented, the protected areas were rapidly adapted to public needs: the development of outside information system, visitor centres, infrastructure of cognitive tourism is in the completion stage in national parks. The heritage objects, state nature reserves and Natura 2000 sites are managed.

The further development of system of protected areas is related to Lithuania's membership in the European Union, the implementation of the European Bird and Habitat directives and the solutions of the general plan of Lithuania's territory. The implementation of the obligations to the European Commission is accompanied by the development of network of Natura 2000 sites.

**Fig. 155.** Smalvos landscape nature reserve with protected hardly changed landscape characteristic to Aukštaitija highlands abundant with hills and lakes *(photo by S. Sinkevičius, 2010)*

In the recent years, the system of national protected areas was supplemented with Žuvintas biosphere reserve, 28 biosphere polygons, the Baltic Sea Talasological Park, new ornithological, botanical-zoological parks and 3 restoration parcels. All mentioned protected areas are established by implementing the requirements of the European Union as well as the obligations assumed by Lithuania. These and other protected areas are conferred the status of Natura 2000 sites.

The system of Lithuanian protected areas is not intended only for nature, natural landscape, biodiversity and protection of natural values. It is also integrated with territorial protection of cultural heritage. The integrated path has been purposefully selected for the protection of values for more than five decades. The majority of values exist next to each other, biodiversity directly depends on the variety of inanimate nature (relief, hydrographical network, soil particularities), and the cultural heritage depends on the natural landscape. Natural and cultural heritage has long become an integral part in Lithuania. Usually, it was difficult to decide whichever was more important, therefore the plans were characterised by complexity:

- the protection of natural and cultural heritage was connected,
- both live and inanimate natural values are protected,
- both unique and characteristic landscape complexes (from natural to urbanised ones) are protected,
- as far back as in 1992, the scientifically based system of protected areas was created instead of the network of isolated protected areas or network of protected areas.

The main features of the Lithuanian system of protected areas are characterised by (source: State Service on Protected Areas, 2012):

- diversity – high variety of species of protected territories. The territories of various categories and types can be established. It provides the possibility not only for the protection of value of landscape and biodiversity, but also for the protection of areas against negative anthropogenic activity, and restoration of valuable complexes and objects, natural resources;
- complexity – complexes and objects of natural and cultural heritage, live and inanimate nature are protected;
- representation – the entire landscape and biological diversity is protected, i.e., not only unique, but also characteristic complexes and objects are protected;
- sufficiency – the territories are established of a certain size ensuring the preservation of characteristic or unique complexes;
- equality – the protected areas are established in the entire territory of country. They are situated as gradually as possible in the territory of country and region;
- flexibility – there is an opportunity to preserve, protect or restore landscape complexes and objects by selecting the most proper, suitable status of protected territory within the meaning of protection and usage mode;
- interdependence – protected areas are incorporated into a single system by creating natural carcass.

The global society is aware of the Lithuanian protected areas included into the UNESCO global list of cultural and natural heritage. This list is composed base on the Convention concerning the Protection of the World Cultural and Natural Heritage (1972). Lithuania ratified this convention in 1992. In Lithuania, there are four objects of exceptional global value included in to the global list of cultural and natural heritage: Vilnius Old Town, Curonian Spit (together with Russian Federation), Kernavė Archaeological Site and Struvė Geodesic Arc (together with 11 other countries).

The wetlands of international importance – biotopes in the junction of water and land characterised by clear biological resources, variety of species and communities, vital both for the nature and human are protected in accordance with Ramsar Convention (1971). Based on the Ramsar Convention, the list of protected wetlands of international importance is composed. Lithuania ratified Ramsar Convention in 1993. After signing of convention, five especially valuable Lithuania territories meeting the convention criteria were include into the List of Wetlands of International Importance protected by Ramsar – Čepkeliai, Kamanai and Viešvilė strict nature reserves, part of Žuvintas biosphere reserve and Nemunas Delta Regional Park. In 2012, Ramsar list of wetlands was supplemented with Girutiškis strict nature reserve located in the Labanoras Regional Park and Adutiškis – Svyla-Birveta wetland complex.

All protected territories located in the Lithuanian seaside are important to the Baltic Sea Region, i.e., the Curonian Spit National park, Seaside and Nemunas Delta Regional Parks.

In order to implement the requirements of the EU directive on the conservation of wild birds (79/409/EEC) and on conservation of natural habitats, wild fauna and flora (92/43/EEC), Lithuania is developing the network of Natura 2000 sites. Natura 2000 sites are integrated into the current national system of protected areas. A common European ecologic network of special protected areas is created under the name of Natura 2000. This network is composed of territories, which contain protected natural habitats included into Annex 1 and habitats of species included into Annex II of the Habitat Directive. Network of Natura 2000 sites provides an opportunity for the maintaining, and, where necessary, restoration of types of natural habitats and s of the good protection of habitats of species in the range of their natural occurrence. The network of Natura 2000 sites includes special protected areas, which are classified by the Member States in accordance with the Birds Directive. The criteria of selection of territories important for the conservation of birds and habitats under Lithuanian conditions were approved by the order of the Minister of Environment of 2001.

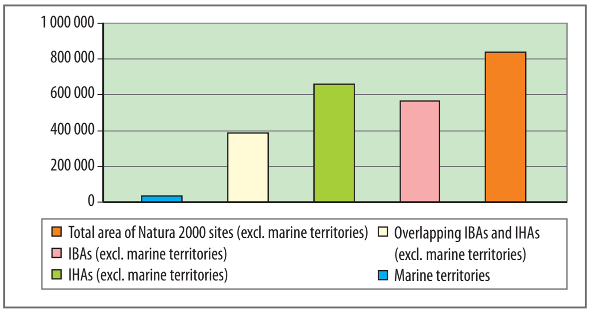
The network of Natura 2000 protected areas of EU importance is developed in our country based on the system of national protected areas, i.e., newly established territories are maximally integrated into the national system of protected territories. Natura 2000 sites are integrated by using the following methods:

- by awarding an additional status for strict reserves and nature reserves, national parks and biosphere reserves, and by establishing additional requirements (where necessary) for the parts of these protected areas;
- by awarding an additional status for protective zones of water bodies, by establishing additional protection and usage mode;
- by installing restoration parcel for the restoration of natural resources, species and their living conditions;
- by installing biosphere polygons for organisation of complex and special monitoring, including biological profile, and preservation of valuable territories.

In 2004–2005, the system of protected areas was supplemented with Nature 2000 sites of EU importance established by implementing the requirements of the EU Birds and Habitat directives. 41 Lithuanian protected areas or their parts were included into the list of important bird areas, i.e., the status of Natura 2000 sites is awarded for current protected areas (strict reserves, nature reserves, national and regional parks, biosphere reserve) or their parts. 32 new important bird areas were established. The total area of Natura 2000 sites (having evaluated the overlap of important habitat and bird areas) accounts for 766 thousand ha or approximately 12% of Lithuania's territory. The statistical data on Natura 2000 sites is presented in Table 9, and their arrangement is presented in Figure 155.

**Table 9.** Natura 2000 sites in Lithuania. *Source: State Service on Protected Areas*

| Category | Number | Area (thousand ha) | Overlapping area (thousand ha) | Share of country's territory (%) |
|---|---|---|---|---|
| Important Bird Areas | 82 | 560.7 | | 8.6 |
| Areas meeting the criteria of Important Habitat Areas | 406 | 651.5 | 400.4 | 10.0 |
| In total | 486 | 811.8 | | 12.4 |




**156 Fig.** Distribution of Natura 2000 sites (ha) in Lithuania. *Source: State Service on Protected Areas*

**Note:** Areas and percentage are calculated having evaluated the overlapping of Important Habitat and Bird Areas.

Although the rates of increase of Natura 2000 sites are impressive in Lithuania, similar tendencies are characteristic in the neighbouring countries as well. When comparing the ratios of current national administrative territory and areas of Natura 2000 sites present in this territory, Lithuania is among 12 EU Member States, where these rations are almost equal.

Lithuania is obliged not only to create a network of Natura 2000 sites, but also to ensure a favourable condition of protected values. Same as national protected territories, Natural 2000 sites require active environmental protection. Legal acts, planning documents are not sufficient, it is necessary to implement the specific protection measures stipulated in environmental protection plans or territorial planning documents.

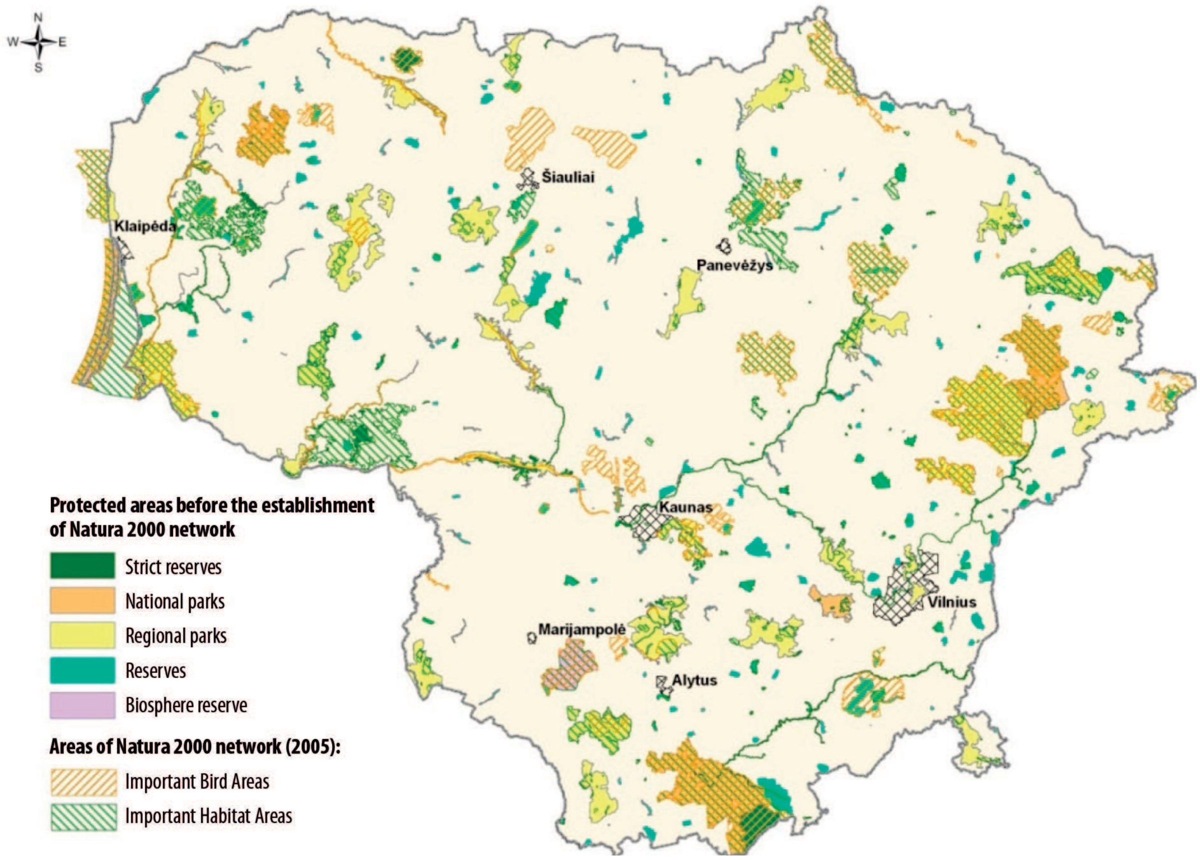



**Fig. 157.** Cartographic distribution of protected areas and Natura 2000 sites. *Source: State Service on Protected Areas*

Based on the Law on Protected Areas, the Lithuanian system of protected areas is composed of: Protected areas of conservational priority, protected areas of ecological protection priority, protected areas of recuperational priority and integrated protected areas. Categories and types are established based on the main objective (refer to Table 10 below) of the establishment of protected areas. The protection and usage mode (regulation of activity) also depends on the territory establishment aims set for one or other type of protected areas.

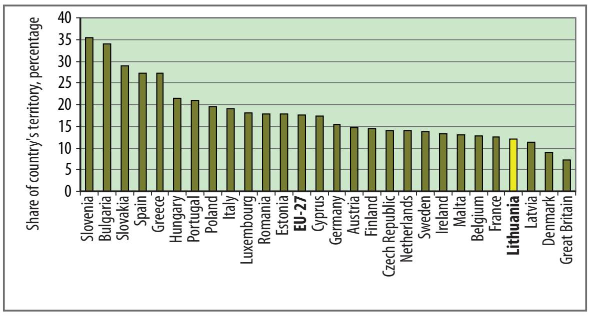



**Fig. 158.** Share of area of Natura 2000 sites of the country's territory in EU-27 countries, 2011. *Source: European Environment Agency*

Unique and typical natural and cultural landscape processes and objects are protected in the areas of conservational priority. These include strict reserves (both natural and cultural), various reserves and natural and cultural heritage objects (monuments).

The protected areas of ecological protection priority are singled out in order to avoid negative impact on protected nature and cultural heritage complexes and objects or negative impact of anthropogenic objects on the environment. Zones of ecological protection are attributed to this category.

The protected areas of recuperational priority are designated for restoration, augmentation and further protection of natural resources. Genetic plots are attributed to this category. Restoration and genetic plots are attributed to this category.

In the integrated protected areas, the conserving, protecting, recreational and economic areas are connected (integrated) based on the general protection, management and usage programme. They include state (national and regional) parks and biosphere monitoring areas (biosphere reserves and polygons).

**Table 10.** Categories and types or protected territories based on the main goal of establishment. *Source: State Service on Protected Areas*

| The main goals | Category of protected area | Type | Protection regime |
|---|---|---|---|
| CONSERVATION | Protected areas of conservation priority | | |
| | | Strict reserves | Very strict |
| | | Heritage objects | Very strict |
| | | Reserves | Strict |
| PROTECTION | Protected areas of ecological protection priority | | |
| | | Areas of ecological protection | Oriented to special or general protection |
| RESTORATION | Protected areas of recuperational priority (restoring and maintaining) | | |
| | | Restoration plots | Oriented to restoration |
| | | Genetic plots | Oriented to restoration |
| CONSERVATION, PROTECTION, RESTORATION, DEVELOPMENT OF RECREATION | Integrated protected territories | | |
| | | National and regional parks | Depends on the functional priority area |
| | | Biosphere monitoring areas | Depends on the functional priority area |

At the moment (2012), Lithuanian protected areas and especially protected areas (of conservational priority and integrated) occupy slightly more than 1 million ha or 15.6% of the total country's area.

These include 5 reserves (2 – cultural) 285 parks, 5 national parks (one – historical), 30 regional parks (one – historical), 1 biosphere reserve, 29 biosphere polygons, and 3 restoration plots. The areas occupied by most valuable Lithuanian protected areas are presented in Table 11.

**Table 11.** Areas occupied by the most valuable Lithuanian protected areas. *Source: State Service on Protected Areas*

| Type, number and name of protected areas | Area (ha) |
|---|---|
| Protected areas of conservational priority | |
| Strict nature reserves (3): Čepkeliai, Kamanai, Viešvilė | 18,406.72 |
| Strict cultural reserves (2): Kernavė, Vilnius castles | 245.85 |
| State reserves (261) | 144,678.54 |
| Municipality reserves (111) | 12,885.42 |
| Complex territories | |
| National parks (5): Aukštaitija, Dzūkija, Curonian Spit, Trakai Historical, Žemaitija (Samogitia) | 144,358.66 |
| Regional parks (30): Anykščiai, Asveja, Aukštadvaris, Biržai, Dieveniškės Historical, Dubysa, Gražutė, Kaunas Lagoon, Krekenava, Kurtuvėnai, Labanoras, Meteliai, Nemunas Delta, Nemunas Loops, Neris, Pagramantis, Pajūris, Panemuniai, Pavilniai, Rambynas, Salantai, Sartai, Sirvėta, Tytuvėnai, Varniai, Veisiejai, Venta, Verkiai, Vištytis, Žagarė | 449,363.59 |
| Biosphere strict reserve (1): Žuvintas | 18,489.69 |
| Biosphere polygons (29): Adutiškis-Guntauninkai forests, Apšė, Babtai-Varluva forests, Balbieriškis forest, Baltoji Vokė, Birvėta, Biržai forest, Blinstrubiškis forest, Būda-Pravieniškės forest, Dotnuva-Josvainiai forests, Gedžiūnai forest, Gelednė forest, Gubernija forest, Kalvarija, Curonian Lagoon, Labūnava forest, Lančiūnava forest, Padauguva forest, Pertakas forest, Plinkšiai forests, Rūdninkai wood, Svyla, Šimoniai woods, Taujėnai-Užulėnis forests, Vainutas forests, Vasaknai, Visbarai, Žalioji wood, Viliukai forest | 234,053.32 |
| Protected areas of recuperational protection priority | |
| Restoration plots (3) | 875.42 |

The areas of protected areas were calculated by using the software of geographic information systems (GIS). The total area of protected territories does not include the parts of the Curonian Spit National Park and Seaside Regional Park located in the Baltic Sea as well as the area of talasological (sea) reserve. The total area of protected areas in the Baltic Sea – 29.6 thousand ha. The area of national parks covered in them is subtracted from the area of biosphere polygons.

All categories of Lithuanian protected areas include objects of regional, international and global importance that are subject to more strict EU requirements, in order to protect and preserve them. These include the territories important for the ecosystem of the Baltic Sea and its stability (HELCOM), ecosystems of disappearing wetlands important for the preservation of biodiversity in Europe (Ramsar Convention), globally unique territories characterised by cultural heritage (UNESCO).

**Table 12.** International-importance protected areas in Lithuania

| World heritage sites (UNESCO, 1972) | Wetlands of international importance (Ramsar Convention, 1971) | The system of Baltic Marine protected areas (HELCOM, 1974) |
|---|---|---|
| • Vilnius Old Town (1994)<br>• Curonian Spit (2000)<br>• Kernavė Archaeological Site (Kernavė Cultural Strict Reserve, 2004)<br>• Struvė Geodetic Arc (2005) | • Čepkeliai State Strict Reserve (1993)<br>• Kamanai State Strict Reserve (1993)<br>• Viešvilė State Strict Reserve (1993)<br>• Žuvintas Biosphere Reserve (1993)<br>• Nemunas Delta Regional Park (1993)<br>• Girutiškis Strict Nature Reserve (2011)<br>• Adutiškis-Svyla-Birveta wetland complex (2011) | • The Curonian Spit National Park (1994)<br>• The Seaside Regional Park (1994)<br>• The Nemunas Delta Regional Park (1994) |

Lithuanian national parks are established for the preservation, management and usage of the most valuable landscape complexes and anthropogenic systems representing the natural and cultural particularities of the ethnocultural areas of the Republic of Lithuania. Their purpose of use is to preserve naturally and culturally valuable landscape complexes and objects, maintain the stability of ecosystems, restoration of destroyed and damaged natural, cultural complexes and objects; develop scientific researches, propagation and support of traditional lifestyle of Lithuanian regions.

At the moment, there are 5 national parks in Lithuania: The national parks of Dzūkija, Curonian Spit, Žemaitija (Samogitian) and Trakai Historical National Park were established in 1991, and the Lithuanian SSR National Park established in 1974 was renamed as Aukštaitija National Park.

All national parks occupy 1,444 thousand ha, accounting for more than 2% of the country's territory.

The oldest Aukštaitija National Park reveals the forested landscape abundant with lakes, protects the natural complexes located in the junction of three unique landscape areas in ecosystems of Žeimena upper reaches, Ažvinčiai (Gervėčiai) old wood and lake Baltis, the landscape of Baluošas, Šilininkai, Tauragnas and Utena forested lake pools, Kiauna valley and Benediktavas moraine massive, other natural values, where almost 104 lakes are surrounded by forests.

The Dzūkija National Park represents the forested landscape of rivers in the general system. This is a region of pinewoods, lower dunes, extraordinary transparent deep valley rivers, small lakes, Nemunas valley, many springs and extraordinary biodiversity. They are distinguished from others by old pinewood villages – Zervynos, Margionys, and Musteika.

Žemaitija (Samogitia) National Park protects the natural complex of Samogitian highlands abundant with lakes (Plateliai and other lakes) and forests with Samogitian landscape representing Jazdauskiškiai hills and Plokštinė spruce forest – strict reserve, Siberija swamp abundant with biodiversity, preserving especially valuable old cultural heritage (mounds, sacred mountains, cemeteries and old settlements), distinctive architectural heritage of this region (churches, paths of passion of Christ – Kalvarijos in Samogitian Kalvarija, Beržoras, old villages with traditional cottages, chapels, wayside shrines, crosses), other cultural heritage values and monuments, nurturing the traditions of the Samogitian region culture, crafts, propagate the heritage of material and spiritual culture.

The biggest value of Curonian Spit National Park is a unique landscape easily damaged by sea, water and wind with the highest dunes in the Western Europe and capes (horns) protruding into the lagoon. It protects the highest sand-dune of the Curonian Spit, its old parabolic dunes near Juodkrantė, grey dunes in the stretch of Agila-Nagliai, deflated Parnidis dunes, forest soils covered with sand, as well as sand plains of seaside and lagoon area and natural complexes of meadows, protects the seaside dunes, specific flora and fauna of the Curonian Spit. It stores the authentic values of cultural heritage of lagoon area – ethnographic cottages of fishermen, old villas in Nida, Juodkrantė, Preila and Pervalka settlements, cultural layers of old settlements covered by sand, memorial sites.

Trakai ant their surroundings occupy an exceptional place among country's landscapes due to their picturesque views. Many archaeological, historical and architectural values remained on the hills and valleys, hilly forests, between lakes and green swamps in potholes.

The Trakai Historical National Park (8,150 ha) is established in Trakai and its surroundings. The core of the national park – the complex of Trakai Island and Peninsula Castles and Trakai Old Town, town's defensive system, particularity of urbanistics and architecture – have been directly related with the natural environment since their very establishment. There are 32 lakes of various origin and size in the park. The entire Island Castle surrounded by Lake Galvė is occupied by the restored castle and duke manor. The restoration of ensemble of Užutrakis manor is also nearly completed.

Regional parks are protected areas established due to their natural, cultural and recreational value for the protection of complexes and ecosystems of regional importance, control of their recreational and economic use. 30

regional parks occupy more than a half of the area of all protected territories, they all have directorates, some of them – visitor centres, nature schools. Each regional park is divided into zones of functional priority: conservational priority (reserves and parks), ecological protection priority, recreational priority and economic priority and zones of other purpose of use.

The territories of all Lithuanian strict reserves are characterised by uniqueness and are characterised by different problems related to these territories and methods of their solution. Strict nature reserves form a solid complex – a space, where they supplement each other, reflect all issues of protection of biodiversity of shallow waters and swamps existing in the Baltic Region. The methods and actions of the protection of natural environment and biodiversity adapted for separate strict reserves compose a total system of value protection and management facilitating the protection of these values for future generations. This system is like a model for the protection of biodiversity in other valuable territories of Lithuania as well as a potential example for other European Member States and countries around the world.

**Table 13.** State and municipality nature reserves. *Source: State Service on Protected Areas*

| Reserves | State | Municipality |
|---|---|---|
| Geological | 10 | - |
| Geomorphological | 40 | 4 |
| Hydrographical | 34 | 3 |
| Botanical | 35 | 33 |
| Zoological | 29 | 26 |
| Ornithological | 10 | 12 |
| Herpetological | 3 | 1 |
| Entomological | 6 | 1 |
| Ichthyological | 9 | - |
| Terriological | 1 | 12 |
| Botanical-Zoological | 27 | 23 |
| Telmological | 51 | 2 |
| Landscape | 47 | 20 |
| Pedological | 11 | - |
| Talasological | 1 | - |
| In total | 285 | 111 |

The approved list of state protected objects of natural heritage is specified each year. Based on the data of cadastre of state protected areas of the Republic of Lithuania managed by the State Service on Protected Areas under the Ministry of Environment, on 1 September 2012, there were 285 state and 111 municipal reserves in Lithuania, 564 state protected natural heritage objects (157 of which are declared as nature monuments) and 222 natural heritage objects protected by municipalities.

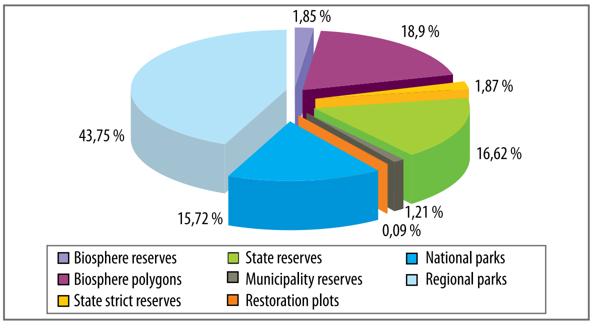



**Fig. 159.** Distribution of area of Lithuanian protected areas (%) by categories. *Source: State Service on Protected Areas*

One of the priorities of the European Union is a qualitative living environment of a person, which is a necessary precondition for the healthy life. People usually understand good life as the material provision, however, in the most developed countries, even a very wealthy life in a damaged natural environment is not considered as qualitative, i.e., fully meeting the full-rate needs of people. It is usual for person to think that a habitat is the place, where he can find shelter and feel safe. Protected areas are one of the important ways to ensure safe and cosy environment.

Based on the Law on Protected Areas of the Republic of Lithuania, the main institution coordinating and organising the activity in protected areas and providing methodological assistance to all institutions acting in protected areas is the State Service on Protected Areas under the Ministry of Environment. The priorities of its activity for 2007–2013 also include the ensuring of proper management and good status of protected areas, including Natura 2000 sites – monitoring of their state, preparation of necessary territory planning documents, organisation of the implementation of protection and management measures.

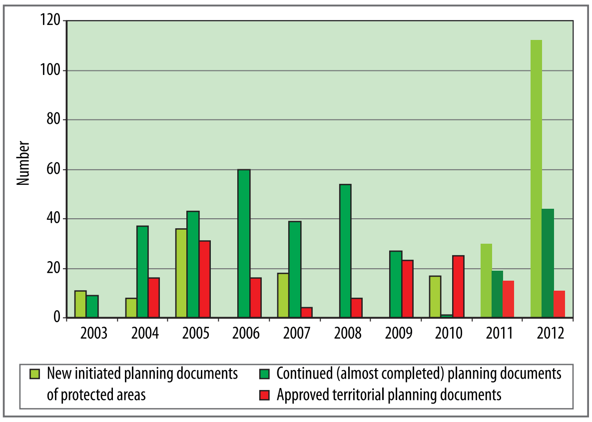



**Fig. 160.** Preparation of planning documents of protected areas, 2003–2012. *Source: State Service on Protected Areas*

The preparation of planning documents of protected areas is constant. In 2011 alone, 13 plans of boundaries and 2 management plans were approved. At that time, approved management plans were held by almost all national parks, therefore, the update of planning documents of special areas of these parks was initiated – new planning documents were initiated and the current ones were reviewed (the plans of management of boundaries of Dzūkija National Park, Nemunas Loops, Dieveniškės, Kaunas Lagoon Regional Parks and boundary and 5 plans of management of reserves, 12 plans for Important Bird and Habitat Areas), the plans of boundaries of new state forest genetic reserves were prepared.

**Table 14.** State protected natural heritage objects. *Source: State Service on Protected Areas*

| | State protected natural heritage objects | Of them: | |
|---|---|---|---|
| | | Nature monuments | Natural heritage objects protected by the municipalities |
| Geological (stones, exposures, failures) | 162 | 72 | 45 |
| Geomorphological (hollows, ravines, ridges, dunes, eskers and other forms of relief) | 36 | 28 | 3 |
| Hydrogeological (springs, founts) | 34 | 19 | 2 |
| Hydrographical (lakes, peninsula, capes, banks, islands) | 23 | 12 | 1 |
| Botanical (trees, their groups, habitats, parks having dendrologic value) | 308 | 26 | 170 |
| Zoological (habitats of protected species of animals, animal settlements) | 1 | - | 1 |
| In total | 564 | 157 | 222 |

In 2012, by orders of the Minister of Environment, 4 environmental management plans were approved covering 4 territories of the network of Natura 2000 sites (8,530 ha, in total). In 2012, 33 new environment management plans were prepared for coordination covering 35% of territories of the network of Natura 2000 sites (16,135 ha). Another 22 nature management plans were initiated as well as 11 additional nature management plans. These are 29 plans of Natura 2000 sites (35,356 ha). In total 47 plans of management of protected areas were approved. Since 2008, 108 plans have been prepared; another 27 plans of Natura 2000 sites were prepared in 2012–2013. The nature management plans of 14 protected territories (usually genetic conservation areas) are in progress.

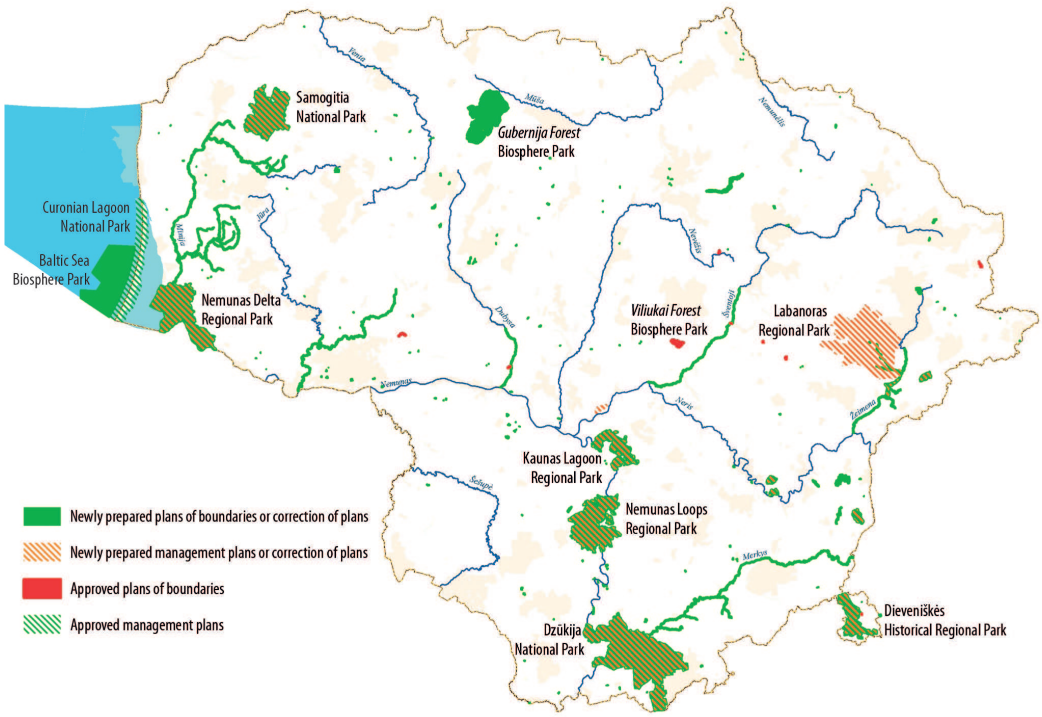



**Fig. 161.** Territories for which the planning documents were prepared in 2012. *Source: State Service on Protected Areas*

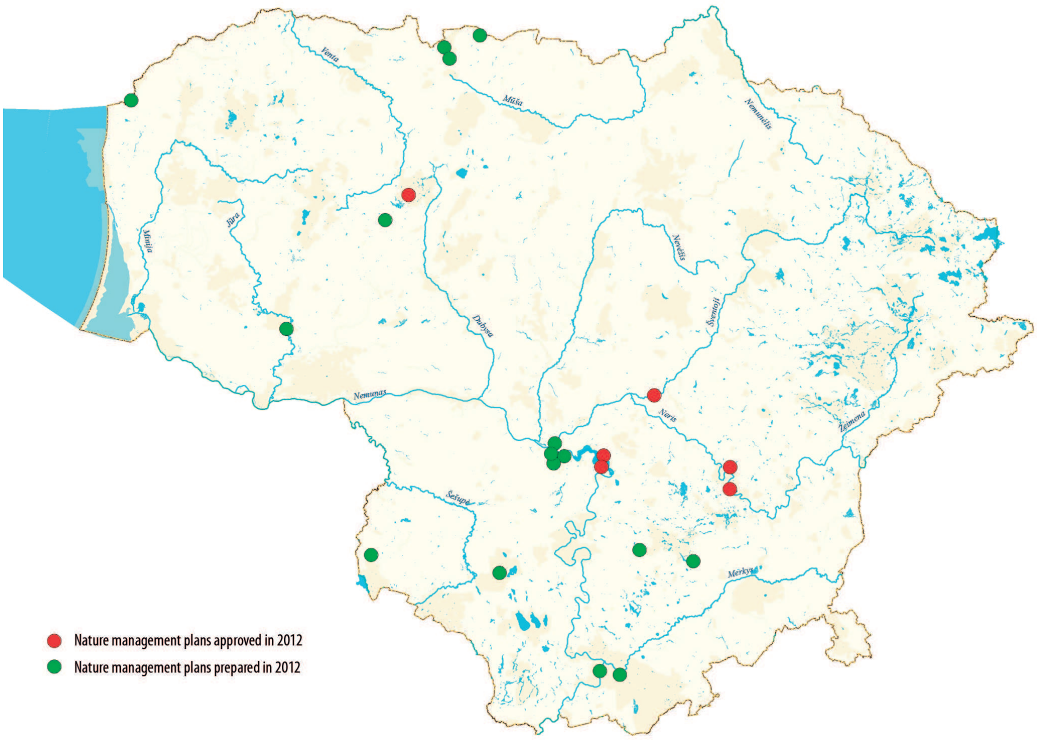



**Fig. 162.** Territorial distribution of nature management plans prepared in 2012. *Source: State Service on Protected Areas*

## OFFENCES IN PROTECTED AREAS

The activity in the protected areas is directly regulated by the Law on Protected Areas of the Republic of Lithuania (Official Gazette, 1993, No 63-1188; 2001, No 108-3902) and the Law on Protection of Immovable Cultural Heritage of the Republic of Lithuania (Official Gazette, 1995, No 3-37; 2004, No 153-5571), Special Conditions of Land and Forest Usage approved by Order No 343 of the Government of the Republic of Lithuania of 12 May 1992 (Official Gazette, 1992, No 22-652), Statutes of the protected areas, individual and typical regulations of protected areas. Separate activities in the protected areas are regulated by the Law on Protected Areas of the Republic of Lithuania (Official Gazette, 1992, No 5-75), the Law on Forests of the Republic of Lithuania (Official Gazette, 1994, No 96-1872; 2001, No 35-1161), the Law on Land of the Republic of Lithuania (Official Gazette, 1994, No 34-620; 2004, No 28-868), the Law on Territorial Planning of the Republic of Lithuania (Official Gazette, 1995, No 107-2391; 2004, No 21-617), the Law on Construction of the Republic of Lithuania (Official Gazette, 1996, No 32-788; 2001, No 101-3597), the Law on Impact Assessment of Planned Economic Activity on Environment (Official Gazette, 1996, No 82-1965; 2005, No 84-3105), other laws and legal acts implementing these laws.

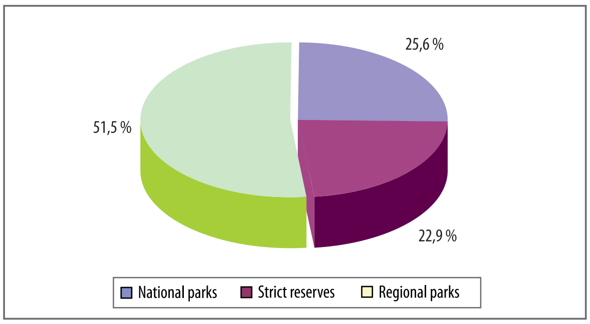



**Fig. 163.** Distribution of recorded administrative law offences in protected areas by separate categories, 2008–2012. *Source: according to the information received from directorates of protected areas and accumulated by the State Service on Protected Areas*

When analysing the environmental offences committed in protected territories in the recent years based on the Articles of Code of Administrative Offences of the Republic of Lithuania, it is possible to make some conclusions and single out certain tendencies. During the period of four years, 3,257 protocols of such offences in the protected areas were recorded based on 32 articles of the Code of Administrative Offenses of the Republic of Lithuania. Some of them were committed very often. The usual offenses included the offences of the regime of protected areas (various parts of Article 76) – 64.7%.; offenses of legal acts regulating recreational fishing (various parts of Article 87) – 13.9%.; breaches of the rules of water protection (various parts of Article 55) – 9.8%. The share of other 29 articles attributed to various offenses accounted for 11.6%.

The tendency of the decrease in offences in 2008–2011 shows more effective administration of these areas, preventive measures and environmental management.

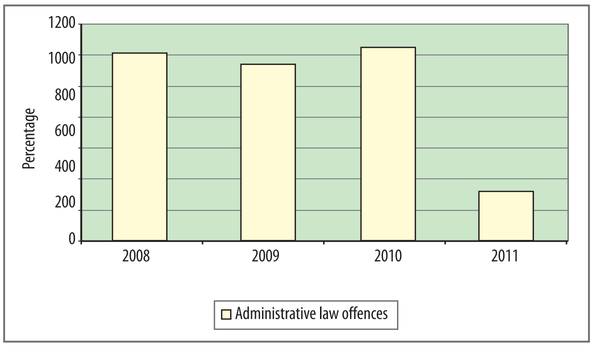



**Fig. 164.** The total number of recorded administrative law offences in all Lithuanian protected areas, 2008–2011. *Source: State Service on Protected Areas, Directorates of protected areas*

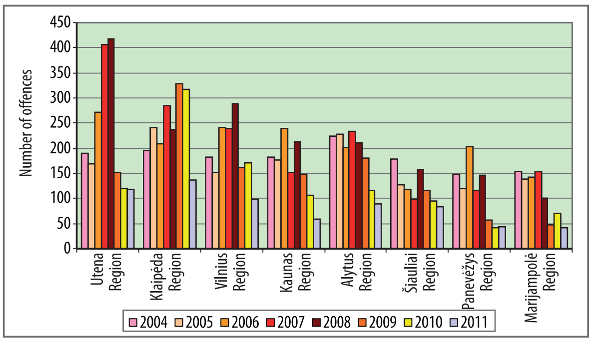



**Fig. 165.** Recorded administrative law offences in the area of landscape protection in separate Lithuanian regions. *Source: Environmental Protection Agency*

When evaluating the overall tendency of administrative law offences in the area of landscape protection in separate Lithuanian regions, it can be seen that smaller protected areas have more strict prevention and control of offences, as compared with the total territory of country, and meet the overall tendency of decrease in such offences. Base on the total number of offences, Utena and Klaipėda Regions are leading among other Lithuanian regions.

In 2011, as compared with 2010, the number of solved offences decreased in all regions. In 2011, the highest number of offences of requirements of animal protection was solved in Klaipėda and Kaunas regions, and the least number – in Panevėžys, Alytus and Marijampolė regions. Same as in 2010, in 2011, the majority of offences of forest protection rules were recorded in forested regions of Vilnius, Kaunas and Alytus.

It has to be said that, including all social and economic difficulties (usage of natural resources for commercial purposes, etc.), there exists insufficient sophistication of various public layers so far. The majority (85–90%) of recorded offences could be attributed to the manifestations of individual consumption attitude to the values of the surrounding environment.

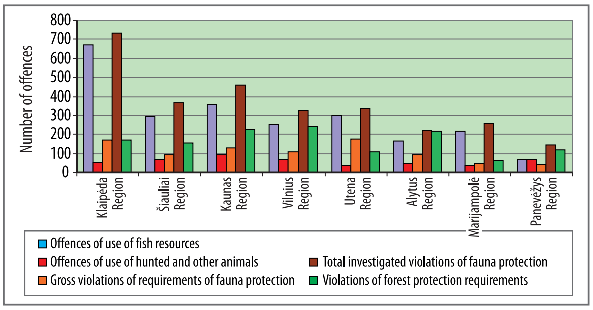



**Fig. 166.** Recorded administrative offences in the area of fauna and forest usage, 2011. *Source: Environmental Protection Agency*

## EMERGING PROBLEMS IN PROTECTED AREAS

Rapid variation of economic and social conditions in the junction of centuries conditioned the status of protected areas. New problems regarding the occurrence of private land ownership in protected areas and lack of experience in regulation of activity of private persons emerged. Many new owners of land want to build a residential house, summer-cottage and cut the forest as soon as possible, without paying any attention on protected values.

- The majority of problems emerging in protected areas are similar to other problems emerging in territories that are no longer protected:
- One of obvious problems present not only in the protected areas, but also in the entire country are dangerous and persistent waste left in forests, by lakes and other ecosystems and not in special sites.

The same situation is with soils located in the environment of abandoned buildings, unmanaged territories, which are contaminated with dangerous chemical elements (heavy metals, oil product residues, etc.).

- Abandoned and unmanaged quarries, started yet unfinished constructions, agricultural industrial centres and other abandoned constructions (without owners) are visually contaminating the natural environment of the entire country and destroy landscape. Over 170 such buildings were destroyed in protected areas, however, some of them are still remaining near protected areas and visually appear into the same landscape, reduce the recreational potential of territories, attractiveness and causes danger to visitors.
- In addition to wide-scale works of the maintenance of proper quality the EU-important habitats, when the variation of communities of plants is "sustained" by biotechnical means (proper haymaking of meadows, grazing, where necessary – elimination of wooden plantation, opening of shadowing, etc.), there is insufficient focus on the essential projects of restoration of separate ecosystems. It is especially relevant in evaluating the ecosystems of wetlands (swamps of various types).
- Although the problem of impact of invasive species on habitats and ecosystems could be attributed to the problems of Lithuanian biodiversity, however, it actually exists in protected territories as well.
- In the course of land reform, the coordination of private and public interests remains one of the most complex and painful problems, first at all, in national parks and other protected areas, where private ownership is possible. Only the terrain of the Curonian Spit and reserves is an exclusive ownership of the state.
- Due to insufficiently ensured protection of protected areas and usage regime after land reform, partly changing social relations, private ownership, regulation of personal interests, it is difficult to ensure the established regime of protection and usage.

The unfavourable image of protected areas as prohibited and closed is replaced with the attractive areas in terms of education and recreation. However, it is important to maintain the optimum ratio between the recreational openness and restriction important for these areas, in order to preserve specific biological properties. Thanks to high-minded employees of environmental area and media, improvement of legal acts, system of territorial planning documents, there are an increasing number of positive tendencies and changes in the attitude towards the regulation of activity in protected areas. Before the purchase of land or forest in protected areas, people seek for information on the permissible and restricted activity in the area. More and more visitors are attracted to the centres of protected areas.

In the ever-changing world, the system of conservation of natural environment becomes increasingly more complex and developed. The management of protected areas is an integral part of overall planning of national (sustainable development) and land-use or economic sector policy, economic sectors, and especially of regional planning.

The recent decade was characterised by the fact that protected areas gained more and more public support; their management efforts ("working bees", campaigns, and other charitable work) were joined by municipal institutions, non-governmental organisations, private companies, and individual persons.

The developed, optimised network of protected areas, first at all, considering the dynamic changes oriented to the protection of habitats, flora and fauna, giving more focus on the protection outside the boundaries of protected areas, by creating buffer protection zones, "biological corridors", territories guaranteeing landscape protection.

The implementation of priorities of strategy of programme of planning and management of protected areas from 2007–2013 is financed by the funds of the structural support of the European Union, which are used for the preparation of documents of establishment and planning of protected areas and their management. The protected territories are continuously equipped with visitor centres attractive by their sophisticated information environment, visual information systems in nature (view towers, exposition of ancient apiculture, biking and horse-riding routes, geological expositions, etc.).

In the area of management of protected areas, more work has been done during the recent years than during a long environmental history of Lithuania. In the past 10 years alone, several large and environmentally important projects were implemented in the protected areas across the country by using the resources of the European Regional Development Fund and Lithuanian budget. The goals of all projects were different; however, they all shared the common aim – to improve the state of natural environment and protection of the natural landscape and biodiversity in Lithuania and to solve main current issues. All these factors argue in favour of preservation of heritage values, landscape and biodiversity in the protected areas, and the sustainable usage of natural resources as well as healthy environment for the public.

The results of works useful for the natural environment (same as planted forest) can be evaluated only in a long-term perspective. However, the tendencies of certain positive changes can already be observed in the society. The increasing flows of visitors in the protected areas clearly indicate the increasing interest of the society (national and foreign) and the need for communication with the environment.

## STATE AND TRENDS OF LITHUANIAN BALTIC SEA COSTS

Lithuania has a very short coastline of the Baltic Sea of the length of 90.6 km. The section of 51 km stretches in the Curonian Spit and 38.5 km – in the continent (the width of Klaipėda Seaport entrance channel connecting these sections – 1.1 km). Therefore, the negative changes of the state of Lithuanian coast area cause concern not only to scientists, but also the Government, media and public. Due to erosion of coasts, the recreational space of leisure areas is worsening and decreasing, and the hydrotechnical facilities and other economic objects located in the coastal area are put at risk.

**Current geodynamic tendencies of the coastal sections.** The evaluation of the current geodynamical tendencies of the Lithuania's coastal sections was based on the data of long-term (2002–2012) measurements performed in the Lithuanian coastal dynamics monitoring network developed (1993) by the Coastal Research and Management Sector of the Nature Research Centre. The annual tests (repetitive levelling) are performed by using electronic tachometer (TOPCON GTS 229) in special stationary 98 posts (50 in the Curonian Spit and 48 in the continental coast). One measurement point represents the coastline of approximately 1 km in the Curonian Spit and the coastline of approx. 700 m in the continent.

The evaluation of long-term geodynamical tendencies of the coast was performed by using geoindicators reflecting both the changes of the coastline and surface silting (budget of coastal surface silting). The budget of coastal surface silting ($m^3/m$): washed away or blown and accumulated substances composing the coast (calculated until the medium long-term level of the sea), volume change ($m^3$) within a year or any other period of time calculated per one linear metre of coastline. The summarised long-term (2002–2012) and recent (2007–2012) geodynamical tendencies for separate coast sections (continental and Curonian Spit coastline) are presented here. The average change of the coastline and silting was calculated separately for the continental and the Curonian Spit coast by multiplying the average of change of adjacent profiles from the distance between them and by dividing the sum of received values from the length of entire section (continental and Curonian Spit coast). It should be noted that the resent (2007–2012) positive geodynamical changes in the coastline also reflect the implemented stabilisation measures stipulated in the coastal management programmes. The long-term tendencies of the dynamics of coastline (summarised for the entire shore of the Lithuanian Baltic Sea) are presented in Fig. 167 and 168. As is clear from these data, in the past decade, in the continental coast, the most significant decrease of coastline was observed in the sections of Šventoji – frontier with Latvia, Ošupis district, River Rąžė – Palanga bridge, Nemirseta – Olando kepurė (Dutchman's Cap) and coast near Melnragė I, whereas in the Curonian Spit – in sections of Pervalka, Preila and Nida coast.

However, in the past 5 years (2007–2012), after the implementation of coastal management measures, the Lithuanian Baltic Sea coastline moved towards the sea both in the Curonian Spit and continental coasts (Fig. 167–170).

