Current management practices for specially protected habitats and species in Latvia: Forests

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Preface: Developing Knowledge Base on Management of Natura 2000 Sites

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This is the third collection of articles about the experience of wild species and habitats management in Latvia. The first two (Opermanis 2002, Auniņš 2008) were published thirteen and seven years ago respectively. By taking a critical look from today’s perspective, we have to admit that the introduction of the first edition (which was later expanded and updated into an introduction of the second edition) already clearly listed all or nearly all of the important matters in relation to the management of species and habitats: it formulated the main definitions and ideas, justified the need for the conservation objectives, explained the selection of management methods and need for monitoring of the management results. It explained the concept of favourable conservation status which today, with Latvia already being a member of the European Union, has become a significant subject of discussion in nature conservation.

During this period, the theory of species and habitats management has not undergone any significant changes, therefore, it is difficult to introduce something completely new. However, the change of generations and reorganisation of institutions has resulted in at least partial replacement (and expansion in general due to the effect of the number of projects) of people involved in the management of protected species and habitats. Therefore, it seemed useful to start this volume by giving a short reminder about a few of the main principles of creation of the Natura 2000 network to gain a better understanding of why Natura 2000 site management is necessary. It seemed important and maybe even interesting to share our findings about the history of species and habitats management in relation to the European Union nature directives and the new European Commission initiatives in this area since 2008. Even though this information mostly concerns the Natura 2000 sites, the principle of the management planning and assessment cycles itself may also be applied to activities outside of the protected areas. Lastly, it seemed useful to analyse some of the institutional and human-related aspects in the planning and reporting of species and habitat management.

A simplified diagram reflecting the way from identification of a Natura 2000 site to ideal management is shown in Figure 1. Establishment process of the Natura 2000 network was started by scientific analysis aimed at finding out how many sites by area, number, and distribution are required for each protection unit (habitat, species, subspecies) listed in the respective annexes of directives, in order to ensure a favourable conservation status. Then the selected sites are provided with the initial conservation status. Information (including, the Standard Data Form which lists what species and habitats may be found in each site and other information) is gathered about each of the sites and then submitted to the European Commission. Further, conservation objectives are set for each site based on the information from the Standard Data Form, which together form the overall objective for each species and habitat at a national level (Louette et al. 2012, European Commission 2012a).

![Diagram of Natura 2000 site management process](image-url)
Preface: Developing Knowledge Base on Management of Natura 2000 Sites

In order to achieve the conservation objectives, proper conservation measures must be planned: where, when, how often, by what means, and what. It should be pointed out that the management measures may be both active and passive (i.e. leaving everything to natural processes or the so-called non-intervention management). Unlike the selection of sites which is based purely on scientific (biological) arguments, the management planning stage also includes the socio-economic factors.

Implementation of the management measures (Figure 1) in most of the cases is a gradual process and is often carried out in line with the next step - monitoring of the management progress (European Commission 2013). Forests conservation measures, in place makes legal sense in the context of the Habitats Directive, which means that a site has received the new status of Special Area for Conservation (SAC) in contrast to Site of Community Interest (SCI) which it had after the European Commission approved the submitted Standard Data Form (European Commission 2012b).

From a scientific standpoint, the term conservation measures in place doesn’t really make any sense as it is hard to know, when and how, to determine the exact moment when all of the necessary measures are finally implemented. On the other hand, I believe that conservation measures (aizsardzības pasākumi in Latvian) is a very correctly selected term as it includes all the nature conservation elements of the management plan, which includes both active and passive nature conservation measures and does not cause ambiguity, unlike the traditional term management (apsaimniekošana) in Latvian) which more or less suggests only active performance. For the sake of understanding, maybe it should (or must) be translated in Latvian simply as "natura conservation measures (species and habitat conservation measures)?

By its nature, the conservation objectives are set, management measures planned, and monitoring plans established for the whole process of nature conservation planning. If for some reason information on the Standard Data Form is incomplete, the development process of the nature conservation plan may also include field studies with an aim to clarify existing conservation problems.

If there are monitoring data showing significant changes in the composition of the endangered habitats or species in a respective territory, it may be a sign of the need to review the Standard Data Form and thus also adjust the conservation objectives and required management measures. Therefore, the defining of the conservation objectives, planning of management measures, and monitoring of results is viewed as a cyclic and recoupping process which should ideally be carried out every 5 to 10 years. Of course, if a site is only or mainly subjected to non-intervention management, a review of the conservation objectives may be required over a longer period of time compared to the sites undergoing active management.

As we know, the designation of sites within the Natura 2000 process did not start as quickly as planned. Regardless of the 1978 Birds Directive which designated the Special Protection Areas (SPA) for birds as early as in the 1980s, the adaptation of the 1992 Habitats Directive, and formulation of the idea of Natura 2000, member states of the European Union where not expressing a great deal of enthusiasm in respect to the designation of Special Protection Areas (SPA and SCI) (Evans 2012, Sundzhet & Creed 2008). For this reason, in 1996 the European Commission launched a series of biogeographical seminars, where government representatives established the progress of the European Commission, as well as to scientific and environmental non-governmental organisations, that they had designated sufficient protected areas to ensure a favourable conservation status for each habitat and species. In the opposite scenario they had to designate new areas or be judged by the European Court of Justice for non-compliance with the binding requirements of directives, which was the case for many of the old member states. In 2004, in 2015, these seminars and bilateral meetings have not yet ceased to exist. Thanks to this process the Natura 2000 network, even though still incomplete, includes more than 27500 sites and covers more than one million square kilometres (about 48% of the EU territory) or roughly 0.7% of the entire world’s largest networks of protected areas.

After two decades of struggling, this fact is the pride of European politicians, who have to admit however, that the establishment of the Natura 2000 network was not quite a voluntary process.

Unfortunately, as of 2015, Latvia has still not met its obligations in the designation of the Natura 2000 sites, at least in respect to the requirements of the Habitats Directive. The European Commission expects that new Natura 2000 plans will be established for the seas and wetlands, as well as the chalk hill river mussel Unio crassus and hermit beetle Otiorrhynchus cervinus. This fact should not be too surprising to the reader as Latvia has the third lowest proportion of Natura 2000 sites of the state land area in the European Union (European Commission 2015), which is considerably below the EU average level of 18%.

Despite still ongoing development of the Natura 2000 network, in 1998, Ostermann (Ostermann 1998) already pointed out the fact that a favourable conservation status of species and habitats protected by the Natura 2000 network would not be achieved without effective management measures in their broadest meaning. At that time this message was apparently regarded as very important as this almost literal text, which would perhaps be more suited to popular science publications, was published by the highly respected Journal of Applied Ecology which would normally publish only the highest quality analytical materials. If this message was clear to almost everyone involved in nature protection, it was something completely new for the general public who believed that Natura 2000 was only a body of nature reserves having no place for any human activity. Later, in 2000, the European Commission issued guidelines for the management of the Natura 2000 areas (European Commission 2000) which were often used by the Latvian specialists even before Latvia became a member of the European Union.

Natura 2000 designation process in Europe is taking longer than expected not only because the old member states had to meet their obligations but also because of the expansion of the European Union (inclusion of Latvia and 9 other countries in 2004, Bulgaria and Romania in 2007, and Croatia in 2013). The fact that the Natura 2000 network is still not completed does not exclude the possibility of attracting financing and carrying out conservation measures of species and habitats in the sites which are already established and have a defined status. Various financial instruments (LIFE(-), GEF, INTERREG, and others) directly or indirectly financing the management of Natura 2000 have been available for most of this time. The focus of these instruments may be different: a particular Natura 2000 site, cross-border site, selected site includes more than 48% of the EU territory or national level. However, a common direction in the management of the Natura 2000 sites was apparently not found and the European Commission launched the new Natura 2000 Biogeographical Process in 2012 to ensure better implementation and improvement of the Natura 2000 network (financing, management, and monitoring). This process is focused on cooperation of the concerned stakeholders at different levels - from national or regional sites within a given area) to international cooperation (Anon. 2015). The main objectives of this campaign are:

• to gather the latest information on threats and conservation requirements of endangered species and habitats;
• to exchange experience about the completed and planned management works;
• to define common objectives, priorities, and management methods;
• to establish a new network of expert and organizations in management matters;
• to support such forms of Natura 2000 management, which are based on social and economic factors.

Within this process seminars on management are organised for each biogeographical region individually - just like before in the selection of the Natura 2000 sites. The seminars invite representatives from

1990s various projects have organised international seminars on many different topics, including, species and habitat management, which have also been described in the previous two books (Oparmanis 2002, Auniiņš 2008). The biggest contribution in this process was made by the Baltic Environmental Forum (BEF), which organised various seminars throughout the years, including seminars on current management issues with a specific aim to establish a closer relationship between the Swedish, Latvian, Estonian experts. Also the LIFE and DANCEE programmes or UNDP/GEF project in Northern Vidzeme included a number of training trips to the Baltic states and Nordic countries, where the managers of Latvian Natura 2000 sites had the opportunity to compare measures not only in theory, but also in practice. Therefore, the mission and valuable use of the new biogeographical process in our region should rather be maintaining and renewing the existing or former initiatives by possibly developing a slightly more systematic approach in order to cover all of the topics on species and habitat management. In any case, those in charge will have to be very innovative in developing contents and in organisational matters in order to make the management process as interesting and as relevant as possible, without losing its educational level.

In order to position the nature management process at an international level, and to improve this process would increase the circle of people involved in nature management, especially those who for some reason have not had the opportunity to experience the exchange of experience.

Lastly, I would also like to point out some positive observations. In the beginning, there might have been some worries that this process would be very theoretical and that the matters which should be discussed on a larger scale had to be presented to a relatively small group of people in the initial seminars (i.e. a classic top-down approach). However, if we look at the list of seminars organised with the participation of the people involved in management activities we have to admit that they have covered many various, important, and even very specific and interesting topics, for example, assessment and monitoring of alpine grasslands, management of military areas, and mapping of marine habitats. I have talked to a lot of people - sometimes to those in charge of the organisation of this process and participants of various workshops in different biogeographical regions. Of course, opinions about the success of this process are diverse, but the majority of the participants had a very positive attitude. Sometimes people have expressed their own worries that this is not only because the management seminars are not imposing any obligations.

Taking into account the complexity and interdisciplinarity nature of environmental science, people involved in nature management must be committed to constant learning from their own experience, their close colleagues as well as experience from other regions in Latvia and abroad (Auniiņš 2008). Hopefully, this collection of articles will contribute to information circulation in Latvia and to the new biogeographical process in the Boreal region. Just like the previous ones, this collection of articles on species and habitat management is also published as a part of a project - this time the LIFE-FOR-REST project which was launched in 2011 and at the time of preparation of this volume it is close to its completion. Therefore, the articles in this collection mainly describe activities carried out within this project and its main topic - forest management.

Three of the articles cover the Osmoderma barnabita beetle and problems related to its protection. The article by Mārtiņš Kalniņš on the Natura 2000 areas required for the Osmoderma barnabita comes at the right time - FOR-REST project which is going to be launched in 2011 and at the time of preparation of this volume it is close to its completion. Therefore, the articles in this collection mainly describe activities carried out within this project and its main topic - forest management.

The third part of this book is moved to another location. It is good to see that this collection of articles alone builds up a good knowledge base about one of the most charismatic beetle species protected in Europe.

Kristine Cīte’s article on experience exchange trips is closely related to both the topic of the Osmoderma barnabita and Boreal forest management programmes, as well as activities carried out within the FOR-REST project. Activities from this project are also described in three other articles on different topics: Boreal forests and their management and restoration of the hydrological regime in swamp forests.

Two articles on certain current nature conservation issues describe the overall situation in Latvia, which is an important part of the FOR-REST project - a participative discussion which is not based on various myths. Article by Liene Suveizda on the amount of protected forests in Latvia is very illustrative and well-timed in order to reduce the exaggeration about the restrictions imposed on economic activities due to nature conservation, which may often be heard in mass media. The article on the number of forest fires in its turn may serve as a significant information in the public discussion on use of prescribed burning in nature conservation incited by the FOR-REST project (see also Oparmanis 2002 in relation to this issue). One article is dedicated to the use of remote-sensing data in nature conservation planning.

Finally, the volume also includes an article on public relations - a practical nature conservation aspect which up till now has received relatively small amounts of attention.

Introduction of this volume could easily be ended with an overview of its contents, however, looking to the future, I would nevertheless like to address the experience exchange of current species and habitat management topics in Latvia. By writing the preface of the second volume in 2008, Ainārs Auniiņš brought up the idea of issuing a collection of articles on nature management in Latvia every two years (Auniiņš 2008), which may not be denied. But then why is this following volume was published only 7 years later? Of course, we could say that this follows the financial situation in Latvia and therefore we will have to be very innovative in order to position the nature management process at an international level.

The answer may be composed of three major excuses. The first, and in my mind the least probable, is the fact that a great deal of specialists do not want or do not feel the need to share their experience. Perhaps it is it is not that much that passes over the experience verbally without informal constraints - to closest friends and colleagues, or in the best case scenario by speaking at a seminar. Perhaps it is believed that it is only worth publishing the results in the case of a true and novel outcome (i.e., a new method developed and applied, population of a very rare species restored), but as such things in real life happen rarely, the ordinary things after the project are only maintained at a conversational level. The experience of species and habitat management is particularly valuable when it is presented as complete analytical material, which accurately describes what was done, how it was done, and why it was done, and which provides a honest analysis of successes and failures. If my assumptions are close to being true, I would like to recommend raising the bar a little higher - to try publishing all of your experience at least in Latvia, but if you ever come across some particularly significant achievements (or the opposite case of a significant failure, which is an equally interesting experience) - to offer such materials for publishing in international journals.

The second reason could be the fact that there is nothing to write about as there is nothing happening in Latvia. However, it is hardly likely knowing how many projects directly or indirectly related to species and habitat management have been or are being carried out in Latvia. Since 2000, within the LIFE and LIFE+ programmes alone 25 projects have been included for a total amount of more than 35 million euros (with nearly half of them being carried out after the last ‘management volume’ in 2008). Almost all project titles include the words management, restoration, and conservation. It cannot be true that the projects have not included anything worth publishing as an article and that all of the thoughts are left only in the technical reports to the European Commission, Powerpoint presentations prepared for seminars, and the popular brochures which probably make up the largest part of the products from the LIFE projects. Some projects have resulted in developing various handbooks, but unfortunately in most cases they were not talking about management experience as such.

The third and most probable reason could be the fact that the creation of material on management experience itself requires certain work and time resources (more time been invested in project organisation events or some quickly manageable works on a Friday afternoon) which unfortunately the potential authors are often lacking. Unfortunately, the lifestyle of the potential authors, project managers, and experts does not promote data analysis and writing. Many of the potential authors are not permanently employed, switching between various different projects, and often even participating in or managing several projects at a time. In any case, the gathering of experience is not included in the direct tasks of every project (and it is the case for the most part), a person must have an incredibly large sense of duty in order to find motivation and time for doing this work. Gathering the experience is the only way (besides articles, I should say) to exchange experience, which, I hope, is not possible once in every two years. Thus, we may conclude that without a special promotion for the creation of materials on the experience of nature management in a format usable by experts, the new biogeographical process will not contribute to an improvement of the situation regarding information circulation.

To improve this situation in the future, I would like to suggest to include such work in the presentation described by the project at a meeting, conference, or in some finished articles, so I cannot imagine how it would be possible once in every two years. Thus, we may conclude that without a special promotion for the creation of materials on the experience of nature management, the new biogeographical process will not contribute to an improvement of the situation regarding information circulation.
conservation and management of Latvian Natura 2000 sites and let’s hope that the findings will be published in a professionally usable format.

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Literature


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1. Introduction
Gauja National Park (GNP) is one of the most significant Natura 2000 territories for Osmoderma barnabita in Latvia. Within the framework of the LIFE + project For-rest, we developed the conservation programme for this species at GNP and implemented the management of O. barnabita habitats in an area of 67.2 ha. Before the commencement of the work, we assessed all known colonies of O. barnabita at GNP and divided them into two groups. Sites where the area of potential park-like landscape exceeded 60 ha, were primarily selected for the implementation of habitat reconstruction works, because a higher opportunity of developing stable and sustainable metapopulations of O. barnabita exist there. The possibility that a complete community of species characteristic of park-like habitats exist in these territories, represented by O. barnabita as an umbrellaspecies, is also higher. Maintenance of the current conditions without more extensive habitat restoration works were planned in the areas where the area of potential park-like landscape was smaller than 60 ha.

Within the territory of GNP the area of potential park-like landscape exceeded 60 ha in only two cases. These two territories include 15 of all 30 known trees with O. barnabita at GNP. The largest territory with an area of 397.6 ha is located in the vicinity of Sigulda - Krimulda - Turaida. 17.7% of the landscape of the territory is occupied by EU importance 9180* Tilio-Acerion forests of slopes, screes and ravines. The project application provided for the clearing of old trees that have previously been growing in open areas and are suitable for O. barnabita from the shade of younger trees, as well as the facilitation of growth of such trees that could serve as habitats suitable for the species in the future. It was based on recommendations that were popularised in the framework of the For-rest project.
Latvia within the framework of inventory of Woodland Key Habitats (Ek et al. 2002), described in special guidelines (Johansson 2005) and in the plan for the protection of O. barnabita (Teljnovs 2005).

