Biodiversity in Lithuania: achievements, challenges and policy

Gintarė Sujetovienė*, Jūratė Žaltauskaitė and Renata Dagiliūtė

Department of Environmental Sciences,
Vytautas Magnus University,
Vileikos 8, Kaunas 44404, Lithuania
Email: gintare.sujetoviene@vdu.lt
Email: jurate.zaltauskaite@vdu.lt
Email: renata.dagiliute@vdu.lt
*Corresponding author

Abstract: Biodiversity is the key to the stability and productivity of natural systems. Preserving biodiversity is, therefore, one of the most important environmental issues for both developing and developed countries. The objective of the study is to reveal the main temporal trends of biodiversity and related indicators in Lithuania, a post-soviet country. The analysis focuses on the biodiversity and related indicators such as forest coverage, protected areas, red list, and administrative infringements in protected areas covering the period of the last two decades (1991–2014) after the reestablishment of independence which is considered a transition period. After the restoration of independence, the country became a participant in international law collaboration. Despite the relatively good situation in biodiversity conservation, loss and fragmentation of the habitats due to economic activities as well as infringements highly contribute to the current challenges. Public information and awareness are rising as well as strong political awareness is still needed.

Keywords: governance; Lithuania; biodiversity; nature conservation.

Biographical notes: Gintarė Sujetovienė is an Associated Professor at the Vytautas Magnus University, Department of Environmental Sciences, Kaunas, Lithuania. Her research focuses on physiological and biochemical response to environmental stress. For more than ten years she is involved in teaching and research on biomonitoring (pollution, climatic change, nitrogen stress) and biological conservation. She has authored several research articles in a number of international journals and presented papers in national and international conferences.

Jūratė Žaltauskaitė is an Associated Professor at the Vytautas Magnus University, Department of Environmental Sciences Kaunas, Lithuania. Her research topics are the toxicity testing of various contaminants, organic and inorganic compounds effects to terrestrial and aquatic organism and the toxicity changes under different environmental conditions. She has published a number of research articles in a number of international journals and presented papers in national and international conferences.

Renata Dagiliūtė holds PhD in Environmental Sciences and Ecology and is an Associated Professor at the Vytautas Magnus University, Department of Environmental Sciences Kaunas, Lithuania. For more than ten years she is involved in teaching and research on environmental impact assessment, environmental policy and economics, sustainable development as well as sustainable production and consumption, resource consumption efficiency, environmental awareness, consumption drivers and determinants. She is an author and co-author of number of scientific papers around sustainability and related issues; also, she has participated in number of international conferences as well as held several public lectures on sustainable consumption and environmental aspects.

1   Introduction

Central and Eastern European countries (CEE) experienced rather cardinal changes in all spheres of life in the last two decades. Changes in political systems' shift from a centrally planned to a market economy had significant implications to the environmental and social issues after the collapse of the Soviet Union (Randla et al., 2002; Lang, 2003; Cherp et al., 2003; Juknys et al., 2008). CEE countries must deal also with the transition to sustainability at the same time which "was very fragmented and never an integrated agenda" (Mžavanadzė, 2009). Quite often economic and political issues have been dominating over environmental aspects (Mžavanadzė, 2009), and market liberalisation in some cases could have led not only to positive environmental impacts but also to negative ones such as diminished environmental control and resource intensive activities (Cherp et al., 2003; Kirkpatrick and Lee, 1997). Little attention to pollution prevention, inefficient resource consumption, lack of public participation and reduced non-governmental organisational (NGO) activities were the features of newly independent states (Kolodko, 1999). Alternatively, the transition period created possibilities to include environmental issues in the new market structures of society and to contribute to environmental impact reduction.

EU enlargement and harmonisation of legal bases opened possibilities for wider stakeholders' participation in the processes of biodiversity protection, benefiting from the participation of nongovernmental organisations in the processes in some cases (Börzel and Buzogány, 2010). However, inherited passivity and weak institutional capabilities and the limited inclusion of public actors in the process of governance rather than the government of biodiversity persist in post-soviet countries (Kluvánková-Oravská et al., 2009). In addition to limited public influence, other challenges such as weak institutions, low trust in governmental structures, the dominant natural science approach and focus on economic efficiency of protected areas persist (Kaltenborn et al., 2002).