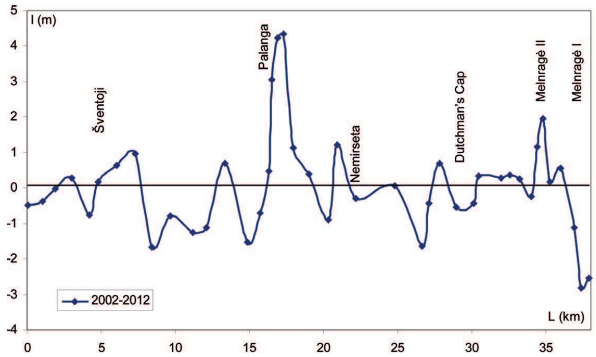



**Fig. 167.** Coastline changes (m/year), 2002–2012, in the continental coast. Abscissa axis "0" – state frontier with Latvia. *Source: NRC, Coastal Research and Management Sector*

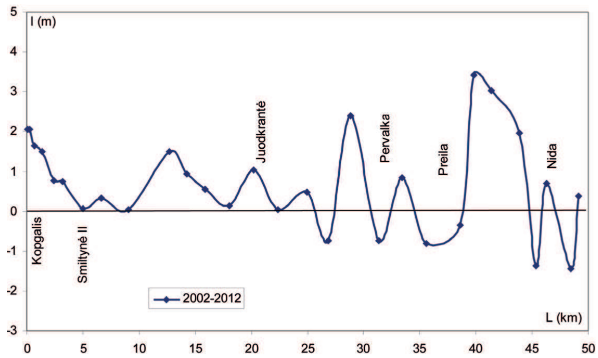



**Fig. 168.** Coastline changes (m/year), 2002–2012, in the Curonian Spit coast. Abscissa axis "0" – southern pier of Klaipėda Seaport. *Source: NRC, Coastal Research and Management Sector*

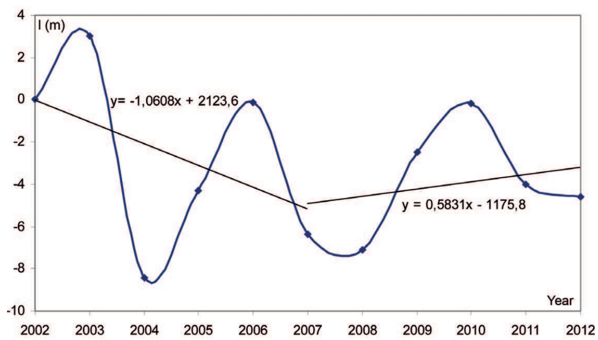
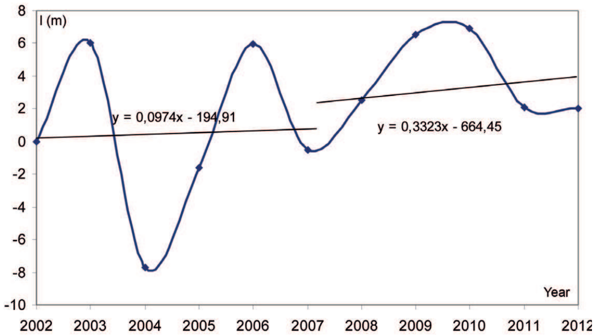



**Fig. 169.** Average variation of coastline in the continental coast in 2002–2012 and 2002–2007 ant its linear trends in 2007–2012. *Source: NRC, Coastal Research and Management Sector*

The tendencies of the dynamics of the state of coast are best reflected by the changes of budget of coastal silting. These findings are presented in Fig. 171–172.




**170 Fig.** Average variation of coastline in the Curonian Spit coast in 2002–2012 and 2002–2007 ant its linear trends in 2007–2012. *Source: NRC, Coastal Research and Management Sector*

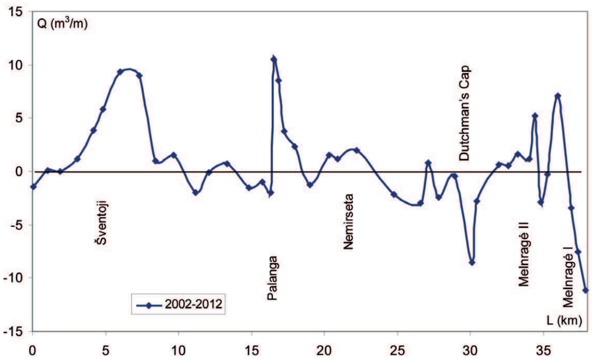



**Fig. 171.** Annual changes of the budget of coastal silting in continental coast, 2002–2012. Abscissa axis "0" – state frontier with Latvia. *Source: NRC, Coastal Research and Management Sector*

The tendencies of stabilisation of the state of coast (accumulation of powdery sand silting) after implementation of coastal management measures during the last five years are well reflected by the results of analysis of comparison of the periodical linear trends of 2002–2007 and 2007–2012, which are presented in Fig. 173 and 174.

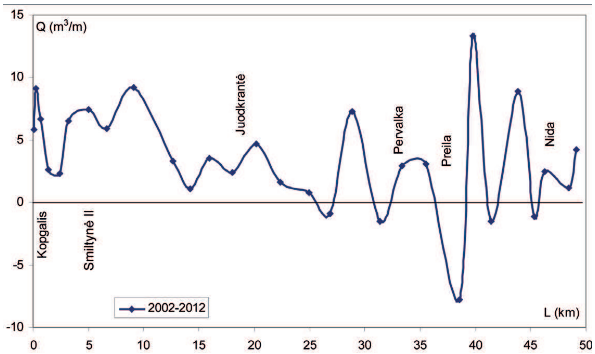



**Fig. 172.** Annual changes of the budget of coastal silting in the Curonian Spit coast, 2002–2012. Abscissa axis "0" – southern pier of Klaipėda Seaport. *Source: NRC, Coastal Research and Management Sector*

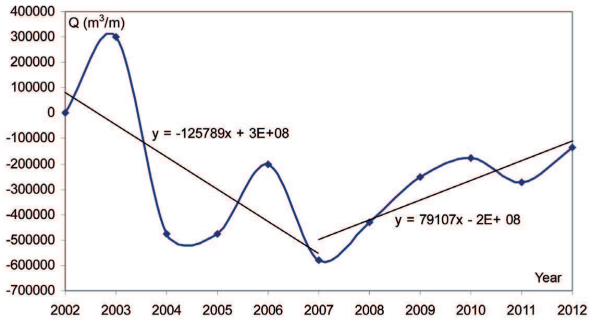



**Fig. 173.** Variation of the average level of coastal silting in the continental coastline in 2002–2012 and 2002–2007 ant its linear trends in 2007–2012. *Source: NRC, Coastal Research and Management Sectorius*

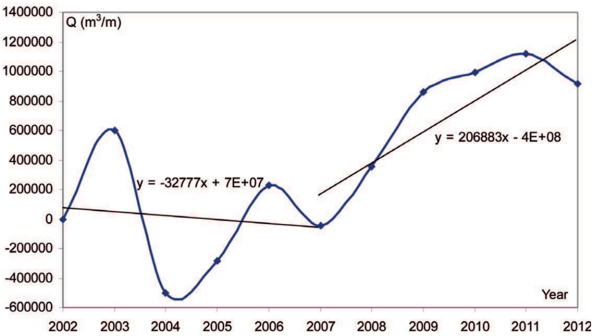



**Fig. 174.** Variation of the average level of coastal silting in the Curonian Spit coastline in 2002–2012 and 2002–2007 ant its linear trends of 2007–2012. *Source: NRC, Coastal Research and Management Sector*

**Coastal management.** When analysing the data presented in Fig. 169–170 and 173–174, it is clear that, the tendency of coastline regression and decline in silting that dominated in the Lithuanian coast in 2002–2007 were replaced by the tendencies of coastline trans-regression and silting accumulation in 2007–2012. This result was achieved by creating a legal and software base of coastal strip management and by starting to implement many complex coastal management measures.

The prepared legal and software base:

- Strategy of Coastal Management of the Lithuanian Baltic Sea (29 November 2001, No 570). The aim of Strategy is to ensure the balanced development of the coastline by preserving the natural complexes of the coastal area and creating conditions for the rational use of natural resources.
- Law on Coastal Strip of the Republic of Lithuania (2 July 2002, No IX-1016). This law describes the aims of establishment of coastal strip, its composite parts, regulates the protection and use of coastal landscape, conditions of the use of land and sea water area and restrictions of economic activity.

Pursuant to the provisions of Strategy of Coastal Management of the Lithuanian Baltic Sea and the Law on Coastal Strip of the Republic of Lithuania, the target coastal management programmes were prepared:

- The Curonian Spit Target Programme (1999, Institute of Geography);
- The Lithuanian Baltic Sea Continental Coast Management Target Programme (2003, Institute of Geology and Geography);
- The Coastal Strip Modified Management Programme (2005, Institute of Geology and Geography);
- The Lithuanian Baltic Sea Coastal Management Programme for 2008–2013 (2007, Institute of Geology and Geography)

When preparing coastal management programmes, first of all, the current state of separate coastal sections and long-term tendencies of its dynamics were evaluated (pursuant to nature researches), and the intensiveness and type of coast usage was recorded. Pursuant to the data of the aforementioned research, the districting of the entire Lithuanian coastline was performed. This action was followed by the establishment of recommended coastal management measures for each district. The complex of recommended coastal management measures includes: fitting of protective seaside dune ridge, management and protection (development of recreational infrastructure – installation of boardwalks or pebble-clay paths and stairs, covering of deflation forms and slopes of dunes with causeways of branches; fitting of upper and sea (western) slope of dunes with fences of brushwood, isolation of dunes from holidaymakers, education of holidaymakers (installation of information-notification stands, etc.), supplement of beach and coastal silting with brought sand, protection of natural processes) and monitoring of the state of coast.

After the implementation of the majority of coast management measures recommended in target coastal management programmes in the coastline of Lithuania, the noticeable improvement of the state of coast was observed in many sections. The best example is the installation of complex of coastal management measures in the central part of Palanga coast (Fig. 175–176).

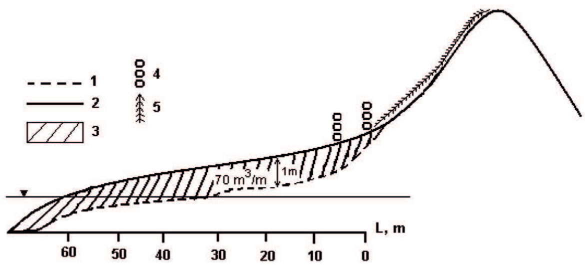



**Fig. 175.** Scheme of complex of coastal management measures installed in the central part of Palanga coast: 1 – beach profile prior to the supplement of silting; 2 – beach profile after the supplement of silting; 3 – layer of filled silting; 4 – fences of brushwood; 5 – western slope reinforcement with branches. *Source: NRC, Coastal Research and Management Sector*

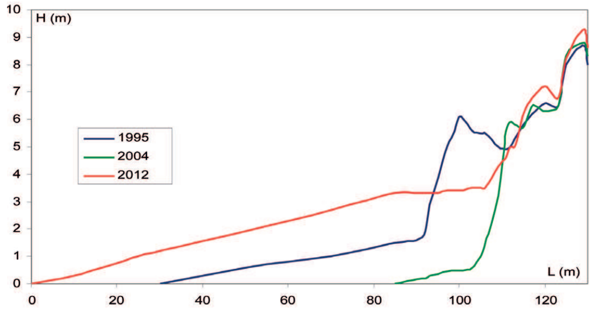



**Fig. 176.** Dynamics of Palanga cross-coast profile (near Kęstutis Street), 1995–2012. *Source: GTC Coastal Research and Management Sector*

One more example should be mentioned, i.e., what happens when no focus is paid on the coastal processes and coastal management. The deepening of Klaipėda Seaport mouth channel and elongation of seaport piers (2001–2002) conditioned an intensive scour of coastal section north to Klaipėda Seaport (the former relatively stable coast – Fig. 177 and 1179) (Fig. 178 and 180).

**Fig. 177.** State of coast north to Klaipėda Seaport and elongation of piers (2001) *(photo by G. Žilinskas, 2011)*

**Fig. 178.** State of coast north to Klaipėda Seaport 10 years after the elongation of piers *(photo by D. Jarmalavičius, 2012).*

**Fig. 179.** The state of coast south to the Palanga bridge before installing the complex of coastal management measures – 2004 (picture above) and after implementation – 2012 (picture below) *(photo by G. Žilinskas and D. Jarmalavičius, 2012)*

The changes of the state of coast after the elongation of seaport piers in the nearby section of the coast are well illustrated by the measurement data (Fig. 180).

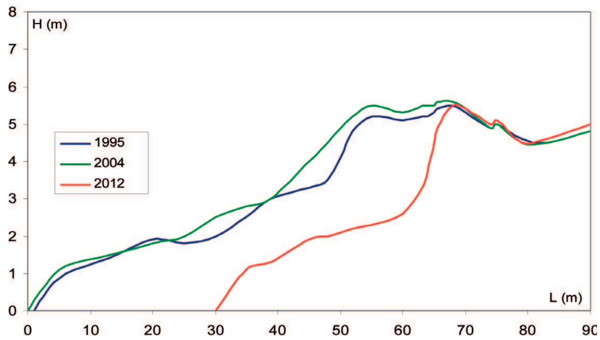



**Fig. 180.** Dynamics of the cross-section profile of Melnragė I coast (approx. 400 m from the seaport pier), 1995–2012. *Source: NRC, Coastal Research and Management Sector*

# Biodiversity

## BIODIVERSITY PROTECTION IN LITHUANIA

Natural and semi-natural ecosystems (forests, swamps, meadows, waters and open sands) occupy more than one third of Lithuania's territory. The majority of flora and fauna species are found in forests – Lithuania is situated in the mixed forest natural area. Based on the biogeographic division into districts applied in the European Union, Lithuania is in the southern periphery of the boreal (northern) biogeographic region. Only a small part of Lithuania belongs to the continental biogeographic region. This circumstance conditions a great diversity of species and natural habitats that formed under the influence of both biogeographic regions.

Biodiversity is the entirety of all forms of life and species of organism and all levels of its organisation (from molecular and genetic to ecosystem-based and regional). The approximate number of all species in the world is believed to amount from 3 to 100 million out and only more than 1.7 million species have been described (catalogised). One of the newest expert conclusions indicates that the total number of species can be approx. 8.7 million. As we known, not all taxonomic groups are equally well examined in the world in respect of species covered by these groups. The best examined (but not completely) are the species of vertebrates, the least examined – invertebrates. The species living in terrestrial ecosystems are better examined that those living in the hydrosystems. Based on the data of tests and plans that has been accumulated for many years, it is possible to make an approximate image on the degree of recognition of biodiversity of our biosphere.

For example, out of 5,600 species of mammals assumed to live in the world, approximately 5,501 (98%) have been found; out of 10,500 species of birds – 10,064 (96%) have been found; out of 12,000 reptiles – 9,547 (80%) have been found; out of 15,000 of amphibians – 6,771 (45%) have been found; out of 600,000 arachnids – 102,248 (17%) have been found and out of 5,000,000 insects – ~10,000 (20%) have been found. The level of cognition of biodiversity in hydrosystems (fresh wasters, seas and oceans) is even lower; for example, out of 45,000 supposedly existing species of fish 32,000 (72%) have been described; out of 150,000 supposedly existing species of arachnids approx. 47,000 (31%) species have been described; out of 200,000 species of molluscs – 85,000 (43%) have been described.

The lists of biodiversity existing in Lithuania are also far from finite. Even the best examined groups of systemic taxons are constantly supplemented with newly discovered species. For example, in 2003, the list of birds registered in Lithuania was comprised of 343 species, in 2011 – of 376 species, and in 2012 – of 380 species. Mostly described are the species of taxons, invertebrates, fungi, lichen, moss, algae newly discovered in the territory of our country, the existence of which is recorded by performing detailed research of fauna/flora in separate territories. Another increasingly more significant part of species is the number of immigrating and registered species of foreign territories. On the other hand, certain local and invasive species are disappearing. Thus, the total number of species attributed to separate systematic taxons of Lithuania is varying, even if insignificantly.

Today, Lithuania's biodiversity is composed of approx. 28,500 species (more than 20,529 species of animals, more than 6,100 species of fungi and 1,796 species of plants, excluding all other forms of life (protists, microorganisms, etc.) and that accounts for approx. 1.6% of the described biodiversity in the world. The list of biodiversity in Lithuania, which is constantly supplemented with newly registered species discovered in the territory of our country, is increasing annually.

One of all recognised features of biodiversity is uneven geographic distribution of all species in separate ecosystems of regions. It is conditioned not only by the current climate conditions, but also by the factors existing for a much longer period, limiting the interaction of the ecologic conditions of population of certain species in more general sense (entirety of abiotic and biotic factors) with the evolution of the same species. All factors regulating the current state of populations of the species can be divided into several main groups: ecologic factors, impact of evolution and anthropogenic activity.

The species of narrow ecologic specialisation (occupying narrow ecologic niches) are mostly disappearing in the terrestrial ecosystems and natural structure habitats/ecosystems. They are especially sensitive to the variation of technologies applied in forest economy sectors (when economic activity is intensified or traditional extensive utilisation of land is terminated/changed). The development of such territories and changes occurring in these territories lead to the increase in the fragmentation of natural ecosystems / habitats and local populations of species, impairment of the conditions for the migration of species, disappearance of the possibilities to exchange in genetic information between the isolated local populations and, thus, their survival is put at risk. Endangered species and/or their natural habitats in hydrosystems are mostly influenced by the water pollution (both with dangerous compounds and surplus of biogenes), change of hydrologic mode, irrational use of natural resources and destruction /cut-off of migration routes.

By implementing the Convention on Biological Diversity (signed in Rio de Janeiro on 5 June 1992; ratified by the Seimas of the Republic of Lithuania in 1995), Lithuania integrated the provisions of this Convention into the national legal acts: the Law on the Wild Flora of the Republic of Lithuania, Law on the National Genetic Resources of Plants of the Republic of Lithuania, Law on Protected Species of Fauna, Flora and Fungi of the Republic of Lithuania and their implementing legal acts.

In Lithuania, the protection of rare objects was already discussed in the Law on Nature Conservation adopted in 1959. The list of protected plants was approved in 1962 with inscription of 176 rare and endangered species of higher plants. In 1976, by the proposal of the Committee on Nature Conservation and resolution of the former Council of Ministers of the Lithuanian SSR, the Red List of Endangered Species of the Lithuanian SSR was published (the publication was presented to the society in 1981), which included 41 species of animals (the total list of species of animals was 42, considering that the entire tribe of humble-bees was included, the list of species of which was not completely known at that time), and 30 species of higher plants (in total, 72-82 species).

The first List of the Endangered Species of the Lithuania SSR as an informational publication for the society designated for the education of various layers of society had certain shortcomings, some of which could be justified by the objective reasons. Based on the then requirements, it had to be prepared pursuant to the principles of classification and standardisation of the Red List of Endangered Species of the USSR without considering the status of species in Lithuania; based on their current status, the species were not divided into separate categories; some well-known rare species were not included intentionally, whereas due to the lack of information, the lower plants, fungi, lichen and a major part of taxons of invertebrates were not reviewed at all. In fact, in addition to the Red List of Endangered Species, there also existed some additional more comprehensive lists of endangered and protected species.


The Red List of Endangered Species of Lithuania – a newly prepared informational publication issued in 1992 (hereinafter the Red List of Endangered Species of Lithuania) – included 210 species of animals, 210 species of plants and 81 species of fungi and lichen; in total – 501 species. In 2007, the Red List of Endangered Species of Lithuania included 768 species of animals, plants, lichen and fungi (Table 15).

Later, in view of the rapid variation of the state of the current biodiversity, new editions of the Law on Protected Species of Fauna, Flora and Fungi were continuously prepared (Official Gazette, 1997, No 108-2727; 2009, No 159-7200). Following Order No D1-130 of the Minister of Environment of the Republic of Lithuania of 11 February 2010 (Official Gazette, 2010, No 20-949), the name of the list of protected species of fauna, flora and fungi included into the Red List of Endangered Species of Lithuania was replaced with the list of protected species of fauna, flora and fungi of the Republic of Lithuania. The Red List of Endangered Species of Lithuania – an informational publication prepared for the general public – always reflected that state of the biodiversity in Lithuania, which was known during the period of its preparation.

Already after the last edition of the Red List of Endangered Species of Lithuania issued in 2007, the lists of protected species, attribution of species to one or other category were supplemented and amended by various orders of the Minister of Environment. For example, upon the receipt of information, in 2010, according to the proposal of experts and by the order of the Minister of Environment, three species of fungi – *Sarcosoma globosum*, *Chaenotheca hispidula* and *Nephroma resupinatum* were transferred from 0 (Ex) category to 1 (E) category, whereas fish Golden Spined Loach (*Sabanejewia aurata*) was included into 4 (I) category. In 2012, additional editions of the list of protected species of the Red List of Endangered Species of Lithuania were issued (White Hellebore (*Veratrum lobelianum Bernh.*) was transferred from 0 (Ex) category to 2 (E) category; Sturgeon (*Acipenser oxyrinchus*) introduced in the Baltic Sea region was inscribed into 0 (Ex) category).

By implementing the European Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (hereinafter – the Habitat Directive), it has been recorded that 55 natural habitats of the EU importance and 50 species of flora and fauna of the EU importance are found in Lithuania.

**Table 15.** List of protected species of fauna, flora and fungi of the Republic of Lithuania. *Source: Ministry of Environment*

| | | Categories | | | | | | In total |
|---|---|---|---|---|---|---|---|---|
| | | 0 (Ex) | 1 (E) | 2 (V) | 3 (R) | 4 (I) | 5 (Rs) | |
| Animals | | | | | | | | |
| 1. | Mammals | 3 | 1 | 3 | 7 | 5 | 4 | 23 |
| 2. | Birds | 3 | 13 | 20 | 31 | 8 | 5 | 80 |
| 3. | Reptiles | – | 2 | – | – | – | – | 2 |
| 4. | Amphibians | – | – | – | 1 | 2 | 2 | 5 |
| 5. | Fish | 2 | 1 | | 1 | 3 | – | 8 |
| 6. | Molluscs | 1 | – | – | 4 | – | – | 5 |
| 7. | Arachnids | – | – | – | 2 | – | – | 2 |
| 8. | Insects | 9 | 4 | 14 | 63 | 33 | – | 123 |
| 9. | Crustaceans | 1 | 2 | – | 1 | – | – | 4 |
| 10. | Leeches | – | – | 1 | – | – | – | 1 |
| | In total | 19 | 23 | 37 | 110 | 51 | 13 | 253 |
| Plants | | | | | | | | |
| 1. | Club mosses | – | 1 | 1 | – | – | 1 | 3 |
| 2. | Horsetails | – | – | – | 1 | – | – | 1 |
| 3. | Ferns | – | 5 | – | 1 | 2 | – | 8 |
| 4. | Conifers | 1 | – | – | – | – | – | 1 |
| 5. | Flowering plants | 12 | 51 | 63 | 66 | 19 | 9 | 220 |
| 6. | Red algae | – | 1 | – | – | – | – | 1 |
| 7. | Brown algae | – | 1 | – | – | – | – | 1 |
| 8. | Charophytes | – | 2 | 1 | 4 | 3 | – | 10 |
| 9. | Mosses | 1 | 19 | 19 | 26 | 28 | – | 93 |
| | In total | 14 | 80 | 84 | 100 | 52 | 10 | 338 |
| Fungi and lichen | | | | | | | | |
| 1. | Fungi | 3 | 27 | 24 | 27 | 31 | – | 112 |
| 2. | Lichens | 12 | 30 | 15 | 6 | – | – | 63 |
| | In total | 15 | 57 | 39 | 33 | 31 | – | 175 |
| | Amount in total | 48 | 160 | 160 | 243 | 134 | 23 | 766 |

The species included into the list of protected species of fauna, flora and fungi of the Republic of Lithuania included into the Red List of Endangered Species are divided into several categories (based on IUCN 2001, 2003): 0 – **extinct or probably extinct species;** 1 - **endangered species** on the verge of extinction, which require special protective measures to maintain their existence; 2 - **vulnerable species**, the number of species and the number of individual in their populations is evidently decreasing; 3 – **rare species** the population of which is small due to their biological properties; 4 – **rare, insufficiently studied species** that cannot be placed into other categories of rareness due to the lack of information; 5 – **restored species**, the number of which previously listed into the Red List of Endangered Species, has been restored. The last publication "The Red List of Endangered Species of Lithuania" published in 2007 included 768 species of fauna, flora and fungi, whereas the list of protected species of fauna, flora and fungi of the Republic of Lithuania of 2012 included 766 species.

It is necessary to mention the systematic units the safety of population of which and further survival are in great danger. Out of mammals, this includes the tribe of bats (*Chiroptera*); out of 15 species known in Lithuania, even 14 species are included into the lists of protected species (lists of the Red List of Endangered Species of Lithuania). Speaking about birds, among 13 species of owls (*Strigiformes*) known in one (occurrence observed) or other (breeding) way – 7 species are among the rare and protected ones.

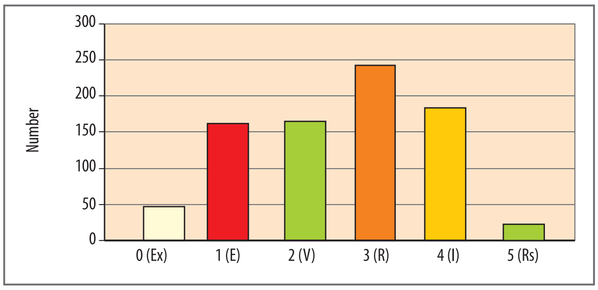



**Fig. 181.** Distribution of protected species of fauna, flora and fungi of the Republic of Lithuania based on the criteria and categories of International Union for Conservation of Nature (IUCN 2001, 2003). *Source: Ministry of Environment*

The legislative provisions and measures of protected species that stipulate the specific tactical aspects of restoration, increase of population and further protection of specific species should be developed in the future. Unfortunately, the further clear strategy of conservation actions is unknown for some species listed as protected. There are many objective obstacles of that – one of them is the lack of required specific information of the objective state of one or other species.

## IDENTIFICATION OF PROBLEMS RELATED TO THE CONSERVATION OF BIODIVERSITY

Conservation of biodiversity in biosphere is a global problem of the 21st century. Although in separate countries and regions the problems are specific, however, the causes, consequences of disappearing of biodiversity and principles of further protection strategy are very similar. Lithuania is not an exception. It faces the same environmental problems as other Member States of the European Union (especially the new ones).

The conservation of biodiversity requires comprehensive information on the ecosystems, habitats and species of that specific region as well as their prevalence and current status, whereas the implementation of specific restoration and preservation activities require special legal acts and specific strategic planning documents. It is necessary to implement specific protection and management measures and be properly prepared for them. Until the recent years, the active measures of conservation of biodiversity were mostly implemented in the protected areas, whereas beyond the boundaries of these areas, the actions of conservation of biodiversity were usually limited to the prohibitions and restrictions of economic activity characterised by negative impact. This is not sufficient for the conservation of species and their habitats. They need to be protected not only in protected areas, but also in the entire range of their prevalence and it requires the implementation of special protection measures. In Lithuania, the major focus was on the preservation of species included into the Red List of Endangered Species of Lithuania, whereas after Lithuania become a part of the European Union, it became obliged to protect the species and habitats of the EU importance, in order to create favourable conditions in as large as possible territory of prevalence of certain species, and sometimes even in the entire range of their prevalence.

The increased and general level of ecological understanding on the surrounding environment encouraged the review of the former strategic provisions of conservation of specific species. The ecological needs of certain species of the European Community force to assume the obligation not only of the protection of individuals of specific species from direct physical destruction (hunting, fishing, picking, etc.), but also to take measures for the conservation of their living environment – habitats, ecosystems, interaction of recorded abiotic factors in them. Passive protection of species is insufficient as various species are lost not only by destructing them physically, but also retract or are eliminated due to occurring natural variation of habitats and ecosystems, when the established existing conditions rather meet the needs of species other than the endangered ones.

For example, when the form of extensive farming creating and maintaining the favourable ecological niches for separate species in respectively formed habitats is replaced with other form of farming or completely terminated. Overgrazing or haymaking formed the habitats and varietal diversity of species of semi-natural meadows and wetlands; after termination of grazing and haymaking the open areas were replaced by bushes and emerging forest.

One of the factors of rapid successive variation of hydrosystems causing actual threat on certain especially rare habitats of plants, is an extensive inflow of biogenes (N, P) disordering the harmony between other factors of abiotic-biotic environment and hydrobionts-hydrophytes.

Rapid variation of environment in Lithuania can significantly impact the remaining hydrosystems of low-mineralised lakes with communities of polygonum plants characterised by water clearness and prevailing open mineral soil in littoral area. Their variation into the lakes of other type causes threat on the autochthonic communities of aquatic plants existing in them. Also, emerges an actual risk of extinction of specific vegetation of isoetids, including two very rare species of lake plants (found only in 6 places in Lithuania) – *Lobelia dortmanna* and *Isoetes lacustris*. The changes of environmental conditions leads to the changes of the state of such lakes and the aforementioned species are faced with an actual threat of extinction.

The majority of reasons of extinction of biodiversity are characteristic to all EU Member States as the prevalence habitats of many species cover a wider area than the administrative limits of the European Union. The major current problems of biodiversity conservation in Lithuania include:

- Extinction of the living environment (areas of habitats) of protected species and worsening of the factors characteristic to those species, especially due to increased use of forest resources, extinction of traditional land use forms in agriculture or their variety, disorder of natural hydrologic mode of wetland and forest ecosystems, development of urban infrastructure and shores of water bodies.
- In case of absence or failure to create opportunities for the restoration of small, fragmented populations of protected species, the destruction of current migration routes or worsening of migration conditions causes the degradation of current populations and their extinction.
- There is a lag in creation of national-scale system (comprehensive data bank) for constant accumulation of biodiversity data, information systems for recording data on natural habitats, their state, prevalence of protected species and habitats, therefore, it is difficult to prepare the project of biodiversity protection and implement specific actions in due time. It aggravates the proper evaluation of the state of biodiversity and necessity to plan protection actions in preparing and coordinating the plans and project of economic activity.
- A very relevant problem becomes the expansion and establishment of invasive species of plants and animals, occupying the habitats of local endangered species or distorting the important ecological relations between the species.
- The current monitoring system, even if acting based on approved programmes and methodologies, is unstable in long-term perspective and highly dependent on the financing.

The extinction of small populations of fragmented and protected species. The typical examples of this problem include Lynx and Eurasian Eagle Owl, which are or will soon be endangered animals. Based on the report of 2007 prepared by the then Institute of Ecology of the Vilnius University, there are at least 30-40 individuals (up to 80) in the Lithuanian population of lynx, and only approx. 5-10 pairs of Eurasian Eagle Owls. The current population structure is of low viability – due to the lack of individuals suitable (mature) for breeding, the number of animals is not increasing. The population of lynx is fragmented and prevails fragmentally in Lithuania. The prevalence of species and flow of population are conditioned by intensive use of forest as the main habitat of species, unsolid nutrition ecological chain, distortion, and poach.

Distortion of the migration routes of migrating animals and worsening of conditions in migration routes. Lithuania has ratified the international agreements (Bonn Convention, AEWA, EUROBATS, and ASCOBANS) and has become obliged for the welfare and protection of migrating animals. The accumulations of migrating animals (birds, bats, Harbour Porpoises) have a seasonal nature in Lithuania. Certain migrating species of animals or groups of species are spending winters in Lithuania.

The major threat on the temporary habitats and winter-places of migrating animals is caused by the change of habitats (drying of wetlands, rapid successive change of plant communities in wetlands and meadows – their further growing with canes, bushes, trees, which conditions the lack of specific nutrition sources for other protected species and further extinction of feeding and breeding places), eutrofication, pollution and disturbance. It is particularly relevant for the protection of populations of water and swamp birds.

The protection control remains a relevant problem and as well as the issues of accumulation, analysis and management of data on biodiversity levels. The major part of measures of the State Environment Monitoring Programme for 2011–2017 designated for the evaluation of the state of living nature is composed of monitoring intended for the evaluation of the state of places of accumulation of EU-important species, habitats and bird migration. This should ensure the accumulation of information forming the conditions for the establishment of the most sensitive areas of European biodiversity and prevention from their extinction.

The harmonisation and exchange of information facilitates the more effective concentration of protection measures, increases integration between sectors, simplifies the collection of monitoring information, provides more opportunities for effective planning of protection measures, control of their implementation, whereas the accumulated information increases the "memory" of institution.

In the area of observation of the living nature, it is sought to evaluate and forecast the changes of the state of habitats and species of the EU importance, the impact of natural and anthropogenic factors, form conditions for the adoption of proper decisions regarding the protection and restoration of habitats and species, operative evaluation of variation of the state of forests in respect of space and time due to impact of carriage of long-distance pollutants and other stress factors, evaluate the impact of pollution and other stress factors on the most prevailing (characteristic) forest ecosystems. The information is collected and evaluated in order to ensure the proper protection and sustainable usage of bio-resources (hunted animals and caught fish).

When implementing CITES, Berne and Bonn Conventions and the related EU legal acts, seeking to ensure the protection of endangered flora and fauna species and their habitats, the experts singled out 15 underlying biological species that are rare in the entire Europe, the protection of which would form conditions for their conservation. It also touched many other species and natural habitats ecologically related to the protected species. The 15 singled-out underlying species include the following plants: American Pasqueflower (*Pulsatilla patens*), Woodpecker Nuksack (*Cypripedium calceolus*), Marsh Saxifrage (*Saxifraga hirculus*), Waterwheel (*Aldrovanda vesiculosa*); birds: Black Stork (*Ciconia nigra*), Wood Grouse (*Tetrao urogallus*), Little Tern (*Sterna albifrons*), Aquatic Warbler (*Acrocephalus paludicola*), Great Snipe (*Gallinago media*); mammals: Lynx (*Lynx lynx*), Pond Bat (*Myotis dasycneme*); fish: European Weathirfish (*Misgurnus fosilis*); insects: Scarce Large Blue (*Maculinea teleius*), Green Club-tailed Dragonfly (*Ophiogomphus cecilia*), Flat Bark Beetle (*Cucujus cinnaberinus*). The plans of protection of these species have been prepared containing the most detailed general information on the species, evaluation of the state of the most important founding places as well as other ecologic parameters, set goals, proposals for the plans of measures as well as the method of their implementation, and indicating the need for financing.

For example, in Lithuania, the population of Woodpecker Nuksack is of satisfactory condition, however, an obvious decrease in the number of population has been observed due to improper forest management, increasing shadowing of sites, eutrofication of soil and pollution as well as picking of ornate blossoms. It is possible to slow down the disappearance and worsening status of populations only by applying immediate nature conservation measures. It is especially important to protect and maintain proper condition of habitats and restore intensely damaged yet still viable populations. According to approximate calculations, the population of Woodpecker Nuksack amounts from 8,000 to 10,000 individuals.

**Fig. 182.** Gentiana cruciata *(photo by S. Sinkevičius, 2011)*

The majority of American Pasqueflower populations are small, composed of isolated plants – usually up to 10 individuals scattered in a large area or small isolated groups. The populations of largest and mostly abundant species remain in the light sand pinewoods and sands in Lithuanian South-East and Eastern region. The populations of this species are highly influenced by the decrease in proper habitats due to anthropogenic activity and farming changes. American Pasqueflower is disappearing also due to invasion of alien species and direct extermination of plants: by picking blossoms and digging mature plants in order to move them to parterres or sell as decorative plants. The entire area occupied by American Pasqueflowers probably does not reach even 500 ha, whereas the total population can amount to 10,000-15,000 plants in our country.

Some endangered species in Lithuania are requiring the conservation of infrastructure of specific components of their habitats, for example, especially rare and protected (1(E) category of the Red List of Endangered Species of Lithuania) butterfly Alcon Blue (*Maculinea alcea D & S*) lays eggs only on the leaves of a rare and protected (2(V) of the Red List of Endangered Species of Lithuania) Cross Gentian (*Gentiana cruciata L.*), which will later be the habitat of the caterpillars. The further development of caterpillars and chrysalis requires the closeness of Black Ants (*g. Mirmica*). In case of absence of all mentioned species in one habitat, there are no conditions for the survival of Alcon Blue.

## INVASIVE SPECIES

Lithuania, same as any other countries in the world, have not escaped the ecological problems caused by invasive species, which, according to the experts, are one of the most threatening to the state of all levels of biodiversity. Usually, the negative consequences are also caused by careless introduction (the intentional or accidental relocation of species outside the boundaries of its historically established natural habitat due to anthropogenic activity). For example, Sosnowsky's Hogweed and Large-leaved Lupine. Newly emerging or intentionally brought species can be characterised by rapid proliferation and adapt to various natural conditions. They are not choosy for habitats, environmental pollution, are resistant to pesticides, usually spread with human assistance. They are especially dangerous to small ecosystems characterised by low biodiversity, because they cannot only exterminate other species, but also cause damage to agriculture, water bodies, shift landscape or even cause danger to human health.

Although the spreading routes of the majority of invasive species have been identified, some species are undergoing extermination, control of spread and further introduction; however, the scale and speed of current measures are low. The list of invasive species officially recognised as dangerous published in 2012 increased almost twice – it already contains 35 species.

**Table 16.** List of most dangerous or potentially dangerous in the future invasive species in Lithuania. *Source: Ministry of Environment*

| Item No | English name | Latin name |
|---|---|---|
| Animals | | |
| 1. | Raccoon Dog | *Nyctereutes procyonoides* |
| 2. | American Mink | *Mustela vison* |
| 3. | Muskrat | *Ondatra zibethica* |
| 4. | Common Raccoon | *Procyon lotor* |
| 5. | Brown Rat | *Rattus norvegicus* |
| 6. | Canadian Goose | *Branta canadensis* |
| 7. | Chinese Sleeper | *Perccottus glenii* |
| 8. | Round Goby | *Neogobius melanostomus* |
| 9. | Spiny-cheek Crayfish | *Orconectes limosus* |
| 10. | Signal Crayfish | *Pacifastacus leniusculus* |
| 11. | Chinese Mitten Crab | *Eriocheir sinensis* |
| 12. | New Zealand Mudsnail | *Potamopyrgus antipodarum* |
| 13. | Zebra Mussel | *Dreissena polymorpha* |
| 14. | Bay Barnacle | *Balanus improvisus* |
| 15. | Ponto-Caspian Amphipod | *Pontogammarus robustoides* |
| 16. | Mysid | *Paramysis lacustris* |
| 17. | Fishhook Waterflea | *Cercopagis pengoi* |
| Plants | | |
| 18. | Manitoba Maple | *Acer negundo* |
| 19. | Sosnowsky's Hogweed | *Heracleum sosnovskyi* |
| 20. | Large-leaved Lupine | *Lupinus polyphyllus* |
| 21. | Black Locust | *Robinia pseudoacacia* |
| 22. | Small Balsam | *Impatiens parviflora* |
| 23. | Black Cherry | *Padus serotina* |
| 24. | Ramanas Rose | *Rosa rugosa* |
| 25. | Wild Cucumber | *Echinocystis lobata* |
| 26. | Daisy Flower | *Phalacroloma septentrionale* |
| 27. | Thicket Shadbush | *Amelanchier spicata* |
| 28. | Giant Goldenrod | *Solidago gigantea* |
| 29. | Tall Goldenrod | *Solidago altissima* |
| 30. | Canadian Goldenrod | *Solidago canadensis* |
| 31. | Canadian Waterweed | *Elodea canadensis* |
| 32. | Asiatic Dock | *Rumex confertus* |
| 33. | Scotch Broom | *Sarothamnus scoparius* |
| 34. | Devil's Beggarticks | *Bidens frondosa* |
| 35. | Baby's Breath | *Gypsophila paniculata* |

The published extended list does not mean that new invasive species occurred in Lithuania – they existed previously and their population simply increased, in certain places, they managed to set in and started to threat the local biodiversity.

The classical example is the Sosnowsky's Hogweed (*Heracleum sosnowskyi*). Once it was recommended and subsequently introduced as an additional feed suitable for livestock and accumulating high content of vegetal mass. Later, it was distributed by florists and beekeepers. Currently, it turned into a plant dangerous for human health and a threatening competitor in plant communities (even autocratic in certain habitats).

Invasive species are not only considered an ecological problem, but also increasing economic losses in the sectors of forestry, fishery, agriculture, tourism, etc.

According to the newest calculation of the EU scientists, over 11,000 alien species are found in Europe and this number is increasing extremely rapidly. Each year tenths of new species of plants from various regions around the world are found in Europe. Each year, invasive species cause losses of up to 12 million euro in Europe, however, only the damages caused by tenth of invasive species are evaluated materially. In Lithuania, 548 species of alien plants are known currently, 46 species of them are invasive and another 60 species – potentially invasive that can cause serious ecological problems in the future. The fight with alien species is very important in order to seek one of the main aims of the European Union – to stop the disappearance of biodiversity.

The populations of certain formerly introduced and the most dangerous or likely dangerous invasive species in Lithuania has decreased noticeably due to so far unknown reasons (American Mink, Water Rat), however, this has no comfort on their status in the short future. Although Spiny-cheek Crayfish (*Orconectes limosus*) became the prey of individual local species (predatory fish, otters, etc.) and other alien species (water rats, American minks), however, its populations has not decreased and is continuously spreading.

There is information about the occurrence of the new invasive species of mammals – Common Racoon – and even cases of its breeding in Lithuania. It is forecasted that the currently occurring European climate change will not bypass the territory of Lithuania, thus, forming favourable conditions for this invasive species. The common racoons have been observed to occur among the wild animals kept in private enclosures in the entire territory of Lithuania. More comprehensive studies on the potential threats of invasive species in the local ecosystems have not been prepared.

## SPECIES PROTECTION AND RESTORATION

Due to objective reasons, the applicable measures for the breeding of endangered species (Pond Bats, Black Storks, Lesser Spotted Eagles, Great Snipes, Aquatic Warblers, Little Terns) and reintroduction of certain species (Wood Grouses, Eurasian Eagle Owls, Lynxes) are insufficient so far, and more accumulating the good experience of breeding of rare species and their adaptation in the natural environment rather than virtually changing the status of the current populations. The restoration of certain dangerously decreased populations will require a longer period than it was considered before.

There is a lack of wider-scale protection plans and other necessary documents for the implementation of certain protection measures for protected species. There is still a lack of actions plans both for the slowing or stopping of spread of separate invasive species dangerous to local species and decrease of their population and also for the breeding and reintroduction of endangered species and application of protection measures for migrating species.

One of the successfully implemented programmes of conservation and restoration of species is the "Programme of the Restoration and Protection of Lithuanian Salmon Resources" which aimed at the restoration of extinct populations of salmon fish. The Lithuanian fishery companies incubated the spawns of wild salmon, whereas the spawn and grown juveniles were methodically let in great quantities to specific rivers of Lithuania. During the implementation of this Programme, the complex means such as improvement of water quality, increase in the protection of spawning sites and main salmon migration routes were applied and facilitated in the restoration of the population. Vilnius became one of few European capitals, where salmon come to spawn from the Baltic Sea. After the cardinal change in the situation that occurred in several decades, the Atlantic Salmon (*Salmo salar L.*) was crossed out of the category 5 (Rs) and even the recreational angling of salmon was permitted.

However, the restored populations of salmon are not yet provided with favourable conditions to reach the inflows of the middle of Nemunas River in greater quantities, where new spawning sites could be formed (or former could be restored). The threats in the Baltic Sea have not been eliminated as well; proper distribution of catch quotas and regulation without damaging the maternal herd; the accumulation of dangerous and persisting compounds (for example, dioxins) in salmon organism.

Atlantic Sturgeon (*Acipenser sturio L.*) or simply sturgeon disappeared from Lithuanian waters 40 years ago. Currently, a sparse population of breeding Atlantic sturgeons exists in France (Gironde estuary and its inflows). Provided with status "critically endangered", the Atlantic sturgeon was included into the International Red List of Endangered Species (IUCN) in 1996. As far back as in 1997, the Helsinki Commission (HELCOM) adopted the resolution regarding the protection of endemic Atlantic sturgeon in the Baltic Sea and restoration of its resources. The increasing interest in the conservation of genetic variety of biodiversity species conditioned the appearance of international agreements on the conservation of endangered species. At the moment, the Atlantic Sturgeon as the species being at the verge of extinction is receiving the focus of many European countries and respective environmental/ restoration measures are being adopted. It is included into the lists of endangered species as well as in the lists of protected species of IUCN and CITES.

In order to realise the plan of the nearly extinct population of Acipenser Sturgeon, many difficulties have been faced. First of all – a small number of survived individuals in the limited territory, long maturity period (7-14 years), almost unknown features of migration and behaviour in spawning sites and seas.

The newest researches on the identification of Atlantic Sturgeon as a species were performed in 2012 and the results were slightly unexpected. After using the methodology of mitochondrial DNA haplotype research, the genetic maps of American Sea Sturgeon (*Acipenser oxyrinchus*) and European Atlantic Sturgeon (*A. sturio*) were compared. These multiplex researches used the samples of the last catch and also the samples of individuals accumulated in museums. It has been determined that American Sea Sturgeon is nearly identical to the European Atlantic sturgeon that used to live in the Baltic and North Seas. According to the scientists, approximately 800-1,200 years ago, American Sea Sturgeons immigrated into the Baltic Sea and interbred with or competed the locate population. This leads to the conclusion that the fish swimming in the Baltic Sea, Northern Sea as well as along the Eastern coast of Atlantic and rivers meeting there, were described by the biologists and named as Atlantic Sturgeons, whereas in the other, Western side of the Atlantic – American Sea Sturgeons. This discovery opened new possibilities for the restoration of species in Europe, since the American Sea Sturgeon is quite widely prevailing in the rivers and lakes of the East coast of North America and the populations are quite abundant.

The Ministers of Environment of the countries located near the Baltic Sea, signed an action plan of the Helsinki Commission (HELCOM) in 2007 on the restoration of population of sturgeons in the Baltic Sea and became obliged to join the works of the restoration of sturgeons performed in Germany and Poland already. The countries also became obliged to prepare the programmes of the restoration of recourses in the rivers suitable for sturgeons. In the course of the implementation of this programme, in Lithuania, approximately 2,000 cubs of American Sea Sturgeons were released into Neris and Šventoji Rivers in Lithuania, in 2011. The works of the growing and formation of reproduction herd of sturgeon cubs started in Rusnė and Simnas ponds. In total, over 13,000 cubs of American Sea Sturgeons were released into the Neris and Šventoji rivers. The let small sturgeons, having lived until the maturity of 1 year in rivers, will reach the Curonian Lagoon and then the Baltic Sea and having reached maturity will return to spawn in Lithuanian rivers after 12-15 years.

Having used the funds of the structural aid of the European Union for the implementation of the priorities of the strategy programme of biodiversity preservation and planning and management of protected territories of 2007–2013, the projects were implemented until 2013 designated for:

- Preparation of actions plans of species protection and abundance regulations means;
- Implementation of means of species conservation;
- Inventory of EU-importance natural habitats, establishment of favourable environmental status and creation of monitoring system of habitats.

Unfortunately, it is so far impossible to stop the extinction of biodiversity and reduction on the global scale – the global aims to stop the degradation of global biodiversity until 2010 were too optimistic, whereas the set results were not achieved. The possible reasons of consequences are analysed and the environmental strategy is planned for the new decade.