Before the commencement of the project in 2012 the management of previously single growing old trees, which have been overgrown by forest, including the management of O. barnabita habitats, has been carried out in Latvia (Anon. 2005, LFN 2007). These management measures were frequently criticised as a threat to especially protected forest habitats. Individual scientific works indicated the potential risk of reducing the variety of species by such an action (Mežaka et al. 2012) or the value of natural oak stands (Kasumovs 2002) which indicated that such an action or planning thereof is taking place at several territories, however, particular reference to only one territory was provided, where the management measures were performed particularly for the protection of O. barnabita and the habitat of EU importance 6530* Wooden meadows (LFN 2007). Critical opinions regarding such a type of management have been voiced during discussions, seminars and mutual communication of experts in the framework of the project, especially regarding the effect of the measures indicated in the project application on ravine forests.

The criticism of the clearing of overgrown park-like tree stands lacked numerical calculations regarding the number of especially protected forest habitat areas that could be endangered by this action. Summary of materials of different projects (Anon. 2005, Bāra et al. 2014), shows that the area of sites managed in this manner in different forests constitutes approximately 0.06% compared to the total area of forest habitats of EU importance in the country (EC 2013). Only some of the areas managed according to his method can be linked to habitats of EU importance in nature. Most frequently these are new secondary forests where old overgrown park-like tree stands groups occur. Therefore it is obvious that there is no reason to make generalisations regarding the potential problem. However, the aforementioned critical remarks proved to be valuable, because they demonstrated that numerical and qualitative reference points are lacking in the area of O. barnabita habitat restoration and management planning as well, which would enable one to obtain an overall awareness of how the management measures fit in the overall picture of the conservation of various environmental assets in Latvia.

At the beginning of the project we specified that we would not associate the management of O. barnabita habitats with the conservation of the habitat 9180* Tilio-Acerion forests of slopes, screes and ravines, since the most appropriate management thereof is non-interference, while park-like habitats used for grazing or similarly managed landscapes are considered to be optimal for O. barnabita. In ravine forests the habitats of O. barnabita were only managed in enclaves where nature trails are regularly maintained and sights of tourist routes are revealed, or, in some cases, along forest edges along fields. The habitats of O. barnabita at GNP were divided into two groups in accordance with the potential of the site to maintain sustainable metapopulations of the species. At smaller-sized sites without the opportunity for expansion, we provided for the preservation of the existing situation; meanwhile, on sites the restoration and the development of the park type landscape were scheduled and the respective works were commenced. The division of the O. barnabita sites in groups with various scope of landscape restoration ambition is at least a partial solution for the described problem of the interaction of such measures with the forest habitat conservation. This demonstrates that only a portion of the localities of the species have sufficiently high significance of restoration to justify the interference in forest habitats, as well as specifies the most significant sites for the protection of O. barnabita.

The objective of this article is to demonstrate what considerations were used for the evaluation of O. barnabita of protection of the thereof, to illustrate the commenced planning and management measures, as well as to characterise the difficulties that were encountered during this process.

2. Material and Methods

2.1. Characteristics of a habitat and criteria for selecting sites for management

O. barnabita belongs to the group of saprophytic species at larger ones - state characteristic to park-like landscapes and differ from the characteristics of the species inhabiting closed forest stands (Svidruňa-Thygeson 2010). O. barnabita is a so-called umbrella species, which means that the provision of appropriate life conditions for many species of invertebrates (Antonsson 2002, Ranius 2002a, Teljnovs 2005). Therefore, while planning the protection of O. barnabita habitats, the overall community of species characteristic of park-like habitats is considered. The most appropriate habitats for these species are traditionally managed wooded meadows or wooded pastures and, to some extent, also parks and avenues. This group of species is closely associated with the quantity of tree species per unit of area, as well as with the overall scale of the landscape (Bergman et al. 2012).

In order to ensure habitats for the entire range of species represented by O. barnabita as an umbrella species, attention must be paid to different elements of the landscape and laws of their mutual interaction during landscape restoration. For a sustainable metapopulation of O. barnabita approximately 20 or more hollow trees inhabited by the species, the local populations of which are mutually interacting, are required (Jansson & Bergman 2006, Bergman 2006). Not all of the hollow trees are suitable for the ecological requirements of the species, Therefore, such a number of trees can be typically reached in the territories where the total number of hollow trees amounts to hundreds or, sometimes, even several thousands (Ek & Johannesson 2005, Bergman Johannesson 2005, Bergman & Johannesson 2006). In addition to hollow trees, which, for instance, in the event of oaks, develop hollows starting from the age of 150 years or older (Ek & Johannesson 2005, Ranius & Nilsson 1997, Teljnovs 2005), younger trees that will replace the old trees in the future are also required. Many species need dead or dying and dappled light, which means that there is a so-called umbrella specie, O. barnabita (Eriksson 2008, Svidruňa-Thygeson 2010, Falk 2014).

The landscapes also need lush, richly blooming trees and bushes, and, a rich composition of grass vegetation in terms of species, because some of the saprophytic species feed on flowers. All of this is possible in mosaic conditions, where sparse wood stands are alternating with glades (Eriksson 2008, Vodka et al. 2009, Falk 2014). This type of landscape exists in traditional agriculture systems; nowadays, it is most common either in the form of permanent wooded pastures or parks.

The combination of all aforementioned conditions poses the requirement that the minimum area where a sustainable habitat of the species characteristic of a park-like landscape is possible, starts at approximately 57 ha, while certain species may even need an area several hundreds of hectares large (Jansson & Bergman 2006, Bergman 2006). Species inhabiting oaks have been researched most extensively and it has been established that about 240 hollows or large circumferences 310 cm of the oaks would be needed in an area of 1600 ha to ensure a rich saprophytic oak fauna (Bergman et al. 2012). Several of these species inhabit smaller areas as well, however, larger areas are required in the long term, because the processes in the habitat are dynamic (for instance, succession of trees of different age) and more space is required for these processes to occur (Bergman et al. 2012). In order to ensure efficient protection of these communities of species, preference should be given to the restoration of sites, where habitat concentrated in larger quantities and within possibly larger areas, and where the sustainable existence of the habitat can be ensured (Ranius & Hedin 2001, Ranius 2002b, Ranius 2002c, Ranius et al. 2011, Bergman et al. 2012).

The potentially area of the habitat is the criterion, which can be used for the grouping of the sites of species by their potential significance. Based on the aforementioned threshold of approximately 60 ha (Jansson & Bergman 2006, Bergman 2006) the areas of the habitat of EU importance 6530* Wooden meadows and pastures have been analysed (Bāra et al. 2015). It was determined as a result that, out of the total of 128 polygons of this habitat in Latvia, none were identified that would simultaneously conform to the 60 ha criterion, be of good quality and could sustain a sufficiently large meta-population of O. barnabita. This conclusion also yielded a practically significant result by demonstrating that only eight sites, although poor in quality, but potentially complying with the size criteria, are currently known in Latvia. In the context of wooded meadows, these are the most significant sites of O. barnabita, because, after the restoration thereof, they will be the most sustainable and will maintain the largest variety of species. Under the conditions where resources are limited, investment in habitat restoration of exactly the largest sites is the most sensible solution, because it is the way of reaching the highest ecological effect with the lowest investment of resources.

The same approach to the evaluation of the O. barnabita sites has been used during the For-rest project for the selection of places where to plan and implement the restoration of O. barnabita habitats at GNP.

The first criterion for the selection of management sites at GNP was the presence of O. barnabita, the second - the landscape had to contain currently existing and potential habitats of O. barnabita, where the species had to exist, the third - the restoration and management possibility associated with the size of the site had to exist. In accordance with the potential size, the sites of O. barnabita at GNP were divided into two classes:

- sites that conformed to the criterion of a 60 ha or larger area, where the creation of stable, long-term meta-populations must be performed in the future, by striving towards the creation of stable, long-term meta-populations,
- sites that is smaller than 60 ha, where the maintenance of the existing local populations without more extensive transformation of the landscape must be performed in the future.
2.2. Information and methods used for the selection of management sites

The following data sources and methods have been used for the assessment of O. barnabita sites:

• The cartographic layer of points of trees with O. barnabita (Environmental data management system “Ozols”), which was checked and specified in nature in 2012 by surveying the surroundings around each tree within the radius of at least 1 km (the survey performed by the expert on invertebrates D. Teļnovs within the framework of the project), as well as supplemented with discovered colonies in 2013 (Figure 1).

• The cartographic data layer, which consists of circles that have been drawn around the trees with O. barnabita. A circle with a radius of 300 m has been drawn around the tree, which approximately represents the maximum distance of spread of O. barnabita and another circle with a radius of 1,000 m (Figure 2), within the limits of which detailed surveying of the territory was performed in order to determine whether a potential possibility of restoration the habitat of the species exists. The mutual overlapping of these circles or the distance between them has been used to determine, which localities could develop united meta-populations. This information has also been used to determine the borders of landscape areas, where conditions optimal for the meta-populations of O. barnabita will be gradually developed in the future (Figures 2 and 3).

• Data of the State Register of Forests on the composition of forest stands. These data have been used to provisionally determine, in the vicinity of which localities the forest stands with broadleaf trees are situated, which could be potentially renewable habitats for O. barnabita.

• Data layer of especially protected habitats and species (Environmental data management system “Ozols”) (Figures 2, 3). These data have been used to identify habitats in the vicinity of O. barnabita localities, which could potentially serve for the development of their habitat, as well as habitats or species, the protection of which contradicts the development of a park-like landscape.

• Laser and hyperspectral data on vegetation and terrain prepared by the project partner Institute for Environmental Solutions. These data have been used to seek tree stands with park-like structure in the vicinity of O. barnabita localities and to specify the borders of the polygons where management of habitat is needed (Figure 2). Sites with old park-like trees that have been overgrown by secondary forest have been analysed within the framework of remote sensing to test the method for the automatic search for afforested park-like situations in the entire territory of GNP. This method needs further specification and upgrading and therefore it was not used for the selection of management sites.

2.3. Management measures

The objective of the project was to perform the restoration of O. barnabita habitats in an area of 60 - 80 ha. After the data on the localities of O. barnabita at GNP have been assessed, and landscapes where habitat restoration must be made have been prioritised, we specified particular polygons where it will be performed during the project. Since park-like habitats require regular maintenance after restoration, the choice of management sites was affected by the potential possibilities of ensuring such maintenance. In order to clarify these issues, several work sessions and meetings with the managers of the lands were organised. The possibilities of harmonising the restoration of habitats with the development of a touristic environment and infrastructure objects or
the integration thereof into agricultural activities were discussed during the meetings. The organisations involved to various degrees were: Nature Conservation Agency, Pārgauja Municipal Council, as well as Turaida Museum Reserve.

2.3.1. Mapping of trees
Mapping of the trees which will be saved after landscape restoration was performed in order to ensure more precise planning of the operation and description of the work task. The objective thereof was to clarify whether the quantity of hollow trees in the renewable polygon is sufficient, whether various stages of tree development are represented homogeneously and in a sufficient numbers of trees, as well as to specify the borders of the renewable habitat. It was planned that the collected information would be used to describe work tasks and determine the works to be performed, as well as probable costs thereof. Before the commencement of operation, the work group of the project studied the experience accumulated during the mapping of park-like trees and the evaluation of their age structure in Latvia, which was performed with similar purposes at Moricasala reserve (Janssons & Hultengren 2002). Experience exchange expeditions to learn about similar experience in Sweden have been organised within the framework of the project. During the description of the mapped trees they were divided by the developmental stages as described in the book Multi-purpose management of oak habitats (Ek & Johannesson 2005), by slightly adjusting it to our conditions.

GPS devices were used for mapping and the obtained data were registered in a shapefile for use with Esri ArcGis computer software. The location of the trees in the mapping was approximate, with the error of +/- 10 m due to the precision deviations of GPS devices. This provides a sufficiently precise result for the evaluation of the situation; however, the final decision on the details of managing each particular tree must be made during the management process, based on the situation on site. Registration of coordinates of each tree was scheduled during the mapping works on site and the following characteristics have been indicated in attribute fields:

- “k_suk” (species) – species of the tree, by marking them with generally accepted forestry symbols: oak = Oz, linden = L etc.,
- “diam_cm” = diameter of the tree in centimetres,
- “stadija” (stage) = stage of tree development.

Stage 1 includes trees with an approximate trunk diameter of 12 - 30 cm (at the height of 1.30 m above the neck of the root), In terms of quantity this is the largest stage and it is frequently difficult to map individual trees, since they often grow in groups. During the restoration of the habitat, the thinning of the new broad leaf trees could be necessary and only then it is possible to decide which tree must be preserved and which must be removed. Therefore Stage 1 trees were mapped only if they were single-growing trees.

Stage 2 includes trees with a trunk diameter of 30 cm or larger (at the height of 1.30 m above the neck of the root), except hollow trees. In terms of forestry terminology these trees are equalised to trees of premature and mature stands.

Stage 3 includes trees that are older than Stage 2 trees, except hollow trees. In terms of forestry terminology these trees are equalised to the trees of overmature stands, which refers to the tree stand where technical characteristics of timber are starting to deteriorate.

Stage 4 includes trees where hollows start to develop, but they are too small, with insufficient amounts of rotting wood.

Stage 5 includes trees with medium sized hollows, which have a sufficient quantity of wood mould for O. barnabita to live in them.

Stage 6 includes trees with large hollows, which have a sufficient quantity of wood mould for O. barnabita to live in them.

Stage 7 includes trees with large hollows that have already lost most of their wood mould and large dry trees.

- “jakopj” (to manage) = the assessment of the need to manage the tree by evaluating the area to be cleared from undesirable trees and bushes against the area of tree crown projection: 0 = nothing to be done, 1 = individual bushes and trees need to be cut, 2 = more than just individual bushes and trees must be cut in an area that is less than half the projection, 3 = undesirable trees and bushes must be cut in an area that is equal to or larger than half of the projection.

- “piezīmes” (notes) – place for miscellaneous notes.

2.3.2. Management of habitats
The management territories within the framework of the project varied from areas where individual bushes around old trees growing on the border of the forest had to be removed, to areas where deforestation was performed by felling the secondary forest and developing a park-like tree stand (Figures 2 and 3). Upon the development of a park-like landscape the proposals that have been provided in various sources have been considered: Management Plan of the Habitat of EU Significance 6530* Wooded Meadows and Pastures (Blāra et al. 2015), Guidelines for the Management of the Habitat of EU Significance 9070 Forest Pastures (Eriksson 2008), the book Veteran trees: A guide to good management (Read 2000), Plan for the Protection of Osmoderma barnabita (Telčovs 2005), the book Multi-purpose management of oak habitats (Ek & Johannesson 2005). The examples that have been reviewed during the experience exchange expedition in Sweden were highly significant for the implementation of management measures as well. During the preparation of polygons for felling works, either trees intended for felling or preserving trees and bushes were labelled with colour, depending on the difficulty of the situation (Figure 4). Before the commencement of works, the representatives of outsourcing service provider companies and employees, who performed the works, were briefed in detail on how to implement the measures and the work performance during the implementation of these measures was regularly checked.

2.4. Problems in the planning and implementation of management measures
Several difficulties were encountered during the project performance, which delayed work performance or reduced the quality of work results. Identification and description of problems associated with management measures can prove to be useful information for the implementers of similar projects or performers of management measures, therefore this article lists and describes the most significant of the identified problems as well.

3. Results and Discussion
3.1. The overall situation of Osmoderma barnabita population and habitats at GNP
Upon the commencement of the project, after repeated investigation in the vicinity of the localities in 2012 and colonies detected in 2013, a total of 23 trees with O. barnabita (trees, where the traces of species activity have been detected) were known. This information was used for the planning of species protection (Figure 1). In addition to already known colonies, seven more trees with signs of the activity of O. barnabita were found at GNP in 2015 (data of N. Ķibilda), which raised the number of colonies to 30 (Figure 3). In accordance with the information included in the Environmental data management system “Ozols”, a total of 522 cases of detection of O. barnabita have been registered in Latvia, which approximately conforms to the total number of currently known trees with this species. In accordance with these data, the currently known number of trees with O. barnabita colonies at GNP constitutes 5.7 % of the total number of known in Latvia.

Upon the evaluation of whether it is possible to restore or develop a 60 ha or larger overall situation of a habitat around the trees with O. barnabita (Figures 2, 3), which was the minimum threshold of area for a sustainable habitat, only two such territories were detected at GNP. All other cases are associated with sites where open agricultural lands or forests of unsuitable composition are situated around. Even if conditions suitable for the expansion of park-like landscape are
found in the vicinity of these, their potential is several times lower than the threshold of 60 ha, while in most cases there is no such opportunity.