According to the International Union for Conservation of Nature (IUCN) the main threats to species in Lithuania are habitat loss, fragmentation and degradation (IUCN, 2013). Other major threats come from pollution due to agriculture and forestry logging and wood harvesting, and residential and commercial development. Habitat restoration, land claims, and management problems are also among the issues to be discussed and

solved (Kaltenborn et al., 2002). As indicated by Schulp et al. (2016), to reach the objectives of the European biodiversity strategy and to reduce the impacts of land use change, better implementation and enhancement of existing policies or even additional measures are needed. Uptake of the land for development is an issue not only in the European Union (Schulp et al., 2016) but in other countries and sites as well (Cai et al., 2015). The objective of the article is to present and discuss the current biodiversity indicators and protection and conservation challenges in Lithuania.

2 Material and methods

Lithuania is located on the eastern coast of the Baltic Sea. The area of the country is 65.3 thousand km^2. The research covers the period of the last two decades after the reestablishment of independence, which is still considered a transition period. The analysis primarily covers the period from 1991 to 2014. It is assumed the transition period will last until the main economic indicators (GDP, incomes, labour productivity, etc.) of Lithuania reach the European Union old members' (EU-15) level on average.

Lithuania is a typical country with transition economy undergoing all these transitions and coping with inherited as well as with arising new biodiversity protection and governance problems. Until the beginning of the 1990, the environmental issues were under the regulation of very limited law on nature protection (1959) and integrated scheme for protection of nature of Lithuania (1986). The later was more realistic and indicated the rather poor environmental situation. Based on 'dilution is the solution' and limited to some formal administrative tools and inefficient use of low governmental appropriation (for example over the period of 1985–1988 the allocations for environmental protection amounted only to 0.5–0.7% of gross domestic product) environmental protection was leading to ecological crisis during this period in Lithuania. Biodiversity has been threatened by excessive use of pesticides and fertilisers, industrial and military pollution of soil, air and water.

Before the collapse of the Soviet Union the only form of forest ownership was state ownership. Some similar pattern existed in land ownership, too. All land and its natural resources were the exclusive property of the State (Lazdinis et al., 2009). Private ownership was limited only to the small private curtilages near the houses. Land reform (1991) still is an ongoing process and has influenced highly the size of the land and forest plots. Increasing the number of owners and decreasing the size of land and forest plots are the main features of reforms leading to some additional biodiversity governance challenges. At the very beginning of the reforms land and forest ownership was re-established first, and only later, biodiversity and protected areas became an issue.

During the last decades, following the restoration of Lithuania's independence, the country became a participant in international legal collaboration. The environmental sector is probably one of the sectors which have been mostly influenced by international conventions and treaties, establishing a framework for environmental protection and sustainable development on global and regional levels (Vaičiūnaitė, 2003; Budriene, 2007). Lithuania has joined or ratified six conventions and one international agreement regarding protection of nature and biodiversity (Budriene, 2007). Lithuania has ratified the convention on Biological diversity (in 1996) and Cartagena Protocol on Biosafety (in 2003); however, the Nagoya Protocol on Access and Benefit-Sharing is still unratified.

The analysis focuses on the biodiversity and related indicators such like forest cover, protected areas, number of protected species, number of species included in the red list of Lithuania, and administrative infringements in protected areas in Lithuania. We characterised land use according to these parameters: proportion of agricultural land, share forested land, land under the conservation status and others. Data on number of protected plant, fish, bird and mammal species were analysed to characterise the changes in the number of protected species. We assessed the changes in the status of protected species assessing the changes of the number of species regarding red list categories (five categories follow the same classification used in the IUCN Red List, 1976). Administrative infringements in Lithuanian protected areas included fauna and forest infringement. Data from the Department of Statistics to the Government of the Republic of Lithuania (Statistics Lithuania), Ministry of Environment of the Republic of Lithuania, State Service for Protected Areas, and the National Land Service of Lithuania are used in this study to reveal the main trends of biodiversity indicators.