In the 10th Convention on Biodiversity countries conference it was decided to plan several strategic aims in the biodiversity strategic plan for 2011–2020.

To fight with the reasons causing the extinction of biodiversity and include the issue of biodiversity into the decision of various levels:

- The society is properly informed on the benefit of biodiversity, protection and sustainable usage:
- Biodiversity is integrated into national and local development strategies and programmes;
- The subsidies and initiatives causing damage on the biodiversity are eliminated;
- Business and government are implementing plans related to the sustainable production and usage and does not allow the usage of natural resources to damage the ecological harmony.

To decrease the direct impact (pressure) on the biodiversity and encourage its sustainable usage:

- the extinction, degradation and fragmentation of natural habitats is reduced or stopped,
- the resources of fish and invertebrates are used sustainably,
- the utilised agricultural, forest and aquaculture areas area used sustainably and protection of biodiversity is ensured,
- the pollution is minimised down to the level, which is not harmful to biodiversity and functions of ecosystem,
- invasive species: the spreading routes are identified, extermination is conducted, the spread and introduction are controlled,
- the negative impact on coral reef is reduced.

To improve the status of biodiversity by protecting ecosystems, species and genetic variety:

- at least 17% of terrestrial land and 10% of marine territories should be protected,
- the further extinction of endangered species should be stopped,
- the genetic diversity of agricultural plants and livestock is maintained.
- to increase the benefit received from biodiversity and ecosystem services to all people:
- the ecosystems that provide the main services (water, health, source of living, welfare) are restored and preserved,
- the resistance of ecosystems is increased, 15% of all degraded ecosystems are restored.

The Nagoya protocol will enter into force until 2015 and will function on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization.

Until 2050, the biodiversity in the EU countries and its ecosystem services as the existing natural property should be protected, evaluated and properly restored regarding their valuable and important contribution to human welfare and economic development of the EU in order to avoid catastrophic changes occurring after their degradation. The European Union set the objective to stop the disappearing of biodiversity and worsening of ecosystem functions by 2020 as one of the aims in the Biodiversity Strategy, in order to restore these systems as much as possible also intensifying the action of the European Union, in order to prevent from the universal (global) disappearing of biodiversity. The main elements of the preservation and restoration of the natural environment of the European Union, ecosystems and maintenance of the current status of their functions and improvement, sustainable development of agriculture, forestry and fisheries, fight with invasive alien species, several groups of aims become the global solutions of biodiversity issues by 2020, i.e.:

1. In order to preserve and restore the natural environment, it is necessary to stop the worsening of status of species and habitats stipulated in the EU nature directives and achieve the well-founded improvement of their status as compared with current assessment results. The evaluation criteria chosen for the achievement of the aim are as follows:
   - to improve the state of protection of 100% more habitats and 50% more species evaluated in accordance with the Habitat Directive;
   - to achieve more stability and better quality for 50% more species evaluated in accordance with the Birds Directive.
2. In order to maintain and improve the current conditions and functions of ecosystems, it is necessary to implement the green infrastructure and restore 15% of impoverished ecosystems by improving their status and functions.
3. By developing the sustainable agriculture, forestry and fishery, it is necessary to achieve the following:
   - the improvement of the state of protection of species and habitats in the agricultural sector, which are dependent on or influenced by agriculture; the increase of areas dedicated for agricultural needs that are subject to the measures related to biodiversity;
   - the improvement of the protection of species and habitats in the forestry sector, which are dependent on or influenced by the forest economy; to ensure that plans of forest management and equal measures meeting the sustainable forest management strategy were applied to all state forests and forest areas funded under the EU Rural Development Policy;
   - to achieve that fishing was sustainable, good environmental status was ensured, and the special management of fishing aimed at avoiding a negative impact on other resources, species and ecosystems was applied.

**Fig. 183.** A particular focus should be on the restoration of over-improved, abandoned and unused lands, by returning their former biological values and restoring ecological functions. Dactylorhiza baltica started to blossom in the restored wetland only after a decade *(photo by S. Sinkevičius, 2011)*

4. When fighting invasive alien species, it is necessary to establish the occurring invasive species and the routes of their access, to control or exterminate the underlying (most threatening) species, prevent from the establishment of new invasive species.
5. When solving biodiversity issues on the global scale, it is necessary to increase the contribution of the European Union into the processes of stopping of extinction of global biodiversity by 2020.

## THE NEW STRATEGIC BIODIVERSITY CONSERVATION PROGRAMME

The need to prepare the updated national strategic biodiversity conservation document stipulating the trends of the policy of biodiversity conservation is dictated by the currently changed situation. There are several main reasons (arguments) to prepare the new documents, i.e.: adoption of new strategic biodiversity preservation documents of the EU and international level (the EU Communication on the EU Biodiversity Strategy to 2020 (2011); the Strategic Action Plan of the United Nations Biodiversity Convention to 2020 updated in 2010).

The preparation of the new biodiversity conservation strategy is stipulated in the action plan of the implementation of Government Programme for 2008–2012; the priority of the activity of the Ministry of Environment for 2012 is stipulated in the Strategic Action Plan of the Ministry of Environment for 2012–2014.

In 2012, the working group was formed for the preparation of biodiversity conservation programme project, the discussion "The Vision of the Preparation of Biodiversity Conservation Programme (strategy)" was organised, the main problems, sectors related to the conservation of biodiversity were identified as well as the possible objectives, goals, measures, evaluation criteria, the requirements of methodology on the structure, etc.

The possible content of Biodiversity Conservation Programme (Strategy) (non-exhaustive list):

- Species and habitats (protected species, invasive species, hunted species, protected areas, habitats, etc.).
- Integration of biodiversity conservation principles into separate sectors (agriculture, forestry, fishery, energy, business, tourism, transport, etc.).
- Protection of genetic resources.
- Ex-situ (botanical, zoological collections) conservation.
- Scientific researches and information exchange (databases, researches, monitoring system, etc.).
- Education, public information and communication.
- Strengthening of administrative and institutional skills (nature protection agency or service, animal care centre).
- Funding sources.

# Natural Resources

## LITHUANIAN MINERAL RESOURCES AND FACTORS INFLUENCING THEIR EXTRACTION

Mineral resources are essential to economic development. During the first 50 years of the 20th century, the amount of the extracted mineral resources was equal to the amount extracted during the entire previous period of mankind existence, whereas, during the last several decades, the extraction additionally increased by 50% and is continuing to increase.

The Communication from the European Commission (COM, 2008, 699) notes that "Raw-materials are essential for the sustainable functioning of modern societies. Access to and affordability of mineral raw materials are crucial for the sound functioning of the EU's economy. Sectors such as construction, chemicals, automotive, aerospace, machinery and equipment sectors, which provide a total value-added of 1,324 billion euro and employment for some 30 million people, all depend on access to raw-materials".

Currently, there are 17 types of minerals explored in various levels in Lithuania (Table 17), 9 types of which (limestone, dolomite, sand, gravel, clay, peat, oil, chalk marl and sapropel) are utilised (two latter types of minerals are used fragmentally).

These are mostly the minerals used in the industry of construction materials and road building and are almost the most important ones based on the amount consumed and economic value (Table 18).

In Lithuania, minerals have been systematically explored since about 1946 and by 1958; the deposits of all currently used solid minerals have been discovered.

The development of the search and exploration works lead to the increase in the number of deposits and amount of minerals as well as the increase in volumes of extraction due to rapid development of construction of industrial and residential buildings, agriculture. In 1960–1972, the country's economic activity required 20–30 million $m^3$ mineral recourses each year: gravel, sand, limestone, dolomite, clay, peat and opoka, therefore, geologists were set the target to find new deposits and "restore" the used deposits in such way.

**Table 17.** Explored underground natural resources in Lithuania at the end of 2011. *Source: Lithuanian Geological Survey*

| | Thoroughly and preliminary explored resources | | Of which: thoroughly explored resources | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Amount | Amount | Amount | Conditional price of unit (million LTL) | Conditional value (million LTL) | Amount | Conditional price of unit (million LTL) | Conditional value (million LTL) |
| | 2010 | 2011 | 2010 | | | 2011 | | |
| 1. Oil (million tons) | 3.8 | 3.7 | 2.423 | 1,586 | 3,842.9 | 2.34 | 2,053 | 4,804.02 |
| 2. Peat (million m³) | 3,341.91 | 3,337.79 | 1,286.91 | 7,46 | 9,600.3 | 1,284.78 | 7,46 | 9,584.46 |
| 3. Limestone (million m³) | 557.16 | 554.10 | 194.26 | 34.5 | 6,702.0 | 193.65 | 34.5 | 6680.93 |
| 4. Dolomite (million m³) | 249.59 | 253.09 | 109.09 | 13 | 1418.2 | 112.54 | 13 | 1463.02 |
| 5. Opoka (million m³) | 19.39 | 19.39 | 19.39 | 19 | 370.7 | 19.39 | 19 | 370.7 |
| 6. Anhydrite (million m³) | 80.69 | 80.69 | 80.69 | 30.4 | 2,453.0 | 80.69 | 30.4 | 2,453.0 |
| 7. Chalk marl (million m³) | 9.41 | 9.41 | 7.22 | 22 | 157.1 | 8.06 | 22 | 177.32 |
| 8. Clay (million m³) | 236.3 | 235.70 | 145.61 | | 1,400.5 | 145.0 | | 1,414.8 |
| 8.1. Devonian clay | 1.41 | 1.41 | 1.41 | 20 | 28.4 | 1.4 | 20 | 28.0 |
| 8.2. Triassic clay | 59.59 | 59.59 | 43.7 | 13 | 568.1 | 47.6 | 13 | 618.8 |
| 8.3. Other clay | 176.32 | 174.70 | 100.5 | 8 | 804.0 | 96.0 | 8 | 768.0 |
| 9. Gravel (million m³) | 1,312.2 | 1,332.0 | 618.7 | 6 | 3,712.2 | 642.56 | 6 | 3,855.36 |
| 10. Sand (million m³) | 521.0 | 526.38 | 239.1 | | 1,463.9 | 245.94 | | 1,496.6 |
| 10.1. Sand for ceramic products | 40.0 | 40.59 | 15.8 | 7 | 110.6 | 15.7 | 7 | 109.9 |
| 10.1. Glass-making sand | 4.08 | 4.04 | 4.08 | 40 | 163.2 | 4.04 | 40 | 161.6 |
| 10.3. Sand for silicate products | 197.1 | 257.89 | 94.1 | 6 | 564.6 | 94.1 | 6 | 564.6 |
| 10.4 Other sand | 297.8 | 223.86 | 125.1 | 5 | 625.5 | 132.1 | 5 | 660.5 |
| 11. Groundwater (million m³ per day) | 1.91 | 1.91 | 1.91 | | 30,828.5 | 1.91 | | 30,828.5 |
| 11.1. Fresh water (million m³ per day) | 1.90 | 1.90 | 1.90 | 1.2 | 20,805.0 | 1.90 | 1.2 | 20,805.0 |
| 11.2. Mineral water (million m³ per day) | 0.01 | 0.01 | 0.01 | 108 | 10,023.5 | 0.01 | 108 | 10,023.5 |
| 12. Sapropel (million m³) | 20.51 | 20.55 | 4.61 | 17 | 78.4 | 4.61 | 17 | 78.4 |
| 13. Gypsum (million m³) | 27.99 | 17.82 | 16.82 | 25 | 420.5 | 16.82 | 25 | 420.5 |
| 14. Fresh-water limestone (million m³) | 1.6 | 1.6 | 0.6 | 18 | 10.8 | 0.6 | 18 | 10.8 |
| 15. Amber (tons) | 112.0 | 112.0 | - | - | - | - | - | - |
| 16. Glauconitic sandy loam (million m³) | 7.4 | 7.4 | - | - | - | - | - | - |
| 17. Rock salt (million m³) | 258.29 | 258.29 | - | - | - | - | - | - |
| 18. Iron ore (Fe >20%, million m³) | 61.69 | 61.69 | - | - | - | - | - | - |
| 18.1. Fe >40% (million m³) | 34.57 | 34.57 | - | - | - | - | - | - |
| Underground resources (in total) | X | | X | X | 59,972.6 | X | X | 63,610.28 |

The expression in value terms is presented for thoroughly explored minerals only. The value of solid minerals was calculated based on calculation of tax for state natural resources. The calculation was based on the assumption that the tariff of tax for underground resources established by the Law on Taxation of State Natural Resources (25 May 2006, No X-616) accounts for 5% of the unit value. The average price of oil unit meets the price level of 4th quarter of 2011. The resources of groundwater were evaluated for 25 years. The calculation was performed by the Lithuanian Geological Survey.

**Table 18.** Extraction of underground resources, 2010–2011. *Source: Lithuanian Geological Survey*

| Item No | Type of mineral | Measur. unit | Amount of extracted resources, 2010 | Amount of extracted resources, 2011 |
|---|---|---|---|---|
| Non-metal minerals | | | | |
| 1. | Oil | thousand tons | 111.5 | 107.7 |
| 2. | Peat: | thousand m³ | 917 | 1247 |
| | low-decomposing | thousand m³ | 917 | 1,247 |
| | other | thousand m³ | 757 | 890 |
| 3. | Limestone | thousand m³ | 454 | 572 |
| 4. | Dolomite | thousand m³ | 1,150 | 1,447 |
| 5. | Opoka | thousand m³ | - | - |
| 6. | Anhydrite | thousand m³ | - | - |
| 7. | Chalk marl | thousand m³ | - | - |

| Item No | Type of mineral | Measur. unit | Amount of extracted resources, 2010 | Amount of extracted resources, 2011 |
|---|---|---|---|---|
| 8. | Clay - Devonian | thousand m³ | 4 | 3 |
| | Clay - Triassic | thousand m³ | 139 | 157 |
| | Other | thousand m³ | 60 | 90 |
| 9. | Gravel | thousand m³ | 6,100 | 6,590 |
| 10. | Sand from ceramic products | thousand m³ | 7 | 6 |
| | Glass-making sand | thousand m³ | 35 | 40 |
| | Sand for silicate products | thousand m³ | 102 | 276 |
| | Other sand | thousand m³ | 1,251 | 1,255 |

| Item No | Type of mineral | Measur. unit | Amount of extracted resources, 2010 | Amount of extracted resources, 2011 |
|---|---|---|---|---|
| 11. | Fresh groundwater | thousand $m^3$ | 139,795,000 | 148,555,000 |
| | Mineral groundwater | thousand $m^3$ | 130,500 | 137,600 |
| 12. | Sapropel | thousand $m^3$ | - | - |
| 13. | Amber | kilograms | - | - |

Both the previously discovered and currently explored minerals constitute a valuable national wealth (Fig. 184). The value of thoroughly explored minerals and groundwater alone amounted to 64 billion Litas in the early 2012. It constitutes a large share of the national wealth of the Republic of Lithuania. It should be noted that areas of minerals occupy only approx. 4% of Lithuania's territory; therefore, their areas should not be developed by buildings or used for other needs restricting the possibility to use the mineral deposits eventually.

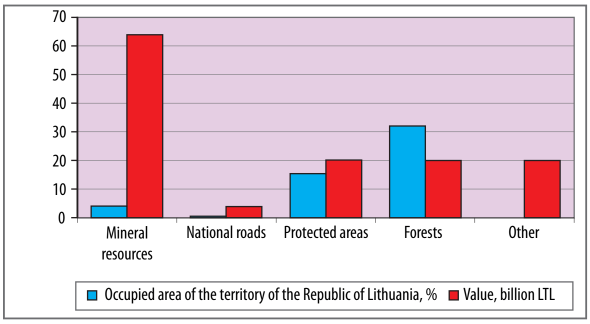



**Fig. 184.** The comparison of the value of composite parts of the national wealth and the area covered by the territory of the Republic of Lithuania. The calculations of the Lithuania Association of Quarries (including only the thoroughly explored mineral deposits). Source: Lithuanian Geological *Survey, Lithuanian Road Administration*

The extraction of the minerals is conditioned by many factors (Fig. 185). The extraction of minerals is associated with the industrial growth and increase in construction volumes. The growth of industry is the most important factor influencing the extraction as well as exploration of new deposits. In the developed countries, the annual amount of extracted various types of minerals amounts to 20 tons per capita.

In Lithuania, this level amounted to 10-12 tons two decades ago, whereas in 1996–2001 – up to 4 tons of local minerals. These are mostly the constructional mineral substances or the raw materials used for their production. Since 2011, due to the development of industry, roads and construction business, the amount of solid minerals increased and reached 5 tons per capita in 2007. During the economic crisis in 2009, the amount of extraction decreased by nearly 40%.

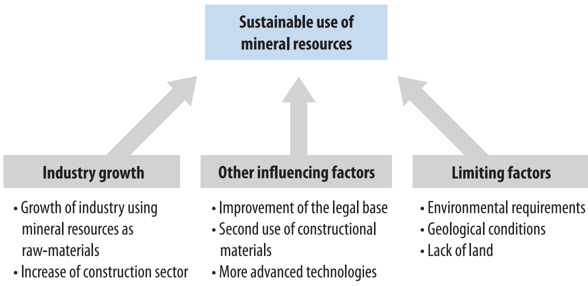



**Fig. 185.** Factors influencing the extraction of minerals. *Source: Lithuanian Geological Survey*

The truth is that the factors decreasing the need of extraction of minerals are also obvious: processing of demolition rubble, new production technologies saving raw materials, environmental requirements, etc. Another important restricting factor is the decreasing geological assumptions for discovery of new deposits, which become more and more complex as well as the lack of land for excavation.

The currently existing legal system thoroughly regulates the conditions and accounting of extraction of minerals and compliance with environmental requirements. The Lithuanian Geological Survey under the Ministry of Environment accumulates data on the minerals, performs the accounting of mineral extraction, approves and registers new deposits, issues permits for the use of underground resources.

For example, at the end of 2007, permits for the use of underground resources and voids were issued to 228 legal persons and one group of legal persons acting based on joint activity agreement. Whereas, at the end of 2011, permits for the use of underground resources and voids were already held by 279 legal persons and one group of legal persons.

## REGIONAL DISTRIBUTION OF EXPLORED AND PROGNOSTIC MINERAL RESOURCES

Based on the particularity of geological survey, the following categories of mineral resources are distinguished:

**Prognostic resources** – the probable mineral deposits of perspective territories or areas. They are classified into suspected and detected.

**Suspected prognostic resources** are the likely amounts of geological-industrial type minerals. Their existence is based on the paleogeographic, stratigraphic, facial-lithological, tectonic, petrographic, and geomorphological and other criteria, whereas the amount and quality – on the likely parameters received by the method of analogy with areas explored in more detail and containing deposits of the same type geological-industrial resources.

**Detected prognostic resources** mean the mineral detected in restricted areas, the amount and quality of which is established in accordance with search features (geological and non-geological) as well as at least one parameter of direct and/or distant geological research. The boundaries of the area of these resources are based on the geological extrapolation.

**Preliminary explored resources** are the mineral resources of the deposit or part of it, the amount, quality, technological properties, hydrogeological, excavation and other conditions are explored in such thoroughness that is sufficient for the performance of the initial environmental impact assessment and calculation of their economic value.

**Thoroughly explored resources** are mineral resources of the deposit or part of it, the amount, quality, technological properties, hydrogeological, excavation and other stratification conditions are explored in such thoroughness that is sufficient for the preparation of the utilisation project.

The different mineral resources are distributed quite unevenly in the territory of Lithuania (Fig. 186-187). Rock salt is located in Klaipėda and Tauragė regions.

The only explored anhydrite deposit is located in Kaunas region. All discovered dolomite deposits are situated in the northern part of the country, in Panevėžys and Šiauliai regions. Peat deposits are situated in the entire territory of our country and mostly in Šiauliai, Vilnius, Panevėžys, Klaipėda and Alytus regions. The deposit of iron ore is located in Varėna region. Deposits of deep-water limestone (travertine, lake limestone, marl) are mostly found in Alytus and Vilnius regions. Resources of gypsum are found in the anhydrite deposit in Kaunas region and also in Pasvalys region. Glauconitic sandy loam is found is Alytus and Vilnius regions. All explored resources of limestone are found in the northern part of Lithuania – territory of Šiauliai region (Fig. 188). Alytus and Marijampolė regions are rich in chalk marl resources. Clay is found in almost all areas of Lithuania, except for Klaipėda region. Most of its deposits were explored in Šiauliai, Marijampolė, Kaunas and Utena regions. Klaipėda region has the richest oil resources; small amounts of it were also found in Marijampolė, Telšiai and Tauragė regions. The only explored deposit of opoka is in Tauragė region. Sapropel is found in the entire territory of Lithuania and the explored resources are in Šiauliai, Alytus, Tauragė, Telšiai and Utena regions. Gravel and sand are the most common resources and the majority of explored deposits are in Vilnius, Kaunas, Utena, Alytus, Klaipėda and Tauragė regions (Fig. 188).

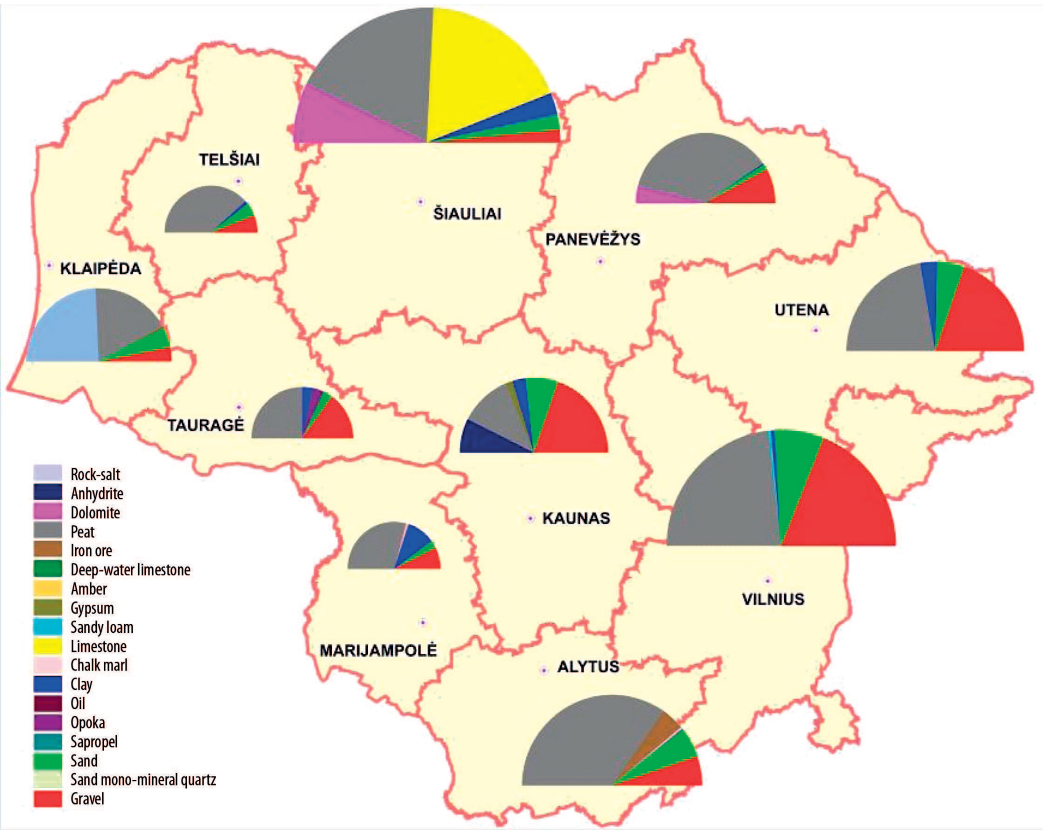



**Fig. 186.** Thoroughly and preliminary explored Lithuanian mineral resources in regions (01.01.2012). *Source: Lithuanian Geological Survey*

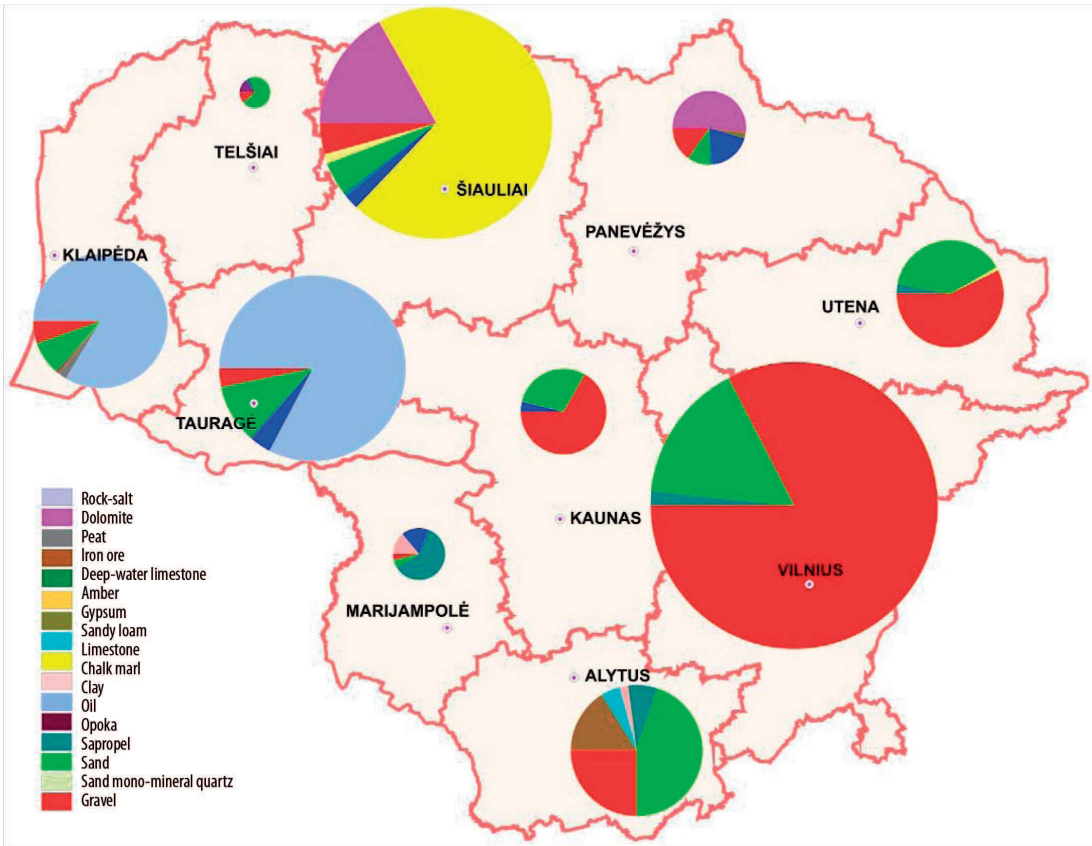



**Fig. 187.** Prognostic Lithuanian mineral resources in regions. *Source: Lithuanian Geological Survey*

The largest resources of sand and gravel of various degrees of exploration are in Alytus, Kaunas, Utena and Vilnius regions. Smallest resources of sand and gravel are in Marijampolė, Panevėžys and Telšiai regions.

Such distribution was conditioned by the palaeographical conditions of glacial melting. The majority of explored and evaluated gravel and sand deposits are in the bedsores of deltas, fluvio-glacial terraces and outwash plains formed by the flows of glacial melting water. The resources explored in these bedsores account for 53% of all gravel and sand resources. Significant sand and gravel resources (approx. 15%) stratify in the alluvial bedsores of the largest Lithuanian river valleys. Approx. 7% of gravel and sand resources are related to the continental dune bedsores. The remaining amount of resources was found in the bedsores of marginal fluvio-glacial and glacial ridges as well as ground moraines with small eskers. The deposits situated in the latter sites are quite small in terms of area.

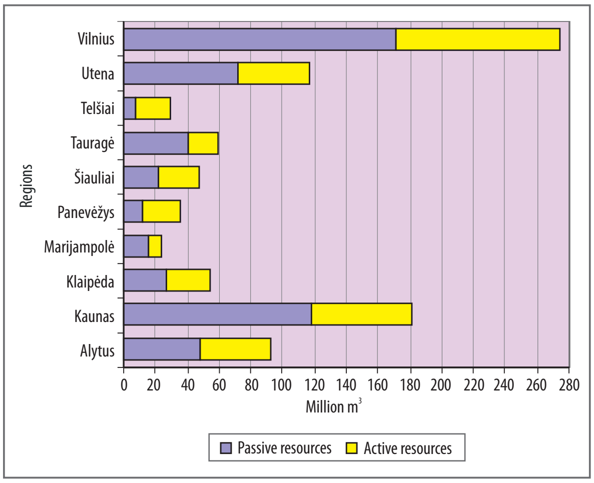



**Fig. 188.** Distribution of gravel and sand resources by regions (million m$^3$). *Source: Lithuanian Geological Survey*

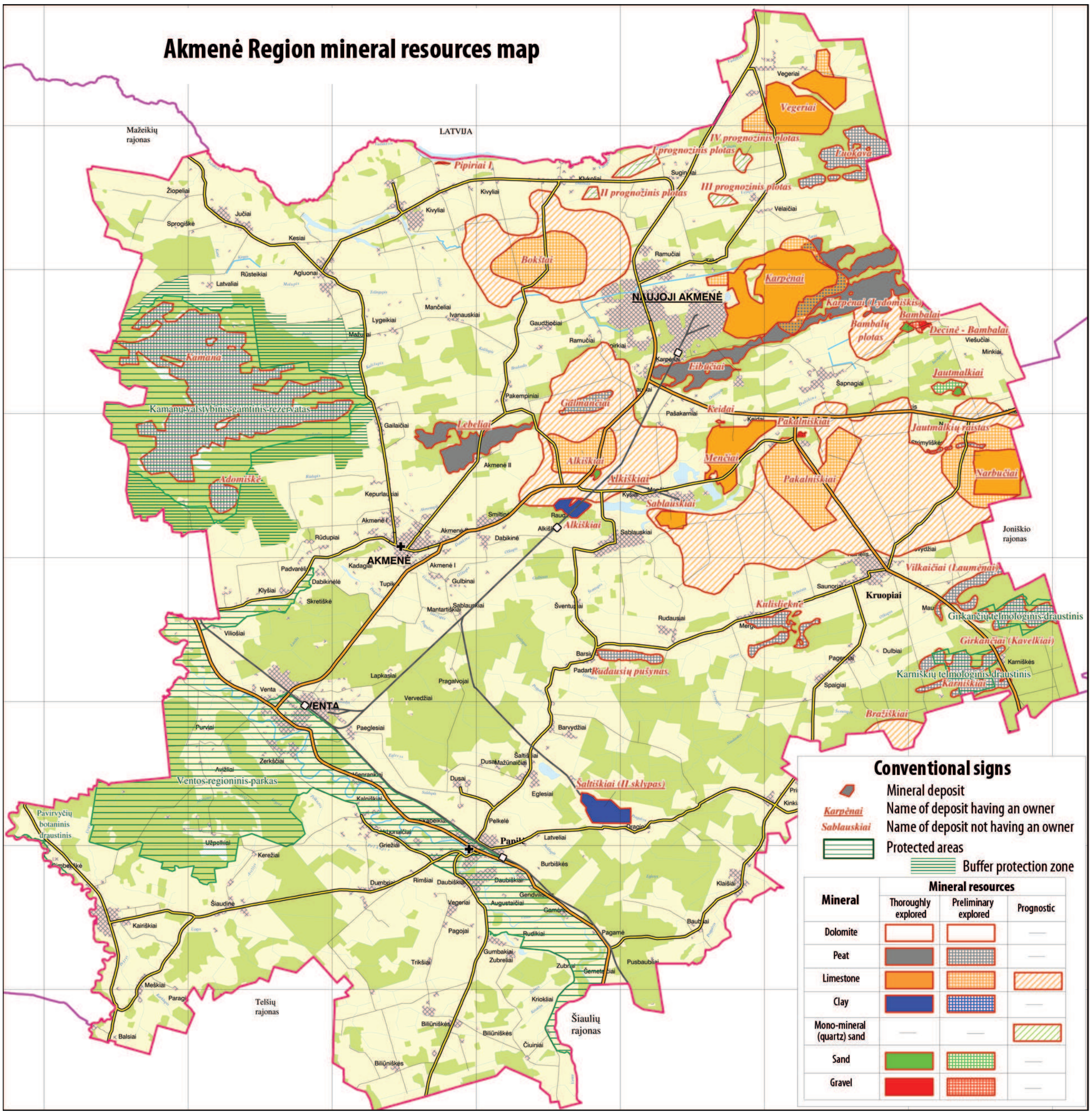



**Fig. 189.** Map of mineral resources in Akmenė region indicating the mineral deposits of various degrees of exploration and their prognostic areas. *Source: Lithuanian Geological Survey*

## TRENDS OF THE AMOUNT OF THOROUGHLY AND PRELIMINARY EXPLORED SOLID MINERAL RESOURCES

The amount of thoroughly explored mineral resources is gradually increasing due to newly explored deposits (Fig. 190). The majority of deposits are explored in preliminary explored areas; therefore, the preliminary explored areas are shrinking relatively, because part of them are turning into thoroughly explored areas. It should be noted that part of deposits are thoroughly explored in other utilised lands.

Whereas prognostic areas have only been decreasing since 2009 as it become increasingly difficult to distinguish them due to geological assumptions, environmental restrictions and decreasing rates of geological cartography. Geological cartography, which has been performed integrally since 1964, by 1 January 2012, was performed in only 48% of Lithuania's territory.

In order to ensure the receipt of proper geological information required for the prognosis of mineral deposits, it is necessary to develop a large-scale (M 1:50 000) spatial geological cartography of the territory of our country.

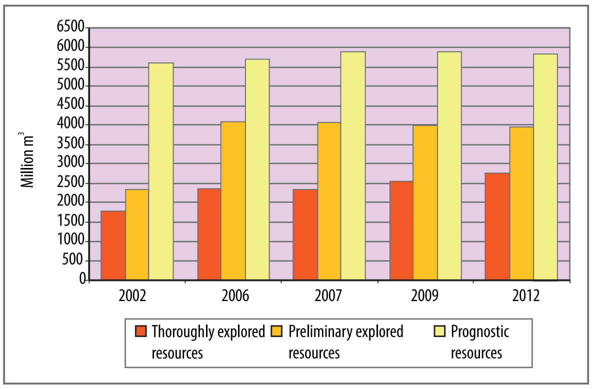



**Fig. 190.** Trends of the amount of thoroughly and preliminary explored solid mineral resources as compared with prognostic resources. *Source: Lithuanian Geological Survey*

## POTENTIAL OF UNUSED MINERAL RESOURCES

Under the law currently in force, it is possible to use only the thoroughly explored resources. In Lithuania, the largest thoroughly explored resources of unused underground minerals include anhydrite (101.5 million tons), opoka (33.7 million tons), gypsum (23.3 million tons), chalk marl (13.1 million tons), sapropel (4.3 million m$^3$) and deep-water limestone (0.6 million m$^3$). All aforementioned thoroughly explored resources constitute an actual potential of country's mineral resources. In addition to these resources, there are other less explored mineral resources under the ground as well as new preliminary explored types of minerals (rock salt, iron ore).

They are not used for various reasons: insufficient exploration, complex extraction conditions, lack of investment, however, the main reason is the lack of local industry requiring these raw materials and the extraction and exportation of them does not have economic justification at the moment. However, these minerals are a reserve for the future and its exploration and usage will be conditioned by the economic conditions and future technologies.

## EXTRACTION INTENSIVENESS

Throughout the entire Lithuania's history, the volumes of extraction reached the maximum in 1989–1991 (Fig. 191). The restoration of Lithuania's Independence was followed by the economic restructuring, which conditioned the recession in the extraction industry. After 1996, the extraction started to increase again.

The extraction of minerals, especially sand and gravel, especially increased during the period from 2001 to 2008. In case of persistence of the rates of growth of construction industry and infrastructure works of this period, there would soon have been a lack of explored sand and gravel resources. Therefore new deposits of sand and gravel would be necessary, however, their discovery and extraction is extremely complicated by the emerging lack of free land for excavation.

According to data of 2011 (Table 18), the extraction of minerals is increasing in Lithuania again. The highest amounts of extracted minerals include gravel, dolomite, peat and limestone. In 2011, 6,590 thousand m$^3$ of gravel were extracted – 400 thousand m$^3$ more than in 2010, 1,447 thousand m$^3$ of dolomite (297 thousand m$^3$ more), 1,247 thousand m$^3$ of low-decomposing peat (by 330 thousand m$^3$ more), 890 thousand m$^3$ of other type of peat (133 thousand m$^3$ more), 572 thousand m$^3$ of limestone (118 thousand m$^3$ more).

At the start of 2012, the permits to use mineral resources were issued to 279 national companies. Five companies held permits for use and exploration of oil deposits.

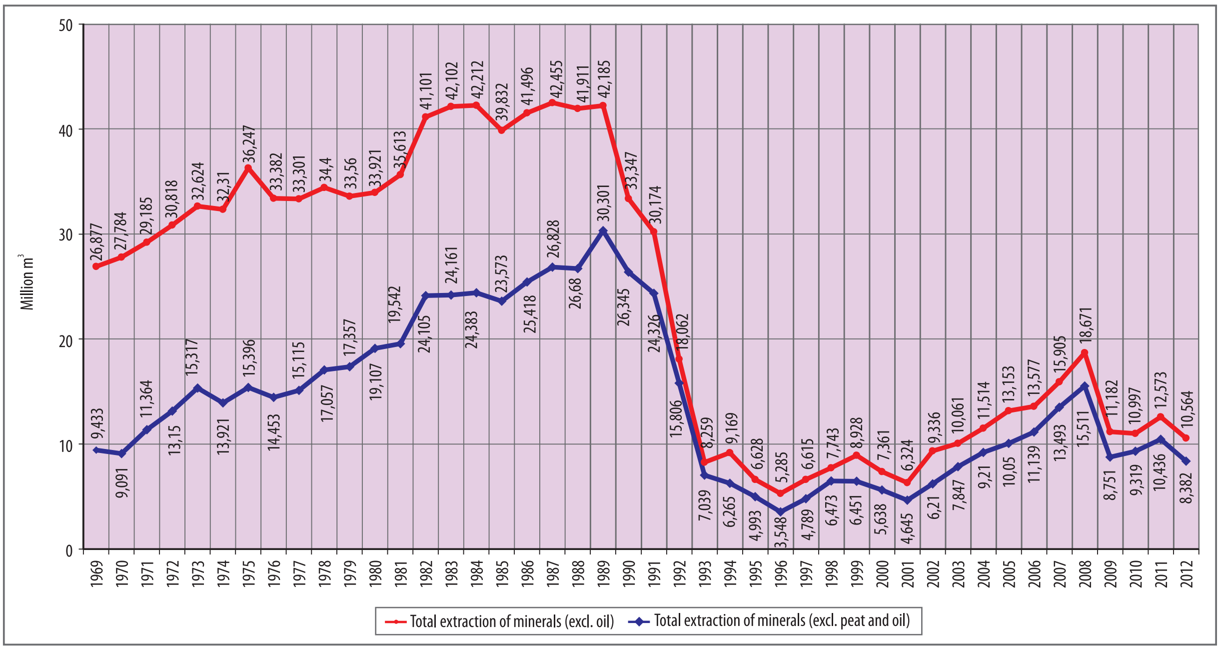



**Fig. 191.** General variation of volumes of mineral extraction. *Source: Lithuanian Geological Survey*

# TENDENCIES OF EXTRACTION OF THE MOST IMPORTANT MINERALS

## Dolomite Resources and Extraction

The resources of dolomite nearest the surface stratify in the Northern part of Lithuania. All explored deposits and prognostic deposits are located in Pakruojis, Joniškis, Akmenė, Biržai and Rokiškis regions. The largest resources of dolomite are located in Pakruojis district. It is excavated in Petrašiūnai II (Fig. 192–194) and Klovainiai deposits. Skaistgirys dolomite deposit is excavated in Joniškis district. It is the dolomite of suites of upper Devon of Pliaviniai (Čėdasai), Įstras, Stipinai (Petrašiūnai and Klovainiai), Kruoja (Savėliškis) and Žagarė (Skaistgirys). The dolomite of these suites is characterised by different texture, physical and mechanical properties, whereas the chemical composition is less different. The amount of CaO varies from 26% to 32%, MgO – from 15% to 20%, insoluble remains – from 5% to 18%. The largest dolomite extraction amounted to 2.359 million m$^3$ in 2008, whereas in 2011 – 1.447 million m$^3$ (Fig. 192).

Large dolomite resources allow the development of its extraction; however, it is important to use this raw material as effectively as possible, to find new opportunities of dolomite use, researching the perspectives of extraction of metal magnesium and its compounds from dolomite during the process of production of calcium saltpetre and sodium.

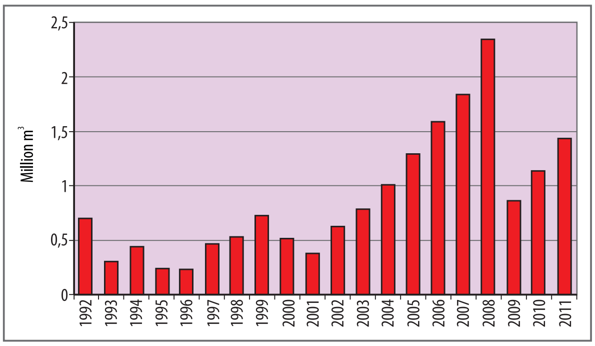



**Fig. 192.** Variation of dolomite extraction volumes. *Source: Lithuanian Geological Survey*

Dolomite is used for the production of chippings, finishing boards for internal finishing, fertilisers and mineral wool.

**Fig. 193.** Dolomite deposits in Petrašiūnai quarry, Pakruojis region *(photo by J. Satkūnas, 2012)*

**Fig. 194** Explosion in Petrašiūnai dolomite quarry. User AB "Dolomitas" *(photo by J. Satkūnas, 2012)*

## Limestone Resources and Extraction

Deposit of limestone stratifying near surface was explored more than once and started to be used for the production of lime in the inter-war Lithuania.

**Fig. 195.** Limestone excavation in Karpėnai quarry, Akmenė region. User AB "Kalcitas" *(photo by J. Satkūnas, 2012)*

The largest deposit of limestone resources of the upper Permian period suite of Naujoji Akmenė is located in Akmenė region (Fig. 187). The only Gražiškiai area where the suspected (50 million tons) prognostic resources were calculated is in Šiauliai region.

The limestone deposit stratifies under the bedsores of 3-18 m of Quaternary and, less often, Jura or Triassic period. The thickness of limestone deposit is of 5-28 m. It gradually deepens to south-west direction (10-12 m within 15 km).

The thoroughly explored limestone resources amount to 373.2 million tons, preliminary explored – 761 million tons, prognostic detected – 1,780 million tons.

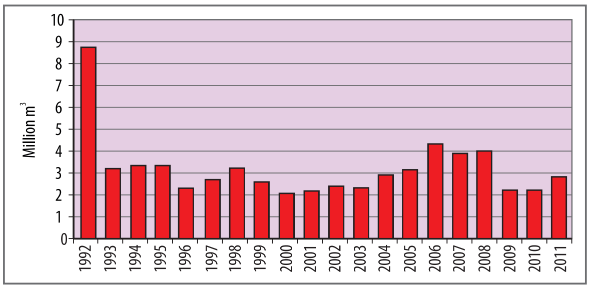



**Fig. 196.** Variation of limestone extraction volumes. *Source: Lithuanian Geological Survey*

The limestone obtained in Karpėnai (Fig. 195) and Menčiai quarries are mostly used for the production of cement. It is also suitable for the production of constructional and technological lime and lime power for the liming of acid soils. In 2006, the largest amount was excavated during the entire period from 1993 and 2011 (Fig. 196).

## Gravel and Sand Resources and Extraction

Sand and gravel are used for building and repair of roads, environment works, production of concrete, and construction works. Sand can also be used for the production of silicate bricks (deposits of Sandrupis, Beržupis, Giraitė, and Ropėja).

Balceriškiai sand deposit in Trakai region is suitable for the production of vibro-plates and cement (deposits of Alkiškiai, Paežerys, and Viduklė), for thinning clay in the production of bricks, tiles, drainage pipes.

In 2006, the largest amount was excavated during the entire period from 1993 to 2011 (Fig. 197).

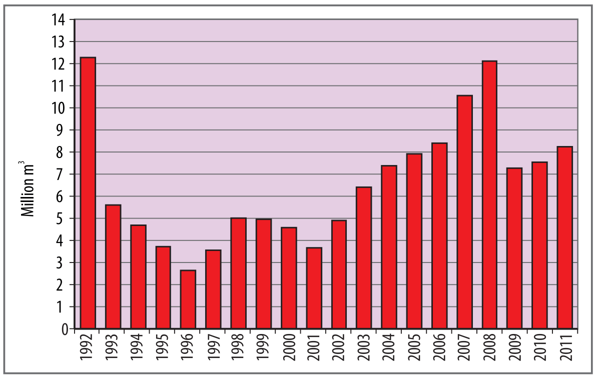



**Fig. 197.** Summarised variation of volumes of sand and gravel excavation. *Source: Lithuanian Geological Survey*

## OPERATION OF QUARRIES AND RENATURALISATION OF THEIR TERRITORIES

Any type of excavation of minerals is certainly influencing the environment, however, the nature and scale of impact is the function of interaction of various natural conditions and technical/economic possibilities of human. Having excavated the minerals, there usually exist conditions for the recultivation of excavated areas so that not only the consequences of excavation were neutralised, but also the decrease of functional-aesthetical value of landscape was avoided (or even increased) (Fig. 199). Currently, all minerals, except for oil, are excavated in open workings (quarries) in Lithuania. The depth of gravel, sand, clay, peat and dolomite quarries is usually of 6-12 m, limestone, and opoka – 15-30 m. The only deepest quarry, where the clay of Triassic system is excavated, is of the depth of 50 m. In some quarries (peat, limestone, dolomite, clay and less often sand), the level of groundwater is deepened by instantaneous flow or by pumping out. The monitoring of impact on the groundwater is currently performed near 7 largest quarries – peat (Laukėsa, Aukštumala, and Rėkyva), limestone (Karpėnai) and dolomite (Krivaičiai, Petrašiūnai, Klovainiai).

The mineral deposits and their prognostic areas occupy 4.14% of the country's territory (without oil deposits), whereas with oil deposits – 4.4%. According to the data of 2012, the areas designated for the mineral extraction companies amounted to 23.2 thousand ha (including the area used for the excavation of peat – 13.9 thousand ha), or only 0.36% of Lithuania's territory. The area of land damaged during excavation works amounts to 13.6 thousand ha. About 78% of this area is occupied by operated peatbogs.

After the restoration of Lithuania's independence and turn to market economy, many excavation companies announced their bankruptcy. They left uncultivated lands damaged by excavations.

Together with farming quarries of former kolkhozes, the area of such abandoned damaged lands amounted to 16,000 ha (including peatbogs covering the area of 13,620 ha). However, the increase in production needs resulted in the decrease in the number of abandoned quarries without owners; the excavation companies are preparing and implementing recultivation works by restoring and managing the landscape damaged during excavation works. Since recultivation is performed only after full operation of mineral deposits and they are usually excavated for more than one decade, the rates of quarry recultivation are not intensive (Table 19) – approx. from 13 to 80 ha of parts of quarries are recultivated annually. Only after the end of operation of one deposit, larger areas are recultivated, for example, in 2005, Sulinkiai peatbog was recultivated (508 ha).