One of the large sized landscape with potentially one metapopulation of *O. barnabita* is in the area of Sigulda - Krimulda, the other in the vicinity of Ungurmuiža (Figure 1). The first territory extends into the avenues and parks of the town of Sigulda. The urban environment can be suitable for *O. barnabita* (Telnov, Matrozis 2012), however, since the aforementioned territory is located beyond GNP and the territory of project implementation, it was not evaluated in more detail.

The existing avenues, parks, renewable wooded meadows or other current or potential park-like stands were taken into consideration, while determining the external borders of those two landscape areas. These landscape areas also include various other landscape units, for instance, built up territories, open fields and line forests, where the development of a park-like habitat is not planned. However, considering the distance of maximum dispersal of *O. barnabita* (200 - 300 m), the fragments of park-like habitats in these landscape areas are situated sufficiently closely to each other to be considered, either currently or after restoration measures, as ecologically connected for the maintenance of the respective species of society. Further on in this article these landscape areas shall be called park-like landscape areas.

The size of the park-like landscape area in the vicinity of Sigulda is 397 ha, while the area of the park-like landscape area in the vicinity of Ungurmuiža is 190 ha (Figure 2). Under ideal conditions, trees inhabited by *O. barnabita* should be found within the limits of park-like landscape areas, which are not mutually farther from each other than approximately 200 - 300 m and which are found in numbers equal to or larger than the number required for the maintenance of a stable meta-population (approximately 20 or more inhabited hollow trees) (Janson & Bergman 2006). However, the borders of the particular park-like landscapes are representative of the spread of potential habitats of *O. barnabita* rather than of that of the species, because no group of trees with specie within GNP that would conform to the aforementioned conditions is known. However, considering the drawbacks in the quality of the landscape, the park-like landscape areas of Sigulda and Ungurmuiža are relatively most saturated with colonies of species and current or potential park-like habitats within GNP. Therefore among the most widely known, these are definitely the most appropriate sites at GNP to create long-term conditions for stable meta-population at the 8th polygon.

Seven trees with traces of *O. barnabita*, which were found in 2015 (data of N. Khlida) in addition to the ones in accordance with which management measures were planned (Figure 3), bear evidence that *O. barnabita* could actually be found in a larger number of localities within GNP than currently known. However, the particular data currently do not raise doubt about the borders of park-like landscape areas, because seven new finds fall within the Ungurmuiža park-like landscape area.

### 3.2. Prospects of habitat management at the sites of differing significance

Out of the total of 30 known trees with *O. barnabita* at GNP, 15 are included within the two park-like landscape areas determined within the framework of the project (the total area thereof is 587.5 ha), while another 15 colonies are located at the sites smaller in terms of appropriate habitat area, where more extensive reconstruction of the habitat is impossible (Figure 1). Various protective measures are possible in both groups of colonies - clearing of old park-like trees from bushes, planting new trees, creation of artificial hollows, etc., however, the significance thereof differs. In the event of limited resources the management measures at large park-like landscape areas should be prioritised, because these areas potentially represent a wider range of especially protected species and can maintain more stable meta-populations of species (Ranius & Hedin 2001, Ranius 2002b, Ranius 2002c, Ranius et al. 2011, Bergman et al. 2012).

#### 3.2.1 Sigulda - Krimulda - Turaida landscape area

Sigulda - Krimulda - Turaida park-like landscape area, the total area of which is 397.6 ha, with 17.7% of the area occupied by fragments of park-like habitats of various quality (Figure 2, Table 1). Various management measures have been implemented within the framework of the project at 59% of these habitats. The remaining polygons (hereinafter, see Figure 2) include several park-like stands or avenues that are already in good condition: the 17th polygon (Krimulda Park), the 16th polygon (avenue near Krimulda), the 6th polygon (the park at Turaida Castle). The 1st - 5th polygons are overgrown old park-like landscapes at Turaida Museum Reserve and near it, where restoration of habitat should be performed. The 15th polygon is a forested meadow (the 10th polygon) is an overgrown old park-like stand in the middle of the field. In both of these polygons the old trees must be cleared from bushes. The 9th polygon continues the park-like landscape developed within the framework of the project that was performed in the 8th polygon.

Both polygons, together with the meadow westwards from the polygons create a unified scenery, which, pursuant to appropriate restoration and management, including grazing and mowing, will conform to the requirements of EU habitats 6530* Wooded meadows and 9070 Wooded pastures. The 19th polygon is a slope forest area between two slopes of ski runs. Various tree-hung tracks have been developed at this forest stand, trees and bushes have been partially cut, as a result of which it no longer a fully functional shaded slope forest with stable microclimate, but it is still too bushy to serve as a habitat for park-like species. If this forest stand was transformed into a stand more similar to park-like landscape, it would be more suitable for the respective community of species and still appropriate for the business activities that have been commenced there. 19.7 % of the landscape is occupied by EU forest habitats or places that are very similar to them. The total number of EU forest habitats present in this landscape is three: 91D® Tilia forest, forest remnants of slopes, scree and ravines – 63.7 ha, 91D® Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* – 9.0 ha and 91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis*
and Ulmus minor, Fraxinus excelsior, along the great rivers – 5.7 ha (Figure 2). Habitats 9180* Tilio-Acerion forests of slopes, screes and ravines and 9050 Herb-rich Forests with Picea Abies are situated also outside the park-like landscape area, but close to its border. The EU forest habitats found in the landscape area and adjacent territory should be retained unchanged from the point of view of biological diversity, because the ecologically most appropriate regimen for their conservation is non-interference. The exceptions, where the planned measures for the management of O. barnabita partially affect forest habitats are individual enclaves, where nature trails are maintained constantly or sceneries on the tourist routes are revealed, as well as some narrow belts on the periphery of the park-like landscape area. Considering the cultural and historical heritage of the territory and its extensive use for touristic purposes, the situation in the area of forest habitat protection is still ambiguous. Possibly, at some individual sectors, the development of park-like landscape could be considered at the expense of currently protected forest habitats. The unresolved issues regarding the approval of the protection of different assets have been described in detail in the section on the procedure of park-like landscape area planning.

The remaining part of the Sigulda - Krimulda Turaida park-like landscape area (62.6 %) is occupied by secondary forests of various age, grasslands, water bodies, gardens, land under buildings and roads (Figure 2). The area12 of this part of the landscape are not typical park-like landscapes, where the community of species represented by O. barnabita lives, however, placed in patches together with old park-like tree stands, they are ecologically linked as part of one system. The parks that form part of this landscape. By transforming them into park-like habitats a larger and more functional park-like landscape will be developed. An abandoned field is situated to the southwest of the western side of the 16th polygon, which is a suitable place for the development of a new park-like landscape by planting new broadleaf trees.

3.2.2. Ungurmuiža landscape area

Out of the entire area of the Ungurmuiža park-like landscape area, which amounts to as much as 17.5 % is occupied by park-like habitats of various quality (Figure 3, Table 1). The management of 77.1 % of these habitats has already been performed within the framework of the project. There are several park-like tree stands that are already in good condition or avenues of various quality among other polygons (hereinafter see Figure 3): the 4th polygon (Ungurmuiža Park), 2nd, 6th, 7th, 9th, 11th polygons (avenues along the roads). The 5th polygon is an avenue overgrown by the forest, 12th polygon is a field, and the 10th polygon at the initial phase of being overgrown. Bushes must be removed in the last three polygons. The 1st polygon is a sparse tree stand, where no further thinning is required, but in the 3rd polygon the thinning of the tree stands needs to be continued after 5 - 10 years. 8.2% of Ungurmuiža park-like landscape area is occupied by EU forest habitats (Figure 3) 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli and 9020* Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes, which could be important for the expansion of a park-like landscape. Planning of the protection of these habitats in Latvia is recommended from the point of view of wider landscapes, by selecting the sites where especially significant stands for biological diversity are concentrated and facilitating their spatial continuity (Brīmelis, Jankovska 2013). Currently it is not definitely known, whether these forest habitats of the Ungurmuiža territory conform to a site of such significance, where the activities that are necessary in GNP have they been evaluated in terms of landscape ecology. The particular stands are a part of the forest massive that is approximately 400 ha large, which is separated by agricultural lands from other, larger forest massives. Dry boreal class forests and forests on drained lands dominate this aggregate of forests, a considerable proportion thereof consists of secondary forests on former agricultural lands as well (data of the State Register of Forests). This could be detected, because the fragmented EU forest habitats are not situated in the forest massive that are especially significant for the protection of broadleaf habitat types. Obviously only the particular forest stands have conservation value. An increasing number of old spruces is observed within these EU forest habitats, which suppresses older broadleaf trees. In these cases regular removal of spruce regrowth is recommended in order to protect the habitat (Brīmelis, Jankovska 2013). This aspect of management partially coincides with that which is required for the species characteristic of a park-like landscape. The main difference lies in the fact that a park-like landscape needs a much thinner stand of trees than necessary for a park-like landscape. An increase in the conservation of a park-like forest habitat. Old wide-crowned trees can be found along the sides of these habitats in Ungurmuiža, which bears evidence of the presence of at least partially cultural landscapes here in the past.

The total area of detected park-like tree stands in the Ungurmuiža park-like landscape area is 33.2 ha (Table 1), which is considerably less than the previously mentioned threshold of 60 ha, which would be necessary for relatively self sufficient park-like habitats. Unless the recommendation of 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli and 9020* Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes of the territory of Ungurmuiža proves to be especially significant for the protection of exactly this habitat, at least the partial transformation thereof into park-like tree stands should be considered, because the expansion thereof in the territory of Ungurmuiža is definitely needed. According to the current planning the forest sectors have not been definitely marked as potential park-like habitats that need to be developed, because, as mentioned earlier, the information on their significance for the protection of forest habitats in a wider context is lacking. From a practical point of view, this issue may be left unresolved currently, because the management that is required for the particular protected forest habitats approximately can be detected in the future, but if the management of forest habitats is performed, this will also be a step towards the development of a park-like habitat, if such an option is provided for during the next phase of planning. More clarity on the landscape and ecological context of forest habitats is expected after the general mapping of habitats in the territory of GNP and in Latvia.

In contrast to the Sigulda - Krimulda - Turaida park-like landscape area, there are only a few secondary forests that could be transformed into park-like habitats. The most significant is the forest stand in the northern part of the 3rd polygon, where deforesting is recommended to develop a younger local population of trees (data of the State Register of Forests). This could be especially significant, because the 3rd polygon from the east and it is an appropriate combination for the development of permanent pastures. In the event of such a management solution, this part of the landscape will be transformed into landscapes typical for 6530* Wooded meadows, after the following a certain time period. The remaining forest stands in this landscape area are small clusters of forest in a vast landscape of open fields. Park-like tree stands of single-coding trees in the fields must be developed in these clusters.
3.3.1. Mapping of trees

Although digital mapping of potential park-like trees was initially planned as the central instrument for the development of artificial hollows, there were a number of problems in its implementation. Firstly, the administrative framework for the protection of specially protected habitats and species in Latvia was not fully prepared, which made it difficult to collect and use the data collected in field conditions for the detailed planning of activities and determining the amount of work to be done. Under ideal conditions, the mapping of park-like trees was finished, but due to the complexity of the situation, the mapping succeeded only partially, and the required trees were simply marked with the paint on sites, while trees to be removed were marked with a different colour and counted for the evaluation of the volume to be cut. Under ideal conditions, the mapping of park-like trees must cover the entire area of park-like landscape areas and, based on that, the boundaries of manageable areas must also be determined, the solutions for the shortage of the trees of a particular category must be planned (for instance, by creating artificial hollows), if such has been detected, etc. Although most mapping were implemented only partially, it was a positive contribution. In the parts of the area where it was performed, it helped in specifying the borders of polygons, while at the Ungurmuiža landscape it also helped to approximately determine the distribution of this action was also reduced. As a result of that the number of Stage 1 trees was actually much higher than registered, because, due to high numbers, they were marked in some of the cases only. An increase in the number of appropriate stage hollow trees is expected in future, because 158 trees of Stage 4, where hollows have started to develop, were found. The overall distribution of the stages of tree development does not bear evidence of disruptions in the succession of phases in the long term or insufficiency of any of the phases at present. This means that in the section of the polygon that has been mapped currently, the development of artificial hollows in live trees and similar actions are not topical.

3.3.2. Management of habitats

Out of the area of 60 – 80 ha scheduled within the framework of the project, the management of O. barnabita habitats was implemented in an area of 67.2 ha (Table 1, Figures 2 and 3). The management measures implemented at the Sigulda - Krimulda - Turaida landscape area were implemented in an area of 41.6 ha, which constitutes 59% of park-like habitats in this landscape area. The 7th, 10th, 12th, 13th, 14th and 18th polygons are associated with tourism infrastructure, which includes parks, forests, and other natural areas. The milling of stumps and the development of artificial hollows were carried out in the Sigulda - Krimulda - Turaida landscape area (Figure 8). The ecological, as well as economically best solution for the further maintenance of this polygon is the development of permanent pastures.
The management measures performed at the Ungurumžu landscape area cover 77.1 % of the park-like habitats detected in this landscape. 1st, 2nd, and 3rd polygons consist of parks and avenues with appropriately organised management. The 3rd polygon of the Ungurumžu landscape area (Figure 3). Ortophoto (on the left) © Latvian Geospatial Information Agency, represent the changes in the canopy layer; they were obtained by vegetation laser scanning. The next phase of management implementation of management measures after 5 - 10 years (Figure 9).

3.4. Problems in the planning and implementation of management measures

The developed programme for the protection of *O. barnabita* was not as detailed as initially intended and a deviation from the initial time schedule of practical management works occurred, as well as the implementation of these works had to be more accurate. Several conditions that promoted these drawbacks and that must be taken into consideration in Latvia while implementing similar projects, have been identified during work performance. Generally, the largest problems and unplanned delays in timing were caused by various environmental protection issues that have not been discussed and formulated at the national level.

3.4.1. Resistance to structured planning and action

Various expert opinions in conflicting situations regarding the management of *O. barnabita* habitats and the conservation of EU forest habitats were indicated in the introduction of this article. We hope that the programme for the protection of *O. barnabita* at GNP offer by us is sufficiently substantiated and accurate in order to avoid a threat to EU forest habitats, at least within GNP. However, most of the discussions during various seminars or individual conversations with Latvian experts of nature protection held within the framework of the project bear evidence that even the current planning is rather frequently not fully accepted. One of the issues that meets resistance is the offer to group the sites of *O. barnabita* by the significance thereof and to admit that there are sites, where landscape reconstruction must be performed on a wider scale and sites where it is neither economically, nor ecologically justified. Such type of grouping allows one to determine the management of which objects must be prioritised under the conditions of limited resources, thus reaching a relatively better effect with relatively less resources. However, on the one hand, concern is voiced that such planning of management will lead to the neglect of smaller sites, while on the other hand, objections are raised against “too large scale” of restoration works at the large sites, where a secondary forest may need to be felled in order to restore park-like habitats. We believe that it is significant to be aware that the large sites are the only ones, the size whereof permits the development of long-term sustainable metapopulations of *O. barnabita* and associated species within GNP.

It is a mandatory pre-requisite to reach the objective of EU nature protection that from the site, which arises from the formulation of the Habitats Directive - the retaining of stable or growing population of the species in the long term. Currently, neither GNP, nor Latvia in general has a known metapopulation of *O. barnabita*, which, by the number of mutually interacting micro-populations, could be evaluated as sufficiently large and sustainable, which also means that the overall population of species in the country is neither large enough nor sustainable. This problem cannot be resolved by just refraining from the felling of the remaining trees inhabited by *O. barnabita*, or by occasionally clearing some of them from bushes in freely selected places. Comprehensive renewal of the largest park-like habitats is required for this. There would definitely be fewer differences in expert opinions, if discussions and training sessions on the purposeful planning of nature conservation measures and harmonisation of various interests of different asset protection were to be organised more frequently.

3.4.2. Harmonising of natural, cultural, historical and tourist interests

No considerable discussions have been held in Latvia to date and no solutions have been sought to harmonise the protection of biological diversity and cultural and historical values and use thereof, in situations where the protection of these values can be conflicting. This is especially typical for the Sigulda - Krimulda - Turaida landscape area, which is Latvia’s most popular cultural and historical heritage site among tourists outside Riga. For instance, in 2014 Turaida Museum Reserve was visited by 250,492 tourists (Korkliša 2015), and it is only one of several frequently visited objects in this landscape area. Although previous processes associated with cultural and historical heritage are mainly focussed on separate objects, for instance, Turaida and Sigulda castles, it is clearly understandable that questions of this dimension potentially overlap a much wider landscape.

Most likely the relatively minor attention that culture and history professionals have put to wider surroundings to date has been limited due to a lack of resources, not because of its lack of significance for the maintenance of the significant cultural and historical heritage. The ancient drawings and paintings, which at least partially express the political order of which culture and history professionals have put to wider surroundings to date has been limited due to a lack of resources, not because of its lack of significance for the maintenance of the significant cultural and historical heritage. The ancient drawings and paintings, which at least partially express the political order of which culture and heritage professionals have put to wider surroundings to date has been limited due to a lack of resources, not because of its lack of significance for the maintenance of the significant cultural and historical heritage. 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planning of the restoration of *O. barnabita* habitats would be much simpler and the reprimands regarding the destruction of the landscape could be avoided.