3   Results and discussion

3.1   Changes over the two last decades and the current biodiversity situation

Human land use is a major driver of the distribution and functioning of ecosystems implying changes in, or destruction of, natural habitats. The change in land cover causes a decrease in ecosystem quality along with the extinction of species (Haines-Young, 2009). These changes might also correspond well with other biodiversity conservation related indicators such like forested land protected areas. Some changes took place after Lithuania regained of independence. If in 1991, land used for agriculture amounted to 70% of Lithuania's area, in 1995 this share decreased to 52% and stabilised at approximately 60% afterwards (Figure 1). Reestablishment of land and forest ownership, as well as inventorisation of existing properties, contributed to these fluctuations in the 2000s. Later, the increase in forest coverage contributed to the overall increase in forested land. The process of considering citizens' claims for land and transferring them into private ownership began in 1993 (Lazdinis et al., 2009). In 1998, only 25.3% of the land was private property, and in 2010 this number amounted to 57.6%. Build up land (i.e., urban development and roads) accounted for up to 6% of Lithuanian territory recently. According to Schulp et al. (2016), land take ration would remain neutral in Lithuania despite applied scenarios for biodiversity protection policies. Hence, this gives insights that at least no negative impacts related with land use cover changes should be expected and other drivers should be addressed.

In the last decade, Lithuania's forest cover increased by more than 3% due to the artificial afforestation and the natural forest regeneration (Figure 2). This increase in forest cover was mainly achieved due to the Lithuanian Afforestation Programme (2002), according to which the forest cover area was planned to increase by 3% over the next 20 years from 2002. It was assumed that afforestation of abandoned land was important for restoration of functional habitat connections for the sustainability of biodiversity (Lazdinis et al., 2005). This process has especially speeded up in recent years when 4,000 to 5,000 hectares of unused land naturally regenerate annually. Mostly, it is pastures, wetlands, and peat-bogs that regenerate naturally. The gradual increase in forest cover was estimated every year, and the total forest cover was 33.3% of the country (around

2,177 thousand ha) in 2014 (Figure 2). The increase in the area of forest stands has been observed since 2002 when inventory was performed across the whole country. During the last decade, the forest land area has increased by 2% of the total forest cover (Figure 2). An average forest area per capita increased from 0.57 ha to 0.68 ha during the last decade. The average growing stock volume in all forests since 2003 increased by 11 m^3/ha up to 240 m^3/ha. In comparison with other Eastern Europe countries, the trends of forest cover changes were very inconsistent and the increase occurred in most of them except Estonia and Latvia (Potapov et al., 2015).

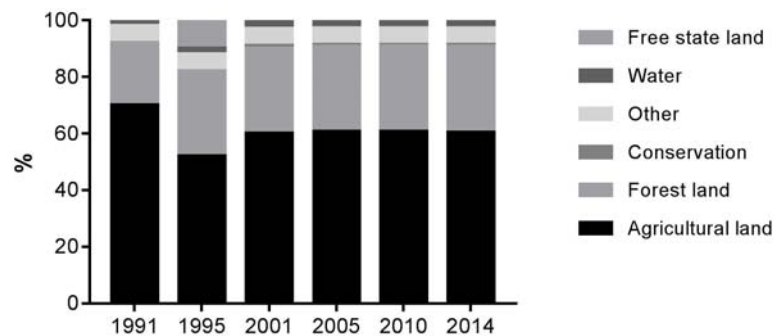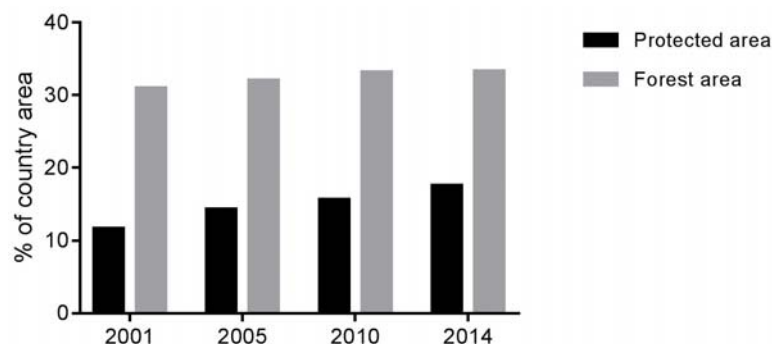**Figure 1** Land, according the main land utility

Figure 2 Changes in forest cover and share of protected areas in Lithuania


State forests in Lithuania occupy 50% of national forest cover, 33% of forests are under private ownership according to the Lithuanian statistical yearbook of forestry. Private forests are managed by approximately 250,000 owners, and the average private forest is 3.3 ha. As the result of private ownership, the forests were cut into small parcels with their owner in opposition to the whole state forest.