**Fig. 198.** Operated Menčiai limestone quarry turned into lake useful for recreation *(photo by J. Satkūnas, 2012)*

**Table 19.** Recultivated areas based on the data of annual excavation reports submitted by users of recourses. *Source: Lithuanian Geological Survey*

| Recultivated areas (ha) | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Areas of deposits of solid minerals | 13.78 | 54.97 | 16.5 | 13.8 | 52 | 17.35 | 87.86 | 36.28 |
| Areas of peat deposits | - | 26 | - | - | - | - | 508 | 12.4 |

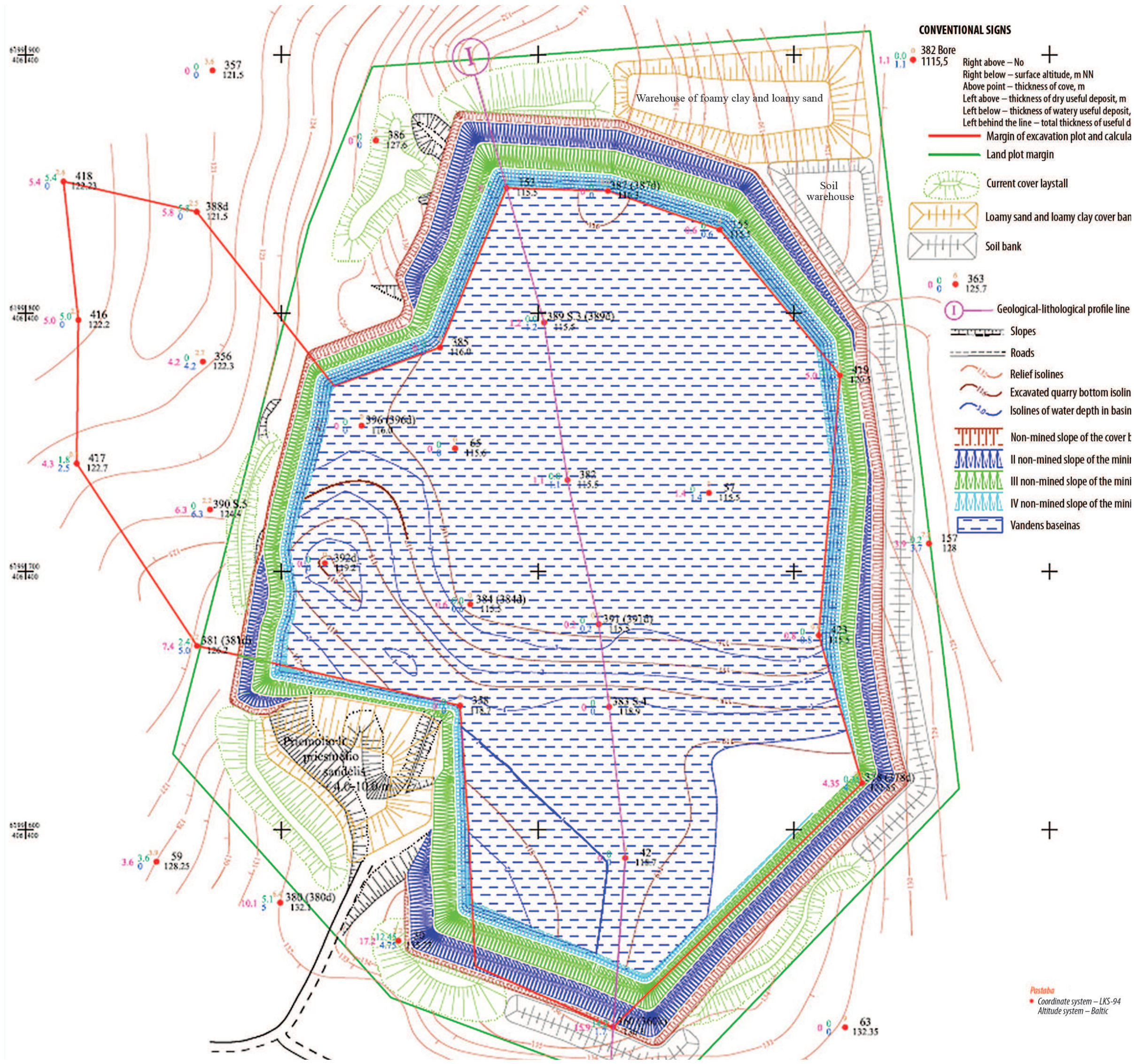



**Fig. 199.** Plan of recultivation solutions – one of the most important parts of utilisation projects (sample). *Source: Lithuanian Geological Survey*

Quarry recultivation is performed based on the utilisation projects prepared in accordance with approved procedure. Utilisation project – the normative document prepared pursuant to the approved rules, stipulating the methods and measures of rational and economic extraction of minerals, land recultivation and restoration of other necessary environmental elements without significant impact on the environment, human health and safety, as well as measures for protection of underground resources remaining in the deposit against consumption and impairment of quality due to temporary termination of their utilisation.

## CONCLUSION

The growth of industry is the most important factor influencing the extraction as well as exploration of new deposits. Currently, there are 17 types of minerals explored in various levels in Lithuania, 9 types of which (limestone, dolomite, sand, gravel, clay, chalk marl peat, sapropel and oil) are utilised. The majority of excavated minerals are used for production of construction materials.

According to data of 2011, the extraction of minerals is increasing in Lithuania again. The highest amounts of extracted minerals include gravel, dolomite, peat and limestone.

Solid mineral deposits occupy only approx. 4% of Lithuania's territory. The currently existing legal system thoroughly regulates the conditions and accounting of extraction of minerals and compliance with environmental requirements.

The excavation areas are recultivated pursuant to the approved utilisation projects. The number of abandoned quarries without owners is constantly decreasing; the excavation companies implement recultivation works by restoring and managing the landscape damaged during excavation works.

## FOREST RESOURCES

Forest was always an important natural resource in Lithuania: forest provides wood, other natural resources, creates jobs, and maintains the development of rural settlements. Another value of forest, as ecosystem, is becoming increasingly important, i.e., the recreation potential, protective and aesthetical functions, importance on the conservation of biodiversity, fight with global warming, purification of air and water. Forests are one of the most conditionally natural Lithuanian ecosystems protecting the stability of landscape and biodiversity. They occupy one third of country's territory, the value of their wood alone amounts to more than 15 billion Litas, whereas the wood-related production account for almost 11% of the total Lithuanian industry production. Developing Lithuanian industry and construction sector lead to largest wood demands, therefore, it is important to maintain positive balance of current increment and cutting volumes. According to the overview of utilisation of forest resources in 2006–2011, the resources of stands are restored in a positive trend, the indicators of forest and stands are improving. The National Sustainable Development Strategy requires not only rational use of natural resources, but also the smooth development of regions and creation of added value. In this view, the forest sector also shows positive changes – the share of exported raw timber is decreasing, the share used in the internal market is increasing as well as the volumes of export of wood products, especially furniture. The focussed work of institutions supervising forests increases the share of mature stands in the total structure, the national forest coverage, improves the varietal composition, productivity of stands leading to the balanced increase of cutting volumes. Another new tendency has become obvious recently – the development of biofuel usage for energy, which allows the use of once low-value waste of wood processing and cuttings.

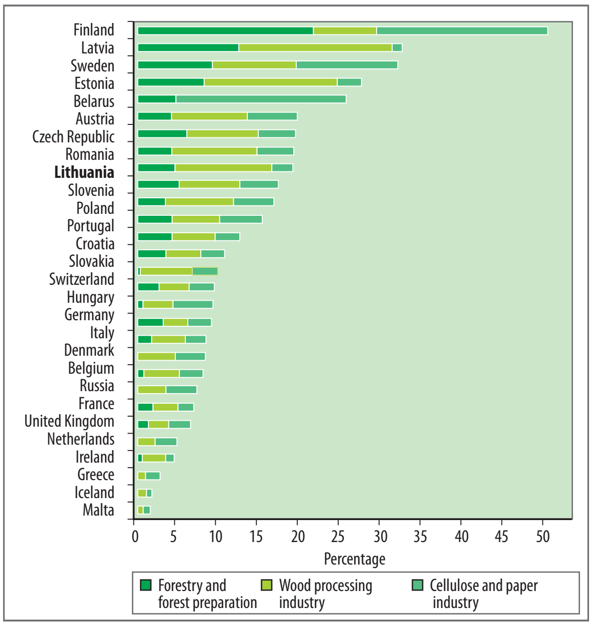



**Fig. 200.** Contribution of forest sector to GDP (percentage) in certain European countries. *Source: Eurostat, 2011*

Forest management and areas of industry related to wood processing constitute a large share of Lithuanian gross domestic product (GDP), which is relatively the largest in Europe (Fig. 200). In 2009, the EU forest and wood processing industry generated 1.3% of non-funded business economy turnover (300 billion Euro) and more than 2 million people were working in this area (1.5% of all labour force). The largest share of GDP generated by the discussed sector is in Finland, Sweden and Estonia.

According to the data of 1 January 2012, the area of forest amounted to 2,173 thousand ha in Lithuania, whereas the total forest coverage is already accounting for 33.3% of country's territory. Since 1 January 2003, this area increased by 128 thousand ha, whereas the country's coverage – by 2.0%. During the same period, the area of land covered by forest (stands) increased up to 2,055 thousand ha. The forests of national importance are now covering 1,076.5 thousand ha, whereas private forests – 844.5 thousand ha, the remaining part is reserved for the restoration of ownership rights. The area of forest per capita increased to 0.68 ha.

On 1 January 2012, the forest area included into Group I (strict nature reserves) amounted to 26.3 thousand ha (1.2%), Group II (forests of special purpose of use) –266.8 thousand ha (12.3%), Group III (protective forests) – 331.2 thousand ha (15.2%), Group IV (commercial forests) – 1,548.6 thousand ha (71.3%). The 42 forest directorates and one national park administered 1,037.0 thousand ha of the area of forests of national importance.

**Table 20.** The main indices of Lithuanian forests. Source: State Forest Service (2012). *Source: State Forest Service*

| Indicator | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Forest area (thousand ha) | 2,121 | 2,136 | 2,143 | 2,150 | 2,160 | 2,170 | 2,173 |
| Forest area covered with forest stands (thousand ha) | 2,014 | 2,030 | 2,040 | 2,046 | 2,051 | 2,057 | 2,055 |
| Total stock volume of wood (million $m^3$) | 401.1 | 404.7 | 421.6 | 426.9 | 479.4 | 489.8 | 501.3 |
| of which: volume of mature forest stands (million $m^3$) | 83.3 | 82.1 | 94.0 | 96.3 | 119.9 | 123.9 | 129.1 |
| Average growing stock volume ($m^3$/ha) | 199 | 199 | 207 | 209 | 234 | 237 | 240 |
| Average growing stock volume of mature forest stands ($m^3$/ha) | 254 | 255 | 260 | 264 | 302 | 307 | 310 |
| Total annual wood increment (million $m^3$) | 13.1 | 13.1 | 13.6 | 13.8 | 16.2 | 16.6 | 17.2 |
| Gross annual increment ($m^3$/ha) | 6.5 | 6.5 | 6.7 | 6.8 | 7.9 | 8.0 | 8.2 |
| Forest coverage (percentage) | 32.5 | 32.7 | 32.8 | 32.9 | 33.1 | 33.2 | 33.3 |
| The area of forest per capita (ha) | 0.62 | 0.63 | 0.64 | 0.64 | 0.65 | 0.67 | 0.68 |
| Stock volume per capita ($m^3$) | 118 | 120 | 125 | 127 | 144 | 151 | 157 |

## CHANGES OF FOREST OWNERSHIP

Approx. 60% of European forests are privately owned. A larger share of forest of non-private ownership is managed by the state (85%), whereas private forests are usually of household domain (82%). Approx. 60% of private forest plots are smaller than 1 ha. During the period from 2000 to 2010, the area of private forests increased by 8.6% in Europe, mostly due to changes in the Eastern Europe.

The most significant changes of private forest area occurred in the Eastern part of Europe after the political changes of the 9th decade. During the period from 1990 to 2000, the area of private forests increased: in Bulgaria – from 0 to 27.2 thousand ha; Czech Republic – from 11 thousand ha to 50.4 thousand ha; Estonia – from 0 to 95.3 thousand ha; Latvia – from 3.2 thousand ha to 143.2 thousand ha; Lithuania – from 0 to 45.8 thousand ha; Romania – from 0 to 35.6 thousand ha; Slovakia – from 0 to 83 thousand ha; Hungary – from 0 to 75.1 thousand ha. In a subsequent period, the most intensive privatisation of forests occurred in Romania. Here, during 2000–2005, the area of private forests increased by 265%, and during 2005–2010 – by additional 61%. In Lithuania, the areas covered by private forests increased respectively by 57% and 9% during the same periods. In Lithuania, the share of private forests is slightly smaller than the EU average (approx. 62%).

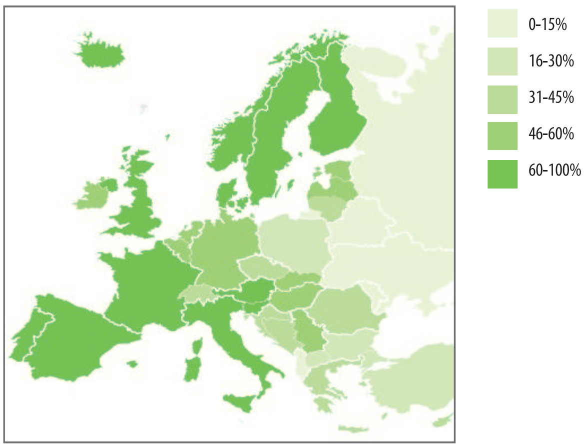



**Fig. 201.** The share of privately owned forest in the EU Member States, 2005. *Source: FOREST EUROPE: UNECE, FAO (2011)*

Before the restoration of independence, the entire forestland belonged to the state. Since 1990, the land (forests) reform was initiated in Lithuania, during which the land (forests) were returned to former owners. The returned forests are mostly private forests that already existed before World War II as well as the area of fertile agricultural land spontaneously covered by forest or planted in later periods. In 1992, the first areas of private forests were registered. The restitution process has not been completed yet, therefore, the area of private forests is constantly increasing. On 1 January 2012, approx. half of all forestland was composed of the area of forests of state importance – 1,076.5 thousand ha (Fig. 202).

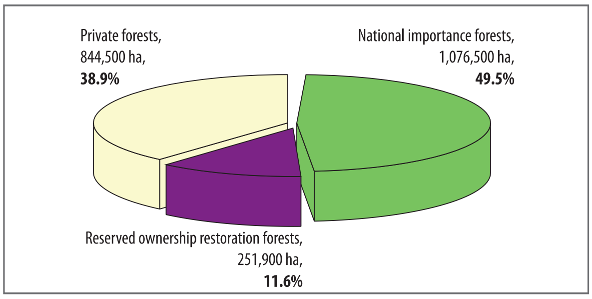



**Fig. 202.** Distribution of forestland by forms of ownership, as of January 1st 2012. *Source: State Forest Service*

In the past twenty years, the distribution of forestland uses changed materially – the share of private forests increased from approximately 1% in the early 1993 to almost 39% in 2012. Until 1998, 84 thousand owners were registered, whereas the area of measured returned forestland used – for another half hundred future owners – in total, almost 350 thousand ha.

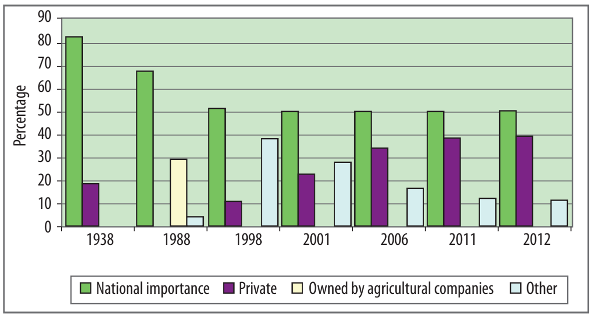



**Fig. 203.** Variation of forest ownership in Lithuania, 1938–2012. *Source: State Forest Service*

Back then, the average area of the domain amounted to nearly 3 ha. In 2000, based on the share of private forests, Lithuania was still lacking behind Hungary, Latvia and Ireland, and had similar proportion of private forests as Czech Republic, Greece and Estonia and surpassed such countries as Poland, Bulgaria and Romania. It is planned that after the completion of the land reform, private forests will account for 40% of the total area of national forests.

The biggest parcel of private forests is located in the area covered by Telšiai forest directorate. Here, the owners of private forests manage 43.1 thousand ha of forestland. A slightly smaller area is located in the area covered by Utena forest directorate – 42.3 thousand ha. In the areas covered by forest directorates of Utena, Veisiejai, Varėna and Anykščiai, private owners held more than half of all forests located in the directorate's territory. The highest proportion of private forests is in Vilnius region (Fig. 204).

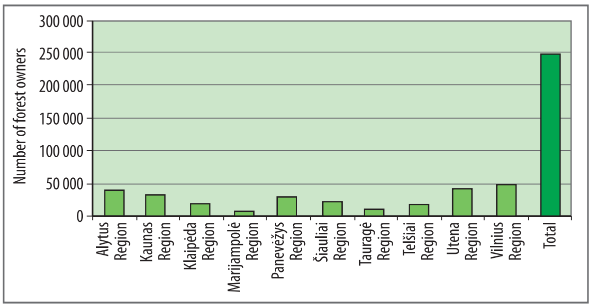



**Fig. 204.** Number of forest owners by regions. *Source: State Forest Service*

On 1 January 2012, there were 248 thousand private forest owners in Lithuania. On average, one owner owns 3.3 ha of forest (Fig. 205).

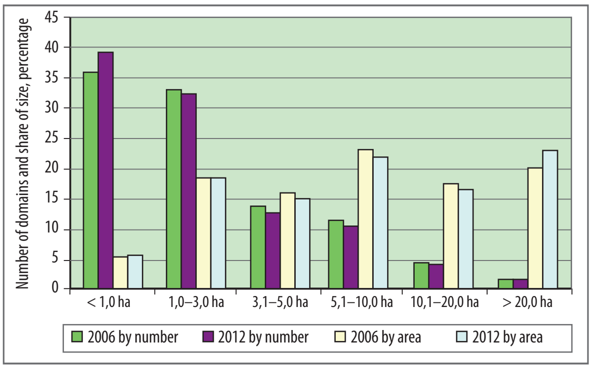



**Fig. 205.** Distribution of the number of private land domains and areas by the size of domain. *Source: State Forest Service*

Varietal structure of private forests is slightly simpler than of state forests – here, a significantly larger proportion is composed of softwood deciduous forests (Fig. 206).

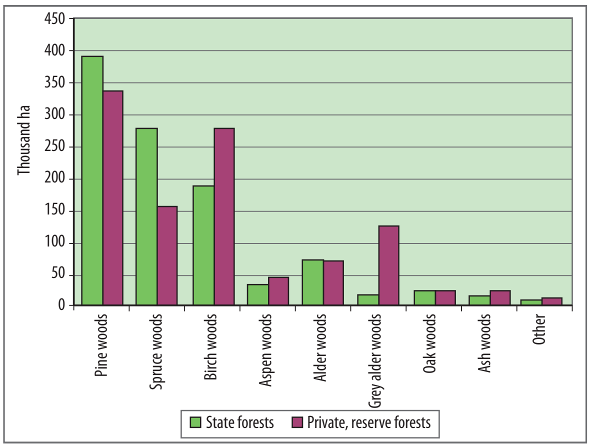



**Fig. 206.** The areas of stands by the dominating types of woods and ownership. *Source: State Forest Service*

The increase in the area of private forests led to the increase in the volumes of forest usage in these forests. The projects of internal forest management show the main information on the stands, necessary types of cuttings and locations, forest restoration works, evaluate the requirements and measures for environment and biodiversity conservation for the forest owners in the perspective of ten years (in case of small domains up to 10 ha – in the perspective of twenty years). Furthermore, one of the problems of private forest management is that the knowledge and experience of the share of forest owners is still insufficient for the effective and sustainable forest resources. This problem is solved by organising trainings and consulting owners – the latter activity is performed by the specialists of the State Forest Service, forest directorates, park directorates, associations and other organisation unifying forest owners.

## FOREST COVERAGE AND ITS VARIATION

One of the most important indicators of changes of the overall state of forest in the country and wood resources is the **forest coverage**. The lowest forest coverage was recorded in Lithuania during the inter-war period due to intensive expansion of communal agriculture, by turning the largest possible areas "taken away from nature" to agricultural areas and performing intensive forest cuttings at the same time. In the 1960s, some melioration areas that failed to serve its purpose, especially pastures, were abandoned and resulted into spontaneous reforestation. The gradual increase of forest coverage was influenced by intensive activity performed by foresters. More significant growth of forest coverage started in the 1980s due to the start of return of land to its former owners, part of areas no longer suitable for agriculture were planted with forest. During the last decade, the spontaneous forestation became more intensive in the areas not suitable for agriculture and other unused areas, furthermore, the majority of new forests have recently been planted namely in these lands.

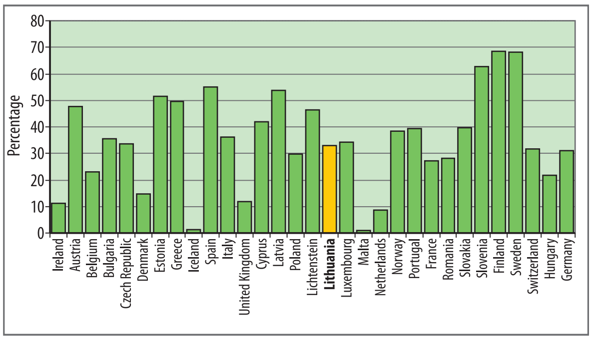



**Fig. 207.** EU forest coverage, 2010. *Source: FOREST EUROPE: UNECE, FAO*

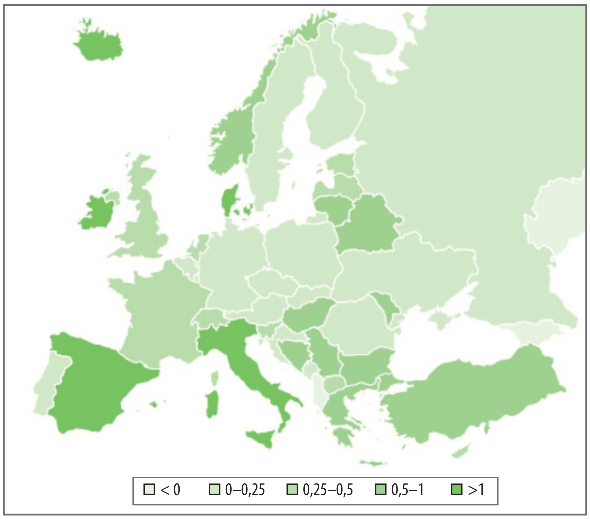



**Fig. 208.** Change of forest coverage in the EU Member States, 1990–2010. *Source: FOREST EUROPE: UNECE, FAO*

Forests occupy the area of 177 million ha in Europe and this area is slowly increasing. Forests and other areas covered by forest stands cover 42% of the EU land territory. In 2010, in six EU Member States, forests covered more than half of territory – in Finland and Sweden about 68%, in Slovenia – 63%, Latvia – 54%, Spain – 55% and Estonia – 52%. The lowest forest coverage was in Malta (1%), Netherlands (9%), Ireland and United Kingdom (up to 12% in both countries) and Denmark (15%).

Forest coverage is very heterogenic among different European countries. The Northern region and European part of Russia are the most forested parts of Europe, whereas the South-East Europe is least forested. Almost half of European forests are dominated by coniferous forests, whereas deciduous and mixed forests constitute by one quarter of all forests. Forest coverage has been increasing in all regions of Europe since 1990. Based on the forest coverage and its changes, Lithuania occupies a middle position in the European Union (Fig. 207 and 208).

The total forest coverage has showed a gradual increase in Lithuania in the past six decades. In order to increase country's forest coverage, it is planned to plant forest in the abandoned lands and areas unfit for agriculture. In the future – in the long-term perspective, it is planned that the area of forest due to planting of low-fertile lands unfit for agriculture with forest stands will increase by approx. 400 thousand ha, whereas the total forest coverage will amount to 35%.

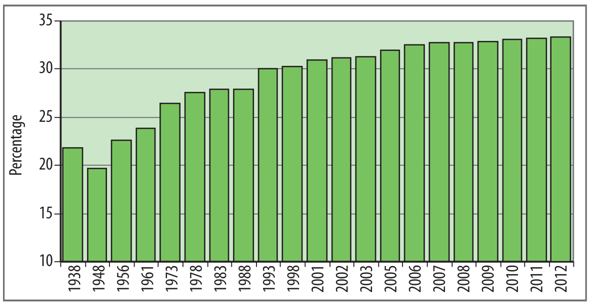



**Fig. 209.** Variation of forest area and forest coverage of Lithuania's territory, 1938–2012. *Source: State Forest Service*

The average forest area per capita is also constantly increasing in Lithuania. According to the calculations of economists, in order to fully meet the internal needs of country, there should be at least 0.4 ha of forest area per capita. In Lithuania, this indicator amounts to 0.68 ha (at the start of 2006, it was 0.62 ha). Based on this indicator, Lithuania is surpassed only by highly forested European countries, such as Finland, Sweden, Norway; however, this indicator is higher than in Austria, Slovakia, Czech Republic, Poland, and Switzerland.

According to the data of the National Forest Inventory, the highest forest coverage was in Alytus (49.1%) and Vilnius (44.0%) regions (Fig. 210).

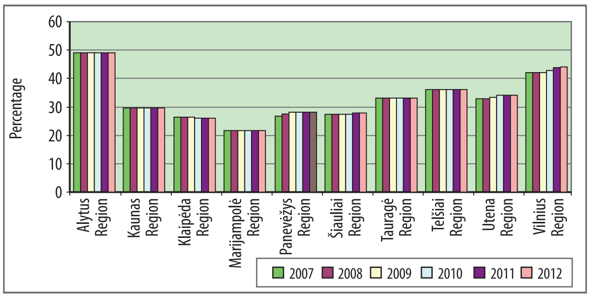



**Fig. 210.** Forest coverage by regions, 2012. *Source: State Forest Service*

Least forested are Marijampolė (21.7%) and Klaipėda (26.4%) regions. The municipalities with highest forest coverage are those of Neringa (83.0%), Varėna (68.9%), Druskininkai (68.7%), and Švenčionys (59.9%), Kazlų Rūda (59.5%); the lowest forest coverage indicator is in Vilkaviškis (10.6%), Kalvarija (13.1%), Marijampolė (15.3%), Pagėgiai (17.0%) and Pasvalys (17.0%) municipalities.

Although the increase of forest area is one of the most important indicators in terms of wood resources, certain other indicators of forest have significantly higher value on forest ecosystems as especially important share of biodiversity resources. The most important potential threats of forestry on the biodiversity of Lithuanian forests include not only intensified cuttings, but also decreasing natural forests and average age forest stands and varietal diversity of stands, disproportion of types of forest stands.

One of such indicators is the variation of the share of primary or **natural forest**.

Only a few primary natural forests with minimal human activity have remained in Europe. It is believed that only 1% of European forests actually maintained their primeval natural state. The degree of naturalness shows the intensiveness of forest use in the historical context. The use of forest changes not only the area of forest, but also its age and varietal structure. The degree of naturalness is described by three categories: primary forest untouched by human, semi-natural used forest and plantation-type forest.

The Food and Agriculture Organization of the United Nations (FAO) defines the natural (primal) forest as the forest where local species of trees are growing, no active human activity is present and ecological process and functions of ecosystems are not visibly damaged. The primary forest is usually characterised by large biodiversity. The area of natural forest is considered as one the most important indicators of wellness of national forest ecosystems. Furthermore, the conservative function of this forest is constantly emphasised not only in terms of biodiversity, but also in soil and water resources, as well as aesthetical, cultural and religious value.

Approx. 87% of European forests (excl. Russian Federation) are classified as semi-natural (Fig. 211). Just 4% of all areas of European forest are attributed to natural forests (8 million ha). The majority of natural forests are in Russia (32% of all forests in the country) and North European countries, the majority of plantation forests are in the Central and Western European region.

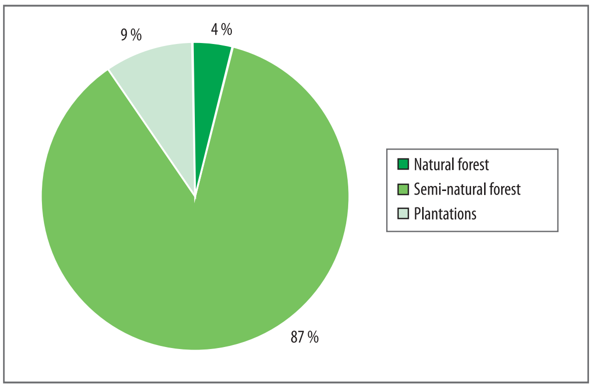



**Fig. 211.** Distribution of European (excl. Russian Federation) forest areas by classes of naturalness, 2010. *Source: FOREST EUROPE: UNECE, FAO*

Almost 85% of Lithuanian forests are attributed to conditionally natural, slightly more than 1% – to natural, the remaining – to forest plantations. The share of natural forest is gradually increasing in Lithuania. This process was conditioned by the increase in the area of forests with restricted economic activity – reserves, special purpose and protective forests.

## COMPOSITION OF FOREST STANDS

The majority of European forests are composed of stands of equal dominating age – from 20 to 80 years of age. In European forests (excl. Russia), approx. 12% of forests are younger than 20 years of age, 43% – from 20 to 80 years of age, 18% – more than 80 years of age, and approx. 27% are the forests of mixed tree age.

Since 1948, the **average age of stands** has been increasing in Lithuania. Reaching 34 years in the early 1960s, after the restoration of Lithuania's Independence, it exceeded 48 years, whereas in 2002, already 53 years.

In 2003, this indicator reached 55 years in the state forests (private forests – 47 years), whereas in the early 2012, the average age of stands in state forests of Lithuania was 56 years of age without reserve forests (in private forests – 50 years, together with the forests of category I, the average age reached 64 years).

Since the 1950s, the areas of mature forest stands have been constantly increasing in state forests: during the last fifty years, their coverage increased by more than three times and currently occupies the area of 330 thousand ha – more than 19% of the total area of forest stands.

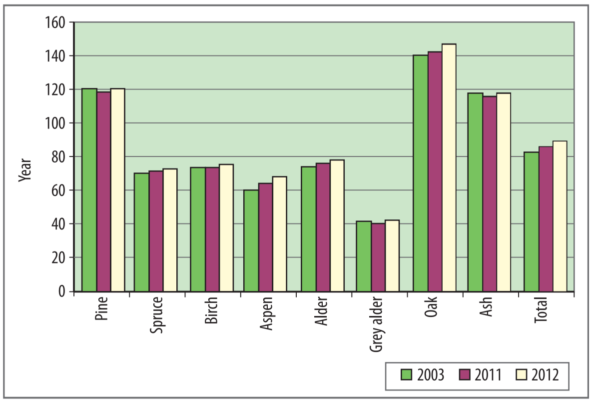



**Fig. 212.** Distribution of mature state forests by the dominating species and age of forest stands. *Source: State Forest Service*

The mature birch woods are currently the most abundant. In the mature state forests, the average age of forest stands reached 89 years in 2012. Thus, during the past decade, the age structure of Lithuanian forests has become more optimal.

Approx. 70% of European forests are dominated by two, three or several species of trees, and approx. 30% are composed of forests dominated by one species of trees – usually conifers. In Europe, the share of forests dominated by one species of trees, decreased by 0.6% during the last 15 years.

Currently, more than one third of clear-cut areas are left for natural regeneration. Lithuania belongs to the natural zone of mixed forests dominated by broadleaved-coniferous forests; therefore, even in case of planting pure plants, later various trees and bushes start to occur in the planting sites and the mixed forest is formed in the course of time. The area of mixed plantation has also been constantly increasing in the recent years: in 1994, the share of mixed plantations constituted only more than one third, in 1999 – more than a half, whereas in 2005 – more than 80% of the total area of plantations. During 2011, the forest directorates restored 9.5 thousand ha (in 2010 – 9.4 thousand ha, in 2009 – 8.7 thousand ha) of forest, 4.1 thousand ha of which were restored by reforestation, 2.4 thousand ha – by natural regeneration, whereas 3.0 thousand ha – in mixed way. Same as in previous years, the majority of forest (4.1 thousand ha) was reforested with spruce trees. 1.5 thousand ha were reforested with pines, 0.5 thousand ha with oaks and 3.5 thousand ha with other trees species.

**Table 21.** Change of the average age of main trees of Lithuanian forests (in years). *Source: State Forest Service*

| Type of trees | Evaluation date | | | |
|---|---|---|---|---|
| | 2003 01 01 | 2003 01 01 | 2012 01 01 | 2012 01 01 |
| | State forests | Private forests | State forests | Private forests |
| Pine | 68 | 59 | 72 | 61 |
| Spruce | 44 | 51 | 45 | 53 |
| Birch | 51 | 48 | 49 | 44 |
| Aspen | 48 | 45 | 46 | 39 |
| Alder | 48 | 46 | 43 | 45 |
| Grey Alder | 30 | 33 | 29 | 34 |
| Oak | 97 | 79 | 83 | 71 |
| Ash | 53 | 56 | 71 | 62 |
| In total | 55 | 47 | 56 | 50 |

In Lithuanian forests, the distribution of **varietal diversity of tree species** is characteristic to the region and is of similar state as in Estonia and Latvia: 10 main species (42% of all species) account for more than 99% of all resources of forest stands. The varietal composition of Lithuanian forest stands showed a relatively insignificant change since the 1950s – the pinewoods (35.1%), spruce woods (20.8%) and birch woods (22.3%) are still dominating, oak woods account for 2%, ash woods – 1.7% of all forest stands (Fig. 213).

Coniferous stands are growing in the area of 1,153.2 thousand ha. They constitute the major part of forests (56.0%). Softwood deciduous forests cover the area of 818.2 thousand ha (39.8%), hardwood deciduous forests – 83.8 thousand ha (4.0%). During the recent nine years (2003–2012), the total area of hardwood deciduous stands decreased by 8.8 thousand ha, pine stands – by 6.8 thousand ha.

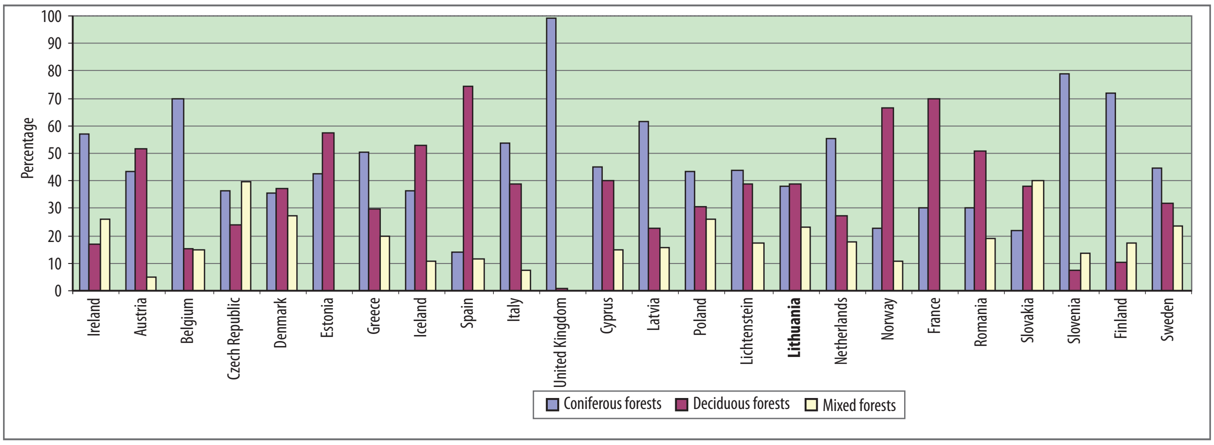



**Fig. 213.** Composition of forests of the EU Member States. *Source: FOREST EUROPE: UNECE, FAO*

The area of softwood deciduous forests has increased by 120.1 thousand ha in 8 years. In Lithuania, the major area of forestland is occupied by pinewoods (722.2 thousand ha). During nine years, their area increased by 10.7 thousand ha. Spruce woods occupy the area of 428.4 thousand ha; their area, as compared with 2003, decreased by 16.9 thousand ha.

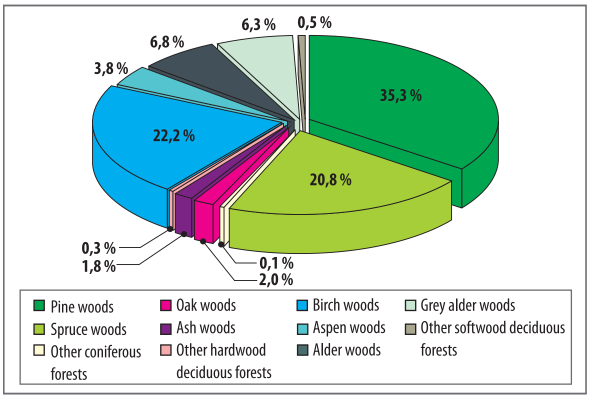



**Fig. 214.** The area of Lithuanian forest stands by the dominating species of trees. *Source: State Forest Service*

Birch woods are mostly dominating among softwood deciduous forests. Since 2003, the area covered by these forest stands has increased by 66.6 thousand ha and, in early 2012, occupied the area of 458.8 thousand ha. The area of alder forests increased up to 141.9 thousand ha. The area occupied by grey alder increased by 6.5 thousand ha and occupies 128.5 thousand ha. The area of aspen forests increased by 20.9 thousand ha – up to 78.2 thousand. Oak woods increased from 35.7 thousand ha to 41.9 thousand ha, whereas the area of ash woods decreased by 30% – down to 35.7 thousand ha.

The entire forests of Lithuania are dominated by coniferous trees; however, the composition of dominating trees is different in different Lithuanian territories (Fig. 215).

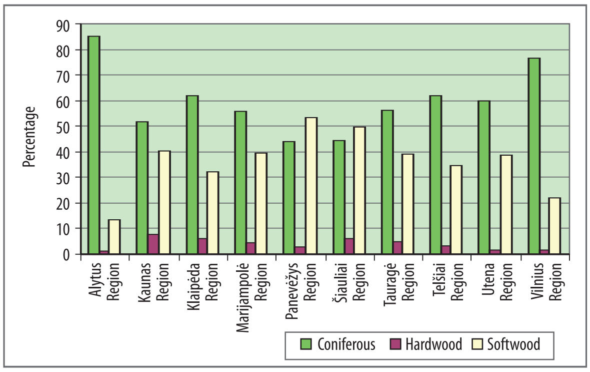



**Fig. 215.** Lithuanian forest structure by dominating forest stands by regions. *Source: State Forest Service*

Coniferous forest stands compose the major part in the forests of Druskininkai (92.78%), Varėna (89.98%), Birštonas (87.92%), Švenčionys (84.38%), Vilnius district (82.80%) municipalities, and least part in the forests of Kėdainiai (19.39%), Pakruojis (19.92%), and Šiauliai district (21.81%), Marijampolė (24.74%) municipalities. Hardwood deciduous trees are less dominating in Palanga (0.01%), Visaginas (0.01%), Neringa (0.04%), Druskininkai (0.08%), Varėna (0.10%) municipalities, and most abundant in Alytus district (22.86%), Kėdainiai (15.86%), Pakruojis (15.18%) municipalities. Softwood deciduous trees compose the least part of the forests of Druskininkai (7.15%), Varėna (9.92%), Birštonas (11.53%), Vilnius district (12.52%), Neringa (13.01%) municipalities, and major part in the forests of Kėdainiai (64.75%), Pakruojis (64.91%), Marijampolė (65.24%), Biržai (65.62%), Šiauliai district (71.03%) municipalities.

## TIMBER STOCK VOLUME OF FOREST STANDS AND ITS VARIATION

The total timber stock volume of the European forests is estimated to be of 114.2 billion m³. The largest stock volumes of wood are in the forests of Russian Federation and Central and Eastern Europe. A 71% – of the timber stock volume of European forest stands are composed of conifers. In the past 20 years, due to the increasing forest areas and forest productivity, the timber stock volume of European forests has annually increased by 432 million m³.

**Variation of the timber stock volume of forest stands** – the indicator reflecting the total quality of forest timber resources. Since 1948, the timber volume has showed increase in Lithuanian forests (Fig. 216). It was mostly conditioned by the increasing forest coverage; furthermore, the trendy farming contributed to this; by thinning, increasing the increment of stands for the mature forest stands to accumulate as higher timber volume as possible. According to the data of the National Forest Inventory, since 2003, the total timber volume increased from 453.4 million m³ to 489.8 million m³ (2011).

In the beginning of 2012, more than 501 million m³ of tree stem timber was accumulated in country's forests (Fig. 216), and 17 million m³ of timber is growing in Lithuanian forests each year. The largest stock volume of timber was accumulated in pinewoods - 211 million m³. Since 2003, the stock volume of timber in these woods increased by 29 million m³. During the same time, the stock volume of timber increased from 76 million m³ to 80 million m³ in spruce woods.

The stock volume in birch woods increased from 79 million m³ to 85 million m³ during the period of nine years. The stock volume of timber accumulated in alder woods increased from 38 million m³ to 46 million m³. The stock volume in aspen woods (35 million m³) showed almost no change during nine years. The stock volume of grey alder showed insignificant change – 22 million m³. 11 million m³ was accumulated in oak woods and 6 million m³ – in ash woods.

The average stock volume of timber in state forests increased from 226 m³/ha (2003) to 240 m³/ha (2012). The volume of timber accumulated in mature forest stands of Group III and IV increased from 109.9 million m³ to 129.1 million m³ during the period of nine years. The current annual increment of timber increased from 16.0 million m³ to 17.2 million m³ and amounts to 8.2 m³/ha. The stock volume per capita increased to 157 m³.

The productivity of forest stands in Lithuanian commercial forests is higher than in Finland, Norway, Great Britain, Netherlands, Italy, France, Sweden, Denmark, and Latvia. The relative timber stock volume in Lithuania exceeds the average of this indicator in the European Union. The rate of increase of timber stock volume per hectare of forest was close to the EU average in 2000–2011. The overall volume of timber in Lithuanian forests will increase in the future, because of the forecasts that the annual volume of forest cuttings should not exceed 50-60% of the annual increment of timber.

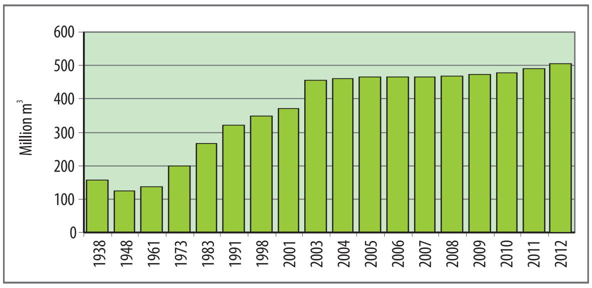



**Fig. 216.** Variation of the volume of forest stands in Lithuania, 1938–2012. *Source: State Forest Service*

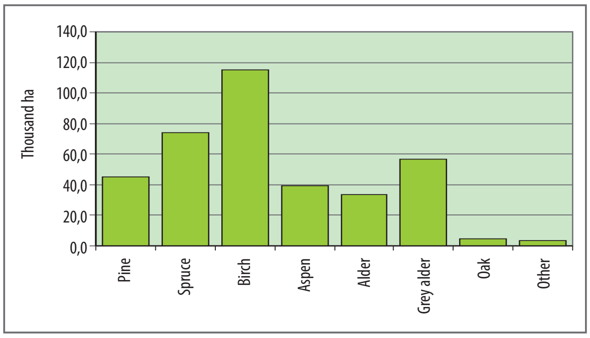



**Fig. 217.** Distribution of mature operational forest stands (Group III and IV forests) by dominating species of trees. *Source: State Forest Service*

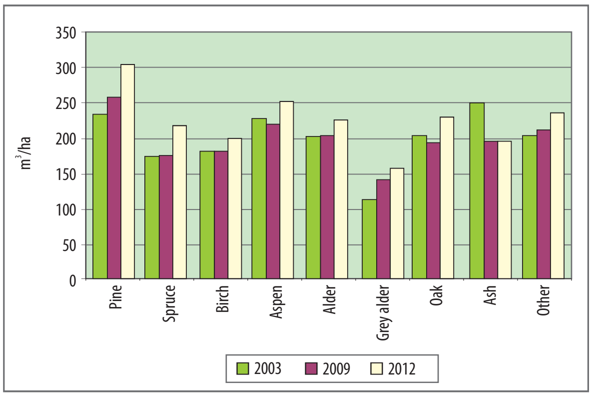



**Fig. 218.** Changes of stock volume of forest stands by dominating tree species, 2003–2012. *Source: State Forest Service*

According to the data of the National Forest Inventory, the largest volumes of timber are in the forests of Vilnius region – 104.0 million m³ (Fig. 219). It is nearly one fifth of the total volume of tree stems in the national forests. In other regions, the volumes of timber are significantly lower: Alytus – 68.4 million m³, Utena – 63.6 million m³, Kaunas – 53.4 million m³. The least volumes of timber are in Marijampolė (28.0 million m³) and Klaipėda (31.7 million m³) regions.

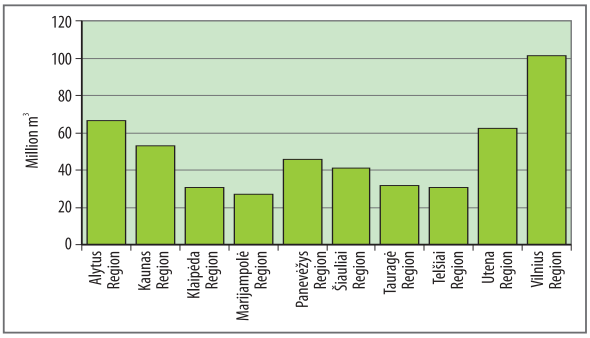



**Fig. 219.** The accumulated stock volume of forest stands by regions. *Source: State Forest Service*

The productivity of forest stands is also different in different regions (Fig. 220). It is largest in Southern and Eastern parts of Lithuania – Marijampolė, Alytus and Vilnius regions.

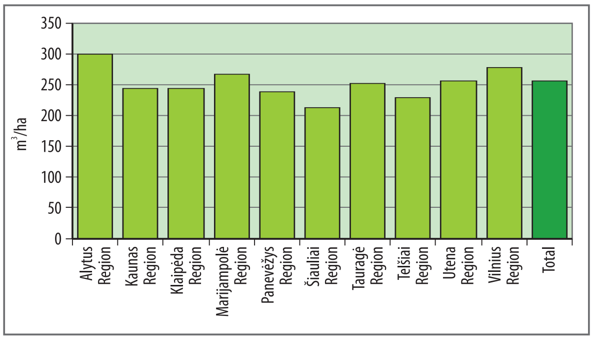



**Fig. 220.** Productivity of forest stands in regions. *Source: State Forest Service*

## USE OF FOREST

In 2005–2010, slightly less than 2/3 of natural increment of forest stands was harvested in Europe each year, which meets the principles of sustainable use of natural resources (Fig. 221). Some countries exceed this average due to natural calamities that had a catastrophic impact. Currently, the most intensive use of timber is in Switzerland, amounting to 99% of the annual increment in certain cantons.