### 3.4.3. Administrative barriers

Administrative obstacles have been encountered during project work as well, in terms of unwritten assumptions in the documentation of state authorities. The selection of manageable sites was considerably complicated by the opinion that actions within the framework of the project managed by a state institution may be implemented on the land owned by the state. The logic of this assumption is clearly understood. From the point of view of the institution, all formal procedures should be simpler on the land belonging to the institution itself and ordering the territories directly managed by the institution is only logical, before resorting to measures performed on the land of other owners. The awareness that cooperation means extensive negotiation and immersion in the interests of other involved parties, including the search for a compromise, is a restricting factor of such type of cooperation. Unfortunately this attitude leads to a dead-end, if a habitat of a species, which is mainly located on land belonging to other persons, must be managed. Historically, the selected forest properties in Latvia have been owned by the state, while agricultural land, including park-like habitats, is predominantly owned by private land owners. Being aware that the administrative obstacles reached within the framework of the state-owned land only, the initial position was changed during the project development and possibilities of performing management activities on the land belonging to several owners were sought, however, this was associated with considerable difficulties during the implementation of the project.

The next obstacle was connected with forest felling limitations. In accordance with the regulatory enactments of the Republic of Latvia, forest felling operations may be performed at such forests, where the inventory of the forest has been performed in order to include the data thereof into the State Register of Forests and the regulations of GNP provide that a forest management plan must be drawn up. These issues are frequently associated with the implementation of nature conservation because, which, consequently, could improve the positive attitude towards nature conservation in general.

### 3.4.4. Supervision of management measures

The habitat management measures implemented within the framework of the project were planned by marking the trees to be removed and the trees to be preserved and by describing several other conditions of the activities in the contracts of parties implementing the measures. Nevertheless, at almost all the managed objects, the work performance was associated with inaccuracies - cutting individual trees that had not been scheduled for removal or failure to cut the trees that had to be removed, as well as compliance with the deadlines sometimes balanced on the verge of contract violation. Habitat management works were performed by various companies that had won state procurement tenders. Before the commencement of works, the presentation of the company and employees, who performed the works, were briefed on how the management measures must be performed, as well as the work performance was regularly checked. Unfortunately, the project did not represent a sufficient funds to ensure the continuous – everyday presence of project employees. The supervision was seriously complicated by the fact that the companies frequently attracted subcontractors and employees, which were replaced during the project. This, naturally, was negative conditions had to be explained to the companies, with which the contract had been concluded, their subcontractors and every employee, who was attracted anew. Due to the limitations of resources available during the project, the provision of detailed explanations to each person involved in the process could only be ensured partially and, although the works in general were performed in accordance with the contracts, the details of implementation could be much more accurate. The experience of the project bears evidence that man-days for the supervision of works must be ensured in the amount that guarantees the almost constant presence of project employees. During the planning of such projects, it would be provided that during its management each object must be visited by project employees at least once daily or in exceptional cases once every two days. Inclusion of the condition that upon the attraction of subcontractors or changing employees the company has the duty to promptly inform the project and provide for the time that is required for the briefing on work performance into the contracts with companies is recommended.

### Acknowledgements

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### Literature


Brūtēlītis, G., Jankovkova, I. 2013. Latvijā sastopamo Eiropas Savienības aizsargājamā meža biotopu (biotopu kodi 9010, 9020, 9000, 9008, 9100, 9105) aizsargājamo dabas ainavu pievedēs. Daugavpils aizsargājamo dabas ainavu pievedēs plāne

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Current management practices for specially protected habitats and species in Latvia: Forests

1. Introduction

Bog woodland is a high-priority protected forest habitat in the European Union (91D0*) where you can encounter a number of rare and endangered plant and animal species, for example, dwarf birch Betula nana, early coralroot Corallorhiza trifida, heartleaf twbayblade Listera cordata, heath spotted orchid Dactylorhiza fuchsii, swamp willow Salix myrtillodes, and wood grous Tetrao urogallus (Bambe 2013).

Structure of a bog woodland (91D0*) is rather homogeneous. It is made of oligotrophic or mesotrophic communities of coniferous and mixed trees or birches and black alders. The shrub layer most commonly is quite sparse. Bog woodland usually have mound micro-relief with an explicit dwarf-shrub layer. The groundcover is poor. It is composed of moisture-loving species - sedge as well as certain grass and caulescent species. Sphagnum dominance is especially typical at the moss layer (Bambe 2013).

Even though this habitat is common in Latvia (around 3% of the land area (Bambe 2013)), it is both in bad functional condition and poorly protected. The 17th report of the Habitats Directive for the period of 2006–2012 states that the area of bog woodlands is significantly shrinking along with a decrease in the quality and functions of the existing habitats. One of the main reasons for the poor condition of bog woodlands is the drainage process, and the elimination of this process would provide possibilities to significantly improve the condition of the habitat and ensure its sustainability.

A specialised programme was developed and hydrological stabilisation activities for the improvement of degraded swamp forests were carried out for the first time in Latvia within the Forest Habitat Restoration at Gauja National Park project (LIFE10 NAT/LV/000159 FOR-REST) which was carried out by the Nature Conservation Agency and financed by the European Commission’s LIFE+ programme. Over the course of the project 37 ditches with a total length of 13954 m were partially or completely backfilled or blocked by wooden dams, improving the hydrologic regime in 138 ha of bog woodland (91D0*).

The programme developed within the project is a good methodological base for further bog woodland (91D0*) hydrological stabilisation projects in Latvia. In future habitat restoration projects it is recommended to focus more on informing the public about the planned activities.

Keywords: Gulbjasalas Raised Bog, hydrology, drainage, designing, bog woodland

Hydrological Restoration of Bog Woodland at the Gauja National Park nature reserve zone Gulbjasalas raised bog

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Summary

Bog woodlands are high-priority protected forest habitats in the European Union (91D0*), while in Latvia they are mostly in bad functional condition and poorly protected. One of the main reasons for the poor conditions of bog woodlands is the drainage process, and the elimination of this process would provide possibilities to significantly improve the condition of the habitat and ensure its sustainability.

A specialised programme was developed and hydrological stabilisation activities for the improvement of degraded swamp forests were carried out for the first time in Latvia within the Forest Habitat Restoration at Gauja National Park project (LIFE10 NAT/LV/000159 FOR-REST) which was carried out by the Nature Conservation Agency and financed by the European Commission’s LIFE+ programme. Over the course of the project 37 ditches with a total length of 13954 m were partially or completely backfilled or blocked by wooden dams, improving the hydrologic regime in 138 ha of bog woodland (91D0*).

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1. Introduction

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such high-moisture and anaerobic conditions, just like in bogs, plant residues are decomposing slowly and forming peat (Bambe 2013). Hydrological changes of a bog woodland caused by amelioration stop the process of its natural development and ignite reverse processes by making it more like one of the dry forest types. Drainage lowers the groundwater level and causes more rapid fluctuations between dry and wet periods (Similä et al. 2014) which gradually may turn into significant changes such as faster annual tree growth. During the 19th century (Figure 3), it is confirmed by literature, which describes drainage works carried out in the forests and caused changes of bog woodland in forest habitats due to the decrease in groundwater level and the subsequent more sudden seasonal fluctuations.

2. Historical Description of the Area before Restoration Activities

Gulbjusala Raised Bog is located in Gauja National Park, around 7 km northeast from Cēsis (Figure 1), and its area is 669.38 ha. According to the administrative division, the nature reserve is located in Raiskums Parish, Pārgauja Municipality.

The area typically has an expressive relief formed by melting waters from the glaciers of the last glacial period (10 000 years ago) and the gradual formation of wetlands at the relief hollows (Kalniņa 2008). The area is composed of an interesting complex of Gulbjusala and Melnezers Raised Bogs, dystrophic and dyseutrophic lakes (called Auciema dzelzves) (Engēle, Salniņa 2007) as well as Lake Driškins which is included in the nature reserve with its rare oligotrophic lake habitat (Figure 2). The point of interest of the project - bog woodlands (91D0*) are settled around the raised bogs and enclose the mentioned lakes.

Before 1960, the natural hydrological system of bogs, lakes, and surrounding bog woodland of Gulbjusala Raised Bog also included Lake Kūdums, which today is nothing more than 0.2 - 0.3 ha of overgrowing open water pools. In the same year, a detailed design was developed for Gulbjusala Raised Bog as a potential site for the production of peat litter. According to the design, it was planned to drain and extract a major part of the bog, which would be around 106.2 ha. However, peat extraction was suspended shortly after and stopped after the formation of a 19 ha peat field ready for extraction at the north side of the swamp. From 1957 - 1960, Lake Kūdums was drained in order to improve the peat extraction project and the fertility of the surrounding agricultural land.

Water from the lake was drained to the River Lenčupe through a channel.

The oldest, detailed enough, map materials on the area of Gulbjusala Swamp, proves that the territory had already faced an amelioration process at the end of the 19th century (Figure 3). It is confirmed by literature, which describes drainage works carried out in the forests near Lake Driškins and Lake Melnezers at that time owned by the master of Ungurmuiža Manor (Petersen et al. 2004). However, it is believed that a more significant effect on the natural hydrological regime in the area was left by the amelioration works carried out in 1937, by creating the draining-ditches which have retained their functionality up until today (Figure 4). Those, along with the following major drainage works in 1960, significantly changed the natural hydrological regime of Gulbjusala and Melnezers Raised Bogs, as well as the forests and lakes around them. This intervention promoted the bogs getting covered with forests and caused changes of bog woodland in forest stand, micro-relief, and vegetation typical to swamp forest habitats due to the decrease in groundwater level and the subsequent more sudden seasonal fluctuations.

3. Materials and Methods

The boundaries of the LIFE+ programme’s FOR-REST project differ from the boundaries of Gulbjusala Nature Reserve (Figure 4). The project area did not include the private land properties and Lake Driškins; however, it added bog woodlands to the north up to the road, which naturally form a single bog woodland ecosystem together with the bog woodlands in the nature reserve. The whole area of 568 ha selected for the project is located on state-owned land.
Detailed area survey and assessment of the condition of bog woodlands were carried out before the improvement work of the ecological quality in Bog Woodland (91D0*) located in the project area. Based on the survey and condition assessment, guidelines were developed for the prevention of drainage impact on the habitat. All of the aforementioned information on the condition of the habitat before its restoration and guidelines, as well as methodology for their implementation, is summarised in the hydrological regime restoration programme, which was developed by the Institute of Environmental Solutions (IES). This programme served as a base for the developers of the regime restoration programme, which was developed by the Institute of Environmental Solutions (IES). The programme was designed to provide a possibility of restoring the original raised bog habitats. Therefore, the prevention of drainage effects within this project was planned only to provide a possibility of restoring the original raised bog habitats. Therefore, the prevention of drainage effects within this project was planned only to improve the condition of the Bog Woodland (91D0*) areas which may be seen in Figure 5, covering a total of 138 ha.

Based on the data from the remote sensing, the habitat expert assessment, and hydrological monitoring data before the prevention of the drainage effects, the condition of Bog Woodland (91D0*) was heterogeneous. The most adverse drainage effects were observed in the forest stand. The forest pines of bog woodland typically have a relatively low annual increment, which forms a rather dense crown structure, often with deformed and twisted branches. It is so because trees under excessively wet conditions have difficulties with oxygen and nutrient intake (Similä et al. 2014). Changes in trunk shape and branching of some of the pines found in the Bog Woodland (91D0*) of the project area clearly evidenced changes in the hydrology of the habitat. Meaning, branching in the mid-part of the trunk had remained twisted as typical to bog woodland and bog pines, while closer to the top it was more homogenous and evidenced more drained conditions which are also more suitable for tree growth (Figure 6). In some places there were also some dead pines with the dense branching and bent trunks so typical to degraded Bog Woodland

**Figure 4.** Map of European Union protected habitats and ditches network in the project area before hydrological restoration. Background is orthophoto map of 2007 year. Habitat expert Viesturs Lārmanis mapped the habitats.

**Figure 5.** Provisional map of European Union protected habitats that should restore back to the situation around 1937 – the year before intensive drainage of the project area. Background is forest crop map dated on 1937. Provisional habitat mapping has done by habitat expert Viesturs Lārmanis.

**Figure 6.** Growing pine with branch shape obviously indicates significant improvement of growing condition after previous drainage in the area around Nature Reserve of Gulbjusala raised bog. Photo: O. Purmalis, 2013.

**Figure 7.** Dead pines which probably died after previous drainage of a territory in Nature Reserve of Gulbjusala raised bog because their lack of adaptation to dried conditions and more variable water table. Photo: O. Purmalis, 2013.
measures planned for the project.

Overall, seven groundwater level monitoring wells were made within swamp forests of the project area (Figure 8), which were equipped with industrially manufactured perforated polyvinyl chloride pipes (diameter 50 mm, length 2 m) which is a chemically inert and certified material. The pipe ends were enclosed with lid to avoid direct impacts caused by precipitation. Every two weeks the wells were inspected by measuring the distance between the ground surface and the groundwater level in the pipe.

According to the hydrological monitoring data collected in Finland as a part of the Boreal Peatland LIFE project, fluctuations of the groundwater level in undisturbed Bog Woodland (91D0*) throughout the year on average do not take place lower than 20 cm below the ground surface (personal report of Juoni Pettinen). According to the Bog Woodland (91D0*) hydrological monitoring data from Gulbjusala Raised Bog before the start of the habitat management activities planned for the projects, the average groundwater level in most of the measurement wells varied between 20 cm and 30-50 cm which is considerably lower compared to the aforementioned typical value for the habitat under undisturbed hydrological conditions. Besides, the hydrologic monitoring of this project also showed that the groundwater level may sometimes drop by as much as 20-40 cm within two weeks. In habitats with peat soil and a natural, human-unaffected hydrological regime, the seasonal fluctuations of groundwater level are relatively small and take place closer to the ground surface - no lower than the aforementioned 20 cm below the ground surface (Simila et al. 2014).

3.2. Activities for the Prevention of Drainage Effects

Nāra Ltd. examined the condition of the hydrological system within the area and ascertained that the majority of ditches were silted or in some places even completely overgrown, while only a part of the ditches were in good condition. Depth of the ditches in some areas exceeded 2 m, while the average value was 0.7-1.1 m. Width of ditch bottoms ranged from 0.4-2.0 m and slopes from 1:1 to 1:2. Throughout the area, both ditch bottoms and soil piles left after the ditch excavation had not been cleaned for a long period, in some places being heavily overgrown with trees and shrubs. For part of the ditches, embankments are fairly small as they have sunken due to peat soil and do not stand out from the surrounding terrain. Anumber of beaver dams were on deepest ditches, especially in more dense forest areas. In some ditches the beaver dams had significantly reduced their drainage effects.

By focusing on the Bog Woodland (91D0*) areas shown in Figure 6, the developers of the detailed design plotted out the four major measures for the prevention of drainage effects:

- construction of peat dams which would block the ditches;
- construction of wooden piling dams which would block the ditches;
- complete filling of ditches;
- partial filling of ditches;

The peat dams were planned to be constructed with an upper width of 8 or 10 m, which would be equal to the upper width of the respective ditch plus a 1 m extension over each bank. Height of the dam was planned to be 0.2 m above the ground surface. Areas which required the construction of peat dams would also include the removal of the 0.2 m thick topsoil layer. One of the peat dams were created to reinforce the existing beaver dam. This was a fairly old beaver dam, which had created a sustainable hydrological regime in its nearest surroundings suitable for the habitat.

The wooden piling dams were planned to be installed in ditches where more than 80% of the volume had silted up or overgrown with sphagnum. Backfilling of such ditches was regarded as inefficient; however, there was a possibility to carry out periodic filtration of groundwaters. Individual piling walls were planned to be built in the lower end of high water content ditches which were planned to be backfilled, in order to prevent the backfill erosion risks. The piling walls were 2 m deep and 4.8 m wide. Height of the piling walls was planned to be 0.0-0.2 m above the ground surface in the overgrown ditches, but in the lower end of ditches to be backfilled - at the level of backfill surface. Supply of specially prepared piling wall material would be inconvenient, therefore, the piling walls were planned to be constructed from trees growing nearby. The piling walls were planned to be built manually creating a structure of three mutually displaced beam rows, which was sunken in the bottom and banks of the ditch.

To provide access for the technical equipment, it was necessary to clear the ditch embankments left after their initial excavation from shrubs and tree cover. The ditches were planned to be backfilled from the existing peat embankments, but in the case when there was not enough material to do so, it was permissible to mix in tree stems and roots from the cut down trees. Backfilling was planned to be carried out in the direction from the upper course to the lower course of a ditch in order to decrease water affinity during the digging work. Not all of the ditches were intended to be backfilled completely. If there was a possibility that a completely backfilled ditch would affect the hydrological regime outside of the 138 ha project area, the ditch was backfilled only partially or even left as it was.