During the earlier Soviet-era (1940–1960) establishment of the protected area was based mainly on conservation and restoration of hunting resources. During the later period the first protected areas' planning documents were prepared, reserves were created. During this period, the protected areas covered 130,000 ha, i.e., 2% of the country area. Later, new reserves and one national park (Aukštaitijos) were established. The 1980s were an important period for the development of protected area networks. The scientists have prepared the scheme of territories particularly for conservation

importance. The total area of reserves has reached more than 27,000 ha. The total territory of the protected area was approximately 5% at the end of the Lithuanian Soviet Socialist Republic (Figure 2). The intractable issue was not the formation of protected areas but to ensure the required conservation regime.

The sharp increase in the number of protected areas was noticed after re-gaining independence in 1990. During the first years of independence, the continuation of a previous task, the network of Lithuanian national parks, was finished. Since 1990, four new national parks and 30 regional parks were established; the system of national and municipal reserves was created. Later, the establishment of a network of Lithuanian protected areas corresponding to European standards was finished. There are 1,151 protected areas which cover 15.7% of the country's territory (Figure 2).

**Figure 3**   Number of protected species in state reserves and national parks
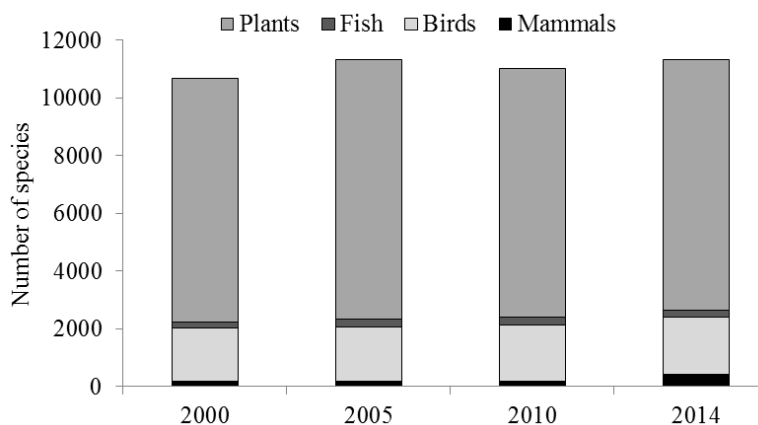
Protected areas contribute to the biodiversity conservation maintaining key habitats and ensuring the maintenance of natural processes across the landscape. With the increase of the area of protected territories, the number of species protected in those territories also increased (Figure 3). In the national parks and reserves 420 species of mammals, 1,832 birds, 262 fish and 8,685 plant species were under protection. During the last decade, a significant increase in the number of mammal species was observed though the protected species of plants decreased by 317. Despite that the number of individuals of such protected species like Eurasian lynx (*lynx lynx*) increased, other species [like Eurasian badger (*meles meles*), fallow deer (*dama dama*), wild boar (*sus scrofa*)] populations have also increased by more than two times.

The first Red Book (1981) not only has contributed to the conservation and protection against destruction of wetlands, streams and their valleys, grasslands, and woodlands, but it was a stimulus for the research of rare and endangered species. The list consisted of 41 species of animals, one genus of humble-bee and 30 species of higher plants. It had some shortcomings. First, it contained all the rare and endangered species of the Soviet Union despite their status in Lithuania. Second, species were not assigned to the categories as an indication of the status of endangered species. Third, a taxon of the lower plants and some of the invertebrates were not included. Therefore, the next Red Book (1992) has contained many more species of animals, plants, fungus, and lichens – 501 in total

(Figure 4). Under continual intensive research, the Red Book (2007) was refilled with more than 250 species after 15 years.