Until 2007, the production of round wood showed a stable growth in the EU. The use was stable reaching the rise in production volumes in those years when the forest was mostly damaged by climatic factors (2000, 2005 and 2007). Since 2008, the decrease in the volumes of production has been observed, which was conditioned by the global economic crisis especially due to decrease in demand of wood in the construction sector. Lower variation of turnover was observed in the area of timber of deciduous trees. In 2009, the highest volumes of production were recorded in the area of roundwood (78.9%); the remaining part (21.1%) was composed of fuel wood. In 2009, in the EU, the larger share of produced timber was composed by coniferous – 67.9%. In 2010, approx. 578 million m³ of roundwood were produced in the EU amounting to 21.152 million Euro. The majority of wood was produced in Sweden, Germany, Finland and Poland. The volume of Lithuanian production constitutes a small proportion of wood production in the European Union, whereas the largest share of production is composed of roundwood.

**The total amount of harvested timber** is the main indicator showing the anthropogenic impact on forest resources. The most intensive forest felling occurred in Lithuania before the World War II – the felling of that time were almost the same as in nowadays, i.e., approx. 5-6 million m³ annually; however, at that time, it constituted at least twice larger share of timber volume than currently existing in the forest (up to 5%). Before the restoration of independence, when Lithuania was a part of the Soviet forestry system, a large share of wood to be used for processing was imported into the country.

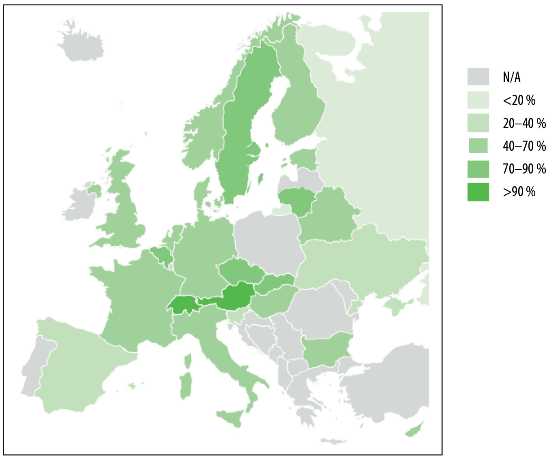



**Fig. 221.** Annual volume of felling of increment in the EU Member States, 2010. *Source: FOREST EUROPE: UNECE, FAO*

From 1991, the material transformation of wood market occurred, new possibilities to trade in wood emerged and the volumes of forest cuttings started to increase in

Lithuania. The volumes of forest cuttings significantly increased in 1993–1996, when it was necessary to liquidate the consequences of storms and massive drying of spruce woods, and amounted to 6 million m³ in 1995.

In Lithuania, the volume of felling has been quite stable in the recent years – approx. 5.7–7.3 million m³ of timber is harvested annually (Fig. 222), accounting for 2% of the volume of timber accumulated in the forests in recent years. In 2010, a large increase in the cuttings was recorded due to windfalls and other factors unfavourable to forest.

The volume of felling in state forests has been slowly increasing recently. In 2003–2009, approx. 3.5–3.7 million m³ of timber were harvested in them. In 2010-2011, the volumes of wood preparation increased up to 4.0 million m³. The volume of timber harvested by main felling almost unchanged in state forests and reached 2.5 million m³. The 63% of wood was prepared by this method (in 2009 – 71%). The volume of medium cuttings increased by 16% in state forests – up to 1.5 million m³. It was conditioned by the damaged caused by wind. The amount of wood prepared by selective salvage felling increased by another 6%, as compared with 2010, - up to 709 thousand m³. The smaller influence on the volume of wood preparation was caused by plain salvage, current and thinning cuttings.

In the state forests, the volume of annual felling is changing only slightly, however, the volume of felling has showed a significant increase in private forests. In 2000, it amounted to 1.0 million m³, whereas in 2010 – 3.4 million m³ (in 2011 – 3.3 million m³). In private forests, the amount of cuttings mostly increased due to their increasing area. Approx. 70–80% of the overall annual increment of wood of these forests are harvested annually in private forests. In all Lithuanian commercial forests, approx. 6.5 m³ of wood is growing in 1 ha per year, and felling amounts to 4.1–4.3 m³ (more than 60% of the wood increment).

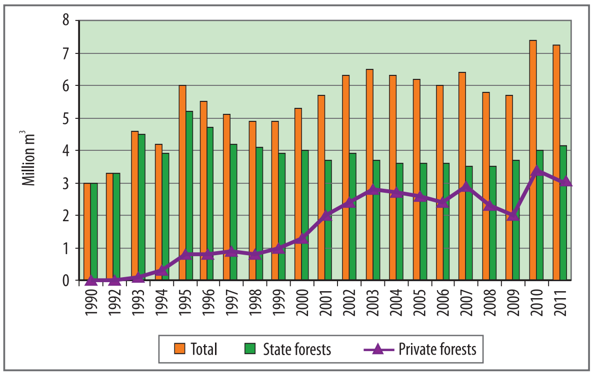



**Fig. 222.** Changes of felling volumes by ownership, 1990–2010. *Source: State Forest Service*

The volumes of felling in state forests are regulated by approving the annual norms of main felling. In 2007, seeking to ensure rational and uninterruptible use of wood resources, the Government of the Republic of Lithuania approved the annual norm of main forest felling in state forests for 2009–2013 being by almost 17% higher than in 2004–2008 – up to 2.8 million m³ timber. The established norm of cuttings will help to ensure the sustainable use of wood resources in state forests for at least 30 years and balance the economic and ecologic functions of these forests.

**The amount of illegally harvested wood** shows the scale of especially harmful impact on forest resources. Illegal cuttings, even if of significantly smaller scale than legal felling performed under forest management projects, cause significantly larger negative effect on forest resources in terms of sustainability and biodiversity. Usually, these are clear cuttings without considering the age, structure and restoring opportunities of forest stands, destroying protective habitats, nests of rare birds, failing to manage the felling sites and causing the risk of the spread of tree diseases or fires. After the accession of the new Member States in 2004, the problem of illegal cuttings has become significant to the entire European Union. The amount of illegal felling of timber, as compared with the overall annual felling, is relatively small in Lithuania and amounts to approx. 0.3–0.5% of the overall amount of cuttings. Pursuant to the statistical information of Estonia and Latvia, the amount of wilfully harvested timber accounts for 0.5–2% of the total amount of felling.

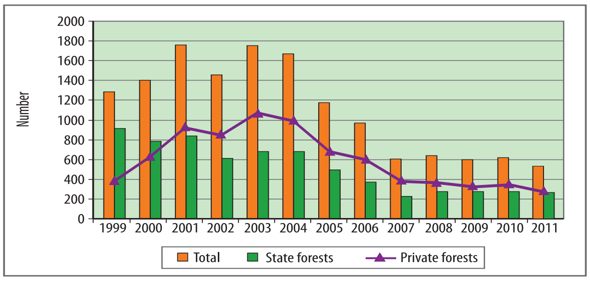



**Fig. 223.** Number of cases of illegal forest felling (1999–2011). *Source: State Forest Service*

In 2000–2004, the amount of wilful felling was significantly increased (Fig. 223). It was directly associated with the process of land restitution. The increase in wilful felling in private forests can be partly explained by the fact that the process of forest return is still in progress; and the area of private forests and number of owners is increasing. The rapid increase in the amount of illegal felling was conditioned by the fact that, having regained the forest, the owners were hurrying to sell the timber due to ignorance or simply wilful seek for rapid profit.

The number of cases of illegal felling has been decreasing during the recent several years. The 527 such cases were recorded in 2011. 8.5 thousand m³ of timber were harvested illegally in a year – by 14% less than in 2010 (9.8 thousand m³). 6.0 thousand m³ of timber were harvested illegally in private forests accounting for 71% of the total amount. The number of cases of stealing of produced timber has not changed in state forests. The 46 cases were recorded in state forests in 2011 (48 – in 2009).

## TRADE IN TIMBER AND ITS PRODUCTS

Roundwood is the main raw material of wood processing industry and important raw material of construction sector, the main source of income of use of forest resources and constitutes the essential share of international trade in wood. The changes of export of round and sawn wood is the indicator of intensiveness of one of the most important forces acting on quantitative parameters of forest resources – international trade in wood. Unlike wood products, which are currently produced from quite a significant share of imported cheaper timber, the amount of produced round and sawn wood is almost directly proportional to the volume of felling. Whereas the export of the types of this wood shows the intensiveness of the impact on forest resources – the more intensive the export, the more intensive forest felling. Pursuant to the principles of the sustainable development, the largest possible use of national product resources, i.e., wood, in the internal market is sought, by exporting more wood products rather than wood. The amount of timber sold in foreign markets, as compared with 2010, increased by one third up to 2.0 million m3. It is the largest amount during the recent 20 years.

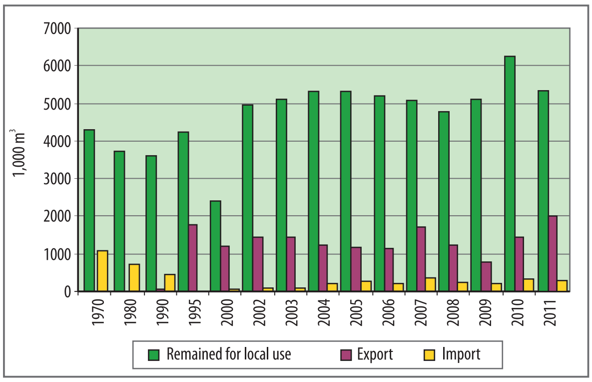



**Fig. 224.** Distribution of the produced timber by groups of use, 1970–2011. *Source: State Forest Service*

A large share of timber remains for the internal national use. In 2011, approx. 5.4 m³ of round timber was used in Lithuania (Fig. 224). Its use in wood industry and energy production increases. In the forest directorates, the average annual price of round timber increased from 86 LTL/m³ in 2009 to 110 LTL/m³ in 2010 and reached 140 LTL/m³ in 2011. The amount of roundwood reached 1.3 million m³. The production of the main wood industry products increased in 2011: veneer, shell, shaving boards, the volumes of production of paper and cardboard increased, however, the production of splint boards decreased.

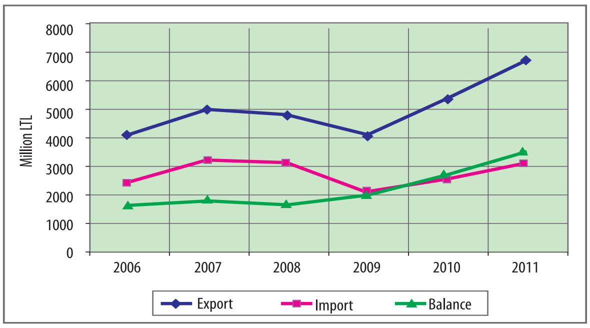



**Fig. 225.** Lithuanian foreign trade in timber balances, 2006–2011. *Source: Lithuanian Department of Statistics*

The growth of economy also increases the volumes of exported and imported wood (Fig. 225). In case of local consumption of cut wood, the export of round timber is gradually decreasing. The similar tendency is likely to remain in the future; only the timber used for the production of cellulose will continue to be intensively exported, as its demand is still very restricted in the internal market.

The export of timber industry products amounted to 5,942 million Litas in 2011. The share of this production in the total national export decreased from 9.1% to 8.5%. The main export markets of timber and timber products remained the EU Member States: Germany, Sweden, Denmark and the United Kingdom. Thus, based on the tendencies of export of produced round and harvested wood, Lithuania can be attributed to the group of countries characterised by sustainable use of these resources.

In 2011, the value of exported furniture accounted for 51% in the total export of timber industry, it increased by 23% up to 3.06 billion Litas. The second most important production was paper, cardboard and their products. The export of roundwood accounted for 7% - 584 thousand m³. Paper, cardboard or their products accounted for the major part of brought timber industry production. The share of harvested timber import increased from 8% to 9%. The brought amount of harvested timber increased by 12% and reached 331 thousand m³. The 25% of this amount (84 thousand m³) was brought from Latvia. The annual import from Belarus has not changed and amounted to 78 thousand m$^3$. The import from Russia increased from 69 thousand m$^3$ to 75 thousand m$^3$.

In the area of timber production and realisation, there was a recent tendency of increasingly intensive use of wood and its waste of processing, especially with an increase in the municipal needs for the use of renewable energy. This tendency is significant in the entire European Union (Table 22), where renewable energy sources provided approx. 9% of all generated energy in 2009, whereas wood and its waste was the main source of renewable energy. The use of this raw material for the generation of energy varies from 16% in Cyprus to 97% in Estonia (Fig. 226). Lithuania looks properly in the EU context, as approx. 87% of the energy in our country is generated from wood and its waste.

**Table 22.** Use of renewable energy in 2010 and sought objective in the EU Member States. *Source: FOREST EUROPE: UNECE, FAO*

| | 2010 | 2020 |
|---|---|---|
| All renewable energy sources | 12% | 20% |
| Biofuel | 5.75% | 10% |
| „Green" electricity | 21% | 22% |
| Biomass: | 150 million tons | 195 million tons |
| Wood biomass | 27 million tons | 35 million tons |
| Equivalent in roundwood | 108-149 million m$^3$ | 140-194 million m$^3$ |

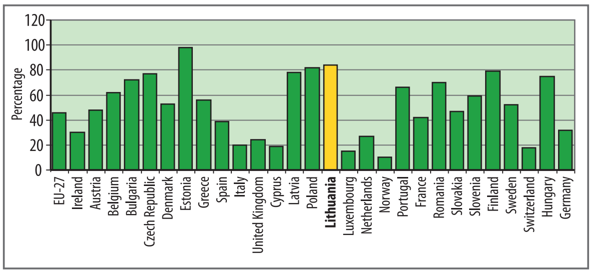



**Fig. 226.** Use of timber and timber waste as renewable energy sources in Europe, 2008. *Source: FOREST EUROPE: UNECE, FAO*

The share of timber and timber industry waste used in Lithuania is increasingly larger. The main method of its realisation is the use for municipal needs (Fig. 227). 155 thousand m$^3$ of wood was used for biofuel in 2011.

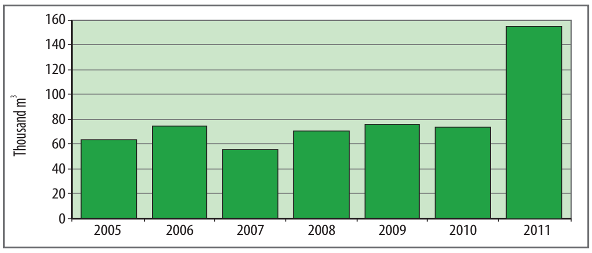



**Fig. 227.** Sale of forest felling waste in state forests, 2005–2011. *Source: State Forest Service*

## REFORESTATION

In rational management of forest resources, it is important for the forest felling to be compensated by replanting it or forming conditions for its natural regeneration. Natural regeneration is recently applied more often as it forms a stable forest ecosystem and ensures better conditions for the biodiversity. Pursuant to the provisions of the Law on Forests of the Republic of Lithuania, the forest in planted and reforesting cuttings, burning places should be restored in three years.

Prior to the accession to the European Union, in the land owned by the State Land Fund, the forests were planted by the forest directorates by planting 1.1-1.3 thousand ha of new forests annually. By implementing the rural development programme, since 2004 the support from the EU structural funds was started to be allocated for the plantation of new forests in private land, therefore, the volume of plantation of forests increased in the area of private lands as well.

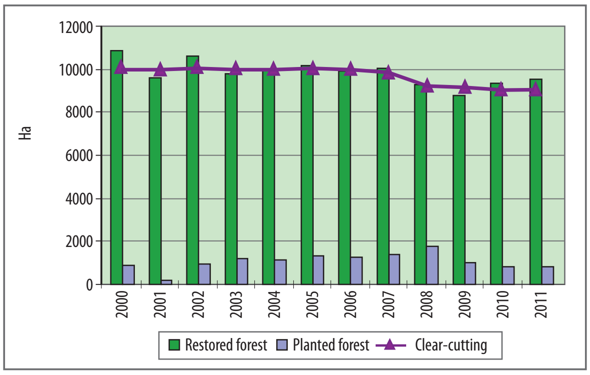



**Fig. 228.** The areas of clear-cuts restored and planted forests in state forests, 2000–2011. *Source: State Forest Service*

Forest directorates restored 9.5 thousand ha of forest in 2011 (9.4 thousand ha in 2010) (Fig. 228). 4.1 thousand ha of which were restored by plantations, 2.4 thousand ha – by natural regeneration, whereas 3.0 thousand ha – in mixed way. Same as in previous year, the majority was the spruce plants – 4.1 thousand ha. Pine plants amounted to 1.5 thousand ha, oak – 0.5 thousand ha and other species of trees – 3.5 thousand ha. In 2011, the forest directorates planted 0.7 thousand ha of forest in the land unfit for agriculture (in 2010 – 0.8 thousand ha). Of the deciduous tree woods, the most plantations were of softwood deciduous species, oaks accounted for one third of the area of deciduous trees.

In 2011, the support of the amount of 45.9 million Litas from the Rural Development Programme was allocated for the lands planted with forest. 3.9 thousand ha of plants were planted per year.

One of the most important long-term goals of the National Sustainable Development Strategy is to increase the Lithuania forest coverage up to 34-36% of the total area of territory by 2020 (according to scientific calculations, such should be the optimum forest coverage of our country). In order to achieve this aim, the area of forests, when implementing this strategy should increase by approx. 13 thousand ha per year.

## ECOLOGIC AND RECREATIONAL VALUE OF FORESTS

Apart from wood, other services provided by forest ecosystem have been appreciated recently. Currently, approx. 18.8% of forests pass to the protected territories of various purposes of use. The preservation of biodiversity requires an important existence of deadwood and windfalls in the forest stands. It is evaluated that the amount of deadwood and windfalls in the forest stands in Europe varies from 8 $m^3$/ha in Northern Europe to 15 $m^3$/ha in South-East Europe. During the recent 20 years, their share has been increasing and also the ecological state of forests has been improving in Europe, however, the situation in different countries is also very different.

A large territory of Lithuanian forests is occupied by the areas used for the protection of natural variety. Forest reserves account for 1.2% of all forests, whereas Group II forests, the main function of which is the protection of biodiversity and recreation, account for 12.3%.

Lithuanian foresters become increasingly more focused on the environmental protection. One of the trendy programmes is the distinction of Key Forest Habitats (KFH) that was performed in 2001–2005 and in still on-going.

In the key forest habitats, the representatives of protected species are dependent on the special forest properties and particularities of their development. Key forest habitats are almost equally scattered in the forests of the entire country; however, the majority of them is recorded in the areas, covered by larger and older forests. In 2012, there were more than 9 thousand KFH in Lithuania covering the area of 27 thousand ha. There are 6,510 KFH in forests of national importance (the total area – approx. 21.6 thousand ha). The remaining habitats are in private forests and forests reserved for the restoration of ownership rights. The average area of one KFH is 3 ha. Every fifth of all key forest habitats recorded in Lithuanian forests is located in private forests. The repetitive KFH inventory is currently in progress, and the potential KFH are evaluated and the current ones are reviewed.

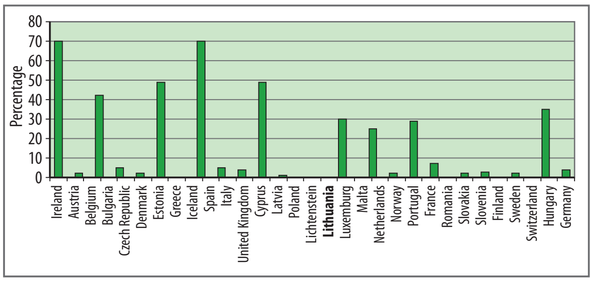



**Fig. 229.** The number of introduced species of trees in the EU Member States. *Source: FOREST EUROPE: UNECE, FAO*

Another important indicator of ecological condition of forests and their naturalness is the existence of introduced or invasive species of trees in the composition of forest stands. The introduced species of trees constitute the majority of trees in certain European countries; however, their share in Lithuania is not significant (Fig. 229).

The foresters are trying their best to meet the increasing public demand for recreation. In the forests, the number of recreational objects increased from 290 (in 1995) to 2,162 (in 2011), of which 2,108 objects are located in state forests. In addition to the currently more abundant rest sites, more cognitive, training, recreational paths are installed, as well as overview sites and camping sites for long-term rest. The major focus is on the recreational forests in protected areas, where recreation infrastructure is prepared in cooperation with forest directorates and State Service on Protected Areas.

## FOREST PROTECTION

In the early 2011, there were 23.4 thousand ha of state important forests damaged by pests, diseases, abiotic factors, animals. Within a year, new damages occurred in the area of 38.9 thousand ha. Due to natural causes, the foci and damages disappeared in the area of 7.2 thousand ha, and they were liquidated by using various measures in the area of 39.3 thousand ha. In the late 2011, there were 15.7 thousand ha of damaged areas left (Table 23).

Damages caused by animals were registered in the area of 7.7 thousand ha, in total. New damages were registered in 3.1 thousand ha of forest. The area of forest stands damaged by abiotic factors increased from 22.4 thousand ha to 28.0 thousand ha. In 2011, wind damaged the area of 20.3 thousand ha.

**The areas of damaged forest stands based on the causes of damages** – is a complex indicator, quite important in analysing both the situation of forest as the source of wood, and the state of ecosystems as important component to biodiversity and landscape.

It should be noted that due to its features this indicator is considered to be the indicator of the impact on forest resources, on one hand, and indicator of the state itself, on the other. Abiotic factors are droughts, fires, strong winds resulting in windfall or burnt areas, weaker state of stands, whereas the intensity of biotic factors (formation of foci of tree pest or tree diseases) makes the forest stands non-resistant to the impact of strong winds.

In 2011, the forest directorates took various protection measures for the improvement of sanitary protection of forest state in the area of 95.2 thousand ha. Biological protection measures were used in the area of 23.9 thousand ha, windfalls and snow damages were eliminated in the area of 29.6 thousand ha, and the measures of chemical fight were taken in the area of 4.2 thousand ha.

**Table 23.** Distribution of damaged forest stands by damage factors, 2011. *Source: State Forest Service*

| | State forests damaged in 2011, area (ha) | | | | | |
|---|---|---|---|---|---|---|
| Damages | At the start of year | Newly emerged | Spontaneously outworn | In total | Liquidated | Remaining at the end of the year |
| Insects | 5,246 | 7,893 | 3,388 | 9,755 | 6,134 | 3,617 |
| Infective diseases | 6,285 | 5,036 | 1,702 | 9,619 | 3,519 | 6,100 |
| Animals | 6,651 | 3,075 | 2,050 | 7,676 | 2,569 | 5,107 |
| Abiotic factors | 5,200 | 22,893 | 96 | 27,977 | 27,085 | 912 |
| In total | 23,382 | 38,897 | 7,236 | 55,043 | 39,307 | 15,736 |

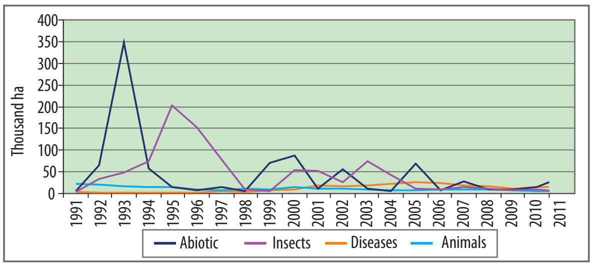



**Fig. 230.** Distribution of damaged forest stands by damage factors, 1991–2011. *Source: State Forest Service*

Share of damaged forest stands accounted for 5.5% of forests in the recent decade, the main share of damages were caused by abiotic factors (especially windfalls), the volume of which can be very contrasting in different years (Fig. 230). During the last decade, the majority of damages were caused by insects (34.1%); next major factor was causes by abiotic factors (29.4%), third – by diseases (24.5%). During the recent five years, the main factors of damages included diseases (34.3%), storms and windfalls (27.8%) and insects (21.4%).

The changes of the **number of forest fires and fire sites.** According to the data of the Department of Forest of the Ministry of Environment, 40% of Lithuanian forests pass to the class of high fire risk by the type of trees, age and growing places.

In the European Union, the highest number of fires and highest risk of fires is in the countries located in the coastline of the Mediterranean Sea – Spain, Portugal, Greece, and France (Fig. 231).

In Lithuania, the State Fire Protection System is created for the protection of forests against fire. State enterprises – forest directorates – extinguish all forest fires despite the status of their ownership. The Directorate General of State Forest under the Ministry of Environment coordinates the work of forest directorates, national parks and maintains relations with the Civil Safety Department, Fire Safety and Rescue Department, National Defence, National Defence Volunteer Forces, municipalities of cities and districts.

In 2011, as compared with 2010, the number of fires in forests increased from 110 to 142. The fires caused damage in the area of 293 ha (Fig. 232). There were 52 fires in private forests, damaging the area of 7.5 ha. The main reason of forest fires, same as in other EU Member States, is the human-induced activity. Due to negligence of visitors, holidaymakers as well as burning of last year's grass constitute the main part of causes of forest fires – approximately 92%. In 2010, as much as one fifth of fires were caused due to burning of grass, 3% of which were caused intentionally, other usually occurred of negligent behaviour with fire.

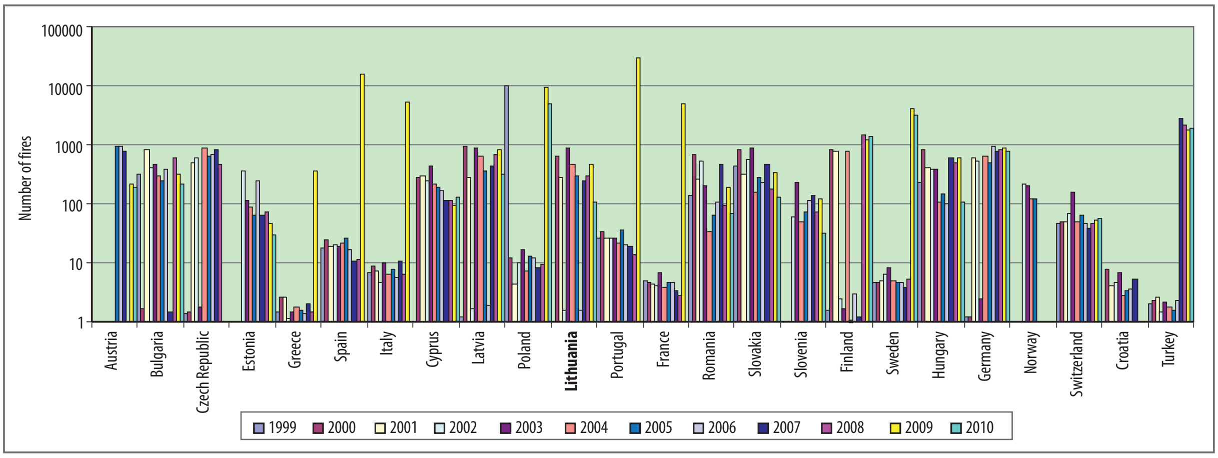



**Fig. 231.** Number of forest fires in Europe, 1999–2010. *Source: Eurostat*

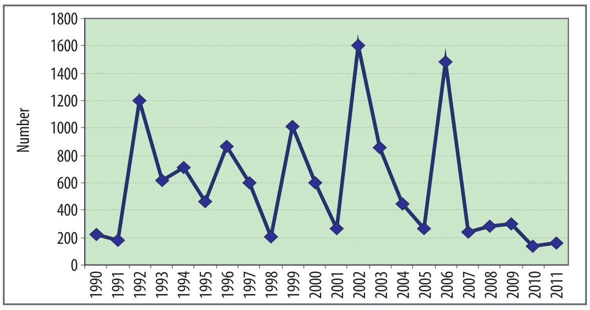



**Fig. 232.** Number of forest fires in Lithuania, 1990–2011. *Source: State Forest Service*

**Defoliation intensiveness** is the main indicator, indicating the state of trees. Crown defoliation is the loss of tree leaves or thorns, as compared with the tree having the entire crown. The reasons of defoliation include not only chemical pollution of environment, but also the direct and indirect result of damages caused by other factors – biotic (especially of fungi diseases, insects) and abiotic. Defoliation is usually evaluated in percentage value, the defoliation of healthy tree is equated to 0%, whereas of dry tree – 100%. The trees with crown defoliation not reaching 10% are usually considered as relatively healthy. The average forest defoliation shows the healthiness of forests and the possibilities of renewal of wood resources.

Since 1997, the average medium defoliation of crowns has been varying insignificantly – from 19.9% to 21.6%. Therefore, the state of Lithuanian forests is evaluated as relatively stable and occupies the medium position between the Central and Eastern European countries (Czech Republic, Poland, Slovakia), where the state of forests is the worst, and Northern Europe (Finland, Sweden), where the state of forests is the best (Fig. 233). The distribution of medium defoliation in separate years in national forests was conditioned by many factors – meteorological conditions, air pollution, forest pests and disease invasions, natural factors, varietal composition of regional forests, age of forest stands and other reasons.

The defoliation of Lithuanian trees has been observed since 1987. Until 1995, the average defoliation of all species of trees was increasing in Lithuania and was the highest during the period between 1993 and 1995. Back then, as much as one quarter of trees were characterised by defoliation higher than 25%. The outburst of healthy share of trees in forest stands observed in 1995–1996 was conditioned by liquidation of the consequences of Ips typografus that significantly reduced the medium crown defoliation. However, after 1996, the share of healthy trees decreased in Lithuanian forests again, the state of forests started to improve (the share of serious and medium damaged trees decreased more than the share of healthy trees) (Fig. 234). It was conditioned by the restoration of the state of spruce woods, favourable weather conditions, reduction of atmospheric pollution mostly due to reduced $SO_2$ emission in the Western European countries.

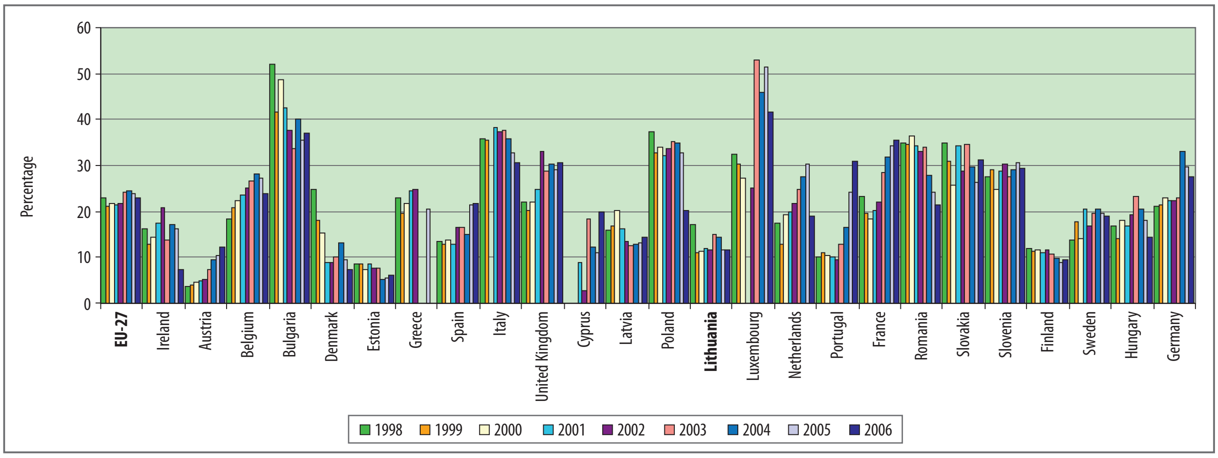



**Fig. 233.** Share of trees with high and medium defoliation in the EU Member States, 1998–2006. *Source: Eurostat*

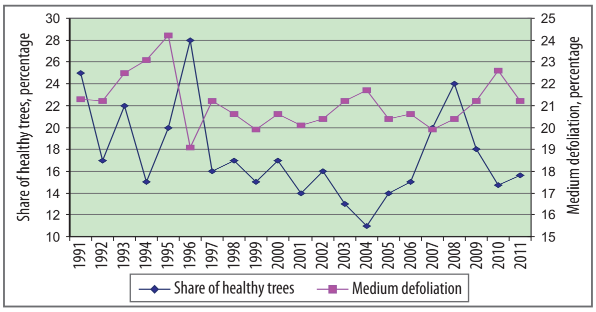



**Fig. 234.** Variation of the share of average tree crowns' defoliation and healthy trees (defoliation 0-10%) in 1991–2011. *Source: State Forest Service*

In 2011, the average crowns' defoliation amounted to 21.2% (in 2010 - 22.6%). The total number of relatively healthy species of trees (defoliation up to 10%) increased by 0.9% and amounted to 15.6% (in 2010 – 14.7%). The share of dead trees (defoliation 100%) increased up to 1% (in 2009 – 0.9%). The average defoliation of deciduous trees was higher than of coniferous by 21.3% and 21.1%, respectively. The number of relatively healthy deciduous trees amounted to 17.3%, whereas of damaged trees – 13.8%, coniferous trees – by 14.5% and 16.3%, respectively. Same as a year before, ash trees were characterised by highest defoliation – 43.4% (in 2010 – 41.2%).

## SUMMARY

According to the data of 1 January 2012, the area of forest covered 2,173 thousand ha in Lithuania and occupied 33.3% of country's territory. The area of forest land per capita increased up to 0.68 ha, the total timber stock volume – up to 501 million m3, the average timber stock volume – up to 240 m3/ha, the total annual wood increment – up to 17.2 million m3, the annual wood increment – up to 8.2 m3/ha.

On 1 January 2012, there were 248 thousand owners of private forests. On average, one owner had 3.3 ha of forest. During the recent decade, the share of private forests increased from 22.7% to 38.9%. It is planned that, after the land reform, the private forests should amount to 40%.

Since 1948, the average age of forest stands has been increasing in Lithuania. The areas of mature forest stands has been increasing in the state forests since 1950s – during the last 50 years, they have increased more than three times and currently occupy more than 19% of the total area of forest stands. Thus, during the past decade, the age structure of Lithuanian forests has become more optimal.

The share of natural forest is increasing gradually. Almost 85% of Lithuanian forests are attributed to conditionally natural, slightly more than 1% – to natural, the remaining – to forest plantations. The optimisation of forest structure is contributed by the trendy economic and forest maintenance measures as well as by more frequent application of the spontaneous reforestation. In order to preserve the varietal diversity of forest stands, currently, more than one third of cutting areas are left for spontaneous reforestation.

The varietal diversity of Lithuanian forest stands has showed only slight changed since the 1950s – the pinewoods (35.1%), spruce woods (20.8%) and birch woods (22.3%) are dominating.

Oak woods account for 2%, ash woods – 1.7% of all forest stands. The timber volume has also been increasing in Lithuanian forests since 1948. It was mostly conditioned by the increasing forest coverage, furthermore, the trendy farming contributed to this; by thinning to increase, the increment of stands by cuttings for the mature forest stands to accumulate as higher volume as possible. The average timber stock volume increased in all forests from 226 $m^3$/ha in 2003 to 240 $m^3$/ha in 2012. The relative timber volume in Lithuania exceeds the average of this indicator in the European Union.

In Lithuania, the volume of harvesting has been quite stable in the recent years – approx. 5.7-7.3 million $m^3$ of timber is harvested annually, accounting for 2% of the volume of timber accumulated in the forests in recent years. In the state forests, the volume of annual felling is changing only slightly, however, the volume of felling has showed a significant increase in private forests. In private forests, the amount of felling mostly increased due to their increasing area. Approx. 70-80% of the overall annual increment of wood of these forests is harvested annually in private forests. In all Lithuanian commercial forests, approx. 6.5 $m^3$ of wood is growing in 1 ha per year, and felling amount to 4.1-4.3 $m^3$ (more than 60% of the wood increment).

A large share of timber remains for the national internal use. In 2011, approx. 5.4 $m^3$ of round wood was used in Lithuania. Its use in wood industry and energy production has been increasing.

In the area of timber production and realisation, there was a new tendency of increasingly intensive use of wood and its waste of processing, especially with an increase in the municipal needs for the use of renewable energy. The share of timber and timber industry waste used in Lithuania is increasingly larger.

Share of damaged forest stands accounted for 5.5% of forests in the recent decade, the main share of damages were caused by abiotic factors (especially windfalls), the volume of which can be very different in different years. During the last decade, the majority of damages were caused by insects (34.1%); in the second place was by abiotic factors (29.4%), third – by diseases (24.5%). During the recent five years, the main factors of damages included diseases (34.3%), storms and windfalls (27.8%) and insects (21.4%). Based on the forest stands damaged by diseases and insects, Lithuania occupies a medium place among other EU countries.

The number of forest fires has decreased recently. Since 1997, the average medium defoliation of crowns varied insignificantly – from 19.9% to 21.6%. Therefore, the state of Lithuanian forests is relatively stable and occupies the medium position between the Central and Eastern Europe countries, where the state of forests is the worst, and Northern Europe, where the state of forests is the best.

## GAME RESOURCES

The hunting traditions have deep roots in Lithuania, however, the conservation and sustainable use of hunted fauna resources as well as regulation of abundance of certain species is important not only in social-economic terms but also for the objectives of conservation of biodiversity. In Lithuania, which is characterised by the least forest coverage among the Baltic States, unregulated population of hooves and beavers can cause a significant damage on the forest habitats; invasive species can contribute to the expulsion of local species, destruction of other species and decrease of biodiversity indicator. Whereas careless intensive hunting can damage the stability of populations of certain species, therefore, the use of resources of hunted fauna in Lithuania should constantly be based on the considered management of the state of populations of hunted animals. The Regulations for Hunting in the Territory of the Republic of Lithuania stipulate 33 species of animals that can be hunted in the territory of Lithuania. Moose, Red Deer, Fallow-deer, Roe, Boar, Wolf, European Pine Marten and Beech Marten, European Polecat, Badger, European Hare, Beaver, Bean Goose, Greater White-fronted Goose, Mallard and Pochard, Garganey and Common Teal, Common Goldeneye, Tufted Duck, Coot, Common Snipe, Woodcock, Partridge, Pheasant, Wood-pigeon, Rook, Hooded Crow can be hunted during specific established periods. The foxes and other invasive species causing damage to the populations of other species or danger of the spread of diseases – Common Racoons, Racoon Dogs, introduced Canadian Minks, Nutria, Water-rats – can be hunted during the entire seasons of the year.

Great Cormorants are hunted in the territories of fishing ponds pursuant to the procedure established by the Description of the Procedure of Regulation of Prevalence of Population of Great Cormorant.

During the discussed period, the greatest impact on the hunted fauna resources is still caused by the direct use – hunt – and changes of the area of habitats appropriate for the species of game animals, especially fragmentation of forest solids caused by the development and intensiveness of use of motor-road network as well as intensive use of forests for recreational purposes, i.e., disturbance of animals, especially during breeding period.

According to the newest data, 31 thousand persons having the right to hunt have been included into the police register. Approx. 28 thousand hunters have been providing data to the digest of hunters recently, 84.5% of which belong to associations of hunters, 4.5% – to other hunting organisations; another 5.8% are individual hunters. There are approx. 3 thousand persons having the right to hunt and hold hunting guns, who are not providing data to the digest of hunters – these are the persons, who acquired a gun for protection purposes.

In Lithuania, the average size of the unit of hunting area is approx. 8.65 thousand ha, the largest units of medium areas exceeding 9 thousand ha, were in Kaunas, Tauragė and Telšiai region territories. The forests occupied approximately one third of the unit of hunting area. The most forested areas are in Alytus region, where the forest coverage of units of area accounts for nearly half of area, and the least forested hunting areas are in the territories of Šiauliai, Marijampolė and Panevėžys regions. The collectives of associated hunters allocated approx. 42% of their budget to animal care, feeding, installation of biotechnical measures improving the conditions of hiding, and breeding, wintering and feeding, approx. 46% – for taxes for use of game resources, another 4-5% – for the compensation of damage caused by hunted animals to forests or crops.

The record of animals killed in motor roads shows the direct impact of fragmentation of natural landscape on the resources of hunted fauna and other animals. The increasing intensiveness of the use of roads and the development of road network cause an increasing negative impact on these resources (according to the official report alone, the number of animals killed in roads increased by as much as 40% from 2008 to 2012) and, of course, cause an increasing danger to the drivers.

The increase in the abundance of certain animals during the recent several years as well as increase of the degree of fragmentation of habitats due to development of road networks caused not only by the building of new roads (even if non-intensive), but also the intensified works of improvement and reconstruction of the quality of works, use of protective fences (in part, also due to increased migration of pendulous labour force from more distant settlements to larger cities), can condition an increasing number of road accidents due to the fault of wild animals. Therefore, it is necessary to consider the more dense networks of wild animal crossings in motor roads and constant maintenance of the quality of protective fences.

The Ministry of Environment is collecting data on eight most intensively hunted or at least mostly demanded hunting trophies of our region: moose, red-deer, roe, fallow-deer, boars, badgers, wolfs and beavers. The abundance of bison and lynx is also evaluated. Although these species are attributed to the species of game animals, their hunt is forbidden.

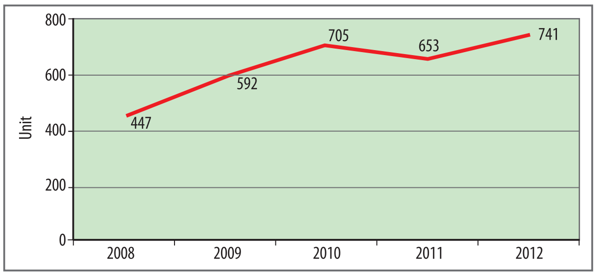



**Fig. 235.** Change of the number of animals killed in accidents, 2008–2012. *Source: Ministry of Environment*

The abundance of these animals is evaluated pursuant to the data on the game resources in hunting areas as submitted by the users of these recourses. Therefore, some data are subject to wide range of reliability and deviations, as the qualification and experience of data submitters are different. This requires the specification of evaluations of separate species of game animals on multiannual basis, which, in case of necessity, would allow the correction of the routine evaluation of abundance of populations performed by the users of resources. The evaluated abundance of game animals and the number of hunting trophies (list of hunted animals) is established for the season of respective year based on the data submitted by the users of game resources until 1st of April of the respective year (for example, the data of the trophies of the hunting season of 2008–2009 are submitted until 15 April 2009). The list of game animals supplements the information on the state of hunted fauna resources. This list is wider (it provides information on all game animals), and also the tendencies of trophies can reflect the abundance of the population of the used species of animal. For example, in case of decrease in the abundance of animals, the hunters should accordingly have fewer opportunities to hunt them, and the number of trophies would decrease.

The most important species among the hunting trophies due to their value, effectiveness of hunt and abundance remain the same: these are cervids – **Moose, Red Deer,** and **Roe** – and **Boars**. According to the data of records of users of resources of game animals, the abundance of cervids has been constantly increasing during the last five years, whereas the hunting varied by approx. 3% for the population of moose, approx. 7% – for red-deer and approx. 20% – for roe. Semi-open biotopes and swampy forest stands are essential for all these three species of hoofed animals. The influence of human activity is low in these habitats, as they do not have significant value for the commercial forestry.

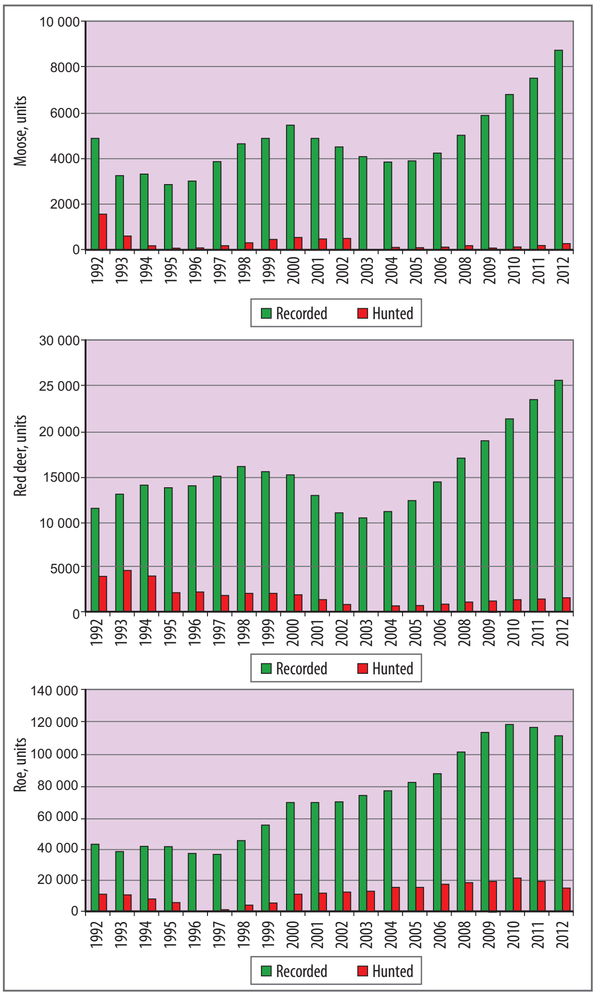



**Fig. 236.** Changes of the abundance and hunting of cervids, 1992–2012.
*Source: Ministry of Environment*

The programme of increase of forest coverage performed in Lithuania improves the living conditions of roe animals – increases the areas of forested habitats and creates favourable conditions for nutrition (the areas planted with forest will soon become young stands with large reserves of branch forage). The cutting sites left for spontaneous reforestation or planted with forest also improve the nutrition conditions for all three species of hoofed animals and, as noted by L. Balčiauskas, the grassing of abandoned meadows with bushes and forest are essential for the red deer and roe. Due to these four factors, the state of habitats of the moose, red deer and roe is evaluated as good in Lithuania.

However, cervids, especially moose, are still suffering from illegal hunting, furthermore, the abundance of moose population is characterised by especially uneven territorial distribution subject to the suitable habitat, therefore, the established limits of their hunt are closely related to the territorial units in view of the evaluated abundance in that specific region.

The population of **boars** that managed to absorb part of non-optimal biotopes has constantly increased since 2008 and even approached the number of 60 thousand individuals, however, according to the available data, the intensified hunt of boars lead to the stabilisation of the abundance in 2011–2012. Too abundant population of boars' conditions especially intensive destruction of grass cover in forests and forest ecotones causes danger to sensitive protected habitats as well as protected species of gallinaceous forest birds, by destroying their breeding sites.