4. Results

Investigation of the project area was started with the collection of remote sensing data in August 2012. The investigation and condition assessment of Bog Woodlands (91D0*) prior to implementation of the management measures continued in 2013. Meanwhile, a programme was being developed for the hydrological restoration of bog woodland at Gulbjusala Raised Bog, which was completed in May 2014. Development of the Technical project was carried out until July 2014. Overall, two years were devoted for situation analysis and planning of the practical habitat management works. This time period also included public discussions and meetings with the locals in order to inform the people about the planned project activities in the nearest surroundings.

Despite the well-timed preliminary works, the practical work on the prevention of drainage effects was started only in November 2014, when an agreement was entered into with CastorMelio Ltd. which won the tender called by the Nature Conservation Agency. Overall, this company carried out activities for the

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2 http://www.metsa.fi/web/en/borealpeatlandlife/
prevention of drainage effects in 37 ditches in accordance with the detailed design. Their total length was 13954 metres. Four peat dams were built in three ditches, 29 wooden piling walls were manually constructed in five ditches (Figure 9), while 29 ditches with a total length of 8730 m were completely backfilled (Figure 10, 11 and 12). Removal of the tree cover was carried out along the ditch routes before the filling works in order to provide access for the equipment.

Already in the first year after implementation of the hydrologic stabilisation activities in the winter of 2014/2015, changes in the measurements of groundwater level were observed (Figure 13). In all seven measurement points the seasonal groundwater fluctuations had become significantly lower and no longer exceeded more than 10 cm within a period of two weeks, while previously in some places the fluctuations could even exceed 20 cm. In none of the measurement points the groundwater level did not drop lower than 30 cm until the second half of the summer; however, at the end of the year it had significantly lowered in all of the sample plots due to a longer non-precipitation period. The largest changes in groundwater level could be observed in the hydrological monitoring points (Well 6, Figure 13) which were located in the proximity of the completely backfilled ditches.

While the lowest changes were recorded in the point (Well 4, Figure 13) where no drainage prevention activities were carried out within a radius of more than 150 m.

The vegetation monitoring data which were collected in September 2014 and then repeatedly in July 2015 did not show any significant differences in respect to the changes in hydrological regime of Bog Woodlands (91D0*) after the implementation of the measures for the prevention of drainage effects. The only notable changes were identified in areas where tree cover was removed along the ditches in order to carry out the backfilling works. These areas did not only include a decrease in the projective surface of forest stand, the disturbance affected all of the existing vegetation, in some places even exposing bare soil. Minimal changes were also observed in the herb and dwarf-shrub as well as moss layers.

5. Discussion

In Latvia, such a project for the improvement of Bog Woodland (91D0*) was carried out for the first time. Besides, there have not been too many projects devoted to this exact habitat and restoration of its hydrological regime in other parts of the world as well. Latvia has gained experience in respect to the hydrological restoration of raised bogs, starting from the first project in 1999 at Teiči Swamp in Teiči Nature Reserve (Bergmanis 2013). Bog Woodland (91D0*) most commonly form near the raised bogs and create a single hydrological system (Bambe 2013), similarly to the case of this project where bog woodlands have formed at the borders of Gulbjusala and Melņezers raised bog.

Due to the excessively wet conditions both the raised bog and bog woodland habitats are formed on peat soil (Aumina 2013, Bambe 2013). Taking into account the similarities in hydrological and soil formation conditions in both of these habitats, the experience may be adapted from and comparative analysis carried out in connection with the previous hydrological restoration projects for raised bogs in Latvia and abroad by improving the assessment with individual Bog Woodland (91D0*) specific nuances from the previous hydrological restoration projects in Finland.

Unlike the previous swamp restoration projects in Latvia (Bergmanis et al. 2002, Pakalne M. 2008, Pakalne M., Strazdina L. 2013), the planning work in this project included the use of high resolution remotesensing data, which are much more accurate than the spatial resolution of orthophoto and topographic maps. The data were used for specific activities for the prevention of drainage effects during development of the detailed design and the condition assessment of habitat before implementation of the actual measures. Spatial resolution of the RGB orthophoto obtained by the IES is 0.05-0.3 m, while for the orthophoto offered by the Latvian Geospatial Information Agency (LGIA) from the newest flights it is 0.4-0.5 m. For older images the resolution ranges up to 1 m (map.lgia.lv).

Resolution of the digital terrain model offered by the LGIA, however, is much lower (20 m) than the LiDAR laser sensor data offered by the IES, which is processed in 0.5 m spatial resolution and offers not only terrain, but also vegetation height and density data.

Image data with the ARSENAL technological system was gathered at the beginning of the project, thus, they provided as much accurate data as possible. This would not be the case with topographical maps that may often be created years or even decades before the project and thus possibly exclude some of the latest changes in the area. However, orthophotos for project needs may also be obtained during the most inconvenient times of the year, for example, the stick
season. The IES may adapt the data acquisition time for the desired season.

LiDAR laser sensor data made the job significantly easier for Nāra SIA, which was in charge of development of Technical project. The field work was mainly necessary to specify measurements of the identified ditches which had already been obtained from remote sensing data in order to carry out hydrological and hydraulic calculations. Use of LiDAR laser scanner data is also considered effective in the hydro-ecological and morphological research of raised bogs (O’Kelly 2007), which may be useful in planning further improvement projects both for bog woodland and raised bog habitats in Latvia and abroad.

Judging from the hydrological monitoring data, which already showed previous indications in the hydrological stabilisation of Bog Woodland (91D0*) within the first year after implementation of the measures for the prevention of drainage effects, the backfilling of ditches and construction of peat and piling dams at Gulbjusaļa Raised Bog has proved itself to be effective. However, we will only be able to evaluate the true effectiveness of the implemented measures over a longer period of time, which is at least 5 to 10 years after the restoration activities. Suspension of monitoring a short while after the projects, as well as the habit of applying the traditional monitoring methods without seeking the most efficient ones in terms of costs and time resources, is one of the most commonly observed drawbacks with regard to habitat and species conservation projects (Montoya et al. 2012). Therefore, it is necessary to continue the started hydrological and vegetation monitoring after completion of the LIFE+ programme’s FOR-REST project at the end of 2015.

The selected methods for the prevention of drainage effects were mostly borrowed from the experience gained during the raised bog hydrological restoration projects. The most effective methods, including in terms of costs, are backfilling of ditches or construction of peat dams by using excavators (Vesterinen et al. 2014). The soil piles remaining from the original ditch digging have usually settled over time and often, ditches which had already been obtained from remote sensing data in order to carry out hydrological and hydraulic calculations. Use of LiDAR laser scanner data is also considered effective in the hydro-ecological and morphological research of raised bogs (O’Kelly 2007), which may be useful in planning further improvement projects both for bog woodland and raised bog habitats in Latvia and abroad.

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Further on, when plotting out similar projects, it is recommended to focus more on informing the public about the planned project activities and the expected outcome as well as to develop a more detailed methodology for vegetation monitoring by paying particular attention to changes in moss and especially sphagnum species before and after the implementation of the project activities.

**Literature**


Planning of the conservation and management of the EU habitat 9010* Western taiga at Gauja National Park within the Framework of the FOR-REST Project

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Summary
Gauja National Park (hereinafter - GNP) is one of the most significant Natura 2000 sites in Latvia for the protection of EU habitat 9010* Western taiga. The overall assessment of the area of habitat at GNP in the Natura 2000 Standard Data Form is 1,835.8 ha.

Within the LIFE + project FOR-REST we performed the development of the habitat protection programme for the territory of GNP and the management of the habitat in a part thereof. The mapping of habitats of EU significance that conforms to the current standards of Latvia at GNP was performed only partially. Therefore, for the purposes of planning, we combined the data of Woodland Key Habitat inventory of 1998 - 1999 with newer, but less comprehensive information that was obtained during the project. The summarised cartographical data bear evidence that the habitat has been mapped in the area of 1,215.6 ha at GNP. Considering data drawbacks, the actual area, most probably, is considerably larger. The area of habitat polygons included in the data layer varies from 0.1 to 36.7 ha, the average area being 3.8 ha. In terms of species that depend on old trees or dead wood, this landscape is highly fragmented and requires the merging of fragments by promoting natural elements in the adjacent forests of lower quality. Due to various limiting factors, we focussed the habitat protection programme on the oligotrophic part of boreal forests of GNP within nature reserve zone of the state-owned forests. In addition to the mapped habitat, this area also includes 4,018 ha of forests which in the past was transformed for the purposes of forestry, where the measures for the renewal of the habitat can be implemented. The habitat protection programme drawn up within the framework of the project includes three conditional stages, which are partially linked to the time periods indicated in the EU biodiversity strategy. The first part includes the forest massif, where we performed habitat management within the framework of the FOR-REST project, and where controlled burning is scheduled during the following years. The second phase of the programme marks measures to be performed until 2020. Various habitat mapping, planning and public relations issues must be organised by that time in order to enable targeted and comprehensive renovation of the habitat in the 4,018 ha part of the forest transformed by forestry activities, or to give up this objective in some part of the area. The third phase of the programme refers to the time period from 2020 to 2050, when the measures that have been planned during the second phase of the programme must be practically implemented. After 2050 the quality of the habitat and areas within GNP should only be improving, until degree of conservation are stabilised in accordance with the meaning of the Habitat Directive. We have already commenced the implementation of the programme within the framework of the project, by managing a 282.5 ha area of the habitat. The management included the development of openings for the diversification of the forest stand and promotion of the development of various types of dead wood. We have also scheduled the commencement of controlled burning of the habitat, however, due to the objections of the active group of people, which gained vast publicity, this measure was cancelled.

Key words: 9010* Western taiga, habitat management, habitat of EU significance, Habitat Directive.
1. Introduction

During the preparation of the application for the project FOR-REST, the evaluation of the area of the EU habitat 9010* Western taiga in Latvia was 22,500 ha (Anon. 2007), while in GNP the area was 1,835.8 ha (Anon. 2012), which constitutes 8.2% of the total area of Latvia. In terms of the area it is one of the three most significant forest habitats of EU significance within GNP (Anon. 2012). Therefore one of the target habitats of the project was 9010* Western taiga, for which the protection programme had to be developed and the management of habitat had to be implemented in an area of 280 - 300 ha. The project application provided the felling of young spruces in older pine forests, which would improve the conditions for light-demanding species. It was planned that the smallest of the spruces would be removed or burnt during controlled burning, which would also prevent excessive fertility of the soil. Promotion of dead wood development was also scheduled by felling and leaving the trees that are larger than 20 cm in diameter in the forest (Anon. 2010). This was based on the recommendations, which were popularised in Latvia within the Woodland Key Habitat inventory (Ek et al. 2002) and described in the guidelines for the management of these habitats (Anshans 2005).

Upon the commencement of the project in 2012, certain assumptions regarding the management of biodiversity of 9010* Western taiga in Latvia had changed, therefore the measures provided for by the project were included in the development of the application for the project attention in Latvia was predominantly focussed on the management of boreal forests that are relatively natural - in accordance with the so called Semi-Woodland Key Habitats, which are mainly of the group of dry boreal forests. In fact during 15 years within various plans of nature conservation measures, where controlled burning of forests was required, it was only cautiously mentioned, but it was almost never scheduled for specific locations and in specific amounts. This issue was topical during the discussion processes of the planning, however, it was overwhelmed by the arguments that the public was not ready for this and controlled burning was replaced by inferior solutions, for instance, by felling the spruce regrowth and burning the branches on bonfires (for instance: LFN 2007), or by doing nothing. The problems caused by the lack of burning were mentioned in the materials associated with GNP (Pilāts 2007) as well, and recommendations were made that in some cases controlled burning might be provided for, however, no particular objects, where it should be done, have been indicated (Anon. 2004). The sites of controlled burning scheduled during FOR-REST project have been earmarked during the planning level, and commencement of practical actions was planned during the project.

This article has two mutually associated lines of messages. The first of them describes the issues that we encountered while developing the habitat protection programme, which refers to the entire WKH while the other deals with particular already implemented management measures based on this programme in smaller forest massif.

2. Material and Methods

2.1. Information on the distribution of habitats at GNP

The total area of all forests at GNP is 48,592 ha (Anon. 2004, Pilāts 2007). The area of the EU habitat 9010* Western taiga indicated in Natura 2000 site Standard Data Form is 1,835.8 ha, which, obviously, is the appropriate evaluation, because the indicated total area of EU habitats 91D0* Bog woodland and 9180* Tilio-Acerion forests of slopes, screes and ravines is exactly the same (Anon. 2012). In 1998 - 1999 the inventory of Woodland Key Habitat (WKH) was performed in most state-owned forests of GNP, except for strict nature reserve areas, as a result of which 18,690 ha of WKH were detected (Pilāts 2007). Afterwards the WKH inventory was gradually continued in the private forests as well, however, it does not include the entire territory of GNP. In 2002 it was determined what types of habitats of EU significance can be found at GNP, however, without the mapping of these habitats (Pilāts 2007).

The project FOR-REST provided for the surveying of 8,000 - 10,000 ha of the forest, which is only approximately 20% of the total area of GNP forests (Anon. 2010). Therefore the most extensive information that was available for the planning of habitat protection was still the WKH mapping of 1998 - 1999. The descriptions of WKH types differ from the descriptions of the forest habitats of EU significance (Ek et al. 2002, Anshans 2013), however they can be partially compared and the WKH mapping can be used to at least approximately evaluate the total area and distribution of various habitats of EU significance. EU habitat 9010* Western taiga most frequently conforms to the Coniferous Forest subtype of WKH.

The combination of four various information sources was used to determine the existing or potential 9010* Western taiga of GNP by transferring it to the united layer of cartographic data by using the computer programme ArcMap.

- In 1998 - 1999 WKH mapping, map of habitats of EU significance of the data base Ozols.
- information on the habitats of EU significance from forest management plans, where such plans were accessible.
- habitat mapping performed within the framework of the FOR-REST project.

In order to verify, whether the forest is still present in the WKH mapped 13 - 14 years ago, we compared the developed data layer with the laser scanning prepared by the Institute for Environmental Solutions within the framework of the FOR-REST project, which visualises the height of vegetation. Since laser data pointed to a considerable number of places, where WKH could have been completely felled or considerably thinned, we additionally checked it at several freely chosen objects in the environment. The surveying of the objects showed that everything that seems to be completely felled or considerably thinned is actually the same in the environment - no WKH, as well as habitats of EU significance exist there any more. These forest stands were consequently excluded from the data layer to be evaluated hereafter.

In order to determine, where the EU habitat 9010* Western taiga could potentially develop in the long term or could be developed by using special management methods, we also analysed the information of the State Register of Forests on forest types, composition and age of tree species.

2.2. Condition of the habitat in Latvia in connection with the targets of GNP

The Conservation Status of the EU habitat 9010* Western taiga in Latvia has been evaluated as unfavourable (Anon. 2013). The decisive parameters for the negative assessment included incomplete species structure of the habitat and insufficient total area of the habitat in comparison with the ecologically viable critical minimum. The principal drawback of the habitat structure was the lack of dead wood, regarding which the monitoring of the Natura 2000 site included in the forest the area of which 73% of the areas of the habitat does not have it in sufficient quantities (work materials of the evaluation in the archive of the Nature Conservation Agency). Meanwhile the total area of the habitat was detected by combining the amounts of the habitats of EU significance (Anon. 2013) with information from the gap analysis study (Angelstam et al. 2005). The study of Angelstam (2005) analysed how many forests of various types could be present in Latvia under natural conditions and calculated the critical minimum of their area that is required for the biodiversity characteristic of them to exist nowadays. The study also evaluated what the current situation is based on the assumption that the forests that are 70 or more years old and already protected could be attributed to the forests of a particular condition. This evaluation has also been provided at the level of the regions of Latvia, where GNP is included into Western Latvia region. The development of the group of dry boreal forests is optimal there and the expansion of protected territories has a low priority level (Angelstam et al. 2005). However, only some of the forests selected by this method have a sufficiently natural structure of forest stands and not all of them are fully functional on landscape level. Therefore it was advised to pay attention to the quality of these forests, including the need for natural disturbances like forest fires (Angelstam et al. 2005).

Rapid decrease of oligotrophic pine forests is a

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Current management practices for specially protected habitats and species in Latvia: Forests

To sum up, on the background of the overall situation in Latvia, the boreal forests of GNP are situated in the region where no special need to expand strictly protected areas exist, therefore we did not consider the development of new protected areas at GNP within the framework of the habitat protection programme. However, this would become topical regarding sites, where to date unknown high quality habitats are found. Meanwhile the improvement of the quality of habitats is a topical issue. The dead wood is lacking at the level of forest stands and landscape ecological issues must be resolved. The habitat lacks natural disturbance in the form of forest fires and this problem is associated with the decreasing number of oligotrophic forests. The solution of all aforementioned issues is researched in GNP in accordance with Natura 2000 site objectives (EC 2004) and will provide an overall positive contribution to the improvement of habitat condition in the situation of Latvia.