Figure 4 The changes of the number of species included in the red list of Lithuania
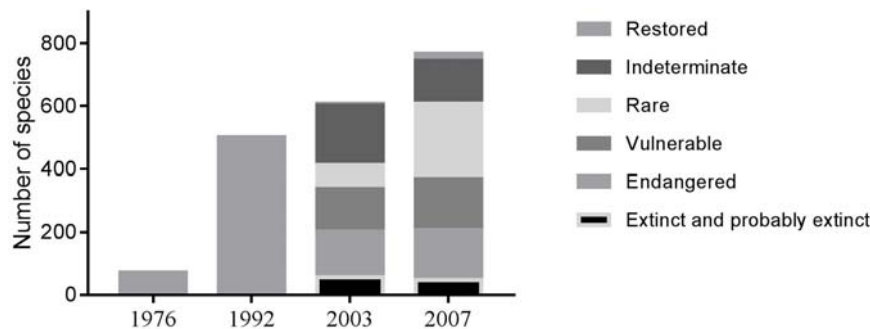
The increase in the number of rare and endangered species are arguable because of the increasing knowledge and data of species. However, it has been suggested the main problems of species conservation in Lithuania are: the decrease and/or worsening conditions of habitats due to resource exploitation, changes in land use, hydrological regime, and development of urban infrastructure (Bukantis et al., 2013, IUCN, 2013). The main cause for the changes in habitat condition is the termination of economic activities such as agriculture and peat exploitation. One of the highest rates of land abandonment was characteristic of Lithuania; 28% of all agricultural land in 1990 was abandoned by 2000 (Prishchepov et al., 2012). Illegal logging also has proved to be an important threat reported for habitats (Bouriaud, 2005). To restore degraded, damaged habitats (wetland, grassland, etc.) active human intervention is needed (Žalakevičius, 2002; Povilaitis and Querner, 2008).

Before the collapse of the Soviet Union, biodiversity in Lithuania has been threatened by excessive use of pesticides and fertilisers, and industrial and military pollution of soil, air, and water. Eco-efficiency of the agricultural sector increased most significantly during the transition period (Juknys, 2003). In 1980, fertiliser consumption in agriculture increased by 4.2 times compared to 1960 (from 233 kg/ha to 996 kg/ha). Due to geo-political and economic changes pesticide and fertiliser use have decreased (Dabkienė, 2016) and now approximately 100 kg/ha of fertiliser and 0.5 kg/ha of pesticides are used per hectare of arable land according to FAO statistics.

3.2 Challenges, existing policies and main fields of action

Lithuania hosts a large proportion of the species that are threatened at the European level. These species are found mostly in wetlands, forests, and grasslands and belong to some taxonomic groups (vascular plants, dragonflies, butterflies and saproxylic beetles). Of the total number of species assessed in the country, 3% are considered threatened, and at least 6% are near threatened at the European level (IUCN, 2013). Many of these species are endemic to Europe. These ecosystems require particular attention to ensure the habitats that remain. Species protection requires careful research and conservation, even having in mind a decreasing number of infringements of fauna and forest use recently

(Figure 5). According to the Lithuanian Environmental protection agency, illegal contractions also decreased, having reached the peak during 2005–2008.

Figure 5   Fauna and forest use infringements
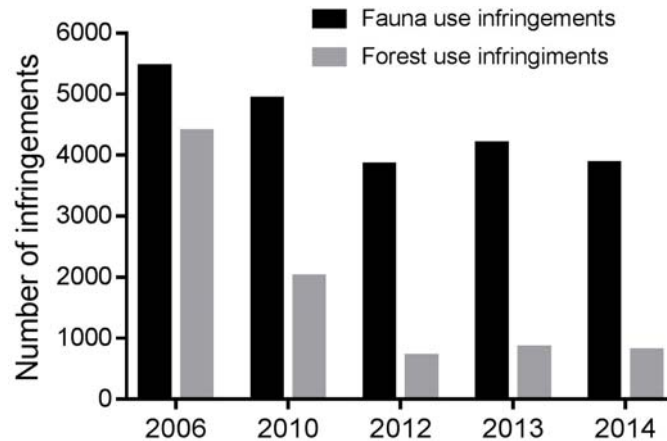
As an EU member state, Lithuania has committed to halting biodiversity loss by 2020 but urgent action is needed to meet this target, and better monitoring capacity is required to measure whether the target is met (IUCN, 2013). The need for the monitoring of valuable sites is stressed by Ziaja and Wójcik (2015) to determine the environmental changes and rates of the site. Involvement of volunteers in biodiversity monitoring could be an option here; however, this kind of public participation in post-soviet countries is still relatively low and should be encouraged (Vandzinskaite et al., 2010). This could have several advantages such like increased sampling, reliable state of the art data, and lower monitoring costs (Schmeller et al., 2008).