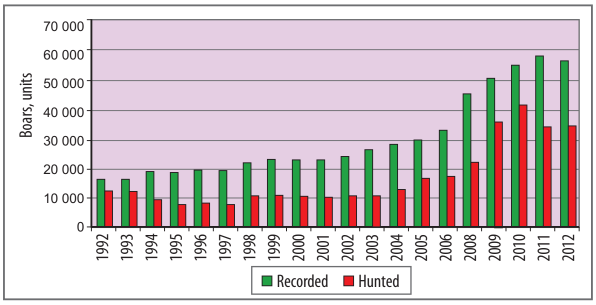



**Fig. 237.** Changes of the abundance and hunting of boar, 1992–2012.
*Source: Ministry of Environment*

The number of **foxes** and other furry small hunted animals among the hunt trophies is well regulated by the fur market changes. Although the hunting of foxes was especially increasing in 2009, now the number of hunted foxes is decreasing, not to mention other animals, the hunting of which is more complex – the hunters choose more valuable catch, not only in terms of trophy, but also in terms of the amount and quality of meat.

For example, the hunting of racoons also decreased by half in 2010–2012, whereas the hunting of Canadian Mink, the abundance of which can probably be decreased only by hunt as any other anthropogenic or other impacts are not relevant to the population of this invasive species, usually do not even top the number of 150 individuals. The increasing abundance of foxes and other small predators causes threat to the populations of other hunted animals, for example, European Hare, Partridge, also causes negative influence on the protected species of other species of fauna, especially birds.

It is worth to mention the specifics of variation of population of the **European Hare,** constituting quite a significant share of the hunter's "package", which varied from 2.5 to 5 thousand animals per year during the period from 2008 to 2012, although it is not easy to evaluate the abundance of this hunted animal. In 1968–1970, it was an especially abundant species – it was evaluated by more than 250,000 of individuals. However, due to the intensifying use of land and operation of population regulation mechanisms, the population of the European hare decreased by several times and the average relative density did not exceed 13 individuals per 1,000 ha in 1985.

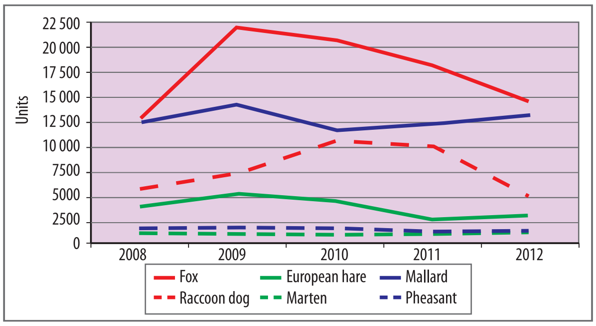



**Fig. 238.** Changes of other intensively hunted trophies of game species, 2008–2012. *Source: Ministry of Environment*

It is supposed that the abundance of population reached approx. 80 thousand hare in 2000–2001. The reasons of decrease of the population of European hare among the hunting trophies are not yet quite clear, however, it has been observed that the abundance of this species is also decreasing in other EU Member States, where the traditional landscape is facing significant changes. The possible main reasons could be as follows: the agricultural activity intensifying in many Lithuanian regions, increasing number of advanced high-speed agricultural equipment, there are guesses that the previous too extensive use of pesticides could also have negative influence on the reproductive characteristics of this species. Furthermore, the size of the population of hare, according to the data of scientific researches, is a classic example of the result of "predator-victim" interaction between species – the greater the population of predators intensively hunting hare and their cubs (foxes, racoons, wolfs, lynxes), the smaller the abundance of European hare. The significant increase in the number of foxes and racoons is likely to have a significant negative impact on the restoration of resources of this representative of hunted fauna.

Traditionally, the annual amount of hunted birds is relative low, the meat of which is mostly used for personal needs. There are 14 species of birds huntable in Lithuania at the moment: Bean Goose and Greater White-fronted Goose, Mallard, Pochard and Tufted Duck, Garganey and Common Teal, Common Goldeneye, Coot, Partridge, Pheasant, Woodcock, Common Snipe and Wood-pigeon. The remaining species of game birds – Rook, Hooded Crow and Great Cormorant – are not considered as trophies: in this case, the type of hunt is applied for the regulation of their population. Without the especially abundant number of hunted mallards, the annual hunting trophies of which amount to 12–13 thousand birds, and hunting of pheasants raised and bred especially for hunting purposes (up to 1.5 thousand of hunted units), the number of other game species, which are way less abundant as compared with mallard, amounts to several hundred per year.

In view of the use, **European Beaver** and **Wolf** are the two species hunted in Lithuania that are characterised by specifics. These species are of EU importance and should be protected, however, Lithuania, having the sufficient number of these species, is granted with the exception for the hunt of these species; however, the sufficient vitality and monitoring of state of populations should be ensured.

European beavers, once extinct in Lithuania (in the 20th century), after reintroduction (repetitive settlement of species in the habitat, where it used to live, but disappeared or was exterminated) and being the species able to occupy other habitats especially fast and actively by adapting them to their needs, quickly spread in the entire Lithuania's territory, by settling even in small forest springs. The abundance of species has constantly increased for more than a decade, after the decrease in the demand of their fur and without abundant population of wolfs, which significantly regulated the number of beavers. The abundance of beavers has been regulated by hunt since the very 2003, and, in 2010, it was allowed to regulate the abundance of beavers causing damage to forests and crops during the entire seasons of the year by destroying already built embankments in non-perspective beaver habitats. In the past several years, the abundance of beavers increased by 4–5 thousand individuals per year, whereas the size of population reached the number 50 thousand. In 2010–2012, after the repetitive increase in the number of beavers among the hunting trophies (more than 20 thousand beavers were hunted in 2012), the growth of population slowed down.

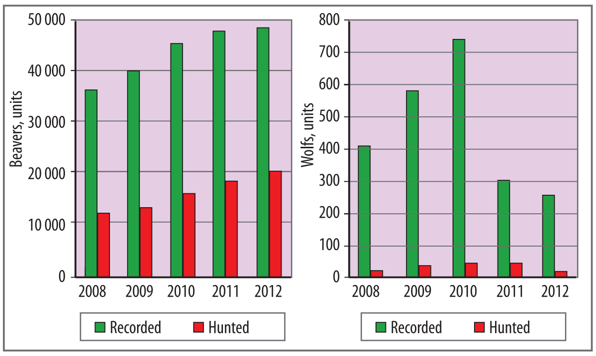



**Fig. 239.** Changes of beaver and wolf abundance and hunting, 2008–2012. *Source: Ministry of Environment*

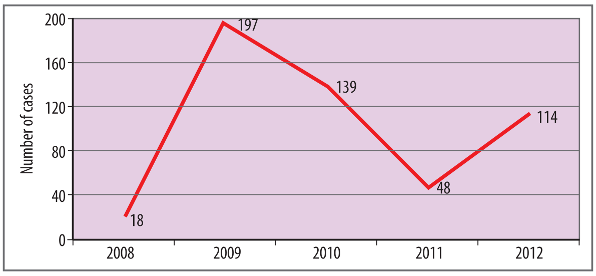



**Fig. 240.** Changes of the number of cases of wolf attacks on livestock, 2008–2012. *Source: Ministry of Environment*

It is supposed that the increase of the focus of hunters on this species was conditioned not only by the threat of compensation of possible damage to farmers and forest owners or changes in fur market, but also by the increasing consumption of beaver meet.

The wolf have long been an important hunting trophy. The significant increase in the population of wolfs during the post-war period was later reduced by promoting its regulation. The number of wolfs has recently dropped from approx. 250 individuals in 2004 to approx. 190 – in 2006, approx. 205 – in 2007 and to 300 – in 2008 (approx. 400 by preliminary evaluation of the users of hunted fauna resources). As it was showed by the research of evaluation of the state of wolf population performed by specialists in 2008, the average density of wolfs reached 2.1–3.5 individuals per 1,000 ha in some places. Since the data of the users of game resources showed excessively increasing number of wolfs (according to approximate evaluation of 2010 – even more than 700 individuals); in 2012, the foresters performed a special two-day national recording of wolfs in Lithuanian forests, avoiding the repetition of calculation of the same animals. The results showed that the size of the population of wolfs was approx. 250 individuals.

According to L. Balčiauskas, the nutrition base in Lithuanian forests is favourable for wolfs – there is a sufficient population of hoofed animals and also increased population of beavers – wolfs are known as one of the main natural factors regulating the abundance of beavers. On the other hand, the insufficient measures of protection of livestock applied by the farmers form an abundant additional nutrition base, especially during the period of training of wolf cubs, when livestock becomes a particularly convenient object for training the hunting skills of cubs. In fact, the damage caused by wolfs to the herds of livestock, reaching up to 1,000 units of livestock per year 10–15 years ago, is now amounting from several tenths to slightly more than 100 cases per year due to the decreased population of wolfs and appropriate measures taken by the farmers in view of the recommendations of environmental specialists and scientists regarding the protection of livestock and sheep herds during the period of training of wolf cubs.

Furthermore, namely during the period from 1994 to 2000, approx. 600–700 wolfs were calculated each year, i.e., in 1994–1998, the population of wolfs was almost reaching or even exceeding (in separate regions) the ecologic capacity, therefore, characterised by great ecological plasticity, wolfs attacked the largest number of livestock, which was relatively easier accessible.

According to L. Balčiauskas, the ecological capacity of wolfs of the examined territory depends on the accessibility of nutrition base. However, the most influencing factor is the number of suitable forest habitats, the area of which is the smallest in Lithuania, as compared with Estonia and Latvia, therefore, wolfs use non-typical habitats in Lithuania, for example, the abandoned agricultural lands characterised by ligneous plants. The fragmentation of forested landscape due to the development of highways, including the development of the network of protective fences, also clearly reduces the selection of habitats for wolfs and close migration between them. According to the data of L. Balčiauskas and Y. Kawata, the ecologic capacity for wolfs is almost by 40% smaller in Lithuania than in Latvia and amounts to 620 individuals (the territorial capacity of wolfs in Latvia – approx. 1,066–1,092 individuals), therefore, the size of Lithuanian wolf population, reaching 200–250 individuals, would be optimum.

## COMMERCIAL FISHING RESOURCES

Fish resources are one of the most important and intensively used resources of the living nature in Lithuania. The resources of commercial fish in Lithuanian waters still constitute an important share of food resources, however, the recreational value of such resources is increasing – the recreational fishing in Lithuania is still one of the most popular leisure and recreational activities. The data of the record of fishing permits and surveys shows that as much as one sixth of all Lithuanian population is fishing occasionally during leisure time, and almost 5.5% of residents consider fishing as one of the most favourable hobbies. It is also necessary to remember the importance of fish as invaluable share of biodiversity resources.

During the recent several years, the consumption of fish for food has increased in Lithuania as much as by several kilograms per capita in 2001 – up to almost 16 kg, however, this consumption still lacking behind the old EU Member States, where the consumption of fish and its products is from approx. 25 to almost 40 kg per capita.

The most important and productive districts of Lithuanian marine fishing are the Atlantic Ocean and the Baltic Sea, internal waters – the Curonian Lagoon and the Kaunas Lagoon. In order to balance the commercial fishing resources of the Baltic Sea and also to implement the aims of the promotion of recreational fishing, the commercial fishing decreased in the maritime and internal waters during the recent several years by implementing the measures of fishing restriction and business diversification, an increasing share of fishing sector was occupied by fish recycling and aquaculture, the conditions were improved for recreational fishing in the internal waters. In the nearest future, it is planned to continue the implementation of the long-term measures of restoration and stabilisation of commercial fish resources: to reduce fishing capacities in distant waters, the Baltic Sea coastal zone and the Curonian Lagoon, modernise the vessels and fishery companies, expand the production of the fish of higher value-added and search for new markets, encourage the production of organic fishing and development of fishery regions.

## DEVELOPMENT AND REGULATION OF COMMERCIAL FISHING

During the decade from 2000 and 2010 alone, the optimisation of the fishing fleet in order to implement the plans of coordination of the capacities of Lithuanian fishing fleet with fish resources led to the decrease in the number of vessels by 35%, although the total tonnage increased by approx. 1.5 times.

If on 1 January 2010, the system of data of fishing vessels engaged in fishing in the maritime water contained 149 vessels, having the right to pursue fishing in the Baltic Sea coastal zone, and 31 vessel having the right to pursue fishing activity in the open Baltic Sea, during 2010, by using the funds of the support under the activity area "Permanent Cessation of the Fishing Activity of Vessels by Handing Over the Vessels to Scrap Metal" of the measure "Permanent Cessation of the Fishing Activity of Vessels" of the priority area "Maritime Fishing Fleet Adaptation Measures" of the Lithuanian Fisheries Sector Operational Programme for 2007–2013, the number of vessels fishing in the coastal area of the Baltic Sea decreased down to 123.

In 2010, the fish caught in the Baltic Sea accounted for only slightly more than 10% of the total amount of fish caught by vessels registered in Lithuania, whereas a decade ago, this amount reached almost 19%. It was conditioned not only by the decrease in the fishing capacities and volumes in the Baltic Sea, but also by the increased catch of Lithuanian vessels in the distant regions – approx. 90% of all sea fish are caught by the Lithuanian companies in the Atlantic Ocean.

Based on the tonnage, the Lithuanian distant fishing fleet accounts for approx. 10% of the total tonnage of the EU distant fishing fleet – in 2012, the Lithuanian distant fishing fleet was comprised by 10 vessels with the total annual amounts of fish catch amounting to 115–125 thousand tons in the several recent years. On 1 April 2012, 148 vessels were included into the data system of the maritime fishing fleet, only 107 vessels of which had the right to pursue fishing in the coastal area of the Baltic Sea, 32 – the right to pursue fishing in the open Baltic Sea. The remaining 9 of the general tonnage (GT) of 40 thousand tons and total engine capacity of 48,116 kW were used for the fishing activity in the Atlantic and Pacific Oceans.

According to the data of the Ministry of Agriculture, there are almost 9 thousand employees in the Lithuanian fishing sector: approx. 6 thousand employees work in fish processing sector, approx. 2 thousand – in maritime fishing sector, and approx. 1 thousand – in the internal waters and aquaculture sector. The turnover of the Baltic Sea maritime fishing amounts to nearly 49 million Litas in Lithuania, whereas the generated value-added – 6.6 million Litas. Pursuant to the data of SE Agriculture Information and Rural Business Centre, in 2010, the revenues from the unloaded fish gained by the Lithuanian fishery companies using the fleet in the Baltic Sea amounted to more than 20 million Litas, whereas the value-added generated by the companies from the fishing could amount to approx. 4 million Litas. During the period from 2000 to 2010, the production of fishing products increased by 70%, at the end of 2010, there were 39 fish processing companies in Lithuanian producing the total amount of 81.2 thousand tons of production of the value of almost 780 million Litas. It should be noted that the major share (approx. 90%) of the raw material was imported by the fish processing companies – in 2010, out of 65 thousand tons of raw materials the fish of the Baltic Sea amounted only to approx. 3.7%. Thus, this activity has a low impact on the Lithuanian commercial fishing resources. Furthermore, the fishing processing companies export the major share of their production (for example, in 2010, as much as 68% of the production was exported or 7% more than a year before).

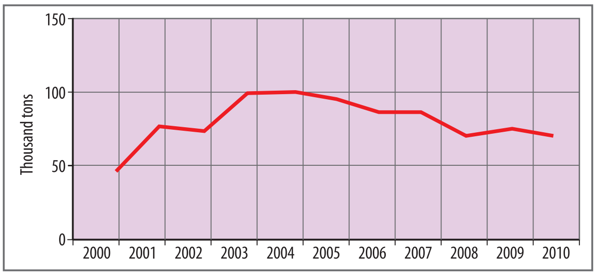



**Fig. 241.** Variation of tonnage of fishing fleet, 2000–2010. *Source: Lithuanian Department of Statistics*

Fish processing production also constitutes the main share of the export of Lithuanian fisheries sector. In 2010, Lithuania exported almost 90 thousand tons of fisheries production for more than 1 billion Litas, thus, maintaining the positive balance of foreign trade in this area (in 2010, the amount of imported fishing products reached the amount of 862 million Litas). After Lithuania became the member of the European Union, this led to the change of the main direction of export – almost 86% of production is exported namely to the European Union countries, especially Germany, France and neighbouring countries of the Baltic Region. During the past five years, the export to the Russian Federation, Belarus and Ukraine decreased by 40% and now constitutes less than 10% of the total amount.

During the last several years, after the implementation of the policy of reduction of fishing in the internal waters in order to ensure the sustainable use of the fish resources in the internal waters and reorganisation of non-economic activity and allocating support for the replacement of activity of fishing companies with another activity, the commercial fishing decreased by a half in the Lithuanian internal waters, and the commercial catch amounted to 1 thousand tons in these waters in 2010.

Currently, the commercial fish is reared artificially in nearly 9 thousand ha of aquaculture bodies in Lithuania, almost half of which are certified for the organic production. In 2010, the amount of 3.2 thousand tons of fish was reared and realised (one third of which – in organic farms) – three times more than the commercial fishing catch in the internal waters – of the total value exceeding 20 million Litas. However, in case of large demand of fresh fish in foreign markets, the export of this production also constitutes a large share (mostly to Poland, Latvia, Sweden, Estonia) – if in 2007, the export amounted to 36% of the aquaculture production, in 2010 – already 46%.

In addition to the already functioning Integrated Fishery Data Information System, the Maritime Fishing Vessels Data System and Fishing Vessels Satellite Monitoring System, the Fisheries Service under the Ministry of Agriculture performing the control of fisheries in the maritime waters expanded the list of systems with new installed Electronic Fishing Register System in 2010 and became the user of the Information System of Freight and Goods transported via the Klaipėda Seaport installed by SE Klaipėda State Seaport Authority. The use of this system allows more effective controlling of fishing vessels of third countries in the Klaipėda Seaport.

Furthermore, by enhancing the control of discharge and realisation of fishery products, the locations of unloading, initial sale and buying were approved in the Klaipėda Seaport in 2008. Based on the provisions of the EU Common Fisheries Policy, the control of the use of fishing resources performed namely during the initial sale forms the conditions for more efficient supervision of the use of fish resources. The initial purchasers of the fishing products started to be registered in the Fisheries Department under the Ministry of Agriculture of the Republic of Lithuania as far back as in 2005, whereas until the first half of 2011, there were almost three hundred in total, and until March of 2012 – 331. During the first buying and sale, the fish caught by the Lithuanian fishing companies in the Baltic Sea and unloaded in the Klaipėda Seaport are usually sold. However, a major part of fish caught in the Baltic Sea is still unloaded in foreign seaports, although the local users are constantly complaining about the lack of fresh fish.

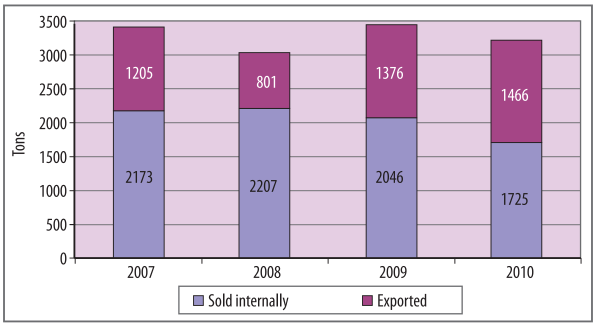



**Fig. 242.** Variation of realisation of Lithuanian aquaculture production in the markets, 2007–2010. *Source: Ministry of Agriculture*

When implementing the measures of the fourth priority "Sustainable Development of Fisheries Regions" of the Lithuanian Fisheries Sector Operational Programme for 2007–2013, during the period from 2008 to 2012, as much as 10 local operational groups of fisheries regions were established in Lithuanian regions having favourable conditions for the development of fisheries activity and the welfare of communities of which is closely related to this activity. Namely, these regions suffered the largest impact of the measures of conservation of commercial fish resources and reduction of fishing capacities restricting the direct volumes of commercial fishing. Therefore, the support under the measures of "Sustainable Development of Fisheries Regions" is allocated namely for the initiatives of the diversification of types of local activity performed by local fishing companies, communities and representatives of local self-government units, tourism development, increase of the value-added of the fisheries products, development of settlements, enhancement of qualification of the employees working in the fishery sector.

In order to develop the cooperation and experience exchange among separate regions, the National Network of Local Operational Groups of Fisheries Regions was established covering all currently operating regional operational groups. Furthermore, it is planned to increase the network by at least 5 additional operational groups of fisheries regions by 2020, because the sustainable development of regions is an important element of the EU Common Fisheries Policy for 2014–2020 having the same significance as the other three priority support areas – "organic" fishery, "organic" aquaculture and integrated policy on maritime matters.

One of the most important objectives of the National Strategic Plan for Fisheries Sector for 2007–2013 is to coordinate the commercial and recreational fishing in the internal waters as the Law on Recreational Fishing of the Republic of Lithuania stipulates the priority namely for the development of recreational fishing in the Lithuanian inland waters. The development of recreational fishing becomes increasingly intensive in Lithuania – more than 60 thousand permits for recreational fishing were issued in 2007, in 2008 – almost 74 thousand, whereas in 2009 – more than 85 thousand permits. The fishing of salmon and sea-trout becomes increasingly popular – if in 2006 only 5 licences were issued, in 2008 – 63, in 2009 – already 1,199, in 2010 – 1,216, whereas in 2011 – as much as 2,474 licences.

On 30 March 2012, a new procedure of issue of permits for recreational fishing came into force in Lithuania forming the more favourable conditions for the recreational anglers to acquire permits for the fishing in state water bodies, which are not rented. It will be possible to acquire these permits by electronic means, which become more and more ordinary these days, i.e., by using online information system of environmental permits or even by SMS. Furthermore, the prices of use of fish resources by recreational fishing that had not increased for almost twenty years and were by several times lower than in other EU Member States, were corrected and reached the prices of annual permits for recreational fishing applied in Estonia and Latvia. Thus, increasing the contribution of recreational fishing to the restoration of fish resources – all funds received for the issue of permits for fishing in state water bodies where fishing is not rented will be used exclusively for the increase and conservation of fish resources.

## IMPACT ON FISH RESOURCES OF MARITIME AND INTERNAL WATER BODIES

The main species of commercial fish in the Baltic Sea include sprats, cods, Baltic herring and plaice, an important species – salmon. Commercial catch that showed a gradual growth since 2000 achieved its peak during the period from 2007 to 2009, the amount of fish caught in 2007 and 2009 varied by approx. 27 thousand tons (almost three times more than in 2000), thus, achieving the volume of especially intensive fishing that occurred in the 1970s.

However, after the optimisation of the maritime fishing fleet in 2010, the Lithuanian fishing fleets caught only slightly more than 15.5 thousand tons of fish in the Baltic Sea, i.e., by 42% less than in 2009.

The majority of caught fish was composed by the catch dominating since the 2004: sprats – as much as 66%, cods accounted only for one fifth, Baltic herring – 10%, whereas plaice – approx. 3% of the total mass of caught fish. According to the data of fish monitoring, the abundance of fish and biomass was gradually decreasing in the Baltic Sea coastal zone during the period from 2007 to 2009. In the Baltic Sea coastal area, especially in the Northern part, the population of the majority of local fish species (turbot, European flounder, cod, etc.) were dominated by cubs, because the older fish were caught. Such results clearly indicated the necessity to reduce the intensiveness of fishing.

In order to manage the use of the most important maritime commercial fish resource, the quotas are established for fishing. In the Baltic Sea, the quotas for the fishing cods, Baltic herring, sprats and salmon are applied to Lithuania. For a long time, Lithuanian fishing companies were fully utilising only the quotas for cod catch (the most profitable species), whereas the quotas for fishing Baltic herring and sprats remained unutilised due to insufficiently developed infrastructure of fishing of these pelagic species, processing capacities and market.

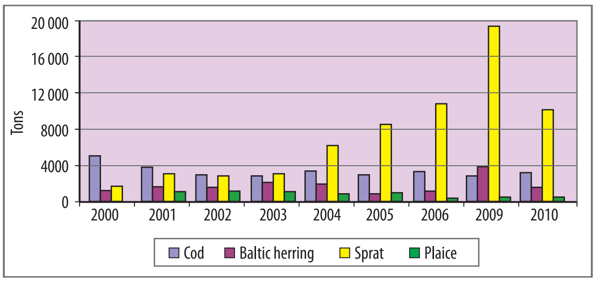



**Fig. 243.** Dominating species of fish among the Lithuanian commercial fishing catch in the Baltic Sea, 2000–2010. *Source: Fisheries Department under the Ministry of Agriculture, Lithuanian Statistics Department*

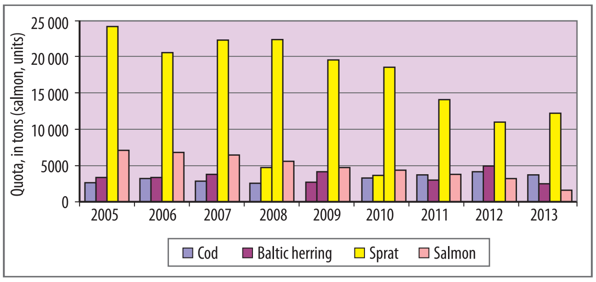



**Fig. 244.** Quotas applied to Lithuania for fishing in the Baltic Sea, 2005–2013. *Source: Ministry of Agriculture*

In order to protect resources of cod and form conditions for their restoration, the quotas for the fishing of this fish in the Baltic Sea were reduced almost annually for the entire decade. However, since 2008, after the start of implementation of the multiannual plan for the cod stocks in the Baltic Sea and the fisheries exploiting those stocks approved by the European Council in 2007, the state of resources of this most commercially important fish in the Baltic Sea has been improving for the last several years. The new scientific information shows the increase in the resources of cod, however, the nutrition range of this fish did not expand, causing the decrease in the weight of this fish.

On the other hand, the increased abundance of cod intensively feeding on the spawn and cubs of pelagic fish conditioned the decrease in the population of sprats and Baltic herring, especially in the southern part of the Baltic Sea. It formed the conditions for a slight increase in the quotas of cod fish – in 2010, the quota for fishing cod applied to Lithuania increased by 13%, therefore, the amount of catch also increased, whereas the amount of sprats and Baltic herring decreased after the establishment of fishing quotas of these fish and balancing of resources for 2013.

The main **internal and transitional water bodies**, where the commercial fishing is pursued, remained the same as in 2004–2007 – it is the Curonian and Kaunas Lagoons and the upper basin of the hydro accumulation power plant of Kaišiadorys.

According to the data of ichthyologic researches, although the fish resources of the **Curonian Lagoon** were more relatively stable for a certain period of time, however, for example, in 2008, as compared with 2007, the total fish biomass decreased by almost one thousand tons (approx. 10%). In view of this, it was recommended that by reducing the intensity of fishing in the Lagoon the quotas for fishing tools of companies ceasing their commercial activity should not be handed over to the remaining companies. Due to the decreased intensiveness of commercial fishing (in total, 18 fishing companies ceased their fishing activity in the Curonian Lagoon in 2008–2009, 76 fishing vessels were reoriented by reducing the fishing capacities by 294.7 GT, or by 42%), the fish resources started to restore in 2009. The experiment catch allowed the establishment that the total biomass of fish in the share of the Curonian Lagoon owned by Lithuania reached almost 9.4 thousand tons – mostly due to the increased resources of breams.

According to the data of scientific researches, since the very 1998, the fish resources have been constantly decreasing in the **Kaunas Lagoon** characterised by intensive commercial and recreational fishing. During the period from 2007 to 2009 alone, the total biomass of fish calculated by experimental catch decreased by almost 150 tons (from 1,229 tons in 2007 down to 1,080 tons) in 2009, furthermore, the average length, mass and fishing effectiveness of one of the most important fish – bream – continued to decrease. It showed an extensive intensiveness of commercial fishing in this water body, therefore, the decision was adopted to encourage some companies to cease the fishing business. Furthermore, this decision was accelerated by other circumstances – the Kaunas Lagoon is characterised not only by exclusive recreational importance, but also has a significant importance on the conservation of biodiversity – it is one of the most important areas in the continental Lithuania for the water birds during the periods of breeding and migration.

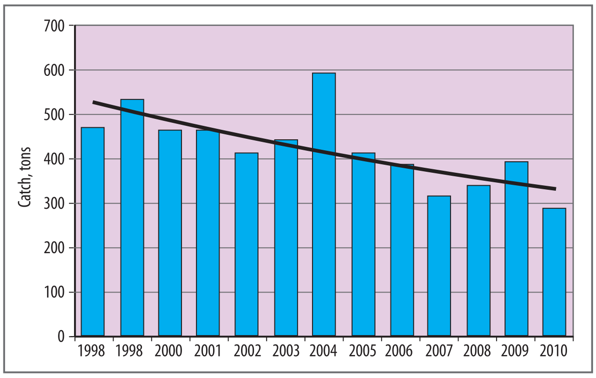



**Fig. 245.** Variation of commercial catch in the Lithuanian coastal area, 1998–2010. *Source: Environmental Protection Agency, Consortium of Maritime Researches*

Therefore, after the amendment of regulations of implementation of the activity area "Re-orientation of fishing vessels of the internal waters to other than fishing activity" of the Operational Programme of the Fisheries Sector for 2007–2013, an opportunity was stipulated for the companies pursuing fishing activity in the Kaunas Lagoon to re-orient to other activity and cease the commercial fishing in this water body. The compensations for vessels and possessed quotas of fishing tools and catch were established, whereas in 2010, the new regulations for the commercial fishing in the internal waters were approved establishing that the commercial fishing would be forbidden in the Kaunas Lagoon and Kruonis hydro accumulation power plant's higher reservoir from 2013. The latter provision was adopted in order to encourage the companies fishing in the Kaunas Lagoon to use the EU support and re-orient the non-perspective fishing business to other activity. By applying these measures, the opportunity to reduce the fishing quota by two thirds in the Kaunas Lagoon occurred in 2010. In 2011, same as in 2010, commercial fishing in the Curonian and the Kaunas Lagoon and certain other national water bodies was also restricted – its intensiveness, as compared with the previous year, was reduced by 56% in the Kaunas Lagoon and by 37% in the Curonian Lagoon. This could be done due to reduced number of fishing companies that ceased fishing business by using the support from the EU Fisheries Fund. Since the very 2010, the fish resources started to increase in these water bodies and more favourable conditions for the recreational fishing were formed.

One of the most significant factors negatively influencing the majority of the commercial fish resources is namely the **commercial fishing**. The reliable impact of the commercial fishing on the diversity of fish communities was established by implementing HELCOM FISH and HELCOM FISH-PRO projects during which the state of the fish communities of the coastal area of the Baltic Sea and the impact caused on them were evaluated. The results showed that the intensiveness of commercial fishing results in the significant decrease of the indicator of variety.

Although the impact of fishing on this indicator is of long-term nature, especially in the Lithuanian coastal area, however, due to the decline in the number of fishing companies in the coastal area and inland waters in the recent years, it is characterised by the tendency of decreasing. However, it is still suggested that nearly one third of the Lithuanian rivers and more than 80% of the lakes incur strong or even extremely strong impact of fishing.

The increase in the number of **hydro power plants** was probably the most threatening factor in the 1960s–1970s reducing the sources of migratory fish in Lithuania.

The main negative impacts on the fish resources caused by hydro power plants include the frequent variation of water level in the river below power plant, physical damage to fish caused by turbines, furthermore, after the construction of the damp, and the affluent virtually changes the hydrological mode of river by destroying the habitats above the damp.

Usual and naturally non-characteristic rapid changes of the water level condition the perishing of fish spawn and fry, when they pass to the land (after the drop of water level due to water retention) or to habitats unsuitable for development (carrying with the water mass after repetitive turn of turbines).

Out of 84 hydro power plants currently operating in Lithuania, as much as 57 cause significant impact on the water bodies. According to the data of the Environmental Protection Agency, of 1,177 water bodies, 28 bodies do not meet the requirements of good ecological state namely due to the impact of hydro power plants. In total, there are 126 water turbines installed in small hydro power station operating in Lithuania, as much as one fifth of which are formed of so-called Francis or inward-flow turbines that cause a particular damage to fish. When replacing the turbines with more advantageous, adapting to any kind of debit, by optimising their functioning, it is possible to reduce the damage caused to fish and other negative impact on the fish resources. However, in case of absence of other measures, there remains the impact of excessive height of affluent and low flow of affluent, the elimination or even mitigation of which is, unfortunately, impossible.

Restoration of migration routes, forming the opportunities to expand the number of rivers and springs with proper conditions for spawning of salmon fish – is a complex task of limited effectiveness not only in Lithuania. For example, as it is indicated by the data of separate researches, the effectiveness of the so-called "Denil" type fish-ladder or permeability for salmon amounts to only 25–39%. The increase of the network of fish passes and their permeability occurs insufficiently rapidly in Lithuania – in 2013, it is planned to install 2 new fish passes – in the damps of Sausdravas River (Plungė region) and Kražantė River (Kelmė) and restore the fish migration route especially in the Vilnia River near Rokantiškis damp especially important for the salmon.

A new potential threat caused to the stability of traditional commercial fish resources in the Curonian Lagoon and the Baltic Sea coastal area is by the alien invasive species characterised by an extremely rapid spread – **Round Goby** (*Neogobius melanostomus*), becoming one of the main catch of recreational fishing in the Baltic Sea. It is believed that this very intensively spreading fish came to the Baltic Sea (Gdansk Bay) in about 1990, and, barely a decade after, it was already found in German, whereas in 2002 – in Lithuanian waters. Since round goby mostly feeds on *D. polymorpha* and mussel in the Baltic Sea and Curonian Lagoon, characterised by effective filtration functions, there is a risk that in case of significant decrease in these molluscs, the quality of water can deteriorate, the decreasing amount of oxygen will condition increasingly intensive algae blooms and the worsening living conditions for other fish. Furthermore, this fish can cause direct negative impact on the effective feeding and spawning of valuable commercial fish, because due to habitats and nutrition base they compete with the important commercial species of benhtopelagic fish, for example, turbot, plaice, live-bearer burbot, as well as feed on their spawns.

Although sometimes fishermen indicate one more factor decreasing the resources of commercial fish in the Curonian Lagoon, i.e., the Great Cormorant (*Phalacrocorax carbo sinensis*), the colony of which is settled in the Curonian Spit near Juodkrantė. However, having evaluated the volume of impact of these birds on the commercial fish resources, the scientists determined that in the ration of cormorants, the absolute majority (82.9% by number and 73.6% by mass) is composed by low-value small fish – ruff, bass and roach, of the average length of 9.5 cm and weight of 16.8 kg.

It should be noted that ruff is the competitor of one of the most important commercial species – bream – due to nutrition base in the Curonian Lagoon, therefore, by regulating the number of ruff and other low-value fish, cormorants are naturally contributing to the balance of the commercial fish resources in the Lagoon.

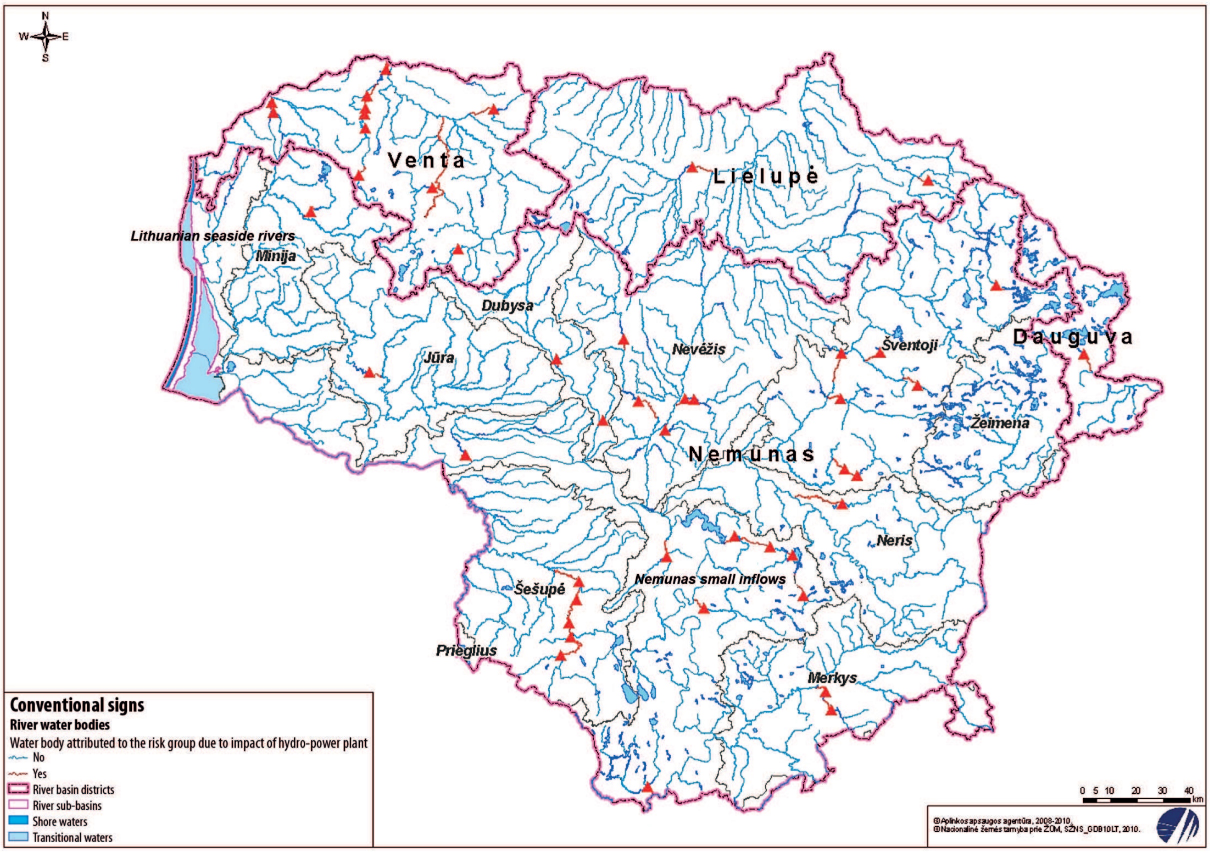



**Fig. 246.** Hydro power plants causing a significant impact and water bodies attributed to the risk group due to impact of hydro power plants. *Source: Environmental Protection Agency*

## PROTECTION AND INCREASE OF THE MIGRATORY FISH RESOURCES

The most valuable species of commercial fish in Lithuanian inland waters are migratory. The following migratory commercial fish are living and breeding in Lithuania: lamprey, twaite shad, salmon, sea-trout, whitefish, smelt, vimba, and eel.

**Salmon and sea-trout** constitute one of the most valuable migratory fish resources. Mature Atlantic salmon migrate from the Baltic Sea to spawn in the cold-water rivers of the Nemunas basin. After the construction of Kaunas Hydro Power Plant in 1959, having the damp of the length of 1.5 km, the affluent of Nemunas River of the height of 25 m conditioned the isolation of the upper reaches of Nemunas basin. The entire Merkys basin was lost and many other rivers, thus, according to newest calculations, destroying up to as much as 80% of vimba and half of salmon population.

The habitats of salmon fish also suffered negative impact from the straightening of river channels. The number of areas suitable for spawning showed a considerable decrease, for example, according to the data of the Environmental Protection Agency, in the region of Nemunas River basin alone, nearly one third of river channels were straightened, including the rivers of Žeimena and Šventoji that are essential for the salmon fish (almost one quarter of these rivers were straightened), Minija – 11%, Jūra – 18%, Dubysa – 32%, whereas of seaside rivers – almost up to 48%. In 1981, salmon was included into the Red List of the Endangered Species of the Lithuanian SSR, and for more than 20 years, this fish has been included into the Red List of Endangered Species of independent Lithuania. Recently, a significant negative impact on migratory fish resources has also been caused by the regulation of hydrological mode of rivers and illegal fishing.

In order to increase the protection of salmon spawning, the procedure of recreational fishing was enhanced in 2009 and the list of 161 river salmons was approved. It was stipulated that during the period of spawning of river trout and sea-trout – from 1st of October to 31st of December – any kind of fishing should be prohibited. In Neris River and other major rivers, the sections of spawning and accumulation of salmon were singled out, where only restricted fishing is permitted from 16th of September to 15th of October, whereas from 16th of October to 31st of December, any type of fishing is forbidden in these areas. The fishing of salmon and trout in the sea is permitted with permit for recreational fishing. As it is stipulated by the regulations of the recreational fishing, one item of salmon or trout can be caught per day. The commercial fishing of salmon and trout is prohibited in internal waters during the entire year.

In the main places of accumulation and spawning of salmon and trout, any kind of fishing is permitted only with licence (since 2012 – angler's card for restricted fishing).

The Programme of Restoration and Protection of Lithuanian Salmon Resources for 1997–2010 and action plan approved by the International Baltic Sea Fishery Commission in 1997 expired in 2010. Before the approval of this plan, the populations of salmon existed in Žeimena and Neris Rivers only. As it is suggested by the data of the state monitoring of migratory fish, the plan was implemented rather successfully. Based on the Programme of Restoration and Protection of Lithuanian Salmon Resources, the important measures for the improvement of salmon fish resources were performed in 1998–2010. They include not only intensive artificial rearing, but also the protection of spawning sites – each year, during the time of spawning of salmon, the action "Salmon", which was especially favourably assessed by the scientists, was conducted and used for the protection of salmon resources against illegal fishing. The water bodies or parts of them characterised by the most intensive migration of salmon and seas-trout were constantly protected, including the Baltic Sea coastal area, the Curonian Lagoon, the region of Nemunas Delta and the Nemunas River, as well as the rivers with typically abundant spawning sites – Neris, Žeimena, Mera, Siesartis, Vilnia, Šventoji. According to the results of the scientific research, this campaign is one of the most effective preventive measures resulting in the increase the resources of salmon for some time already. These measures were implemented annually and gave the noticeable results.

The state of population of salmon and sea-trout gradually stabilised in Lithuania and later the abundance of the juvenile of these species started to increase rapidly both in Neris and Žeimena Rivers that are essential for salmon, and in their inflows – rivers, where salmon was already extinct.

Currently, salmon populations are restored in twelve rivers. Salmon juvenile are found in many areas of Neris River, the amount of salmon was restored in Šventoji, Siesartis, Vilnia, Vokė, Dubysa, Minija rivers and some inflows, also, salmon juvenile are found in the lower reaches of medium and smaller rivers that are essential for salmon.

As suggested by the data of monitoring, the total amount of salmon juvenile started to increase gradually in 2004–2005 and especially increased in 2007–2009. The largest change was recorded in Šventoji River basin, where the average density reached even 13–17 individual/100m$^2$, whereas in Šventoji River – 7.5 individuals/100m$^2$. In Neris River basin, the average density of salmon juvenile increased from 0 to 3.71 individuals/100m$^2$, whereas in the Neris River – up to 7.6 individuals/100 m$^2$.

During the discussed period until 2011, the total density of salmon juvenile increased up to 6.9 individuals/100m$^2$ in Žeimena River, whereas in Žeimena River basin – the total abundance increased up to 2.3 individuals/100 m$^2$. These indicators are the maximum during the entire period of researches. Žeimena River is considered to be the background salmon river, therefore, save for the environmental measures, no other measures of increase of resources are applied, stocking works are not performed, therefore, the amount of salmon juvenile mostly depends on the total ecological condition of river and impact of climatic factors (hydrological conditions, variation of water temperature). The variation of these factors also influences the abundance of salmon juvenile; therefore, the changes of variation of salmon juvenile are monitored in different years.

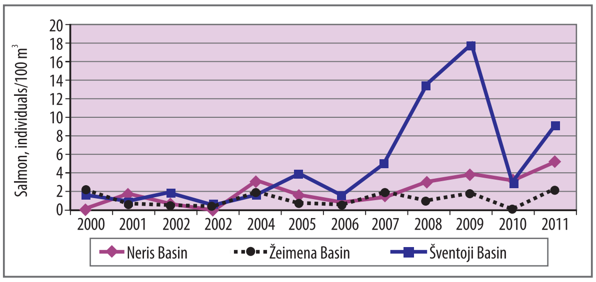



**Fig. 247.** Dynamics of abundance of the salmon juvenile in Neris, Žeimena and Šventoji river basins, 2000–2011. *Source: Environmental Protection Agency*

The year of 2010 was extremely unfavourable to salmon juvenile. The poor spawning of the previous year and unfavourable climatic conditions (heavy ice-drift in spring destroyed the spawning sites located in the banks of the rivers, and, in the second half of summer, the water temperature reached 23–26°C and was lethal to salmon juvenile); therefore the abundance of juvenile in majority of South-East Lithuanian rivers decreased, as compared with the previous year.

However, in 2011, the ecological conditions in Žeimena River were very good, therefore, the abundance of salmon juvenile showed a particular increase. The amount of salmon juvenile is directly influencing the production of salmon smolts – it particularly increased in 2008–2010 and reached 47,83 individuals per year. In 2011, the amount of smolts decreased down to 6,656 individuals due to unfavourable ecological conditions of 2010.

Sea trout is more abundant in Lithuanian rivers than salmon. This species is found in more than 80 Lithuanian rivers. The amount of sea-trout juvenile showed extreme variation during the discussed period. In 2011, it increased in Žeimena River and reached 11.5 individuals/100m$^2$, whereas in Šventoji River – as much as 25.7 individuals/100 m$^2$. As usual, the amount of sea-trout smolts was significantly higher in small and medium size rivers: The recorded maximum abundance reached as much as 136.5 individuals/100m$^2$. The production of sea-trout smolts varied from 5 to 15 thousand individuals in different years, whereas in 2011 the production of smolts reached nearly 11 thousand individuals in the Eastern Lithuanian rivers, in Neris basin – more than 3.7 thousand, in Žeimena basin – almost 2 thousand, whereas in Šventoji basin – more than 5 thousand individuals.

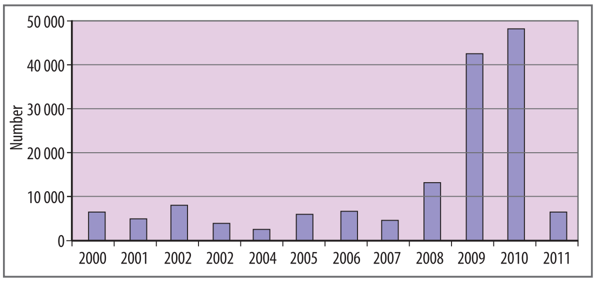



**Fig. 248.** Total production of salmon smolts in Lithuanian rivers, 2000–2011. *Source: Environmental Protection Agency*

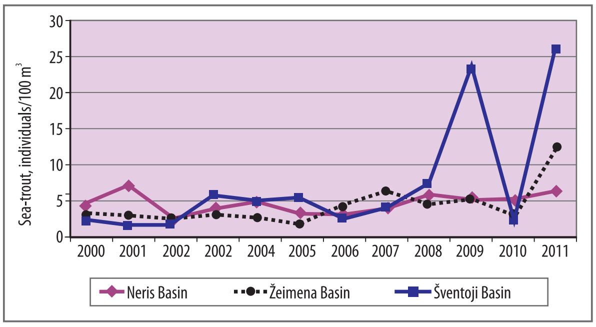



**Fig. 249.** Dynamics of abundance of the sea-trout juvenile in Neris, Žeimena and Šventoji river basins, 2000–2011. *Source: Environmental Protection Agency*

According to the information of scientific researches, 12.5 thousand sea-trout migrated to spawn in Lithuanian rivers in 2011. It is a record number during the past twenty years (in 2010, the number was by half-smaller – only 5.8 thousand). In 2011, the number of salmon swimming to spawn was also higher as compared with previous year – 6.4 thousand. The spawning of salmon was also successful – in many examined rivers, there were more nests of river salmon and they occupied larger area than in previous year. Therefore, according to the evaluation of the scientists exploring fish resources, in 2011, salmon was crossed out from the list of protected species of fauna, flora and fungi of the Republic of Lithuania. However, it is still protected under the EC Directive on the conservation of natural habitats and wild fauna and flora, therefore, in order to maintain good state of salmon resources, their fishing should be restricted. Although the resources of fish increased, according to the data of scientists, the resources of salmon of another thirty rivers flowing into the Baltic Sea are still facing with danger of extinction. The proposal on the Regulation of the European Parliament and Council was prepared and started to be coordinated in 2012 establishing the multiannual plan of management of the Baltic salmon resources and fishing by using these resources.