2.3. Concentration of activities at forests on oligotrophic soils

The habitats of EU significance in Latvia have been interpreted in a way, in accordance with which habitat 9010* Western taiga partially includes the habitat 9050 Herb-rich Forests with Picea abies, which makes the assessment of habitat condition and protection planning difficult (Lārmanis 2013). This situation has developed due to the fact that 9050 Herb-rich Forests with Picea abies are not included in the Latvia’s official list of habitats of EU significance, although they exist in nature (Lārniņš 2014). In order to fully comply with the objectives of the Habitat Directive, these forests still need to be included in the practical nature conservation measures. Therefore the inclusion of these forests into 9010* Western taiga is practiced in Latvia, assuming that they are a more fertile sub-type of boreal forests (Lārmanis 2013). The merger of both these habitats refers only to those situations, where it simultaneously conforms to woodland Key Habitats, because this is the required condition in terms of the Latvian interpretation of habitats, in order to map 9010* Western taiga (Lārmanis 2013). Therefore some 9050 Herb-rich Forests with Picea abies are hidden under 9010* Western taiga, while some - usually slightly younger forest stands with less pronounced signs of naturalness, have not been registered in any of the mapping. The marginal situations of both these habitats are frequently observed at GNP and the lack of clarity on their distribution encumbers the understanding of the overall situation and the planning of protection of 9010* Western taiga, especially because in some of the cases these habitats need a different type of management. The mixture of these two habitats of the EU significance was combined with another common feature characteristic of GNP. Broadleaf forest species are gradually entering a considerable part of GNP pine forests, or these forests are being overgrown by bushes. This is predominantly associated with the fact that the pine stands have either been planted or naturally developed on former agricultural lands in relatively fertile soils. In these cases the directing of habitat management towards the protection of assets characteristic of boreal forest would hardly be justified, considering the fact that broadleaf forest is likely to develop there in the future. The possible long-term development of the forest stand is frequently not currently clear, it may vary between the potential of developing broadleaf forest or fertile spruce tree forest.

Due to the aforementioned uncertainties we decided to refrain from management of forest stands, the interpretation of which is disputable within the framework of the FOR-REST project, assuming that the currently best mode of management thereof is economic non-intervention. This decision was also facilitated by the fact that there is a high probability that in the nearest years the mapping of 9050 Herb-rich Forests with Picea abies will be commenced in Latvia, which will improve awareness on the distribution of various habitats of EU significance at GNP. The presence of this habitat in Latvia has already been confirmed scientifically (Lārniņš 2014), the description of the habitat has been prepared (Anon. 2015a) and the training of specialists in the mapping of habitat has been started.

In contrast to the fertile sub-types of boreal forests, the situation in the oligotrophic part thereof is much simpler. The inclusion of these forests in the habitat of EU significance 9010* Western taiga is usually unambiguous. In the cases when they border on another habitat not included in the official list of habitats of Latvia - 9101 Central European lichen Scots pine forests (Lārniņš 2014, Anon. 2015b), no practical problems arise, because the preferable management thereof is the same (Lārmanis 2013, Anon. 2015b). Therefore, within the FOR-REST project, we focussed the planning and implementation of management on habitat 9010* Western taiga on oligotrophic soils, including the adjacent pine forests on mesotrophic soils in the focus of our attention.

2.4. Concentration of activities in the area of nature reserve zone on the lands belonging to the state

In accordance with the GNP Law five functional zones with various protection modes have been established at GNP: zone of strict nature reserve, nature reserve zone, protected landscape zone, cultural and historical heritage zone and neutral zone. The strictest limitations on general forestry activities are determined in the strict nature reserve zone and nature reserve zone in state and municipal forests, where the felling of forests is prohibited. The provisions of the law are complemented by the provisions of Cabinet Regulation (No. 317 of 2 May 2012), which provides for the prohibition of forest felling in other areas in state and municipal forests, if the forest exceeds a considerable age or conforms to the certain forest type. These provisions prohibit the felling of forest in especially protected habitats and habitats of especially protected species of all owners, where micro-reserves have been established in such forests, or where such micro-reserves have been indicated in the forest management plan, which, in turn, is a mandatory document, in order for the forest owner to be permitted to perform felling in their forest. This regulation provides for various other conditions, which must be observed in forests where the felling of forest is permitted. For instance, in the area of nature reserve zone in private forests no less than 20 cubic metres of dead wood with a diameter that exceeds 25 centimetres at the base must be preserved per each felled hectare.

All restrictions listed were in force before the development of the habitat protection programme within the framework of the project FOR-REST was launched. Although there have been cases where the felling of the forest habitats of EU significance occurred (see Section 2.2), the current limitations are stricter than the former ones and the conservation of the habitat is sufficiently secured. The regulations also promote the protection of various elements that are significant for biodiversity in the vicinity of the habitat. Therefore the habitat protection programme was focussed on the habitat management measures only.

The resources at the disposal of the Nature Conservation Agency, which is the responsible for implementing of the programme, are limited and insufficient for the performance of operations within the entire territory of GNP. Therefore we narrowed the area of programme implementation down to the zones of strict nature reserve and nature reserve situated on the lands belonging to the state. These areas include 57% of all 9010* Western taiga detected at GNP to date (Figure 1), as well as adjacent lower quality forest stands in an...
area of 4,018 ha, where a merger of fragmented habitat could be promoted and the creation of habitat in new places achieved. This does not mean that habitats in the remaining areas of GNP are left unprotected. As mentioned above, they are protected by the GNP Law and regulations. However, in contrast to the zones of nature reserve and nature reserve, no habitat renovation is scheduled in the remaining territory of GNP. As the habitat mapping develops or private initiative on sites takes place, this vision may be changed.

The management of the strict nature reserve zone is also a questionable issue. On the one hand the GNP Law provides that “measures that, in accordance with nature protection plan, are required for the purposes of protection and conservation of the nature reserve” may be implemented there, which could be interpreted as permission to perform habitat management measures. On the other hand, the felling of trees for habitat management has been precisely and unequivocally regulated regarding nature reserve zone. This allows one to believe that, if such action were permitted regarding the strict nature reserve zone, it would be formulated in the same form, but the formulations differ. Traditionally the regulations associated with strict nature reserve zone are interpreted as defined regarding strict nature reserves in the Law on Specially Protected Nature Territories: “unhindered development of natural processes shall be ensured in order to protect rare or typical ecosystems and constituent parts thereof”. It is possible that the legal interpretation of this question is positive regarding habitat management within the strict nature reserve zone of GNP, however, it is not unequivocal and immediately clear.

The traditional opinion on the mission of the strict nature reserve among nature protection specialists seems to be associated with non-interference in the current natural processes. Before the commencement of habitat management in the nature reserve areas of GNP the clarification of legal aspects, as well as the discussion of these issues with nature protection specialists and the responsible public servants would be required, to come to common grounds. Since this issue could not be resolved within the period of implementation of the FOR-REST project, the sites for the actions to be performed during the project were sought only within the territory of nature reserve zone.

3. Results and Discussion

3.1. Distribution, quantity and status of habitat at GNP

By combining information from different data sources, it was determined that 324 polygons with the habitat of EU significance 9010* Western taiga (Figure 1) could currently be situated at GNP, with the total area thereof covering 1,215.6 ha. It is considerably less than the 1,835.8 ha indicated in the Standard Data Form of Natura 2000 site (Anon. 2012). Meanwhile forest site types Cladinoso-callunosa, Vacciniosa, Myrtillosa and Hylocomiosa of various quality, which conform to boreal class forests, but are not included on the map of habitats of EU significance, occupy 4,180 ha of the GNP territory (nature reserve and strict nature reserve on state-owned land) (data of the State Register of Forests).

The structure of these forest stands mainly conform to that of highly productive commercial forests (Figure 2) and they currently do not conform to the quality requirements that have been determined by the EU habitat mapping methodology in Latvia (Lārmanis 2013). However, in the area of strict nature reserve and, since the amendments to the GNP Law of 2000, in the nature reserve area as well, no commercial activity is performed any longer and some of these forests have already accumulated dead wood and other signs of natural forest.

Therefore it is possible that the actual quantity of the forest stands that conform to the habitat of EU significance 9010* Western taiga is higher than the previous estimate, based on partially available data, of 1,215.6 ha.

The developed data layer, in accordance with the simplified approximation, also provides an notion on the fragmentation degree of the habitat. The source information was based on the division into forest stands according to forestry industry considerations, where an ecologically unified polygon is frequently divided into smaller fragments. Therefore forest stands that are closer than 20 m have been merged into homogeneous polygons.

In accordance with forest stands division principles this practically means that mutually adjacent sectors were merged into homogeneous polygons, while the next closest polygon is mostly at least at a distance of 100 m. The size of polygons separated in this manner at GNP varies from 0.1 to 36.7 ha, while the average size is 3.8 ha (Figure 3). Since habitat polygons are usually adjacent to forests of the same vegetation class, although the degree of their naturalness is lower, they cannot be considered to be isolated in terms of all ecological aspects. However, regarding the species that depend on old trees or dead wood, it is a highly fragmented landscape that requires consolidation measures.
3.2. The scheduled measures within the habitat management programme

Several issues that need to be settled before the commencement of habitat management in wider territories were highlighted during the implementation of the FOR-REST project. This affected the habitat management programme, by making it more approximate. In formal terms, the nature reserve, where most of the activities had to occur, are intended for the protection of biodiversity. However, the experience of the FOR-REST project shows that a part of the society not only actively objects to recommended planned burning and the measures for the development of dead wood implemented, but also voice a completely different opinion regarding what should happen in the nature reserve in general. A brief summary of this opinion would be: the forests in the nature reserve must be maintained in order in terms of commercial forestry, they must be cleared from dead trees, etc. It is not the general representation of public opinion, because it was voiced by only some especially active people. However, this opinion is very close to the opinion of a considerable part of society. Since the foundation of GNP in 1973 until nowadays, well maintained pine forest stands, in terms of commercial forestry, have frequently been reflected in photos of various booklets and books, as one of the values of GNP. Before the amendments to the GNP Law of 2000, the commercial-like management of forests in the nature reserve had been daily practice organised by GNP personnel. If informative and educational issues and practical action have had at least some success in shaping public opinion on the special values of GNP, the currently offered measures for the promotion of biodiversity completely ruin the ideal that has been created in the minds of people for a long time and can cause real confusion. This must be taken into consideration during further action. Although we found out that 4,018 ha of currently relatively artificial structure forests are available for management in the strict nature reserve and nature reserve zones, at least some part of them are definitely situated in potential conflict situations, especially, if they are crossed by frequently visited nature trails. Therefore we grouped the habitat protection programme measures into three degrees that include time that is required for settling public relations issues.

The first, most particular, stage of the planned events has been partially completed and refers to the territory in the area of 282.5 ha managed during the implementation of the FOR-REST project. Controlled burning in combination with the promotion of natural forest elements, which includes the creation of openings in canopy and the facilitation of various types of dead wood, has been scheduled here. Development of forest elements has already been implemented in 2014 and 2015 within the framework of the FOR-REST project. The controlled burning has been planned in a manner that would completely embrace the respective forest stands until 2050, the total area thereof is 202.3 ha. Controlled burning has been scheduled for three-year intervals, every time comprising up to approximately 20 ha of homogeneous or closely situated polygons. However, it is only an approximate indication. Both, the size of area at the particular time, and time of performance can be adjusted depending on the capacities. Achieving the situation, where burnt forest of various age could be always available in the forest massif along with forests untouched by fire, is significant. All of this will ensure constant diversity of conditions at the massif of forests and biodiversity should improve as a result of this. After 2050 the controlled burning cycle should be restarted.

We associated the deadline for the second stage of programme implementation with 2020, in order to emphasise the significance of measures and their link with the implementation of wider objectives. This year is the deadline for a range of commitments in the biological diversity strategy of the EU (EC 2011). The decisions regarding the particular forests, out of the total of 4,018 ha of potentially upgradable forests to be managed in order to increase biodiversity, must be made by then. Both an explanation of the measures to the public must be made, as well as a review of whether all territories, which are included in the nature reserve, can serve for the purposes of biodiversity protection considering the public interests, must be performed. Currently it is obvious that a considerable part of the nature reserve has not been intended for the protection of biodiversity in the modern sense of the term, considering the content and actual use thereof at the moment of establishment. It is possible that corrections to the zoning are required. The mapping of EU habitats must be implemented by 2020 as well, where 9050 Herb-rich Forests with Piceaceae must be separated from 9010* Western taiga. The condition of habitats must be evaluated afterwards and the required management measures must be specified respectively.

At the end of this period the management measures must be scheduled with such a degree of detail that is characteristic to the measures of the first stage of the programme.

The deadline for the third stage of the programme is symbolically linked with the vision of the EU biodiversity strategy for 2050 (EC 2011). By then (between 2020 and 2050) all measures that have been scheduled during stage 2 of the programme should be practically launched. After 2050 the quality of the habitat and areas within GNP should only be improving, until they are stabilised in accordance with the meaning of the Habitat Directive.

3.3. Location of the management events implemented during the project

We already explained that due to various limitations the possible area of habitat management measures was initially narrowed down to oligotrophic types of boreal forests, then to the areas of these types of forests in strict nature reserve and nature reserve zones in state-owned forests, while the strict natural reserve territories were further on excluded regarding the measures of the FOR-REST project. It was discovered during the project that the operations are limited by another circumstance - the felling of trees that is required for habitat management is possible only on the parcels of land, regarding which forest management plans (FMP) have been drawn up. This plan has been requested by the GNP Law in connection with the use of forest resources, however, in combination with other regulatory enactments, the requirement is applicable to any type of forest felling. Due to shortages of funds such plans have been developed regarding some of the state forests of the GNP only. At the moment when the selection of sites for habitat management had to be performed, there were only some land parcels at GNP that would conform to all of the aforementioned conditions and have an effective FMP. As a result of this the management measures were implemented at two adjacent parcels of land, where one parcel had an effective FMP, while the FMP for the other parcel could be developed during the implementation of the project. The summary of the process of choosing the site for management leads to the conclusion that the labyrinth of various administrative, informative and resource limitations had much more overall influence on the process than purely ecological considerations. The selected site is ecologically suitable for the management of boreal forests, however, the obtained experience shows that habitat protection planning within the socially-economic reality considerably differs from what it could be, based on ecological considerations alone.

The massif of forests selected for management, including with such a degree of detail that is characteristic to the measures of the first stage of the programme, consists of sectors where management was not performed, was 489.1 ha in area (Figure 4). The age of forest stands there varies from 35 to 148 years. Pine stands conforming to the boreal forest class dominate the massif, except for individual deciduous stands or mixed stands of deciduous and coniferous forests in more fertile soils and river valleys. Except for individual narrow river valleys, 77 years ago this forest massif consisted of forests or forests shortly renewed after felling (Figure 4). Although we have not researched the further history of this forest, most probably at least part of this forest massif has existed for a much longer time. This fact has a positive significance, because the potential for renewal of forest species is much higher in long continuity forests than in forests that have been relatively recently introduced in agricultural lands (Brüinemis, Jankovska 2013).

Figure 4. Forest stand plan of the forest massif managed within the framework of the project in accordance with the data of 1937. Orange colour means pine forest stands, blue – birch forest stands. Darker color means older forest stands, lighter color newest, but striped polygons are new plantations.
3.4. Habitat management measures implemented during the project

The managed forest stands occupy a total of 282.5 ha, or 58% of the forest massif (Figure 5). There are the different ages of forest stands in the following proportions: 35-60 year-old stands 5%, 61-90 year-old 36%, 91-120 year-old 41%, 121-150 year-old 17%, older stands 1% (Data of the State Register of Forests (SRF)).

The forest stands were divided into four groups by the method of habitat management. The first group included all sectors where no management was performed within this massif of forests, assuming that the best solution for their protection is non-interference. They occupy 206.5 ha or 48% of the total area of forest stands (Figure 5 - unfilled part of map). Predominantly these are forest stands that have been qualified as conforming to the habitat of 9010* Western taiga in the meaning of Latvian habitat mapping, because they have a sufficient number of characteristics pointing to their naturalness (Figure 5). The second group of forest stands untouched by management measures are forest stands in more fertile soils (see explanation in Section 2.2).

The third type of management included the development of forest canopy gaps and increasing the quantities of dead or dying wood. These measures were performed in an area of 77.4 ha (Figures 5, 6).