The former Soviet Union inflicted prevailing environmental damage throughout the Soviet Republics (Peterson, 1993). Accession to the EU period has opened new possibilities for biodiversity protection that has allowed to improve legislation and to expand the existing biodiversity protection system. Habitat (92/43/EEB) and Bird (2009/147/EC) directives together with financial EU mechanisms contributed to this process significantly. Alternatively, relatively high biodiversity in Lithuania, as well as in other nations, has enriched the biodiversity of European Union. During the accession period Lithuania negotiated on more the liberal management of species such as *Canis lupus* or *Castor fiber* that are relatively abundant in Lithuania but protected in the EU. Lithuania has more than 30,000 species but the potential maximum is still unknown. The main problems limiting research of local fauna and flora populations are minimal available genetic data and lack of high-quality specialists. Local actors lack deeper knowledge of the biodiversity concept, and positive results of the biodiversity conservation efforts would come along with active learning, education, and training about biodiversity values and conservation instruments (Lazdinis et al., 2007). It is indicated that management types of the understory of the forests may have negative effects on plant diversity (Wu et al., 2016). Hence, rising awareness is a crucial aspect here. Private non-industrial forest owners could also have addressed this, but their motives should be taken into account as Polomé (2016) suggests, as they might be driven not only economic motives but also intrinsic motives to adopt some environmentally-friendly practices.

Brédif et al. (2017) also suggest motives by the actors involved might be a key for an effective, proactive participatory approach to area management and biodiversity protection.

Other challenges include contraposition of economic activities and protected areas as such. People, in general, perceive creation of the protected sites as limitations to their activities, though Schulp et al. (2016) indicates species richness in Natura 2000 areas in general benefits from the restriction of land use changes, thus, probably providing better ecosystem services and benefits for society. Of course, areas' context and special characteristics are very important to have efficient policy results (Schulp et al., 2016). Effective nature conservation management should include economic, social, and cultural aspects. Therefore, the inclusion of society in a biodiversity protection target should be a priority. More than nine of ten (91%) respondents in EU think this is a serious global issue and only 55% (in Lithuania 52%) think this is a serious issue in the local area where they live. More than half (61%) of respondents totally agree the EU should better inform citizens about the importance of biodiversity, correspondingly 56% in Lithuania (Special Eurobarometer 436, 2015). On EU level, the most common action taken to protect nature and biodiversity is respecting nature protection rules such as not leaving waste in natural areas (92%) (in Lithuania 91%). Approximately one quarter of respondents (26%) have heard of the Natura 2000 network, including 16% who say they have heard about it but do not know what it is. The majority (73%) have never heard of it. In Lithuania, these numbers are even lower: only 18% of Lithuanians have heard of the Natura 2000 network, including 13% who say they have heard about it but don't know what it is (Special Eurobarometer 436, 2015) Low public awareness might be a challenge to implementing biodiversity targets and contributing to sustainable development. However, protected area management decentralisation and local participation involvement in management and decision making is a challenge not only for Lithuania but for other EU countries as well (Hovik et al., 2010).

An action plan on conservation of landscape and biodiversity for the period of 2015–2020 was adopted in 2015. For biodiversity conservation and restoration, different measures are foreseen including improvement and consolidation of different legal acts, development of scientific research, monitoring and data gathering, combating alien invasive species, and securing all activities related to genetically-modified organisms. The plan also intends to ensure a good state of the landscape, biodiversity, natural and cultural values, their proper use and handling, and adapting them to visitors in protected areas.

Hence, public awareness raising, involvement in management plans and activities could be addressed to contribute to the national and global nature and biodiversity protection objectives. A desirable future still holds a vision of active public participation in developing policies and planning protected area management (Kaltenborn et al., 2002). Strong, reliable institutions, responsible for protected areas are also of importance. Built confidence and transparency contribute significantly to the attitudes of the general public, reduce incentives for environmental impingements and build responsibility. As Kluvánková-Oravská et al. (2009) indicate with the example of Serbia, post-socialistic influence (lack of democratisation) may lead to institutional weakness and overexploitation of natural resources. State-society cooperation is still on its way, as a top-down approach usually dominates in the biodiversity governance in the case of CEE (Börzel and Buzogány, 2010).

4   Conclusions

Lithuania has successfully implemented the international obligations in environmental conservation. However, all efforts have mostly been made only to correspond to the international obligations; any activities that exceed these requirements are very rare. Many species already receive some conservation attention, but others do not. Species protection requires a combination of research and coordinated efforts. To meet the target of halting biodiversity loss, there is need of a better monitoring capacity, results analysis, and high-quality specialists. The strength and capacity of responsible institutions should also be addressed to cope with arising challenges and potential and existing impingements in nature and biodiversity protection. Public involvement in management and planning as well as volunteering in biodiversity monitoring should be considered very important aspects of the whole protection system.