**Eel** is one of the most valuable species of commercial fish not only in Lithuania but also in other countries. Its resources have been rapidly decreasing and, according to the data of the International Maritime Research Council, are currently out of the biologically safe margin. The preventive measures were started to be implemented in Lithuania from 2008, reducing the impact of fishing on unstable eel resources. For example, the number of rivers where the fishing of migrating eels is permitted was decreased by 40%, and it was forbidden to use eel catchers in lakes during the spawning period. At the end of 2009, the European Commission approved the plan of restoration of European eel resources in Lithuania. In 2010, the commercial fishing of eels was restricted in Lithuania.

**Smelt** is the most abundant migratory fish in the Baltic Sea coastal area and the Curonian Lagoon. They have quite a significant commercial and recreational significance, therefore, receives a particular focus, the abundance is evaluated annually and fishing is regulated. Until 1990, the commercial fishing of smelt was not performed in the Baltic Sea, however, during the recent decades, this fishing has become more intensive: in 1993, more than 16 tons of fish were caught, after a year – almost 21 tons, whereas in 1999 – as much as 216 tons of smelt. In 2005, in the Baltic Sea alone the smelt catch exceeded 165 tons, whereas in the Curonian Lagoon and Nemunas Delta – 200 tons. In 2009, in the Baltic Sea coastal area, 107 tons of fish were caught, however, in 2010 – only 17 tons of smelt. Smelt is short-lived fish; therefore, even an intensive fishing does not cause a significant harmful impact on its resources. According to the scientists, up to half of its resources can be caught without causing damage to the population. According to the data of R. Repečka, the smelt resources of Nemunas population can amount up to 2,700 tons. The variation of smelt abundance is highly influenced by the natural and hydrological conditions. However, when observing the recorded tendency of small decrease in the abundance of smelt, which can be maintained by too intensive fishing for atypically long period of time, the commercial fishing of smelt returning from spawning has been prohibited in the Curonian Lagoon since 2003. The limit of smelt fishing sites and tools in Nemunas lower reaches has been recorded and the volume of smelt fishing in the Baltic Sea coastal area has been restricted.

The decrease in the resources of **lamprey** has recently become particularly noticeable. Therefore, in 2012, 8 rivers were eliminated from the list of rivers where limited fishing of this fish was permitted.

## PROTECTION AND RESTORATION OF THE MIGRATORY FISH RESOURCES

The most important species of commercial fish, which receive the highest focus during the stocking in the internal waters, include whitefish (Vištytis and Plateliai), vendace, zander, burbot, pike, catfish, eel, tench, crucian, carp, and the most valuable salmon fish – salmon, sea-trout and river trout.

Until 2009, the resources of peleds were also restored (for example, in 2008, it was planned to release approx. 9 million smolts of this fish). More than 90% of all artificially reared fish used for stocking are released into the state water bodies, where the permits to use the fishing area are not issued.

In view of the regulation adopted by the European Council in 2007 stipulating the measures for the restoration of European eel resources, the EU Member States must prepare the national plans for the restoration of resources of these species and take measures to enable at least 40% of migrating eel to reach the sea. In 2011, Lithuania started to implement the project for the implementation of the plan of management of eel resources prepared under the activity area "Support for the Implementation of the European Eel Resources Management Plan in Lithuania" of measure "Measures Intended to Protect and Develop Aquatic Fauna and Flora" of the Operational Programme for the Lithuanian Fisheries Sector for 2007–2013. The 134 thousand reared European eels were released into 21 water bodies of national importance. In 2012, 110 water bodies of national importance suitable for rearing eels were stocked with 440 thousand reared eels, whereas in 2013 it is planned to acquire another 1 million European eels of glass stage and introduce them into a similar amount of water bodies of national importance suitable for rearing eels.

Although **live-bearing burbots** are characterised by exclusive prolificacy, the majority of their spawns are destroyed by bass, ruff and other fish, as well as more and more frequent floods starting even in the wintertime during spawning period. Despite the several-year intensive artificial rearing, the resources of burbots have not shown significant increase in Lithuania. Therefore, the protection of natural resources, especially spawning sites is probably the only opportunity of their increase. The recreational fishing during the migration and spawning period of burbots was prohibited in 2006 – as suggested by the data of scientific research this measure formed the conditions for the obvious revival of burbot population.

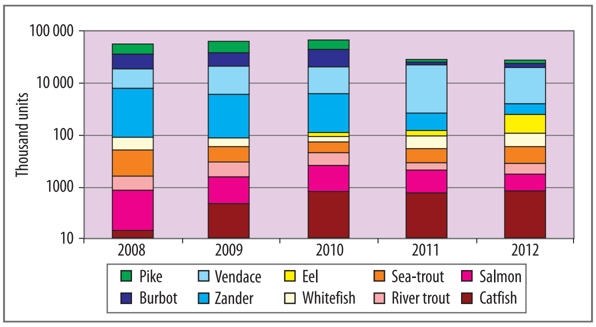



**Fig. 250.** Main changes of the amount of stocking of the most important restored commercial fish in the water bodies of national importance, where the permits for fishing are not issued, 2008–2012. *Source: the Ministry of Agriculture*

In 2012, when implementing the Operational Plan on the Baltic Sea of the Helsinki Commission signed by the members of the Baltic Sea region in 2007 and obligation to join the works of restoration of sturgeon resources, the programme of restoration of population of **American sea sturgeon** in Lithuania for 2012–2020 was approved.

The aim of this programme is to create the conditions for the restoration of conservation of the population of America sea sturgeon (*Acipenser oxyrinchus*), the species included into the List of Protected Species of Fauna, Flora and Fungi of the Republic of Lithuania. American sea sturgeon is one of the mostly going extinct species of sturgeons included into the Red Lists of Endangered Species of Russia, Germany, Poland, France and Lithuania. As it is indicated in the programme, by the end of the 19th century, these sturgeons (Atlantic sturgeon (*A. sturio*) was previously considered to habitat in Lithuania) were found in the Baltic Sea, Nemunas and its inflows – Neris, Merkys, and Šventoji. The increasing water pollution, river dams and melioration impoverished the habitats, destroyed the majority of spawning sites and especially intensive (even during spawning period seeking for profit from trade in spawn) and uncontrolled commercial fishing conditioned the extinction of this species in Lithuania in the midst of the 20th century. The last individuals were caught in the Curonian Lagoon in 1960, Nemunas – in 1962, near Palanga – in 1975. After the start of implementation of restoration of resources of this fish, approx. 13 thousand smolts of American sea sturgeons were released into Neris and Šventoji Rivers in 2011–2012, part of them being the smolts already reared in Lithuania – Rusnė.

## OTHER NATURE RESOURCES

Another species of wild fauna, the use of which is regulated by the orders of the Minister of Environment, in order to preserve the stability of resources – the Burgundy snail. Almost all resource of **Burgundy snail** collected in natural and semi-natural environment are exported. After the permission to use the resources of snail, the access to contribute to the restoration of these resources was also formed. If in 2002 it was permitted to collect 500 tons of snail, in 2006 – 780 tons. According to the data of the Department of Statistics, the annual amount of snail purchased in Lithuania has stabilised recently and amounts to 350 tons per year.

At the moment, snails are purchased and processed by four companies and there are 150 snail purchase points operating in Lithuania. In case of demand and increasing popularity of rearing of Burgundy snails in farms, it is likely that the volumes of collection of snails in natural environment will decrease in the future.

The resources of vegetal origin forming the main share of the so-called small nature assets are used at different intensity. The majority of such resources include mushrooms, the collection and purchase of which can be characterised by great variation in different years. Other natural resources of such type include berries, herbs, and nuts.

The statistics of small nature assets collected by residents and used for personal needs is not accumulated, therefore, it is possible to evaluate and compare only the purchased amounts of these resources.

The amount of **mushrooms** harvest is conditioned by the climatic conditions, especially rain (moisture) and temperature. According to B. Vasilkovas, in productive years, it is possible to collect 100 kg of edible mushrooms in one ha of forest in Lithuania. In total, according to information of various authors, the average annual harvest of edible mushrooms can amount to 16–30 thousand tons in Lithuania, whereas the biological harvest is likely to be by twice greater as suggested by A. Urbonas. However, the varietal structure of mushrooms harvest is also difficult to forecast, it can be quite different in different years. According to J. Mazelaitis and A. Grincius, the year 1957, for example, was characterised by a particular abundance of Edible Boletus in Varėna forests, however, the next such productive year for this species was recorded only after 7 years – only in 1964. Up to one third of the harvest of edible mushrooms are annually lost due to damage cause by worms.

In the 1980s, the points of prepared mushrooms collected 300–500 tons of mushroom each year (according to V. Urbonas, this amounts exceeded 1,000 tons only in very productive years), and usually of 3–4 species. In the 1990s, the volumes of purchase increased gradually and almost 4 thousand tons of chanterelle and edible bolete were purchased in 1996. At the end of 1990s, the purchase varied from 2-4 thousand tons and only especially dry 1999 resulted in a purchase of less than 1,000 tons of mushrooms – barely 838 tons.

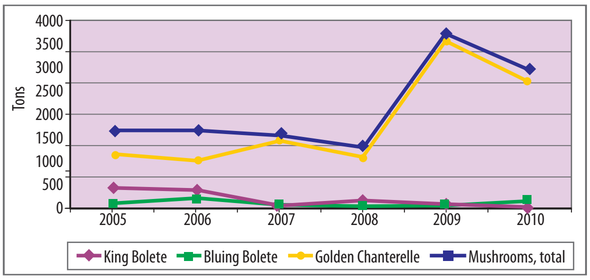



**Fig. 251.** Purchase of mushrooms, 2005–2010. *Source: Lithuanian Department of Statistics*

According to various evaluations, the residents annually collect and another 7–11 thousand tons of edible mushrooms and use for personal needs.

In the recent years, the mushrooms of several tenths of species are usually purchased each year, the most common species – King (Edible) Bolete, Velvet Bolete, Orange-capped Scaber Stalk, Bluing Bolete, False and Common Morel, Dotted-stalk Suillus, Chanterelle, Man on Horseback, Delicious Milky Cap, Horn of Plenty, Honey Mushroom, Northern Milk-cap. The main species of purchased mushrooms are Chanterelle, Edible Bolete and Bluing Bolete, which has become popular recently. The amounts of the majority of other species are insignificant, slightly larger amounts of purchase are characteristic to False Morel, Orange-capped Scaber Stalk and Velvet Bolete (the significant amount of the latter (as much as 89 tons) was purchased in 2010).

Chanterelles usually account for 84-96% of all purchased resources of mushrooms. During 2005–2010, the amount of purchased mushrooms increased from average amount of 1.6 thousand tons in 2005–2007 up to 3.7 thousand tons in 2009, whereas in 2010 – reached almost 3 thousand tons. Smaller amounts purchased of Bolete and Man on Horseback.

The collection of **forest berries** slightly increased from 2005 and exceeds thousand tons almost each year (1,312 tons were purchased in 2009), however, usually only bilberries. The amounts of purchase of other forest berries are decreasing; the collectors are usually engaged in more intensive and cost-efficient use of small forest assets – bilberry and chanterelle. In the 1960s, the amounts of collected bilberries were mostly equal to the currently collected amounts – 800–1000 tons per year, however, the amount of collected cranberries and cowberries was significantly higher – in total, almost 700–800 tons per year – i.e., by several ten times more than recently. Currently, 6–7 types of forest berries and fruits are purchased regularly – usually forest raspberries, cowberries, blackberries, bilberries, cranberries, strawberries, buckthorn and rowan fruits. The major share of purchased forest berries and fruits is composed by bilberries; approx. 1,000 tons and more are purchased annually, only in 2008 this amount was almost three times lower and amounted to 325 tons. The amount of purchased crowberries and cranberries is significantly lower. If the amount of purchased crowberries varies from several to several tens of tons (9.83 tons in 2006, 3.18 tons in 2007, 23.52 tons in 2008, 11.06 tons in 2009, and 16.59 tons in 2010) during the last several years, the amounts of purchased cranberries were insignificant. For comparison, in 2008 – almost 46 tons, during the last 2 years – barely several hundred kilograms. The larger amounts of buckthorn berries are purchased in different years – especially during the recent years. Almost 576 tons were purchased in 2008, most likely by partly compensating the income from small harvest of bilberries.

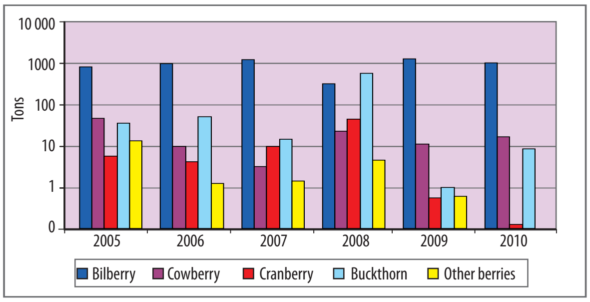



**Fig. 252.** Purchase of forest berries, 2005–2010. *Source: Lithuanian Department of Statistics*

Use of **medicinal plants** and **reed** resources also varies in different years due to not only climatic conditions, harvest, purchase prices and demand, especially of cane, which is dictated by the construction fashion – for example, the developing market of coating roofs with cane.

If at the end of the previous century the amounts of purchased cane amounted from several to several ten tons, in 2001, the purchase suddenly increased to almost 200 tons. During the period from 2005–2010, the most impressive amount – more than 770 tons – was purchased in 2005.

Lithuanian pharmacopoea includes 189 species of medicinal plants, whereas the number of the species of aromatic plants, according to L. Šveistytė, exceeds one hundred. As suggested by the statistical data, the areas of medicinal and berry plants cover almost 198 thousand ha, berries – approx. 140 thousand ha. Almost half of the area of berries (47%) is occupied by bilberries, approx. 15% – by cranberries, slightly more than one tenth – by raspberries. In view of the medicinal plants, the largest areas are occupied by junipers, alder buckthorn and ground pines. There are seven seed (genetic) plots of medicinal and aromatic plants – Dusia, Bestraigiškė (Lazdijai region), Prienai (Prienai region), Veliuona, Kasikas (Jurbarkas region), Labanoras (Švenčionys region) and Dieveniškės (Šalčininkai region). The seed (genetic) plots of medicinal and aromatic plants attributed to national genetic resources of plants occupy the total area of more than 76 ha. These plots are mostly located in forest habitats.

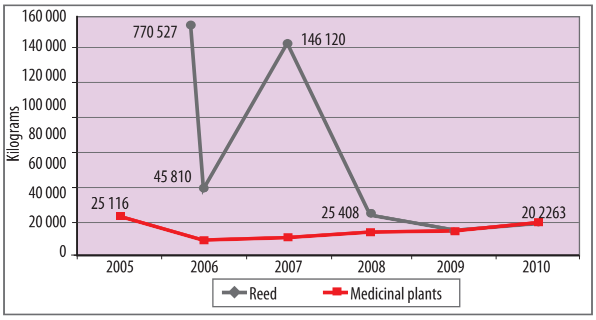



**Fig. 253.** Purchase of reed and medicinal plants, 2005–2010. *Source: Lithuanian Department of Statistics*

The negative impact on the medicinal and aromatic plants and their habitats is caused by the increasingly intensive agricultural activity and its uncoordinated development when the land use, cultivation of natural meadows is virtually changed, intensive forestry, spread of invasive species, soil erosion. Quite a significant amount of species of medicinal and aromatic plants are growing in meadows, therefore, the changes of the structure of meadows have a significant impact on the amount and quality of vegetal resources – the natural vegetation is lost not only due to sowing, but also due to ceased traditional use – abandoned meadows with bushes and young stands. Processes of melioration and operation of peatbogs due to which more than two thirds of various types of swamps were lost, seriously damaged the population of medicinal plants that used to grown in fens and bogs. According to L. Šveistytė, the human-induced loss of growing places conditioned the decrease of such medicinal plants as Calamus, *Menyanthes*, Common Centaury, Jacob's Ladder, *Salvia pratensis L.*, sundew, etc., whereas the use of pinewoods decreased the resources of bearberry, wild thyme, common juniper, dwarf everlast.

According to L. Šveistytė, approx. 300 tons of medicinal plants are processed in Lithuania each year, approx. 50% of which are brought from foreign countries, approx. 30% – collected in natural and semi-natural environment, the remaining 1/5 is grown in industrial farms of medicinal plants (approx. 60 tons). At the end of the 1990s, the purchased amounts of this raw material amounted to approx. 80–90 tons, however, since 2000, this amounts is only about 20–30 tons – approx. 1/3 of the previous purchase volumes. Approx. 20.3 tons of medicinal plants were purchased in Lithuania in 2010 – mostly nettle and Menyanthes leaves, blossom of dwarf everlast, thyme, knot-grass, tutsan. In view of medicinal plant fruits, which constitute a relatively small share of all purchased forest berries and fruits, hawthorn fruits and bearberries are mostly purchased.

# ENVIRONMENTAL OUTLOOK AND SCENARIOS

# Climate Change

## LITHUANIA'S CLIMATE OUTLOOK UNTIL 2050

The future climate changes are mostly associated with the concentration of greenhouse gas emissions. In 2000, the Intergovernmental Panel on Climate Change (IPCC) published a special report on the possible scenarios of greenhouse gas emissions and other emissions important for the development of climate sphere (Special Report on Emissions Scenarios, 2000). The Lithuania's climate forecasts have been composed by using the output data of modelling based on two emission scenarios (A1B and B1). The A1B scenario stipulates a very fast economic growth, increase in population number until the midst of 21st century and later the decrease, fast installation of modern technologies and balanced consumption of fuel. Based on the B1 scenario, it is likely that fast globalisation, the variation of population number is similar as it is stipulated in A1B scenario, but especially fast turn of economic system to informational and less consuming society, intensive installation of new clean technologies is likely to occur. The data of these scenarios – output data of general circulation model (GCM) based on which the world climate research centres model the future climate changes.

The global climate change results in a special focus on the possible changes of climate extremity. The change in the medium conditions usually remains less noticeable than increasing and less occurring extreme climate phenomena. In this aspect, the regional differences are clear: due to the impact of local factors (topography, distance from the sea, etc.), sizes of low-likelihood extremities can be very different even in the neighbouring territories. Therefore, the forecasts of Lithuanian climate were subject to the regional climate model CCLM (COSMO Climate Limited-area Model), under which the modelling includes the application of dynamic resolution reduction method. The initial conditions for the dynamic reduction of resolution are received from ECHAM/MPI-OM general circulation model.

CCLM was created for weather forecast and applied by the German Weather Service from 1999. CCLM model is also applied to the climate change researches and covers the entire part of the European territory. The size of its mesh grating is 20x20 km. The results of modelling output are provided for two periods: reference 1971–2000 and prognostic 2001–2100 (Domms, Schättler, 2002; Steppeler et al., 2003). In this chapter, the Lithuanian climate forecast is presented in the near-term future for 2021–2050.

# Air

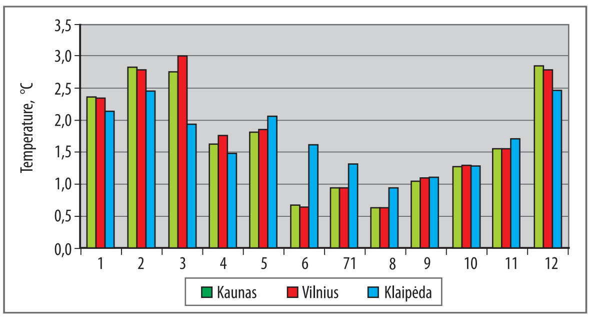
## AIR TEMPERATURE

The air temperature will increase in Lithuania's territory. Pursuant to the output data of the model, in the midst of the 21st century, the average annual air temperature will be 1.6–1.8°C higher based on A1B climate scenario and 1.3–1.4°C higher based on B1 scenario, as compared with the end of the 20th century.

Air temperature will rise in all months of the year although more significant changes are forecasted for the cold season (Fig. 254). Based on A1B scenario, the most significant changes (>2.5°C) are planned for the months of February, March and December, whereas the less significant changes will be of the temperature of June-August (0.7–0.9°C).

Based on the B1 scenario, the most significant increase (>2.5°C) will NCObe in December, whereas the changes of June will be minimum – on average, the air temperature in Lithuania will be 0.3°C higher. The territorial differences of forecasted changes are also noticeable. In the seaside, the air temperature will rise during the cold season, whereas the likely changes will be higher in summer than in the remaining part of country's territory. It indicates the decrease in spatial differences (especially in summer) in Lithuania's territory.

a)




b)

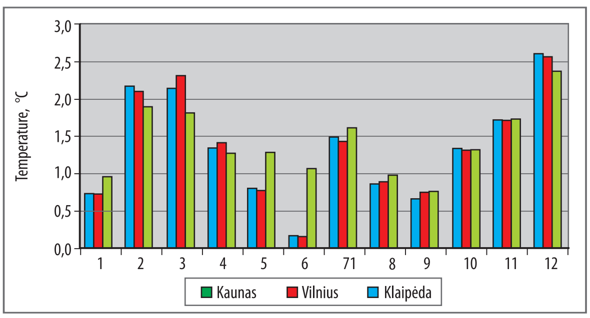



**Fig. 254.** Forecasted air temperature changes in Lithuania in 2021–2050, as compared with basal period of 1971–2000, according to CCLM model A1B (a) and B1 (b) climate scenarios *(E. Rimkus, 2010)*

The rise of air temperature will be accompanied by the repetition of extreme temperatures. During the warm season of the year, the number of hot days (with the maximum air temperature at ≥30°C) will increase and the most significant changes are forecasted for July. Furthermore, such hot days will be more frequently recorded not only in summer, but also in April-May and September. The number of cold days (<–20°C) will decrease in the future and the most negative tendencies of the number of such days are forecasted for January. On the other hand, the likelihood of repetition of short, but strong waves of cold will remain relatively high in January and February.

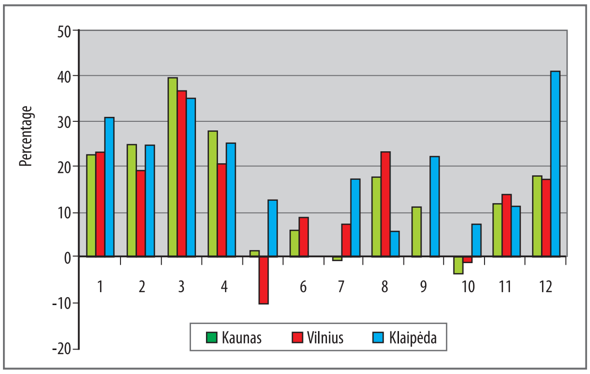
The rise of air temperature will be accompanied by the decrease in the average number of days with snow cover. By the midst of the century, their number should decrease by 20–35 days, on average (higher changes are stipulated by A1B climate scenario). The likelihood of the formation of constant snow cover will also decrease. The average maximum thickness of snow cover should also decrease by 5–7 cm.

## PRECIPITATION RATE

Modelling results based on A1B climate scenario stipulate a significant increase in precipitation rate in Lithuania's territory in the first half of the 21st century. The annual precipitation rate should increase by 60–150 mm (i.e., 9–19%). The increasingly stronger western and southwest air carry will condition the increase in the precipitation rate in Lithuania's seaside areas and the Samogitian highlands. It means that the territorial differences of precipitation rate will further increase in Lithuania's territory. The precipitation rate is likely to increase the most in March (>30%), whereas in May, June and October, only minimum changes are forecasted (Fig. 255, a).

In May, the precipitation rate in Eastern regions can even decrease (down to 10% in Vilnius). Higher changes during the cold season are related to a significant increase in air temperature during the cold season: warmer and more moisture containing air masses will bring more precipitation (mostly in liquid state). The seaside areas will suffer more significant changes in January and especially in December than the remaining territory.

a)




b)

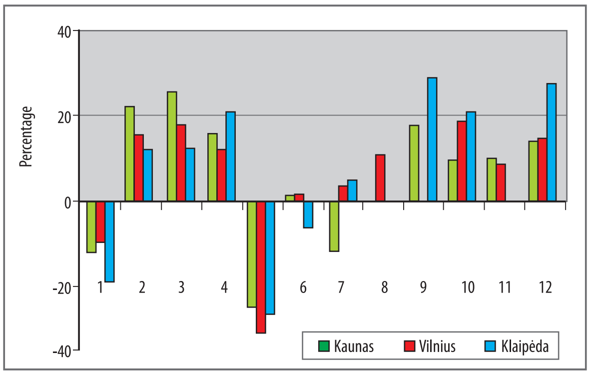



**Fig. 255.** Forecasted air temperature changes in Lithuania in 2021–2050 as compared with basal period of 1971–2000, according to CCLM model A1B (a) and B1 (b) climate scenarios *(E. Rimkus, 2010)*

B1 scenario stipulates lower changes of precipitation rate. Although the annual precipitation rate increases in the entire Lithuania's territory (from 13 mm in Panevėžys to 73 mm in Klaipėda, 2% and 10%, respectively), however the sign of annual changes will vary more significantly (Fig. 255, b). Significant (10–40%) decrease in precipitation rate is stipulated in May. In addition, more precipitation is forecasted for January. In summer, the changes will be minimum. Based on this scenario, the precipitation rate should mostly increase in Lithuania's territory in March, September and October (>15%). In the seaside areas, the precipitation rate will increase more significantly in the second half of the year, whereas in the remaining part of Lithuania – at the start of the year. This also shows the forecasted increase in territorial differences in Lithuania (differently than in case of air temperature).

Although the precipitation rate will increase, the number of days with precipitation will show only a slight increase in the midst of the 21st century (up to 2–3%). It means that a significant increase in the number of cases of heavy precipitation is very likely. It is approved by the output data of the CCLM model. The number of cases when the daily precipitation rate will exceed 10 mm should increase. By the midst of the 21st century, the number of such cases will increase by 10–20% in Lithuania. More occurrences of heavy precipitation will mostly be characteristic in the seaside areas and the Samogitian highlands. In the Western Lithuania, the number of such cases will mostly increase in autumn, whereas in the Eastern Lithuania – in winter. The A1B scenario stipulates slightly higher changes in the major part of Lithuania and B1 emission scenario forecasts higher changes only in the northern part of the central plain. The increase in the occurrence of heavy precipitation is related to the increase in the part of conventional precipitation in the total amount of precipitation.

## DURATION OF SUNSHINE

Both scenarios forecast the tendencies of decrease in the duration of sunshine in Lithuania in the first half of the 21st century. On average, the annual duration of sunshine in Lithuania should decrease by 110 hours (6%) based on A1B scenario and by approx. 60 hours (3%) based on B1 scenario.

Relatively higher negative changes are forecasted for the cold season, although based on B1 scenario; the sun is likely to shine 5–20% longer in January (Fig. 256).

In summer, the duration of sunshine will decrease only slightly. Based on the A1B scenario, the sun will shine longer only in May and October, whereas, in December, the values of this parameter will decrease significantly (25-35%). Negative changes will be the most significant in December based on B1 scenario as well (18-26%). Territorial differences of changes will not be very significant. The duration of sunshine will decrease most in the Eastern Lithuania and least – in the seaside areas.

a) b)

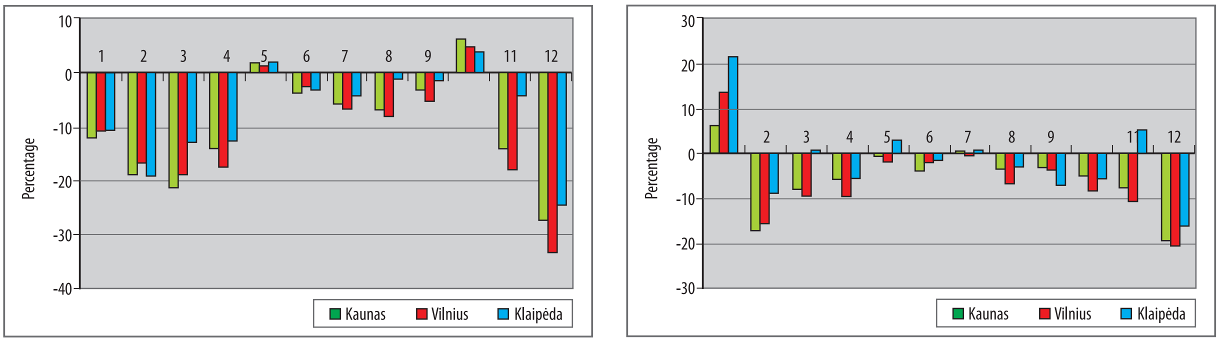



**Fig. 256.** Forecasted sunshine duration changes in Lithuania in 2021–2050 as compared with basal period of 1971–2000, according to CCLM model A1B (a) and B1 (b) climate scenarios *(E. Rimkus, 2010)*

The climate changes which became more evident in the second half of the 20th century are likely to become more significant in the next decades. In order to ensure safe functioning of economy, social and environment sectors, it is necessary to prepare and implement the strategies of adaptation of climate change. The implementation of such national strategies would increase the resistance to the impact of climate change. When adapting to the climate change, a number of important works could be done on the local and regional levels.

Namely the local level and regions, their population and various sectors directly incur the impact of climate change (floods, damages caused by storms, etc.). Although the majority of strategic aims can be formed on the national level, the major part of measures for the adaptation to the climate change should be implemented on the local level (Bubnienė, Rimkus, Štreimikienė, 2006; Bukantis et al., 2007; Arustienė et al., 2012).

## PERSPECTIVES OF AMBIENT AIR QUALITY CHANGE

The future tendencies of air quality changes in Lithuania are highly dependent on whether the Visaginas NPP will be built or not. In case of decision to build this power plant, the need to use thermal power plants would decrease and the emissions of sulphur, nitrogen oxides and particular matter would decrease accordingly. Whereas in case of refusal of construction of this power plant, the thermal power plants would continue to be used intensively. In such case, the reduction of emission of listed pollutants would be more complicated. It is possible to forecast that the growth of Lithuania's economy would respectively increase the demand for energy. However, it is questionable whether it will be satisfied by wide use of alternative energy sources. In such case, the need for energy production from biomass will become particularly important. When evaluating the available national capacities, it is possible to state that at least half of the Lithuania's energy needs can be satisfied by incinerating biomass. It would also be possible to decrease the greenhouse gas emissions significantly.

Other perspective alternative of pollution minimisation related to the saving of centrally used thermal energy is the implementation of the multi-dwelling house renovation programme and increase of energetic efficiency of buildings. After the reduction of energy needs of this sector, the emissions would decrease accordingly.

The further development of eco-transport is likely. In this case, it is possible to mention the use of biofuel and development of electric-cars. The future changes of transport emissions will depend on the results of implementation of these measures.

When evaluating the climate changes, it is obvious that the number of extreme phenomena will increase further: mostly storms, squalls, as well as non-typical variations of extreme temperatures. All sectors of our country will have to adapt to these needs: biodiversity, agriculture, forestry, healthcare, water resources, etc.

# Water

## OUTLOOK OF LITHUANIAN WATER RESOURCES QUALITY

The National Sustainable Development Strategy approved by the Government of the Republic of Lithuania by Resolution No 1247 of 16 September 2009 stipulates that the main objective of Lithuania's sustainable development based on the indicators of economic and social development and effectiveness of the use of resources is to achieve the 2003 average of the EU Member States based on the indicators of environment pollution by 2020 – not to exceed the EU permissible standards, comply with the requirements of the international conventions restricting environmental pollution and impact on global climate.

The National Sustainable Development Strategy stipulates the long-term and short-term objectives for the water sector. The long-term objectives include the achievement of the good state of groundwater, rivers, lakes, the Curonian Lagoon and the Baltic Sea, preservation of high varietal diversity of water ecosystems, proper condition of surface water bodies for the satisfaction of recreational needs and provision of all country's residents with the drinking water meeting the safety and quality requirements.

The main long-term objectives are as follows:

- reduction of water pollution with hazardous substances so that the discharge of hazardous substances would not exceed the standards of the European Union and would not prevent from seeking for good state of water bodies;
- reduction of the pollution in the Baltic Sea and the Curonian Lagoon caused by the land sources, vessels and activity in the sea and other water bodies;
- reduction of water pollution from agricultural sources;
- ensuring of the protection of groundwaters from pollution and encouragement of use of groundwater resources;
- development of effective system of evaluation and management of the risk of floods in view of the social, economic and environmental aspects.

Short-term objectives include the achievement of the reduction of surface and groundwater pollution, by properly using the funds of the state and municipalities as well as the private funds and support from the EU structural funds.

The main short-term objectives are as follows:

- reduction of nitrogen pollution from point pollution sources by 810 tons, phosphor – by 80–85 tons, 7-day biochemical oxygen demand $BOD_7$ – by 1,050 tons, as compared with 2004;
- reduction of diffusive pollution with nitrogen and phosphor;

- installation of water resources management system based on the principle of river basins – enabling all country's residents to participate actively in setting the targets for the water management objectives in the area of water resources and selecting the measures for their implementation;
- ensuring that the entire economic activity was organised to prevent the substances that are dangerous to environment and human health from passing into surface and groundwater bodies.

After Lithuania joined the European Union, the progress in the reduction of pollution from point pollution sources has been observed in Lithuania. Modernised or newly built waste water treatment facilities in major cities allowed the national-scale reduction of release of main pollutants into surface waters.

The short-term objective of 2010 – to reduce the nitrogen pollution from point sources, phosphor and $BOD_7$ – was achieved, i.e., the nitrogen pollution from point sources decreased by 1.009 tons, phosphor – by 195 tons, $BOD_7$ – by 1,584 tons, as compared with 2004. Although this short-term objective was achieved, the good ecological status of certain water bodies cannot be achieved due to nitrogen, phosphor and $BOD_7$ pollution from point sources. When preparing the plans for the programmes of Nemunas, Dauguva, Lielupė and Venta basin regions and measures for the achievement of water management aims in the basin regions (B. Paukštys, 2011), the impact of pollution from point sources on the status of water bodies was analysed in detail. As it is known, the sources of pollution include the facilities of cities, settlements and industrial plants releasing the surface wastewater. Pursuant to the requirements of the Council Directive concerning urban waste water treatment (9½71/EEC), from 31 December 2007, the waste water from the agglomerations with a population equivalent (p. e.) of more than 10,000 should be treated according to the established requirements, from 31 December 2009, waste water collection systems meeting the established requirements should be operating in the agglomerations with p. e. of more than 2,000 and, from 31 December 2009, the waste water should be treated based on the established requirements in agglomerations with p. e. from 2,000 to 10,000.

The condition of certain water bodies will remain of poor ecological status even after the implementation of the main measures stipulated in the Directive concerning urban waste water treatment, therefore, in such cases it is necessary to establish individual requirements for the concentration of aforementioned substances in discharged waste water in view of the status of the individual water body-recipient (physico-chemical, hydromorphological indicators).

The development of waste water collection infrastructure would allow the protection of water bodies from illegally discharged water pollutants in forbidden areas. Furthermore, the current pollution of surface (rain) waste water discharge facilities is recorded only from the rain waste water collected in most polluting, usually industrial and production territories, and from residential and public territories, if the area of such territory is at least 10 ha. The pollution of surface waste water not included into the accounting can have a significant impact on small water bodies, therefore more attention should be paid on the infrastructure of surface (rain) waste water (development of networks, reconstruction or construction of waste water treatment facilities) as well as their accounting and control.

In order to reduce the pollution with total phosphorus, it is necessary to forbid or restrict the domestic and industrial use of detergents containing phosphorus. The implementation of this measure would have a particularly positive influence on the quality of lakes as phosphorus compounds have a tendency to accumulate in lakes.

In order to check whether economic entities comply with the environmental requirements, it is necessary to enhance their control, i.e., it is necessary to perform not only planned inspections, informing certain economic entities in advanced, but also unplanned inspections. Furthermore, it is necessary to enhance the accountability and liability of economic entities. These main measures would form conditions for the achievement of better ecological status of water bodies in Lithuania.

The second short-term objective is to reduce the pollution with nitrogen and phosphorus from diffusive sources. The diffusive pollution sources are distinguished into two main groups: pollution conditioned by agricultural activity and pollution conditioned by residents discharging waste water, which is not collected and treated. In agriculture, the diffusive pollution is formed due to fertilisation of crops by using livestock manure and mineral fertilisers. One of the main measures reducing the pollution of the Nitrates Direction (91/676/EEC) is the construction of manure storages in the farms keeping more than 10 livestock units (hereinafter – the LU). Until 2012, such stock-raising farms had to install manure storages. Another measure stipulated in the Nitrates Directive is the fertilisation procedure by indicating the standards of fertilisation with chemical fertilisers and livestock manure and the fertilisation of soggy, flooded, frozen soils or soils covered with snow. In Lithuania, the established standard of nitrogen fertilisation – 170 kg/ha and it is completely forbidden to use manure and slurry on the soil from 15th of November to 1st of April, as well as from 15th of June to 1st of August, except for fertilisation of fallows, meadows and pastures. However, even after implementation of these measures, the diffusive pollution from agriculture will cause significant influence on the ecological status of water bodies as there are stock-raising farms smaller than 10 LU and they are not obliged to build manure storages, furthermore, the use of mineral fertilisers is not strictly regulated. Therefore, in areas, where the main measures of Nitrates Directive are not sufficient for the achievement of good status of water bodies, it is necessary to apply additional measures for the reduction of diffusive pollution. It is necessary to note such additional measures as manure management in small farms, mandatory preparation of fertilisation plans and performance based on the approved methodology of preparation of fertilisation plans in farms of the area of more than 10 ha, the increase of manure absorption efficiency coefficient, fertilisation by 20% smaller norm than economically optimum fertilization, planting of sandy and mixed lands with intermediate plants and other measures. Therefore, in order to reduce the diffusive pollution, it is purposeful to prepare the respective legal acts ensuring the legal regulation of the aforementioned measures.

The Law on Supply of Drinking Water and Waste Water Management stipulates that, by 2015, at least 95% of residents should be centrally provided with water and wastewater management services from providers. After the implementation of the provisions of the Law and ensuring the activities of provision of drinking water and wastewater management, it is expected to improve the status of environment and form the conditions for the economic development.

To ensure positive tendency, it is necessary to develop the water supply and wastewater management infrastructure meeting the requirements in the major urban areas and small settlements. This would allow the reduction of pollution from residents discharging the wastewater, which is not collected and treated.

The third short-term objective – the installation of water resources management system based on the principle of river basins enabling all country's residents to participate actively in setting the targets for the water management objectives in the area of water resources and selecting the measures for their implementation – was already achieved in 2010.

The fourth short-term objective is to ensure that the entire economic activity was organised to prevent the substances that are dangerous to environment and human health from passing into surface and groundwater bodies.

The results of the research of hazardous substances showed that the highest concern (on Lithuanian-scale) is the impact of "new generation" substances – phthalates and organic tin compounds – on water environment. These substances were detected in examined mediums, i.e., wastewater, wastewater sludge, surface water and bottom sediments, and their concentration exceeded the current and stipulated limit value quite often. It is obvious that the objectives stipulated by the Water Framework Directive and good condition of water quality could be difficult to achieve due to these substances. Although the limit values for all hazardous substances and groups of material are validated, however, in many cases, there are no proper measures for the ensuring of their implementation and control, whereas the list of substances by industry sectors submitted in the Programme of Reduction of Hazardous Substances does not include many worrisome hazardous substances, e.g., phthalates, organic tin compounds, phenols and their etoxylates, brominated diphenyl ethers.

Wastewater management regulation stipulates the requirements on the discharge of wastewater to natural environment and presents the list of controlled parameters by industry fields. This list does not include the aforementioned substances and their groups as well.

The wastewater discharged by the operating entities is subject to controlled parameters listed in the issued permit. However, usually, these are traditional parameters, such as metals, biochemical consumption of oxygen, total nitrogen, certain polycyclic aromatic hydrocarbons, and volatile organic compounds. So far, the issue of permits have not included the evaluation of the "new generation" substances (phthalates, organic tin compounds, phenols and their etoxylates, etc.). The reasons of this could be various, for example, insufficient knowledge and experience of industry and permit-issuing and control institutions in establishment of these substances in raw materials used by the enterprise and evaluating their discharge into the environment by technological processes; insufficient opportunities for the research of these substances in Lithuania in order to find out whether they are detected in wastewater, to control them and impose respective sanctions in case the concentration exceeds the limit values.

The following measures are recommended for the solution of these problems:

- to update the list of hazardous substances in legal acts regulating water pollution, which should be evaluated, established and/or controlled by the type of source of pollution (field of industry). However, it should not be requested for each company to examine all hazardous substances characteristic to the entire specific sector. Such requirement should be based on the use of hazardous substance in raw materials and/or likelihood that this substance is discharged into the waste water supply or surface waters (i.e., in view of the technological process);
- to request the companies to have electronic database of imported, produced and/or used hazardous substances including not only the preparations, but also the information on the composite parts (currently, it is required to have a "paper-based" accounting of hazardous substances). This would facilitate the establishment of any hazar-

dous substances in the raw materials, the preparation of reports and fulfilment of other legal acts and also ensure better conditions for the control of companies;

- to prepare clear recommendations, guidelines for the industry, institutions issuing permits and performing control how to detect hazardous substances in raw materials and their discharge with waste water. It is necessary to review the permits at least of those waste treatment facilities that discharge hazardous and priority hazardous substances to the natural environment. The substances detected in their waste water should be included into the permits and the requirements for their monitoring should be established (2-4 times per year, as it is requested in the regulation of waste water management). Furthermore, these waste water treatment facilities should be inspected by state institutions at least once per year;
- the Environment Monitoring Programme for 2005–2010 does not include the "new generation" substances. However, in view of the research results, at least di-2-ethylhexyl phthalate (DEHP), organic tin compounds, nonylphenols and octylphenols should be examined in respective mediums (wastewater, wastewater sludge, water bodies-recipient, bottom sediments).

When evaluating the long-term objectives, the first and third aims were thoroughly discussed in the short-term objectives, therefore, the second, fourth and fifth aims will be discussed in more detail.

Marine Strategy Framework Directive (2008/56/EC) obliges the Member States to prepare the marine strategy for sea waters pursuant to which the good marine environment state should be achieved and/or maintained.

The properties of good environment state of the Baltic Sea and associated aims were established pursuant to the qualitative indicators indicated in the Marine Strategy Framework Directive:

- biodiversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions,
- non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems,
- populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock,
- all elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity,
- human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters,
- sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected,
- permanent alteration of hydrographical conditions does not adversely affect marine ecosystems,
- concentrations of contaminants are at levels not giving rise to pollution effects,
- contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards,
- properties and quantities of marine litter do not cause harm to the coastal and marine environment,
- introduction of energy, including underwater noise, is at levels that does not adversely affect the marine environment.

In order to implement the requirements of the Marine Strategy Framework Directive, it is necessary to evaluate the current status of sea environment, establish environmental aims and measures for the achievement of the good status of the Baltic Sea environment and, on the basis of these results, update the National Baltic Sea Environmental Protection Strategy by 15 July 2014, the implementation of which will assist in the reduction of sea pollution and achievement of the set sea environment protection aims by 2020, i.e., achieve and/or maintain good status of sea environment.

The fourth long-term objective is to ensure the protection of groundwaters from pollution and encouragement of use of groundwater resources.

In order to protect the groundwater from pollution it is necessary to continue the reduction of pollution from point and diffusive sources, clean (manage) the contaminated areas. It is necessary to solve the issue of provision of residents with high quality drinking water, the most relevant of which is the increased concentration of fluorides, chlorides, ammonia, nitrates and certain other chemical components in certain Lithuania's territories.

Therefore, by using new hydrogeological information, modern mathematical modelling methods and in view of the EU requirements on the quality of drinking water, it is necessary to reassess the available groundwater resources and prepare the programme for the provision of residents with proper quality drinking water. Furthermore, it is necessary to treat all currently known polluted territories, whereas the settlements where the quality of water does not meet the requirements of hygiene norms should be explored and fitted with new water sites providing high-quality groundwater.

The last long-term objective is the development of effective system of evaluation and management of the risk of floods in view of the social, economic and environmental aspects. In 2007, the European Union adopted the Floods Directive (2007/60/EC) the aim of which is to create the system of evaluation and management of risk of floods by 22 December 2015 in order to minimise the negative consequences of floods caused on human health, environment, cultural heritage and economic activity.

The Preliminary Report on the Evaluation of Risk of Floods was approved in 2012 (Official Gazette, 2012, No 9-348) the aim of which was to summarise the preliminary evaluation of risk of floods in each region of river basin or part of international river basin region located in the territory of the Republic of Lithuania pursuant to the available information.

The flood hazard maps and flood risk maps should be completed in 2013.

In 2013–2014, it is planned to prepare the floor risk management plans for each river basin region. The plans of flood risk management should cover all aspects of flood risk management, paying the enhanced focus on the prevention of floods, preparation for and protection against floods, in view of the particularities of specific territories.

Having implemented the long-term and short-term objectives, there would be an opportunity to achieve the main goals of the Lithuania's sustainable development in the water area.

# Waste

## WASTE COMPOSITION AND MANAGEMENT SCENARIOS

For proper management of waste it is necessary to know the forecasted waste flows today and prepare for them in the future. According to the evaluation of environment experts, the amount of generated municipal waste will depend on many factors in the future, especially, on the number of population, economic growth and consumption changes. According to the evaluation of specialists, in 2010-2020, approx. 1.8 million tons of municipal waste is likely to be generated in Lithuania each year.

For precise forecasts of the amounts of waste to be generated by 2020, three possible waste generation development scenarios characterising the annual speed of increase in waste level were theoretically evaluated in 2007 (Fig. 257). They can be relatively defined as low (1%), medium (2.6%) and high (5%) growth scenarios. Medium growth scenario is established based on the medium annual speed of growth of mixed municipal waste in 2004-2006. It should be noted that this model did not include GDP and emigration increase forecasts and dependence of waste generation perspective on them.

Based on low-growth scenario, the average amount of waste per capita will increase from 313 kg to 391 kg (28%), as compared with 2005. If the amount of waste increases in current rates, the average amount of mixed municipal waste will increase by 60% – from 313 kg to 489 kg per capita. In case of high growth, the amount of waste per capita will increase more than twice in 2020: from 313 kg to 674 kg (120%), as compared with 2005 (Fig. 258).