The quantity of canopy gaps was estimated to reach 4-5 items per every hectare (Figure 7). If the stand already had natural canopy gaps or it was obvious that gaps would soon develop instead of a dying group of trees, etc. the number of gaps to be developed was reduced accordingly. The development of canopy gaps was united with the promotion of the quantity of dead wood, incl. ring-barking of trees, where the trees would die gradually and the resulting canopy gaps would become visible in the following years only. The target volume of dead wood was 20-30 m³/ha, which is the approximate minimum quantity indicated in different sources (for instance, Müller, Bütler 2010, Similä, Junninen 2012, Brūmelis, Jankovska 2013). In the long term the quantity of dead wood in these forest stands will increase, because no further management has been scheduled there. The

![Figure 5. Forest massif managed within the framework of the project. Ortophoto: © Latvian Geospatial Information Agency.](image5)

![Figure 6. Presence of dead wood was promoted by means of tree ring-barking, felling of the trees and the creation of stumps. As the ring-barked trees gradually die at the site visible in the image, a wider forest canopy gap will develop.](image6)

![Figure 7. Fragment from the laser scan of the vegetation in the territory managed within the framework of the project before and after the performance of project measures. Thinning of the denser stand of rounded shape is needed in order to prepare it for controlled burning. Vegetation laser scanning data: Institute for Environmental Solutions 2012, 2015.](image7)
previous accumulation of dead wood was taken into consideration during the implementation of the measures for the promotion of dead wood development, and the amount of the dead wood that needed to be developed was accordingly reduced. Within the forest stands the situation varied from places where the dead wood has been accumulated in considerable amounts, to places, where no dead wood was present at all (Figure 5). The promotion of the amount of dead wood was performed by various methods: ring-barking of live trees for gradual dying, felling of individual trees and leaving them lying on the ground, creating the stumps (Figure 6). Instrumental measurements of dead wood amount were not performed, because it was impossible due to the limited resources of the project. However, the result could be close to that estimated, because the works were planned by experts experienced in measuring the volume of wood in growing forest.

The fourth type of management was in general similar to the third type, however, it provides for further management measures by performing controlled burning (see also Section 3.2). The areas of the aforementioned type occupy 202.5 ha of the forest massif. In contrast to the third type of management, this one requires the issues of fuel, facilitation of combustibility, if required and fire safety measures, to be taken into consideration. Therefore certain actions at these forest stands will have to be additionally performed as soon as it is known when the controlled burning will be commenced. For instance, the firebreaks created by removing ground vegetation get overgrown with time, therefore making the promotion of dead wood development, and the wide resonance of the issue in the mass media.

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The application of remote sensing for the assessment of specially protected habitats and management planning

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Summary
Mapping of specially protected habitats and the assessment of the situation, as well as long-term monitoring, requires the collection and analysis of various parameters or processes characterising the ecosystem. The obtainment of detailed information with traditional ground-based data collection methods require considerable human and time resources. One of remote sensing’s strengths is the ability to collect data over vast territories quickly. It has great potential for mapping the properties of ecosystems while providing opportunities for the thorough examination of data accuracy, as well as for standardised data processing and analysis. The availability of new types of remote sensing data and data analysis solutions ensures an increasingly wider range of opportunities for the research of ecosystems. The purpose of this article is to provide insight into ecosystem parameters, the assessment of which is possible by using hyperspectral images, high spatial resolution aerial images and LiDAR data sets acquired from airborne platforms. This article pays special attention to the experience, which has been received by developing data processing and analysis solutions for the assessment of the status of protected forest and bog woodland habitats within the framework of the LIFE+ programme project LIFE10 NAT/LV/000159 Forest Habitat Restoration within Gauja National Park. It is expected that the use of remote sensing data for the conservation of biodiversity in the European Union and elsewhere in the world will be considerably expanded within the immediate future.

Key words: remote sensing; habitat mapping; habitat assessment; LiDAR; spectral data; ecosystem assessment

1. Introduction
The most common approaches seek to quantify biodiversity of the ecosystem by assessment of the condition of a particular ecosystem in a particular territory, in order to decide whether the respective territory conforms to the quality criteria of the high biodiversity value habitat - specially protected habitat. That essentially involves definition of the permissible deviation from the ideal condition of the ecosystem, which ensures the conditions required for the maintenance of specialised live organisms (Zlinszky et al. 2015).

The ecosystems are characterised by integrated sets of various indicators, for instance, geological structures, abiotic or biotic processes, vegetation states, naturalness, environmental integrity and transformation (degree of anthropogenic influences). The assessment of these parameters is united by the necessity to obtain the values of as many various parameters as possible, for which the analysis of their mutual relations, as well as the significance of each individual element is possible. To acquire such a complex set of information that covers a wide area of specially protected territories, an efficient, standardised and reliable data acquisition system is required. Information collection via traditional methods (ground based data collection) is time consuming and raises questions of accuracy due to the subjective approach of persons collecting the data. The need to resolve such situations creates pre-requisites for the development of information collection approaches and methods that ensure replicable results, efficient data collection in large territories, with the possibility to perform a quantifiable assessment of accuracy. The rapid progress of remote sensing and data analysis technologies observed over the last decades can provide a significant contribution to the analysis of parameters that are significant for monitoring of habitat condition - identification and assessment of species, structural elements and objects. The advantages provided by the solutions that are based on remote sensing can be divided into the following levels: 1) identification of habitat territories in accordance with the conditions characteristic to them, determined by terrain, hydrological and other factors, 2) assessment and mapping of the elements characterising the habitat quality, 3) development of models based on ecological interaction principles for the assessment of habitat protection status and future potential on the scale of
the landscape. Collection and analysis of spectral data collected using aviation platforms has proved its capacity to ensure high precision mapping of species in forest and marshland territories. LiDAR (Light Detection and Ranging) data has demonstrated their usefulness in the determination of spatial structure of terrain forms and vegetation (Złotnicki et al. 2015).

Increased use of remote sensing technologies for the mapping and assessment of habitats will not result in the abandonment of ground data collection as it will be necessary for ground-teaching and the identification of specific habitat characterising parameters that cannot be remotely sensed. The combination of both methods will result in increased accuracy and efficiency of field data collection.

Increasingly GIS and remote sensing is being used for management and planning on national, regional and local levels. The quick provision of reliable data opens up further opportunities for environmental protection planning and implementation of habitat management measures into different levels of decision making processes and territorial development plans.

2. Materials, methods and results

Detection of electromagnetic radiation in optical (wavelengths from 200 nm to 20 µm, including the wavelengths of 380 nm to 780 nm) or microwave (wavelengths from 1 mm to 1 m) spectral range is usually at the base of collecting aerial and satellite remote sensing data (Turner et al. 2003, Thenkabail et al. 2011). Remote sensing technologies are usually referred to when speaking about microwave spectral range data use, however, optical radiation range and appropriate data collection and analysis methods are more commonly used for the observation of ecosystem characteristics.

Optical data collection instruments are divided into passive and active sensors according to the principle of their action. The passive sensors receive the optical signal reflected by the sun or irradiated by the studied object, meanwhile the operation of active sensors is based on the irradiation of the optical signal and the detection of the changed optical signal. Human vision and standard photo cameras are also considered to be passive optical instruments operating in the spectral range of visible light. However, colour and structural changes in the spectral range of visible light are frequently insufficient for the classification of land cover type and vegetation, therefore, spectral analysis methods are used in remote sensing (Thenkabail et al. 2011) by using spectral imaging data or images that have been obtained by using the information in several spectral ranges. For instance, spectral information in the infrared radiation range (700 nm to 1,000 nm) is used as the basis for the evaluation of vegetation and humidity indices. Analysis of multi-spectral data is frequently used as the basis for the classification of functional groups of vegetation and the classification of species.

Spectral imaging devices can be divided into broadband sensors (RGB cameras, CIR cameras, as well as some multi-spectral sensors), where separate channels are spectrally united (summed up) and narrowband sensors (usually multispectral and hyperspectral sensors), where data are collected through several narrow spectral channels. The obtained data can be used for the visual evaluation of the objects/territories of interest, verification of products of the data provided by other sensors, as well as the object-oriented evaluation of parameters (Blaschke 2014). Spectral data obtained by narrow band sensors usually provides better results of vegetation classification and parameter assessment (Thenkabail et al. 2002, Mutanga and Skidmore 2004). Laser scanners or LiDAR scanners that allow data collection on the spatial structure of vegetation and earth surface are the most common active optical sensors (Vierling et al. 2008). Each type of sensor has its own advantages and disadvantages; the combined use thereof allows one to cover a wider range of data for the assessment of ecosystems (Dalponte et al. 2012, Hladik et al. 2013, Nagendra et al. 2013).

ARSENAL, the environmental surveillance and monitoring data collection system used by the Institute for Environmental Solutions (Figure 1), is an example of multimodal combination of passive and active optical sensors (Jakovels et al. 2014). The data collected by this system were used to develop solutions for the assessment of parameters that characterise habitats. The spatial resolution and quality of data depends on the parameters of data collection flight, especially the height above the object and the speed of flight. Low flight time (for instance, at the height of 815 m) allows one to decrease the pixel size of the image, thus obtaining maximum spatial resolution of data. Data collection flight at low speed (for instance, 84 kts at 156 km/h) enables the use of longer sensor matrix exposition times by obtaining better data quality (signal and noise ratio in spectral image data).

High resolution (10x15 cm/pixel) aerial photos were obtained using a digital RGB camera, which essentially is a broad band three-channel passive spectral sensor. The images were later used for the purposes of visual evaluation of the territories, as well as verification of the image classification results.

Narrow band spectral data - hyperspectral images (for instance 191 channel spectral image in a 380 – 5000 nm spectral range) were obtained by combining the use of three hyperspectral sensors, the spatial resolution of which vary from 0.5 to 1 m/pixel. The number of spectral data channels to be obtained, as well as spectral width thereof depends on sensor structure and data collection parameters. For instance, the 27 most informative spectral channels in the visible light and near infrared radiation spectral range were selected for habitat mapping and situation evaluation purposes, which, in accordance with the results of the research described in literature, provide for wider possibilities of vegetation analysis (Adam et al. 2010, Zarco-tejada et al. 2013, Casas et al. 2014).

The spectre of reflected and emitted light in radiance units was obtained for each pixel of the image in the hyperspectral imaging data, which was later transformed into the spectre of reflected light (reflectance) and used for spectral analysis. An example of radiation spectrum obtained by ARSENAL is displayed in Figure 2. Visible light in this case represents only a small part (from 400 to 700 nm) of the total 380 to 5,000 nm spectral range. Chromophores are light-absorbing molecules and compounds that shape the reflected spectrum curve and their concentration can be evaluated by means of spectral analysis methods.

The most characteristic chromophores of vegetation include chlorophyll and carotenoids in the spectral range of visible light, as well as water, nitrogen, lignin and cellulose in the infrared spectral range. Three grey zones in the short wave infrared spectral range represent areas of pronounced water absorption; they are usually used for the separation of atmospheric water (atmospheric correction), but cannot be used for the direct evaluation or classification of vegetation. The medium wave infrared range is peculiar in the fact that radiation emitted within it or thermal radiation starts to dominate over reflected light; this range can be used for the assessment of surface temperature as well. The grey zone at 4300 nm concerns to the area of pronounced carbon dioxide (CO₂) absorption (Eyal et al. 2013).

The spectral data collected by appropriate hyperspectral sensors were used for the calculations of narrow band vegetation indices. These indices represent the concentrations of vegetation chromophores (for instance, chlorophyll), as well as provide information on the status of vegetation vitality/stress. Normalised vegetation index (NDVI) is the most frequently used vegetation index for the separation of the vegetation layer and assessment of chlorophyll concentration and green biomass, which is calculated by using two spectral channels of the red and near infrared spectral range, 675 nm, where the absorption maximum for chlorophyll is observed, and 845 nm, where vegetation is characterised by maximum light reflection, respectively (Eyal et al. 2013).

In a true colour image (RGB image), the colour pattern that a human is used to perceiving with their eyes, the vegetation is visualised in various shades of green. Spectral data were used to create false colour images, where the real colour channels (RGB) are replaced with specific spectral channels, which better highlight the differences between various groups of vegetation or highlight certain vegetation processes. For instance, Figure 3 represents the territory of the bog marshland in a true colour image and false colour image (R = 845 nm, G = 550 nm, B = 675 nm) - where...
chlorophyll-rich vegetation (in this case deciduous trees) is visualised in red colour shades, conifers in green colour shades, while humid vegetation or vegetation poor in chlorophyll rare vegetation in blue colour shades.

These spectral data were used for the classification of functional vegetation groups and species. The methods of digital classification of images can be divided into supervised classification and unsupervised classification methods of algorithm learning. Sample sets are required for the operation of supervised classification algorithms in order to teach them – the identifiable classes must be defined. As a result of the classification each pixel (point) of the image can be attributed to any of the defined classes or evaluated, and spectrally similar areas of image corresponding to the same class can be identified.

The approach of unsupervised learning of classification algorithms is usually more appropriate in the cases where no comprehensive information on the classes found in the territory is available or, when it is necessary to evaluate the potential distribution of a group or species of plants in the entire examined territory. The classes do not need to be defined for the operation of unsupervised learning algorithms, however, it is possible to select the number of classes in which the vegetation of the territory will be divided according to the spectral similarity principle. This approach is commonly used for the assessment of vegetation variety in an ecosystem (Turner et al. 2003, Baldeck et al. 2013), as well as in cases when obtaining or interpreting field data in a particular territory is difficult.

Laser scanning data were obtained by means of an active sensor – LiDar (Light Detection and Ranging) scanner, the primary data product of which is the cloud of dots characterising the spatial structure of the terrain and objects present on the terrain. See Figure 4 as an example of a LiDar dot cloud in a small territory. Each dot of the LiDar data cloud represents the location of the laser signal reflection in three-dimensional space. In wooded areas some of the laser signals are completely or partially reflected from the foliage of the trees (vegetation surface), while some of them will reach the ground (terrain), which results in a multiple layer cloud of dots. This allows one to separate the terrain layer of dots from the LiDar dot cloud (dots of “last” reflection/echo) and the layer of remaining dots that correspond to trees, bushes, buildings and other objects. By performing the respective classification of the laser scanning digital surface models (DSM), digital terrain models (DTM) and normalised digital surface models (NDSM) were obtained; see Figure 5 for examples.

Terrain model (DTM) was used to characterise the surface of the ground in the researched territory. Separation of slopes and evaluation of height and inclination is also attributed to the evaluation of terrain based on DTM, which is a significant parameter for the characterisation of specific habitats; for instance, wooded dunes of the Atlantic, Continental and Boreal region. (2180) or Tilio-Acerion forests of slopes, scree and ravines (9180*). Terrain filtering enables the mapping of local terrain changes, thereby helping to highlight local elevations (hillocks, bars or dunes) or depressions (holes, trenches).

The assessment of differences in height in the terrain was used for the separation of slopes, to do this the differences in height of adjacent terrain pixels were calculated and pixel sets were separated where

<table>
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<th>Table 1. Most common vegetation</th>
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<tr>
<td><strong>Vegetācijas indeks (akronīms)</strong></td>
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<tr>
<td>Normalizētās starpības vegetācijas indekši – (b1–b2)/(b1+b2)</td>
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<tr>
<td>Normalized Difference Vegetation Index (NDVI)</td>
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<tr>
<td>Modified Normalized Difference Vegetation Index (mNDVI)</td>
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<td>Photochemical Reflectance Index (PRI)</td>
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<td>Normalized Difference Water Index (NDWI)</td>
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<td>Short Infrared Water Stress Index (SIWSI)</td>
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<td>Normalized Difference Infrared Index (NDII)</td>
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<td>Normalized Dry Matter Index (NDMI)</td>
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<td>Normalized Difference Nitrogen Index (NDNI)</td>
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<td>Normalized Difference Lignin Index (NDLI)</td>
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<td>Dry Matter Content Index (DMCI)</td>
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<td>Normalized Difference Leaf Mass per Area Index (NDLMAI)</td>
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<td>Normalized Difference Tillage Index (NDTI)</td>
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<td>Normalized Difference Foliar Water Content Index (NDFWCI)</td>
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<th>Spektrālo kanālu attiecības indeksi – b1/b2</th>
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<tr>
<td><strong>Structure Insensitive Pigment Index (SIPI)</strong></td>
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<td><strong>Plant Senescence Reflectance Index (PSRI)</strong></td>
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<tr>
<td><strong>Cellulose Absorption Index (CAI)</strong></td>
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<tr>
<td><strong>Carotenoid Reflectance Index 1 (CR11)</strong></td>
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<tr>
<td><strong>Carotenoid Reflectance Index 2 (CR12)</strong></td>
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<tr>
<td><strong>Anthocyanin Reflectance Index 1 (ARI1)</strong></td>
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Figure 4. LiDar data example from GNP.
the height difference of adjacent pixels characterises a certain inclination of the terrain; see Figure 6 as an example. Thus, the analysis of terrain characteristics can provide cartographic support data for the precise mapping of habitats both during desk studies and field work. The information that characterises the terrain can be used for the planning of habitat management or habitat restoration measures. The use of detailed digital terrain models is especially useful while planning the measures for the restoration of hydrological regimes. This was graphically demonstrated during the development of the programme for the restoration of hydrological regime as well as the technical project of the measures for the restoration of hydrological regime that is favourable for the raised bog habitats at Gulbjusalas bog (GNP) and peripheral Bog woodland (91D0*) habitats.

The hyperspectral images in combination with LiDAR laser scanning data were used within the framework of implementation of the project “Forest Habitat Restoration within Gauja National Park” LIFE10 NAT/LV/000159 as supporting data for the mapping of individual types of forest habitats and evaluation of the situation, as well as for the evaluation of specific structures or parameters and detailed planning of the measures for the improvement of specially protected habitats.