References

Börzel, T. and Buzogány, A. (2010) 'Environmental organisations and the Europeanisation of public policy in Central and Eastern Europe: the case of biodiversity governance', *Environmental Politics*, Vol. 19, No. 5, pp.708–735.

Bouriaud, L. (2005) 'Causes of illegal logging in central and eastern Europe: small-scale forests economics', *Management and Policy*, Vol. 4, No. 3, pp.269–292.

Brédif, H., Laurent, S. and Valenzisi, M. (2017) 'Stakeholder motivation as a means toward a proactive shared approach to caring for biodiversity: application on Plateau de Millevaches', *Land Use Policy*, Vol. 61, pp.12–23.

Budriene, A. (2007) 'Review of biodiversity research results from Lithuania that contribute to the sustainable use of biodiversity in Europe', in *Proc. of German EPBRS Meeting: European Biodiversity Research for a Sustainable Europe*, pp.25.

Bukantis, A., Ignatavičius, G., Satkūnas, J., Sinkevičius, S., Šulijienė, G., Vasarevičius, S. and Veteikis, D. (2013) *Lithuania's Environment: State, Processes and Trends*, Environmental Protection Agency, Vilnius, p.216.

Cai, Y., Zhang, H. and Pan, W. (2015) 'Detecting urban growth patterns and wetland conversion processes in a natural wetlands distribution area', *Polish Journal of Environmental Studies*, Vol. 24, No. 5, pp.1919–1929.

Cherp, A., Kopteva, I. and Mnatsakanian, R. (2003) 'Economic transition and environmental sustainability: effects of economic restructuring on air pollution in the Russian Federation', *Journal of Environmental Management*, Vol. 68, No. 2, pp.141–151.

Dabkienė, V. (2016) 'Fertilizers consumption on Lithuanian family farms', *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, Vol. 16, No. 4, pp.77–82.

Haines-Young, R. (2009) 'Land use and biodiversity relationship', *Land Use Policy*, Vol. 26S, Supp. 1, pp.178–186.

Hovik, S., Sandström, C. and Zachrisson, A. (2010) 'Management of protected areas in Norway and Sweden: challenges in combining central governance and local participation', *Journal of Environmental Policy and Planning*, Vol. 12, No. 2, pp.159–177.

IUCN (2013) *Lithuania's Biodiversity at Risks: A Call for Action*, p.9, edited by, del Carpio, A.P., Sánchez, S., Nieto, A. and Bilz, M., International Union for Conservation of Nature, Brussels, Belgium.

Juknys, R. (2003) 'Transition period in Lithuania – do we move to sustainability?', *Environmental Research, Engineering and Management*, Vol. 4, No. 26, pp.4–9.

Juknys, R., Miskinis, V. and Dagiliūtė, R. (2008) 'From transition to sustainability: a comparative study', *Environmental Research, Engineering and Management*, Vol. 43, No. 1, pp.61–68.

Kaltenborn, B.P., Vistad, O.I. and Stanaitis, S. (2002) 'National parks in Lithuania: old environment in a new democracy', *Norsk Geografisk Tidsskrift*, Vol. 56, No. 1, pp.32–40.

Kirkpatrick, C. and Lee, N. (1997) 'Market liberalization and environmental assessment in developing and transitional economies', *Journal of Environmental Management*, Vol. 5, No. 3, pp.235–250.

Kluvánková-Oravská, T., Chobotová, V., Banaszak, I., Slavikova, L. and Trifunovova, S. (2009) 'From government to governance for biodiversity: the perspective of central and Eastern European transition countries', *Environmental Policy and Governance*, Vol. 19, No. 3, pp.186–196.

Kolodko, G.W. (1999) 'Transition to a market economy and sustained growth: implications for the post-Washington consensus', *Communist and Post-Communist Studies*, Vol. 32, No. 3, pp.233–261.

Lang, I. (2003) 'Sustainable development – a new challenge for the countries in Central and Eastern Europe', *Environment, Development and Sustainability*, Vol. 5, No. 5, pp.167–178.

Lazdinis, M., Angelstam, P. and Lazdinis, I. (2007) 'Maintenance of forest biodiversity in a post-soviet governance model: perceptions by local actors in Lithuania', *Journal of Environmental Management*, Vol. 40, No. 1, pp.20–33.