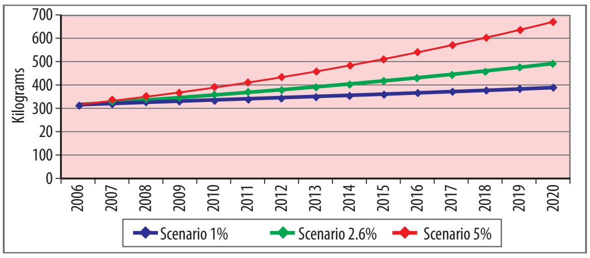



**Fig. 257.** Generation of mixed municipal waste per capita based on the three scenarios of development of waste generation, 2006-2020 *(G. Ignatavičius, 2011)*

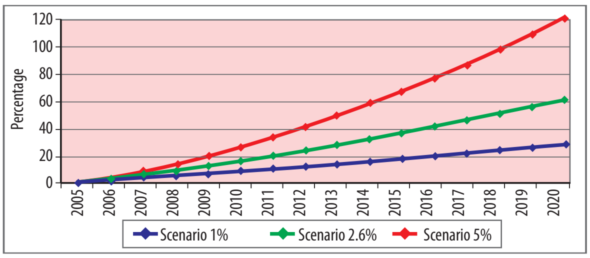



**Fig. 258.** Percentage of mixed municipal waste generation per capita based on the three waste generation development scenarios, as compared with 2005 *(G. Ignatavičius, 2011)*

Pursuant to available calculations, it is possible to state that in case of low-, medium- and high-growth, 473 kg, 597 kg and 813 kg of municipal waste will be generated respectively, calculating per capita. Based on the medium-growth scenario, in 2020, Lithuania will achieve the current amount of waste generated by Central and Eastern European countries. In 2003, these countries generated the average of 580 kg of municipal waste per capita.

Due to impact on climate change, biodegradable waste is released into a separate specific waste flow, based on the directives on landfill sites of the European Union. The state tasks and specific management requirements are stipulated for these wastes. When implementing the medium-term and long-term tasks of the sustainable development in Lithuania by 2020, the aim is to reduce biodegradable waste flows into landfill sites by 75% as compared with 2000. When forecasting the progress of waste generation, the aforementioned–tasks were considered in reducing the pass of biodegradable waste amounts into landfill sites. Fig. 258 present the generation of waste for 2007-2020 evaluated by low-, medium- and high- growth of waste, in case of complete fulfilment of Lithuania's obligations in reducing the flows of biodegradable waste into landfill sites. Based on the low-growth scenario, the average amount of waste per capita will decrease from 306 kg to 275 kg (10%), as compared with 2006. In case of current growth (medium-growth scenario), the amount of mixed municipal waste per capita will remain quite stable and will increase insignificantly. From 306 kg in 2005 this amount will increase up to 331 kg (8%) in 2020, as compared with 2006. In case of high growth of waste, this amount of waste will amount to 437 kg in 2020 and will be by 43% higher (Fig. 260).

Mixed municipal waste account for 79% of all municipal waste, therefore, in case of low-, medium- and high-growth, the respective amount of 332, 400 and 528 kg of municipal waste will be generated in 2020. If the amount of this waste will increase in current rate (medium-growth scenario), in 2020, this amount will exceed the average of the Central and Eastern European countries, however, will not reach the average of the Western European countries. In 2003, the Central and Eastern European countries generated 336 kg of municipal waste per capita, on average.

Since the tasks of the National Sustainable Development Strategy obliged to propagate the separation of local secondary waste by 2010 and form conditions for the use of at least 50% of packaging waste, of which at least 55% of paper and cardboard, at least 60% of glass, 25% of plastics and 40% of metal, and the implementation of these aims is significantly approached, therefore, when forecasting the progress of composition of mixed municipal waste, the presumption was made that this waste will be managed respectively in the municipal waste sector as well.

The generation of waste for the period of 2007-2020 was evaluated based on the scenarios, if the obligations of Lithuania regarding the collection and management of secondary waste are fully met (Fig. 260). Based on the low-growth scenario, the average amount of mixed municipal waste will decrease during the entire time and will amount to 246 kg per capita in 2020. This amount will be 20% lower as compared with 2005. Based on the scenario of medium growth, the amount of waste will decrease slightly and will amount to 286 kg per capita in 2020. The amount of this waste will decrease by 6% from 2005 to 2020. The amount of waste will increase only in case of high-growth, as compared with 2005. The amount of mixed municipal waste will increase by 19% from 306 kg per capita in 2005 to 363 kg per capita in 2020 (Fig. 262).

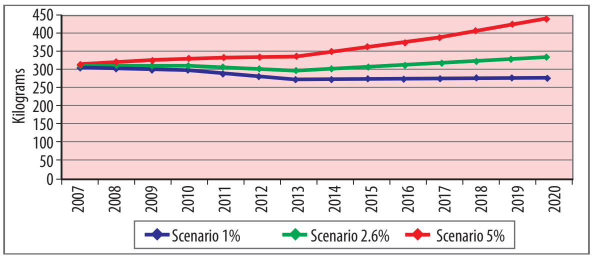



**Fig. 259.** Accumulation of mixed municipal waste per capita in view of the amount of collected biodegradable waste based on the three waste accumulation progress scenarios by 2020 *(G. Ignatavičius, 2011)*

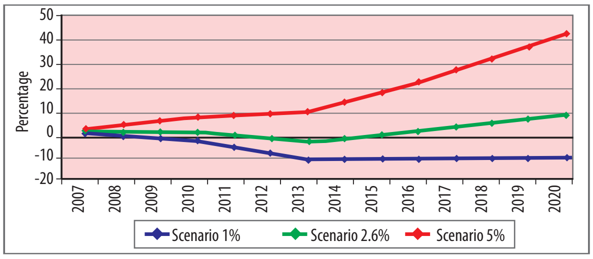



**Fig. 260.** Percentage of mixed municipal waste generation per capita in view of the amount of collected biodegradable waste based on the three waste generation development scenarios, as compared with 2005 *(G. Ignatavičius, 2011)*

When managing both the biodegradable and secondary waste, the growth of waste based on all scenarios is varying in a rather narrow interval. The amount of waste does not increase or decrease more than 20% based on high and low-growth scenarios.

Mixed municipal waste account for 79% of all municipal waste, therefore, in case of low-, medium- and high-growth, the respective amount of 298, 347 and 439 kg of municipal waste will be generated in 2020. If the amount of municipal waste increases in current rates, in 2020, this amount will slightly increase the average of the Central and Eastern European countries of 2003 – 336 kg of municipal waste per capita.

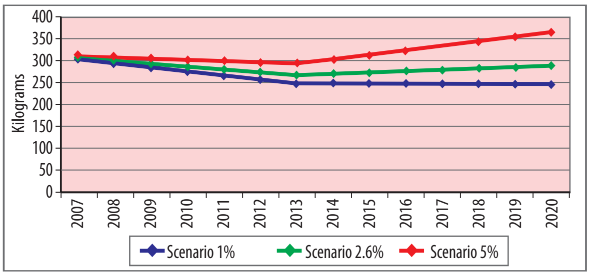



**Fig. 261.** Accumulation of mixed municipal waste per capita in view of the amount of collected biodegradable waste and secondary waste based on the three waste accumulation progress scenarios in 2007-2020 *(G. Ignatavičius, 2011)*

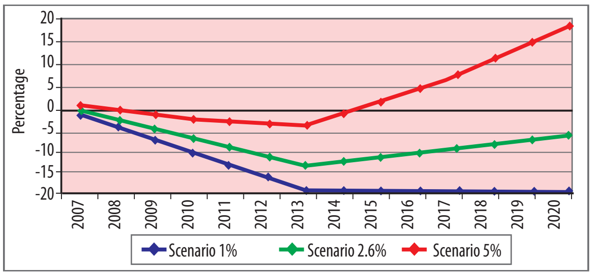



**Fig. 262.** Percentage of mixed municipal waste generation per capita in view of the amount of collected biodegradable waste and secondary waste based on the three waste generation development scenarios, as compared with 2005 *(G. Ignatavičius, 2011)*

## REDUCTION OF GREENHOUSE GAS EMISSIONS IN LANDFILL SITES

One of the EU aims in the waste sector is the reduction of greenhouse gas emissions emitted from landfill sites. It is known than one ton of biodegradable waste produces approx. 200–400 m$^3$ or 143–287 kg of methane gas – dangerous gas causing greenhouse effect.

For the achievement of the aforementioned environmental objective, 2 main methods are indicated: the reduction of the amount of methane emitted to the atmosphere from landfill sites and the increase of usage of emitted pollutants for the production of energy. The target was set to reduce the greenhouse gas emissions from municipal waste landfill sites by 65 million tons in the $CO_2$ eq. by 2020, as compared with 2008 (Fig. 263). Theoretically, it has been calculated that if the landfill sites were completely closed in the EU, the amount of greenhouse gas emissions would be further reduced and, in such case, in 2020 it would decrease by 78 million tons, as compared with the results of 2008.

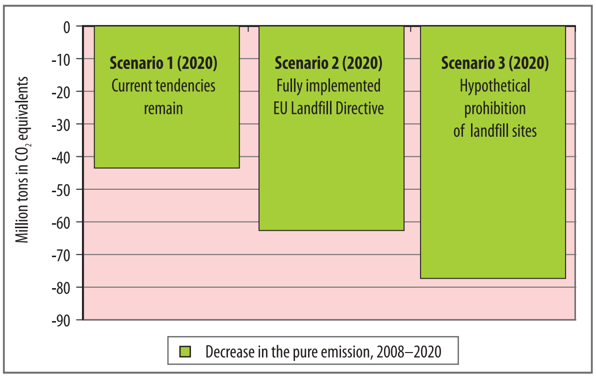



**Fig. 263.** Reduction of greenhouse gas emissions from the EU municipal waste landfill sites based on the three different scenarios. *Source: European Environment Agency*

Lithuanian also seeks to reduce the amount of greenhouse gas emissions emitted from landfill sites. If the tasks of the National Sustainable Development Strategy on the reduction of biodegradable waste flows into landfill sites were performed, the level of greenhouse gas emissions (methane) will also decrease in the landfill sites. Assuming that one ton of such waste extracts approximately 300 m$^3$ of methane gas, in 2020, the emission of such gas in landfill sites would decrease by 65% – 59.8 thousand tons of methane, as compared with 2005. If the amount of biodegradable waste decreases gradually, from 2007 to 2020, the level of methane gas emitted from the landfill sites will decrease by approx. 593 thousand tons (Fig. 264).

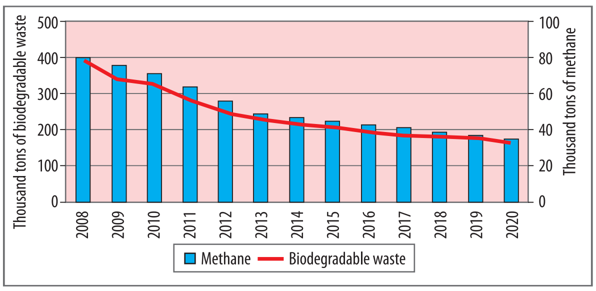



**Fig. 264.** Forecasts of methane gas emitted from the landfill sites and flows of biodegradable waste to landfill sites by 2020. *Source: Ministry of Environment*

When evaluating the results of this model in the EU context, it can be seen that the emission of methane gas from the municipal waste landfill sites alone can decrease by approx. 46 thousand tons or more than 57% by 2020, as compared with 2008. This would be a significant contribution of Lithuania in solving the problems of waste management and greenhouse gas emissions in Europe.

# Landscape and Biodiversity Protection

## OUTLOOK OF LITHUANIAN LANDSCAPEE

Changes of Lithuanian landscape conditioned by natural, anthropogenic and planning factors partly meet the aims and tasks of the National Sustainable Development Strategy. Based on certain sustainable development indicators (percentage share of protected areas and forests), Lithuania is relatively successfully implementing the aforementioned strategy. Based on this strategy, the target total area of protected areas should reach 14–18% of Lithuania's territory, whereas the current value provided on the website of the State Service on Protected Areas of the Ministry of Environment is 15.66% (1,022,699.52 ha).

Landscape variation tendencies are not easily forecasted due to complex social and economic phenomena causing a significant influence on the land use and nature use and due to the influence of free will arising out of the decision of the public and separate individuals. The main factors influencing the trends of the Lithuanian landscape development are the following:

Solutions of the currently prepared National Landscape Management Plan. The Plan should formulate the optimal objectives of landscape structure for different types of landscape and should stipulate how this structure should be achieved.

Land management and use changes are related to the agricultural-economic development and financial levers of the EU structural funds.

The current process of increasing of land plots and planting of agrarian areas with forests will also develop in the future. Infertile or less fertile areas including those affected by erosion will be either abandoned for spontaneous reforestation or, more likely, planted with forests. Due to aforementioned reasons, the degree of naturalness of areas of hilly and sandy plains of the Eastern Lithuania will grow faster than in any other Lithuanian regions.

The increasing use of renewable energy sources and biofuel. The decreasing areas covered by renaturalisation due to felling of spontaneous young stands in agricultural lands for bio-fuel needs are already visually noticeable in our landscape. It is likely that the landscape will be increasingly supplemented with wind power plants and solar electric engineering facilities. This causes the problem of protection of aesthetical potential of landscape.

The intensifying urbanisation of cities, suburban areas, and their development. This would include the densification of road network and improvement of road cover in suburban areas. The improving communication measures and information technologies can condition a higher distribution of individual construction elements and their larger distance from concentrated settlements. It is likely that the concentration of such individual homes will increase near aesthetically valuable natural landscape objects, mostly lakes, i.e., the urbanisation of lake shores will increase and the road network will densify.

If the volumes of forest felling remain similar in state and private forests, the tendency of the decrease of age of forests along with weakening of ecological compensation function of landscape is likely to occur.

The example below shows how, in view of the sequence of land cover changes based on CORINE land cover data (1995, 2000 and 2006), the tendencies of variation of the landscape structure should look like in the territory of Vilnius region in the nearest future (Fig. 265). Levels of tendencies are explained in Table 24.

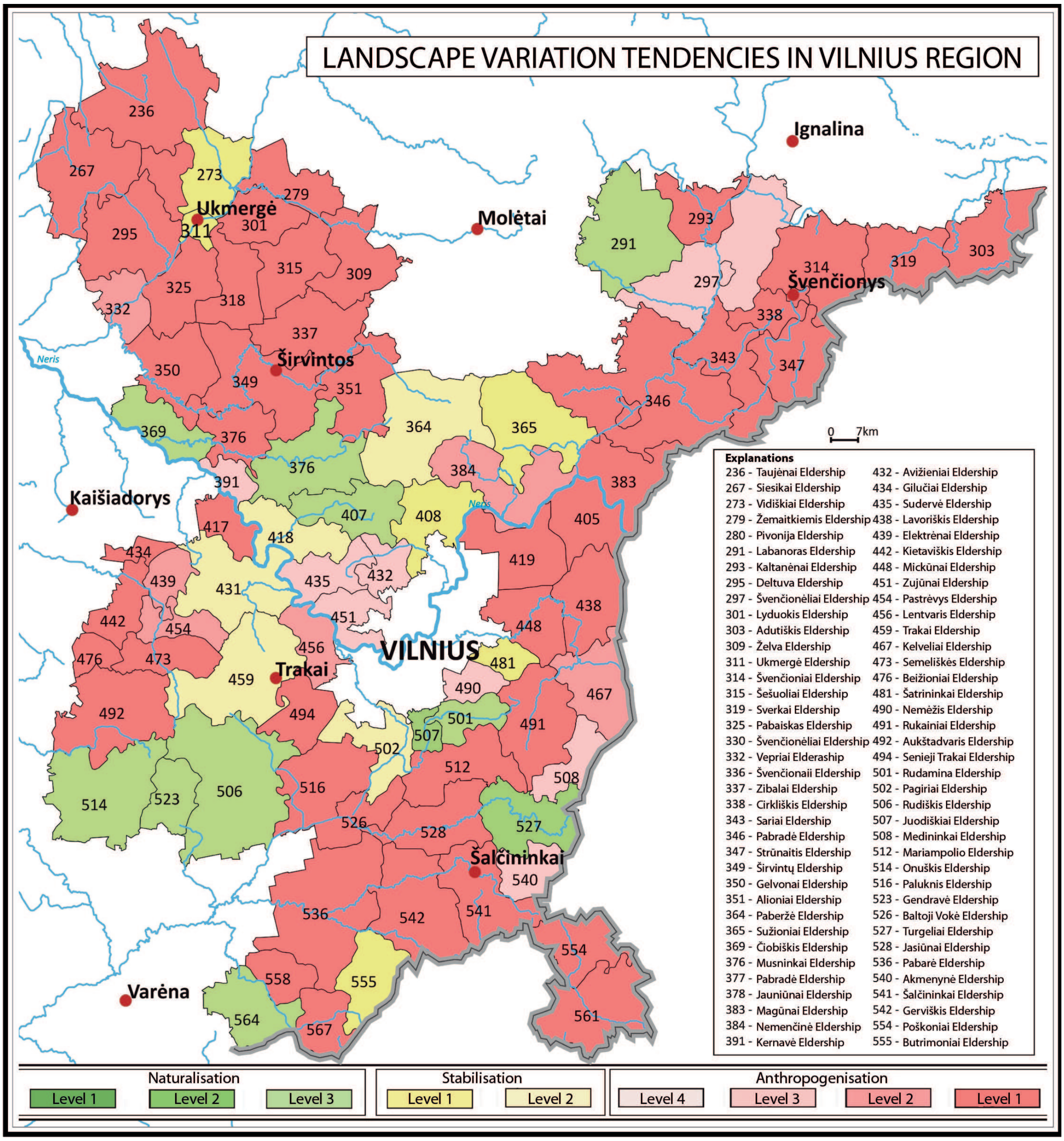



**Fig. 265.** Land cover variation tendencies in Vilnius region (except for the territory of Vilnius city); in view of databases of CORINE, land cover changes of 1995–2000 and 2000–2006 (*according to Armalienė, 2011*). Each type of variation tendency (naturalisation, stabilisation and anthropogenisation) is expressed in levels detailing the strength of tendencies; this is visually expressed by colour intensity *(Armalienė, 2011)*

**Table 24.** Hierarchical levels of tendencies of variation of landscape structure (land cover) by dominating process course in the naturalisation-anthropogenesis scale *(Armalienė, 2011)*

| Landscape variation tendencies | Tendency levels | From 1995 to 2000 | From 2000 to 2006 |
|---|---|---|---|
| Naturalisation | Level 1 | Increase of natural areas | Increase of natural areas |
| | Level 2 | Changes up to 0.5% | Increase of natural areas |
| | Level 3 | Increase of forest felling | Increase of natural areas |
| | | Agrarisation | |
| Stabilisation | Level 1 | Changes up to 0.5% | Changes up to 0.5% |
| | Level 2 | Urbanisation | Changes up to 0.5% |
| | | Increase of forest felling | |
| | | Agrarisation | |
| | | Naturalisation | |
| Anthropogenisation | Level 4 | Increase of natural areas | Increase of forest felling |
| | | | Urbanisation |
| | Level 3 | Changes up to 0.5% | Increase of forest felling |
| | | | Urbanisation |
| | Level 2 | Agrarisation | Increase of forest felling |
| | | Urbanisation | |
| | | Increase of forest felling | Urbanisation |
| | Level 1 | Increase of forest felling | Increase of forest felling |
| | | Urbanizacija | Urbanisation |

## PERSPECTIVES OF LITHUANIAN BALTIC COASTLINE DEVELOPMENT

When forecasting the likely perspectives of the Lithuanian Baltic coastline development, it is necessary to consider the following factors:

- the current state of coastline sections and their geodynamical tendencies;
- planned anthropogenic factors likely to have influence on the coasts;
- impact of climate change.

*Geodynamic tendencies of coastline sections.* These factors have already been discussed in previous chapters. It is only necessary to note that if the tendencies of long-term coastline section dynamics show that coastline section is destroyed, the likelihood that (in view of annually reducing reserves of coastal area silting at Lithuanian coasts and especially continental coastal area) the condition of coast will improve in this section (without implementing coastal management measures) is practically equal to zero. The process of degradation of coast is most likely to develop in such sections. It is possible that, after 15 years, the total length of washed coastline section in Lithuanian seaside areas will increase from 21.7 km (current) to 32 km (in 2027) (in case of termination of implementation of coastal management measures). In view of the established trends of long-term changes, it is also possible to state that (in case of termination of coastal management measures); the total length of coast sections where the accumulation is currently occurring (mostly favourable and attractive for recreation) will decrease in the future. It is likely that after 15 years there can remain only 5–8 km of accumulation type coastal sections in the Lithuanian seaside areas.

The most disadvantageous development perspectives (in geodynamical point of view) are planned for coastal sections in Šventoji – frontier with Latvia, Ošupis region, Rąžė-Birutė hill, Nemirseta-Dutchman's Cap, Melnragė I and Klaipėda seaport technogenic coast sections and Pervalka, Preila and Nida coast sections – Curonian Spit.

*Anthropogenic factors able to influence the stability of coast.* Economic growth and rapid economic development is also occurring in the seaside areas. In the nearest future, the Šventoji seaport restoration works are planned, the possibility of construction of deep-water seaport is also becoming more realistic. The recreation and urbanisation in the seaside area is intensifying each year. The consequences of global climate change will have a particularly important role for the further development of Lithuanian coastal area. These factors will certainly have one or another (unfortunately, most probably negative) impact on the Lithuanian coastal area.

*Planned seaport construction works.* Although it has not been yet decided how the Šventoji seaport will look like, however, it can be preliminary stated that (if the piers of mouth of the seaport to be built were built to the depth of 7 m, as it is planned), the deficit of silting would accumulate to the north of seaport, the potential impact zone of which will eventually reach Papė seaport in Latvia. In the southern side of seaport to be built, the surplus of silting will accumulate; the potential impact zone of which can eventually reach Monciškės. If the coastal development occurred according to classical regularities (the similar reaction of coast was to the construction works of Šventoji seaport), in order to reduce the deficit of silting likely to accumulate to the north of seaport, it will be necessary to apply the method of redeployment of the silting from the southern side to the northern side (by passing).

However, in case of selection of improper configuration of seaport piers and spatial position due to which large sea water affluent will form at dominating south-west winds during storms, the silting deficit can also form in the southern side of the seaport. In such case, the condition of coast will also significantly worsen in the southern side of Šventoji seaport. The deficit of silting in both sides of seaport piers will be inspired by periodical deepening of seaport inflow channel (if it was necessary, in order to maintain the desired constant depths).

*Deep-water seaport.* The future of construction of deep-water seaport is covered by more uncertainties than Šventoji seaport: will it be built at all, when and what territory will it cover, what will be the length and configuration of piers, etc. The final decision has not been made yet, although the alternative of Būtingė has become more favourable recently. Speaking about Klaipėda alternative, according to preliminary evaluations, the potential zone of impact of possible deep-water seaport can reach the shore section to the south of Alksnynė in the Curonian Spit and capes of Dutchman's Cap in the continental coast. However, it would be indiscreet to establish the nature of impact of deep-water seaport on the coastal area without detailed design of future seaport, without performing detailed morphometric, hydrodynamic, lithological and lithodynamical researches and without modelling the potential hydrolithodynamic situation after building the seaport on its basis. Only after the fulfilment of previous conditions (Klaipėda alternative), it will be possible to find out whether the accumulation of silting will settle in the southern side of seaport (Kopgalis) due to significantly elongated southern pier at the coast, or the scour will occur due to significantly increased sea water affluent during storms, or maybe there will settle a harmony between these two factors and the shore will remain stable. The same can be said about the future impact on the coastline section to the north of seaport. Without detailed researches and modelling it is impossible to say what will condition the state of the coastal zone at Melnragė I: the "lee" (Influencing the stability of coast) provided by the future deep-water port (reminding a rectangular island by its shape), or a powerful affluent (which would condition high scour of coast), which would be formed at strong northern winds, etc. Speaking about Būtingė alternative, the nature of impact on the coast would be analogous to the already described case of Šventoji seaport, but would be more intensive (due to significantly higher parameters of deep-water seaport).

*The growth of recreation intensiveness and urbanisation development.* The attractiveness of recreational zones directly depends on the state of coast. The coastal sections of Šventoji, Palanga, Giruliai and Melnragė I and II are intensively used for recreation at the continental coast. The total length of all these recreational sections amounts to 23.1 km (or approx. 61% of the total length of continental coastline). In the Curonian Spit, the coast sections of Smiltynė I and II, Juodkrantė, Pervalka, Preila and Nida are used for intensive recreation. The total length of the coastline of recreation zones of the Curonian Spit amounts to 18 km (or 35.3% of the share of coastline of the Curonian Spit, which belongs to the territory of Lithuania).

In the intensive-use recreation zones, high numbers of holidaymakers cause negative impact on the state of coast and especially dune ridge. Due to damages caused to the vegetation, the deflation processes become more intensive as well as their development on the top of dune ridge and in both slopes. The dependence of the degree of damage caused to dune ridge on the intensiveness of recreational load is well reflected by the results of performed researches. For example, in the protective coastal dune ridge of Palanga characterised by high recreational load, deflation forms cover even 82% of the overall area of dune ridge in some areas, in Nida dune ridge characterised by lower recreational load, the highest spread of deflation forms accounts for 17%, whereas in protected areas of the Curonian Spit (where recreation is prohibited) – only 0.9%.

Due to intensifying construction of residential houses in seaside towns (especially Klaipėda, Palanga and Šventoji) more and more people purchase accommodation by the sea and this has a direct impact on the increase in the number of persons visiting seaside areas. The construction of residential houses and villas or resorts beyond dune causes enhanced risk on the state of dune ridge. In the past 10 years alone, the number of objects located between Šventoji and Ošupis has doubled. The dune ridge is usually damaged during the construction beyond dune: the eastern slope is damaged by construction equipment, dozed, etc. Furthermore, the paths used by residents and visitors to reach the sea over dune ridge quickly turn into ditches fragmenting the dune ridge until its very base.

Thus, the development of recreational load and urbanisation will encourage the degradation of dune ridge. After the disappearance of dune ridge, the area of land flooded with sea water during heavy storms should increase up to three times, whereas in case of extreme (hurricane) storms – even up to five times.

*Impact of climate change.* Climate change is also attributable to the factors potentially and already having impact on the stability of the Lithuanian coastline.

The climate warming causes rapid rise of the Baltic Sea level. If, in 1898–1975, the average sea level increased relatively low (+0.4 mm annually, i.e., increased only 3.1 cm during 77 years) near Lithuania coastline, during the period from 1976 to 2011, the sea level increased relatively fast (+3.4 mm annually, i.e., increased by 12 cm during 35 years). Although such increase of level does not cause significant flooding at Lithuanian coastline, however, due the wavy affluent formed during storms it only increases the destruction of coasts.

The most significant negative impact is currently caused on Lithuanian coastline by increasingly strong winds and rising air and water temperature in winter time (and the intensification of these factors is likely to occur in the future), also the decreasing number of days with freeze at the coastline and snow cover caused by the impact of these factors.

Due to climate change and intensifying cyclone activity, the heavy storms became more frequent in Lithuanian coastline area, whereas the period of still became shorter. If earlier deep cyclones occurred every 6–8 years in the seaside areas, now they occur every 2–3 years.

Furthermore, in the past 30 years, the south-west (affluent) winds became more frequent and their speeds increased, whereas the speeds of south-east winds decreased, i.e., the number of days with high sea water levels increased (encouraging the scour of coasts) and the number of days with low levels decreased (causing influence on the coastal accumulation). The occurrence and duration of strong winds, the speed of which exceeds 25 m/s, also increased. Therefore, the coastline destroyed by storms fails to restore its harmony profile.

The intensiveness of coastline destruction is also increased by the rising air temperature, which is usually conditioned by warming winters in our latitudes. Warming winters are followed by decreasing frost waves (the wave of frost is considered occurred when air temperature of –16°C remains for 5 or more days). It should be noted that, in 1991-2005, the temperature of the Baltic Sea near Klaipėda (as compared with 1961–1990) and the Curonian Lagoon near Nida was higher by approx. 0.6°C. The duration of ice phenomena in the coastline depends on winter temperature.

During the period from 1961 to 2005, the number of days with ice phenomena decreased by approx. 50% in the Baltic Sea coastline area near Nida, i.e., from approximately 60 days of the duration of ice season in 1961–1975 to 26 days in 1991–2005. It is not difficult to guess what impact is caused on the state of coasts. The coastal ice is a natural pier protecting the coast from the impact of frequent storms during winter. Furthermore, the freezing beach and dune ridge sand is much more resistant to wave abrasion, and almost completely eliminates the damage caused by wind deflation. The same applies to the decreasing number of days with ice cover.

By summarising, it is clear that in case of failure to pay proper attention on our coastal protection, in the near future, the processes of destruction of coasts will settle in the majority of coastal sections. This will cause not only the reduction of Lithuania's territory, degradation of unique coastline landscape, loss of attractiveness of seaside recreational zone, but will also cause an actual threat to the hydrotechnical facilities on the coastal zone and other economic and residential objects.

# Natural Resources

## FUTURE DEVELOPMENT OF MINERAL EXTRACTION

40. Future development of mineral extraction depends on many factors: economic, geological, technological, environmental, legal, etc. The most important ones are discussed below.

### Economic Factor

Minerals are natural mineral substances stratifying in the depths of the earth that are essential for the material production or other needs. Minerals, for example, metal ores, energy resources, rare elements can be one of the main driving forces of the economic and social progress of the society. However, as it was already mentioned, the depths of the Lithuanian land mostly hide the chippings and finishing stone, gravel and sand used for the construction industry and road building. It is not useful to transport such minerals in great distances; therefore, they can be used only from local resources and for local industry needs. Therefore, the intensiveness of extraction of Lithuanian minerals depends on the general factors of economic development – in case of economic growth tendencies; the extraction of minerals will increase and in case of economic recession will decrease.

If the extraction of minerals had increased gradually, in the same rate as from 2001, the extraction volume that was characteristic before the restoration of Lithuania's independence, would have been achieved by 2015, however, such intensive growth of extraction and production volumes dropped by nearly 40% as compared with the previous year, due to economic recession and economic crisis in 2009.

The data of 2011 show that, as compared with 2010, the extraction of minerals is increasing again. With the increase in extraction in such rate, the annual amount of 20 tons or various minerals per capita excavated in the developed countries would be achieved in Lithuania only in about 2035.

To forecast the level of increase in the extraction of minerals in the future is possible only pursuant to the scenarios of economic development.

The use of yet unused mineral resources (rock salt, iron ore) is believed to be conditioned by the economic conditions and new technologies in the future.

## Availability of Mineral Resources

As it is revealed by the dynamics of extraction volumes, the extraction of minerals, especially sand and gravel, showed a rapid increase during the period from 2001 to 2008.

In case of remaining rates of growth of construction industry and infrastructure works of this period, the lack of explored sources of sand and gravel would have been felt quite soon. Therefore, new deposits of sand and gravel would be necessary, however, their discovery and extraction is very complicated not only due to geological conditions, but also due to emerging lack of free land for excavation.

It should be noted that the conflicts between land owners and users and excavation companies seeking to use the sources of minerals became more frequent in the territories of explored mineral resources. They usually occur when land owners are not direct ownership inheritors but rather persons who bought land purposefully in the sites of mineral resources and artificially raised prices of the land of deposits. The negative consequence of this process will soon have impact on country's economic development as this will cause the increase of prices of raw materials and construction materials made of these raw materials.

Therefore, the provision of resources should be evaluated not only in terms of the amount of resources but also in terms of access to these resources. It should be noted that deposits of solid minerals occupy only approx. 4% of Lithuania's territory; therefore, their areas should not be used for other needs restricting the possibility to use the mineral deposits.

The deposits of the main currently used solid minerals – limestone, dolomite, gravel, sand, clay, decomposed peat, sapropel – are sufficient for many decades (Table 25), however, low-decomposing (light) peat, clay of the Devonian era, monomineral quartz sand and oil resources are quite limited, therefore, their extraction should be very rational. With the annual increase in the demands for sand and gravel in the construction industry, the resources of these minerals are rapidly decreasing and are so far supplemented with newly explored deposits. Based on the rates of extraction of 2011, the deposits of explored sand resources will be sufficient for more than 100 years, whereas the gravel resources explored until 2012 will be sufficient for 98 years.

**Table 25.** Amount of thoroughly explored mineral resources on 01.01.2012 and the forecasted period of their extraction. *Source: Lithuanian Geological Survey*

| Item No | Mineral | Meas. Unit | Thoroughly expl. resources 2012 01 01 | Extraction, 2011 | Duration of extraction (years) |
|---|---|---|---|---|---|
| 1. | Anhydrite | million $m^3$ | 80.69 | – | |
| 2. | Dolomite | million $m^3$ | 112.54 | 1.45 | 78 |
| 3. | Peat | million $m^3$ | 1,284.78 | 2.14 | > 100 |
| 4. | Limestone | million $m^3$ | 193.65 | 0.57 | > 100 |
| 5. | Clay | million $m^3$ | 145.0 | 0.25 | > 100 |
| 6. | Sand | million $m^3$ | 245.94 | 1.68 | > 100 |
| 7. | Gravel | million $m^3$ | 642.56 | 6.59 | 98 |

It should be noted that provision with, for example, sand and gravel resources is unequal in different locations due to geological conditions. If, in Alytus region, the current explored resources will be sufficient for 137 years (calculating in the extraction rates of 2011), in Klaipėda region, these resources will be available for only 13 years.

When excavating minerals, natural resources are irreversibly consumed except for a small share of secondary recycled raw materials, for example, demolition rubble. The formation of the majority of mineral deposits lasted from several thousand to several hundred million years, whereas the use of them lasts for several decades. Thus, minerals are not renewable natural sources. Even for the formation of deposit of peat, which can be conditionally referred to the renewable mineral, requires 8-10 thousand years, and this deposit can be excavated within several decades.

## Necessity of Preservation

When excavating minerals, natural resources are irreversibly consumed except for a small share of secondary recycled raw materials, for example, demolition rubble. The formation of the majority of mineral deposits lasted from several thousand to several hundred million years, whereas the use of them lasts for several decades. Thus, minerals are

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When calculating the extraction forecasts in such way based on the provision with resources, it is necessary to consider the geological conditions of the respective region and other extraction circumstances

Furthermore, the excavation of solid minerals causes irreversible changes to the natural environment. Therefore, the excavation of minerals should be sparing, i.e., meeting not only the needs of current society, but also of future generations and causing as minimum impact on environment as possible. This requires not only reliable knowledge on the land resources, the impact of extraction on the environment and strong linear extraction regulation system, but also good practice principles of considerate extraction.

The Constitution of the Republic of Lithuania stipulates the exceptional state's ownership of land's depths thereby emphasise the importance of underground resources in the life of the state.

The consideration of underground resources and protection measures are stipulated and implemented when preparing thematic programmes and strategies, when composing the legal system for the usage of earth's depths. For example, the National Environment Strategy, which is currently in progress, stipulates the following: "It is necessary to achieve that the rates of extraction of underground mineral resources were twice lower than the GDP growth rates, by encouraging more clean methods of extraction considering and protecting resources, use of secondary raw materials, the replacement of depleted sources with renewable. It is necessary to protect unused mineral deposits against development during the process of territorial planning, by optimising legal procedure of land takeover for the public needs (use of minerals)".

When preparing and improving the strategies and legal acts of the use of underground resources, it is necessary to follow as wide and comprehensive attitude as possible, the key principles of which are as follows:

- the society cannot survive without using natural resources. Therefore, the extraction of minerals is an inevitable process;
- depths of earth are not only the source of raw materials or component of living environment, but also the natural sphere sensitive to external impact;
- any mineral resources are limited and have a localised area in earth's crust and thus are unique, therefore, their deposits are exceptional natural objects having a priority of use in respect of other natural components;
- when protecting (sparing) mineral resources for future generations, the current society should not be impoverished as only a developed (prosperous) country is able to invest into sufficient material and intellectual resources for the creation of new technologies and materials allowing the replacement of ordinary minerals or their sparing utilisation.

## FOREST SECTOR OUTLOOK

In the nearest future, the Lithuanian forest sector is likely to be developed in accordance with the National Forestry Sector Development Programme for 2012–2020 approved on 23 May 2012.

The use of wood resources is related to the general economic situation in the country. Based on the scenario of slower development, the demand of wood with the current cutting and wood processing volumes will be met until 2030. Based on the optimistic economic development scenario, the wood processing industry will grow and wood demand will exceed the supply between 2015 and 2020, the need for wood mass will increase especially for energy needs, in order to achieve the aim of renewable energy "20 by 2020". Based on this development scenario, the need for imported wood will increased. If other renewable energy sources, including the biomass generated from other sources but not wood, are developed more rapidly, the pressure to supply wood will be lower. According to the evaluation of experts, the share of EU wood in the scale of renewable energy sources will decrease from 50% in 2010 to 40% in 2020. In Lithuania, the production of energy is possible by using up to 750 thousand $m^3$ of forest felling waste. Although the need for biomass is constantly increasing, only 155 thousand $m^3$ of it was sold in 2011, therefore the available resources are used insufficiently.

After the completion of privatisation of forest lands, the areas of forest not used for economic activity will decrease leading to the formation of possibilities to increase wood production volumes without increasing the intensity of cuttings. During the next 15 years, the amount of main felling would have to decrease by approx. 6% in state forests, and it is likely to increase by 6–7% in private forests.

At the end of the period, it would be possible to produce 7-8 million $m^3$ of wood by all felling in all forests each year – with the main felling alone, it would be possible to cut more than by 2.5 million m$^3$ in both state and private forests until 2014, whereas later – until 2020 – the amount of main cuttings could increase up to 3 million m$^3$ in private forests. By 2020, pine cuttings should increase the most – by nearly 1.5 times, also the spruce, birch, alder cuttings should increase, the felling of aspen should decrease more than double. The sources of birch and alder should be more intensively harvested in private forests, where they are more abundant now. Bare cutting is currently the most widely applied type of felling: in 2006-2010, such felling accounted to 73.8% of the overall area of main felling. More ecologically acceptable cuttings of other species should be applied more frequently in the nearest decade. The structure of stands will be optimised; the area of oak woods is likely to show the most significant increase in the country.

More intensive cooperation is planned to be developed in the area of private forests; currently, more than 200 thousand forest owners are small (the owned areas of forest are smaller than 10 ha). Such small plots have low farming efficiency, the application of more modern measures is irrational, and therefore, the cooperation should expand.

The development of Lithuanian forests can also be conditioned by the international context. There are four scenarios of European forest development by 2030 (UNECE and FAO) prepared: 1) to maximise coal biomass; 2) to give priority for biodiversity; 3) to increase the use of energy from wood (as source of renewable energy); 4) to stimulate innovations and competitiveness in the forest sector.

The likely scenarios are compared with the current model of forest use (current or referential scenario), which also remains the possibility of sector development.

By applying the current scenario, the indicators of stands should increase slowly but steady. The stock volume of European stands would increase from 29.0 billion m$^3$ in 2010 (174 m$^3$/ha) up to 33.3 billion m$^3$ in 2030 (195 m$^3$/ha). The volume of use should also increase – by 15% during 2010–2030. It is planned that by 2030 the demand in wood will increase by 20%, and the need of it from energy production will be higher. At the end of the period, the supply of and demand for wood will be balanced.

In the first scenario, it is planned to apply methods without changing the volumes of forest, usage under which there would be more coal accumulated in forests, therefore, the volumes of wood would increase significantly – by 7.8% more than in accordance with the current scenario (up to 209.5 m$^3$/ha). The age of stands would increase as well as the recreational value and resistance to unfavourable climate factors; the deadwood and windfalls in forests would increase due to less intensive intermediate and sanitary felling.

Based on the second scenario, the diversity of stands and structure would approach to natural (Fig. 266), there would be more mixed forests, all windfalls and deadwood would remain in the forest. Due to older cutting site, in 2030, the volume of stands would increase to 218.8 m$^3$/ha. There would be a significant increase in forests used for the protection of biodiversity (6.2 million ha more than in case of current scenario). It is evaluated that the demand for wood will remain the same. Due to changes there would be much more coal in woods than based on the current scenario, however, the supply of wood would decrease down to 190 million m$^3$ and would be lower than the demand (difference – 176 million m$^3$). The difference can be solved by cultivating special intensive growth plantations.

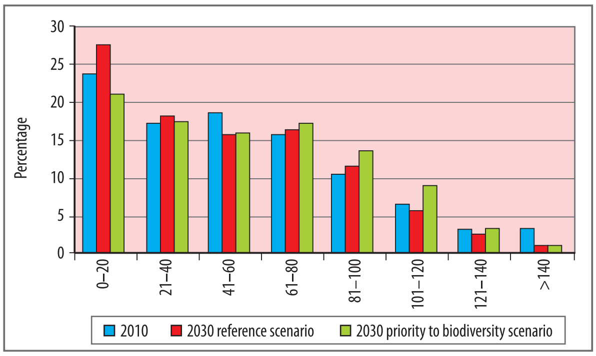


**Fig. 266.** Distribution of forest age classes by current and biodiversity priority scenario. *Source: Directorate General of State Forests*

Based on the third scenario, the main aim of forest management is to seek for target indicators of renewable energy.

It is planned that, in 2030, the need for wood for energy needs will amount to 860 million m$^3$, accounting for 60% of the total consumption of wood (nearly twice more from 2010 – 435 million m$^3$); the total wood production would achieve 1.4 billion m$^3$ in 2030, i.e., by 250 million m$^3$ (22%) more than based on the current scenario. Windfalls and deadwood would be eliminated from forests by using fertilisers; the forest farms will become more intensive.

The fourth scenario is less relevant to Lithuania, as it would be applied in the EU and the global scale. The innovations should cover not only the processes of cultivation and production, but also business models and marketing. Based on this scenario, in addition to intensive forest usage, an increasing focus is forecasted for the vitality and biodiversity in the forests of the Northern European forest region (which also includes Lithuania). Intensive cuttings of stands of the age of more than 100 years will be coordinated with the measures used for the maintenance of more favourable conditions for the support of biodiversity.

## DEVELOPMENT OF GAME RESOURCES

The resources of hunted fauna are varying cyclically when the variations of the abundance of certain species are especially high due to climatic and other factors, especially in case of roes, boars (of latter – due to population, self-regulation, including disease outburst). It is necessary to maintain the system of hunting limit by using resources of corvine animals. By performing the prevention of illegal use and limiting the influence of fragmentation and distortion factors, as well as purposively planning the hunting limits in the regions in view of territorial distribution, it is necessary to stabilise the vitality of moose population – in the optimum habitats, the abundance of this species could achieve 3-4 individuals per thousand ha of forest. On the other hand, it is important to maintain optimum abundance of populations of other corvine animals – roes and red deer, as well as in view of the evaluated abundance in separate regions: in case of roes it could achieve approx. from 15 to 50 individual per thousand ha of forest, on average, deer – up to 15 individuals per thousand ha.

The forecasted beaver's population increase rate was successfully managed by intensifying the hunting, however, without maintaining at least the current hunting volumes, and without regulating the non-perspective number of beaver habitats, the abundance of beavers can start to increase again, since they can successfully adapt to varying environmental conditions.

In order to avoid especially high variations of hare population and ensure its stability, it is necessary to regulate the abundance of invasive predators and foxes and apply more optimum measures of hunting planning – this could form conditions for the restoration of resources of this species within a decade, by reaching up to 50-60 individuals per thousand ha in optimum habitats.

In view of the ecological plasticity of wolf, as a species, it can be reasonably suggested that the state of Lithuanian habitats is favourable for this species, however, is influenced by two groups of factors of contrary nature – the initiatives of increase of forest coverage, including the National Forestry Sector Development Programme, and decrease in the agricultural intensity are favourable for this species, however, the fragmentation of habitats by intensively used road network, as noted by L. Balčiauskas, is currently having an obvious negative influence on the spatial structure of wolf population – distribution in the Lithuanian territory – and restricts the possibilities of crossing. Furthermore, the increasingly intensive recreational load of forests is also likely to cause enhanced negative impact on the stability of population of predators. Since the wolf is living in many Lithuanian protected areas, no additional measures are necessary for the protection of their habitats, however, the state and territorial distribution of wolf population requires repetitive evaluation after the completion of the highway-fencing programme.

Assuming that the population of 250 wolfs is optimum in Lithuania's territory and reliably ensures the vitality of population, in case of increase of population, it would be possible to increase the hunting quota and form it in regional principle, first of all, ensuring effective regulation of population of these animals in Kupiškis region and North-West Lithuania, where wolfs cause the most significant damage to farmers.

The programmes of restoration of species can form conditions for the stabilisation of lynx population in the Lithuania's territory, because the cases of registration of this species are becoming more frequent. Same as in case of wolfs, it would be necessary to evaluate the impact of fragmentation caused by intensively used highways, especially with protective fences, on the vitality of lynx population.

The varying climatic conditions (especially warming winters) can become more favourable for the spread of new aggressive invasive species – common racoon – in Lithuania. The radical measures should be planned in advanced and applied in order to control the spread of this species causing particularly serious damage to ornithofauna.

## OUTLOOK OF BIODIVERSITY IN LITHUANIA

The state of biodiversity is an integral part not only of the state of continental environment of the entire Lithuania, but also of larger region. The majority of separate species conservation strategies become a part of the strategy of the entire European Community and wider European networks. The major part of occurring consequences is related to the causes of global anthropogenic destructive impact on the natural environment. Separately indicated very important causes include the global climate change, global pollution of ecosystems, increasing and global scale of invasions and direct physical impact on ecosystems.

The research results in Important Bird Habitats show that with habitats moving to the northeast direction, 17 out of 49 populations of protected birds in Lithuania breeding in western, south-west and south peripheries of habitats will be the first ones to suffer the impact and are faced with danger of extinction. The remaining 32 species the breeding populations of which are in northern, north-east, east, north-west peripheries or central part of habitat, should not face extinction due to climate warming. It is likely that, during the 21st century, 1/3 out of 72 protected species in Lithuanian Important Bird Areas will extinct. In four important bird areas, up to 1/3 of species should extinct, in 19 territories – from 1/3 to ¾ of species, and, in 8 territories, all 181 protected species should extinct. Thus, more than 60% of Important Bird Areas in Lithuania can remain as perspective in the 21st century provide suggestion that the climate change will occur in the rates forecasted at the moment (Žalakevičius et al., 2009).

The climate change and related ecosystem shifts and their modifications will have enhanced influence on the varietal diversity, abundance and distribution of plants and phytocenotic structure of habitats.

The cases of spread of invasive species and further outspread are believed to become more frequent in the future. The adaptation starting from the cellular level ending with community is possible. The threat of emergence of new alien dangerous plants and fungi is likely to increase considering the direction of the spread of invasive species (from warm climate regions to warming climate regions). New threats of unnecessary intentional and spontaneous introduction are emerging and increasing (crustaceans, fish, reptile and even mammals). The emerging and low controlled populations of certain species are causing new issues of various levels even now (beaver, cormorant, certain species of gobies, Siberian hogweed, etc.).

It is difficult to fight with already established invasive species (Canadian mink, racoon dog, small balsam, rugosa rose, large-leaved lupine, etc.), some already conquered or likely to conquer/destroy certain local (including protected) species.

The emerging changes of biodiversity cause new practical environmental problems arising in the junction of science and politics. In order to create effective measures for biodiversity protection, we have to find new ways to identify and objectively evaluate the arising threats in order to use the available protection measures as effectively as possible. It is important to use the available and newly accumulated systemic knowledge on the biology of species, stability of ecosystems and habitats, maintain their possible or even restoration methods and ways.

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