Lazdinis, M., Carver, A.D., Lazdinis, I. and Paulikas, V.K. (2009) 'From union to union: forest governance in a post-soviet political system', *Environmental Science and Policy*, Vol. 12, No. 3, pp.309–320.

Lazdinis, M., Roberge, J.M., Kurlavičius, P., Mozgeris, G. and Angelstam, P. (2005) 'Afforestation planning and biodiversity conservation: predicting effects on habitat functionality in Lithuania', *Journal of Environmental Planning and Management*, Vol. 48, No. 3, pp.331–348.

Mžavanadzė, N. (2009) 'Building framework for national sustainable development assessment and application for Lithuania: sustainability in transition', *Journal of Environmental Assessment Policy and Management*, Vol. 11, No. 1, pp.97–130.

Peterson, D.J. (1993) *Troubled Lands: The Legacy of Soviet Environmental Destruction*, pp.288, Westview Press-Routledge.

Polomé, P.H. (2016) 'Private forest owners motivations for adopting biodiversity-related protection programs', *Journal of Environmental Management*, Vol. 183, No. 1, pp.212–219.

Potapov, P.V., Turubanova, S.A., Tyukavina, A., Krylov, A.M., McCarty, J.L., Radeloff, V.C. and Hansen, M.C. (2015) 'Eastern Europe's forest cover dynamics from 1985 to 2012 quantified from the full Landsat archive', *Remote Sensing of Environment*, Vol. 159, pp.28–43.

Povilaitis, A. and Querner, E.P. (2008) 'Possibilities to restore natural water regime in the Žuvintas Lake and surrounding wetlands – modelling analysis approach', *Journal of Environmental Engineering and Landscape Management*, Vol. 16, No. 3, pp.105–112.

Prishchepov, A.V., Radeloff, V.C., Baumann, M., Kuemmerle, T. and Müller, D. (2012) 'Effects of institutional changes on land use: agricultural land abandonment during the transition from state-command to market-driven economies in post-Soviet Eastern Europe', *Environmental Research Letters*, Vol. 7, 024021 DOI: 10.1088/1748-9326/7/2/024021.

Randla, T., Kurisoo, T. and Vilu, R. (2002) 'On eco-efficiency and sustainable development in Estonia', *International Journal of Environment and Sustainable Development*, Vol. 1, No. 1, pp.32–41.

Schmeller, D.S., Henry, P.Y., Julliard, R., Gruber, B., Clobert, J., Dziock, F., Lengyel, S., Nowicki, P., Déri, E., Budrys, E., Kull, T., Tali, K., Bauch, B., Settele, J., van Swaay, CH., Kobler, A., Babij, V., Papastergiadou, E. and Henle, K. (2008) 'Advantages of volunteer-based biodiversity monitoring in Europe', *Conservation Biology*, Vol. 23, No. 2, pp.307–316.

Schulp, C.J.E., van Teeffelen, A.J.A., Tucker, G. and Verburg, P.H. (2016) 'A quantitative assessment of policy options for no net loss of biodiversity and ecosystem services in the European Union', *Land Use Policy*, Vol. 57, pp.151–163.

Special Eurobarometer 436 (2015) *Attitudes of Europeans towards Biodiversity*, European Union.

Vaičiūnaitė, R. (2003) *Lithuania', in Implementation PEBLDS in Central and Eastern European Countries*, CEEWEB 2003, pp.75–92.

Vandzinskaite, D., Kobierska, H., Schmeller, D.S. and Grodzińska-Jurczak, M. (2010) 'Cultural diversity issues in biodiversity monitoring – cases of Lithuania, Poland and Denmark', *Diversity*, Vol. 2, No. 9, pp.1130–1145.

Wu, W., Hu, Y., Li, Y., Gong, J., Chen, L., Chang, Y. and Xiong, Z. (2016) 'Plant diversity and vegetation structures in the understory of mixed boreal forests under different management regimes', *Polish Journal of Environmental Studies*, Vol. 25, No. 4, pp.1749–1757.

Žalakevičius, M. (2002) 'The state of biodiversity and its conservation problems in the most important wetlands of Lithuania – in strict state reserves', *Acta Zoologica Lituanica*, Vol. 12, No. 3, pp.228–241.

Ziaja, M. and Wójcik, T. (2015) 'Changes in vascular flora of the Rzeszow Reservoir after 20 years (SE Poland)', *Polish Journal Environmental Studies*, Vol. 24, No. 4, pp.1845–1854.