Remote sensing data sets without specific processing were used during the field work of habitat surveying, which ensured relevant and detailed information on the previous management of the forest stands, as well as allowed the evaluation of specific parameters characterising forest stands, for instance, the composition of forest species at forest stands and distribution and sizes of crowns, which allows for indirect evaluation of the intensity of gap dynamics of a forest stand.

A data layer that identifies territories with particular terrain slopes, which are used for detailed mapping of the habitat Tilio-Acerion forests of slopes, screes and ravines (9180*) in the territory of Gauja National Park have been obtained as a result of analysing LiDAR data. Vegetation surface laser scanning data were used to identify pine forest stands, where undergrowth or regrowth of other tree species of a particular height had developed.

This information can be used while planning forest management measures for the development of habitats in dry pine forests.

Detailed terrain data, which were obtained from LiDAR laser scanning, were used to identify and assess drainage systems, as well as to plan measures for the restoration of hydrological regime aimed at the improvement of Bog woodland (91D0*) habitat in Gulbjusala bog area.

The digital surface model (DSM) may be used for the 3D representation of the researched territory in combination with the true colour image; see Figure 7 as an example. This creates a spatial understanding of the studied area while also enabling virtual research. False colour image (R = 845 nm, G = 550 nm, B = 675 nm), where the differences between different vegetation groups are better highlighted, can also be used instead of a true colour image.

Normalised surface model (NDSM) can be used for various tasks of tree and bush vegetation structure assessment, for instance, the assessment of overgrowth of bogs, marshes or grasslands, valuation of forest stand age or tree height structure, separation of bog vegetation points (mas.l.) and terrain surface level (mas.l.).
Various tasks of vegetation assessment and classification of the researched territory were performed during the combination of hyperspectral and LiDAR data. Data processing and analysis process can be described in several steps. Principal data sets - vegetation and non-vegetative cover is separated during the first step of data processing; during the second step LiDAR data is used to classify the vegetation into separate height groups by separating trees and bushes from low vegetation, which facilitates further detailed classification of vegetation by analysing spectral data, as well as improves the classification result; supervised and unsupervised classification algorithms are used in the third step to analyse the data of interest - classification of species, similar types of vegetation or certain conditions of vegetation.

The results of data analysis for the combined use of hyperspectral and LiDAR data in marshland territory is provided in Figure 10 and Figure 11.

Separation of the tree cover layer by using frequently used vegetation indices such as NDVI and NDSM allows one to evaluate the density of the canopy, which is one of the most significant criteria for the mapping of bog and marshland habitats and the evaluation of their condition. Low vegetation in the marshlands often creates small mosaic-shaped areas, therefore in some pixels of spectral data the information on vegetation structure has been fixed in the form of mixed spectrums. Collection of representative samples for the application of a supervised learning algorithm is complicated and therefore the selection of an unsupervised learning algorithm approach for vegetation classification in such cases is useful - the result of the classification of low vegetation in a marshland is represented in Figure 10. Additionally, the result of vegetation classification conforms to the humidity assessment of low vegetation in the depressions of local terrain.

Supervised learning algorithms can be used for the classification of individual trees into main groups - deciduous, coniferous and dry trees by indicating sample trees of each class of interest in the image of the analysed area in accordance with visual evaluation of high resolution aerial photography and false colour images for the purposes of algorithm training. The result of deciduous and coniferous tree classification correlates with the mapping of the normalised vegetation index (NDVI) for the tree layer, see Figure 11, where high NDVI values conform to deciduous trees and low to coniferous trees. Supervised learning algorithms are also used for detailed classification of tree species in the researched territory. Precise information on several individual tree crowns for further species classification, as well as the planning of management measures and the assessment of the results of such measures (see Figure 8 as an example). LiDAR point cloud provides the possibility of assessing the vertical structure of forest stands for the separation of specific conditions like undergrowth of the forest stand, regrowth or understory. The point cloud received as a result of laser scanning can be analysed by spatially separating a part of the point cloud, which corresponds to the crown layer of the main tree species of the stand and the layer of lower trees and bushes; see Figure 9 as an example. The information on the vertical structure of the forest stand was used for identifying forest stands where the measures for habitat management need to be performed, for instance, thinning or controlled burning of undergrowth or regrowth, as well as for the precise quantitative assessment of the management measures in these territories.

The collection, processing and analysis of remote sensing data within the framework of the LIFE10/NAT/LV/000159 project “Restoration of Forest Habitats within Gauja National Park”, for the first time, ensured the possibility to obtain topical and detailed terrain data for the central part of Gauja National Park, valley of the river Gauja with tributaries and lateral ravines. The processing and analysis of the collected LiDAR data demonstrated graphic and easily applicable results, meanwhile the elaboration of specialised solutions was required for processing and analysing of spectral data. Furthermore, considerably more time was required for this task if it was initially planned. The analysis of spectral data was affected by lighting conditions during data collection. Image processing problems were caused by non-homogeneous illumination conditions between flight lines and cloud shadows present in the spectral images.

Knowledge of the required time for the solution of data processing problems and the acquired results mean that future focus should be on the collection of spectral data under good light conditions (without clouds, and as much as possible, simultaneously). Additionally, data analysis must be performed for small territories or territory blocks, where illumination intensity can be balanced.

The collection and analysis of remote sensing data in Latvia’s specially protected nature territories should be continued on a wider scale. This would ensure more precise and comprehensive information on the situation - terrain, forest stand composition, water object configuration, etc. for more efficient evaluation and mapping of the condition of the protected habitats, as well as for the planning of further restoration and management measures.

Several significant challenges exist for the use of remote sensing data for nature conservation measures, including the mapping, monitoring and evaluation of specially protected habitats, as well as the planning of habitat development, restoration and management. Firstly – customarily, the costs of spectral imagery and other data sets are high. However, it must be noted that as the remote sensing data collection technologies and the options for their use develop, the possibilities to obtain higher spatial and spectral resolution data at lower costs are growing simultaneously. Furthermore, specific data processing software and equipment with high performance are required for the processing of remote sensing data. An improvement in equipment performance with a simultaneous reduction in costs, as well as an improvement in specific software availability, is also observed regarding these aspects. Nevertheless, the costs of data processing software and hardware are not insignificant (Turner et al. 2003). An even more significant challenge for nature conservation specialists is that experts and managers of management measures frequently lack the specific knowledge and experience that is required for the processing and analysis of remote sensing data sets. Compatibility of the data collected by remote sensing equipment and data obtained during field research is one of the most crucial factors that will receive additional attention in the nearest future for the purposes of the use of remote sensing data for the assessment of biodiversity. In most cases the accuracy of data collection obtained by remote sensing and field data collection is comparable; however, methods and results can demonstrate different approach to the same type of habitat (Zimzoky et al. 2015). Further development of data analysis methods is expected, therefore experts are to develop solutions for direct linking of ecological parameters with the parameters obtained by remote sensing data, coupled with the expected progress.
in the development of ecology and environmental protection measures, development of increasingly mutually compatible solutions should be expected. The development of more efficient and successful implementation of environmental protection policy at local, national and EU levels is dependent on closer and more substantial cooperation between remote sensing specialists and environmental conservation experts.

### Literature


**Dalponte, M., Bruzzone, L., Gianelle, D. 2012.** Tree species classification in the Southern Alps based on the fusion of very high geometrical resolution multispectral/ hyperspectral images and LiDAR data. *Remote Sensing of Environment* 123: 258–270.


Crisis communication in nature preservation. Raising public awareness within the FOR-REST project in Gauja National Park. The case of prescribed burning.

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Summary
From 2011 until 2016, the Nature Conservation Agency together with its partners, carried out the *Forest Habitat Restoration in Gauja National Park* project financed by the European Commission’s LIFE+ programme and the Latvian Environment Protection Fund. One of the project objectives was the promotion of awareness about the restoration and management activities in European protected forest habitats among conservation specialists, municipalities, and local residents. By studying the publicity experience of the project as well as the methods used to achieve the project objectives related to public awareness, monitoring of publications and media clipping was carried out in a specific phase of the project, interviews were taken from the staff members involved in publicity activities as well as theories on communication, environmental communication and public participation methods were studied.

Key words: Communication, public participation, media relations, crisis and risk communication

1. Introduction
Communication with the public in various meanings is not only a democratic need, but also a significant factor in order to achieve the objectives - also in nature preservation. Sustainable nature conservation is not possible without public participation. Public participation on the other hand is not possible without a successful dialogue. Establishment of determined and professional relations with the public and its various target groups promotes not only a positive relationship between the parties, but also involvement of the public in the conservation and management of protected areas and the preservation of biodiversity. Making society interested in becoming a part of nature conservation is one of the most important tasks in environmental communications when it comes to matters of nature conservation (Salna, Daģis 2007). Modern nature conservation is a package of activities and measures which includes public participation. Besides, taking into account that a part of the specially protected nature areas (SPNA) are held by private owners, it is important to take care of their awareness and involvement both at an individual and collective level. With professional communication it is possible to carry out the awareness-raising function (information exchange between the information provider and target groups), relations function (establishment and maintenance of relations), image and reputation function (SPNA, industry image), stabilisation function (loyalty and professional actions in crisis situations), and consistency function (unified policy, viewpoints, and opinions within an industry or organisation).

When carrying out any kind of activity in nature conservation, a strategic and sustainable approach to communication is as important as the communication itself.

Raising awareness among various audiences was one of the objectives within the *FOR-REST* project in order to achieve the set goals - promotion of awareness about restoration and management activities in European protected forest habitats among conservation specialists, municipalities and local residents.

2. Material and Methods
The following methods were applied to inform the public about project activities and to promote public awareness about the topics discussed within the project.

1) Project website http://for-rest.daba.gov.lv/ was created and is maintained: the website provides information about the project as well as its objectives, activities and results. No target audience was defined during the development of the project’s website.
2) Information stands and signs: 14 stands and 50 informative signs have been placed in the areas where the project activities have been carried out, which provide information about the project and its activities in the specific area.

3) Topical Seminars: seven seminars were organised during the project in order to inform nature experts, organisations, local people and other interested parties about the project and its activities.

4) Audiovisual Materials: four short films have been shot about the project activities - restoration and management of different habitats. The short films were used in nature education centres, topical events as well as offered for distribution to mass media.

5) Printout Materials: the following printout materials have been made and distributed during the project: 1000 informative brochures about the project, 2500 informative overviews on habitat restoration works. The printout materials have been created in the amount intended in the project application.

6) Project Overview: this publication has been made to gather information about the project objectives, activities and results. It was issued in 1000 copies (200 in English and 800 in Latvian). It is planned to be distributed among industry experts, municipalities of the project area, their public libraries etc. It was not intended to use a public relations or public participation specialist within the project. It was also not intended to have a communication strategy which would help in achieving the set objectives and, in general, provide information to the public about the course and results of the project. Also, no crisis communication model was developed. The communication activities were carried out by the project management team by using the resources of the leading partner - Nature Conservation Agency. In certain phases of the project which may be regarded as a communication crisis, a communication plan was developed for specific activities which was more like fighting a fire, not strategic and determined communication management. No monitoring was intended or carried out within the project to determine whether and to what extent the respective objective defined in the project had been achieved.

Risk and crisis communication is one of the keystones in strategic communication, which allows you to control the communication instead of it being controlled by the events. Risk is a component of planning which allows you to reach goals easier on any dimension - business, public sector in general, the industry or the project.

The classic communication methods were applied in order to ensure public awareness about the project activities, mostly focussing on mass communication. Certain phases of the project also included personal and direct communication activities. Mass communication is important as the world has become a mass communication community. The information is received and used on a wide audience level (Lazdiņa et.al. 2010).

However, taking into account that the activities carried out during the project affected certain target audiences and areas, strategic focus on specific audiences with specific methods would be more effective. It would allow results to be achieved by more efficient use of the project’s human and financial resources, as well as protect the project from crisis situations, once again proving that it was necessary to develop crisis communication before the initiation of the project.

Many of the project activities faced a clash of opinions. By using both personal and public communication, certain groups of society expressed dismay about conservation activities in Osmožemsi barnabita habitats in Sigulda and Pārgauja municipalities, which included the clearing of a considerable amount of trees and shrubs for example. There was also a lack of understanding among various audiences in respect to the plan of swamp forest restoration. However, the most negative response, which may also be regarded as the largest crisis of the project, was related to the planned prescribed burning experiment on a site which was situated on state-owned land in the summer of 2014.

The respective publication in turn became a catalyst for other media sources, which started releasing news about the mentioned activity. The aforementioned printed media also continued to portray the intentions of burning and other project activities with headlines such as Useless Experiment Destroys Gauja National Park, the Green Parasites, Legalisation of Crime or Taking Care of the Nature?, Gauja National Park will Undergo Prescribed Burning - Local People in Shock, Fire Before Burning, etc. The majority of expert opinions still came from local residents. While the background information about the project and its activities was interpreted in favour of biased and negative publicity.

The classic communication model was applied in the planning work of this activity which was focussed on mass communication.

Step 1. A press release was distributed with information about the planned activity.

Step 2. Inspired by the press release a publication was released by one specific printed media, with the primary sources and opinion leaders not being the creators of the project or experts, but rather local people instead.

Step 3. The respective publication in turn became a catalyst for other media sources, which started releasing news about the mentioned activity. The aforementioned publication in turn became a catalyst for other media sources, which started releasing news about the mentioned activity. The aforementioned publication in turn became a catalyst for other media sources, which started releasing news about the mentioned activity.

Step 4. The project team and its leading partner the Nature Conservation Agency, created a communication plan and started releasing more specific information with titles such as Nature also Needs Fire, About the Planned Groundcover Burning Activities in Gauja National Park, and others, explaining the project’s usefulness etc. The project team organised a media trip to the activity site where media received information directly from the primary source - the project team and the Nature Conservation Agency. Yet the topic was quite challenging, first of all, to suppress the biased headlines provided by media in a short period of time and,

Figure 2. Risk or crisis. (Lehtonens, Silina, Ābelniece 2011).

Figure 3. Shannon – Weaver communication model (adapted). (Lazdiņa et.al. 2010).
secondly, to create public awareness that burning may also have positive effects. Particular attention was paid to the fact that in Latvia the keyword burning has been cast in a negative light for decades - state institutions and agencies have launched a number of campaigns against the burning of last year’s grass with an aim to change public opinion and get rid of burning. The author believes that the aforementioned, overall public unawareness and lack of understanding served as a base for the negative response, which led to a communication crisis. And there is nothing one can do about it as we know that, for example, in Finland prescribed burning has been applied for almost one hundred years, but not environmental rhetoric in its essence, the media as a mass communication channel, has a large role in influencing society. Without any doubt it is the most powerful information distribution channel. The negative opinion in the mass media may be explained by fairly limited experience and a restricted approach to environmental communication, which has made us perceive it as media relations, public meetings, events, and publications, but not environmental rhetoric in its essence, the development of environmental thought, environmental risk communication, and nature representation. Unfortunately, environmental journalism in Latvia is a very small niche form of journalism, which is represented by only a few specialised journalists. This aspect is not helping raising public awareness on the respective matters as well. Overall, environmental and nature conservation matters take up only a tiny portion of the journalism and media world. The outcome is also shaped and affected by communication barriers as well as notions about the respective situation, process, or aspect (Lazdiņa et al. 2010).

**Literature**

Proposals for the establishment of NATURA 2000 sites for the conservation of Hermit beetle Osmoderma barnabita

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Summary
In accordance with the data of the report to the European Commission on the situation of habitat and species protection in Latvia for 2007 - 2012 (Article 17 report), the population size of the Hermit beetle Osmoderma barnabita protected both in Latvia and Europe is estimated at 350-1000 localities. Specially Protected Nature Territories (hereinafter - SPNT) with Natura 2000 site status contain 71 (41 %) of population, while 103 (59 %) of population are situated outside these sites. The objective of the work is to conduct a feasibility study regarding the development of new Natura 2000 sites for the protection of Osmoderma barnabita, in order to ensure that at least 60 % of Osmoderma barnabita localities in Latvia are situated in territories with the status of a Natura 2000 site. In order to assess how many of the known Osmoderma barnabita localities are located in the SPNTs, grouping of colonies with 300 m and 1000 m buffers around Osmoderma barnabita localities was performed. Among the existing SPNT, with Natura 2000 site status, localities of Osmoderma barnabita were detected in the direct vicinity of 15 SPNT, with Natura 2000 site status. Localities of Osmoderma barnabita were found at 22 SPNT, without Natura 2000 site status - nature monuments - dendrological plantations (6) and avenues (16). The granting of Natura 2000 status, amendments to the boundaries of the existing Natura 2000 sites or the development of new nature reserve territories must be performed in order to achieve the set objective of ensuring the protection of at least 60 % of the population of the species.

Key words: Natura 2000, Osmoderma barnabita, protection of species

1. Introduction
The last assessment of the population of Hermit beetle Osmoderma barnabita in Latvia was assessed in 2013, while preparing the report (Article 17 report) to the European Commission on the status of protection of habitats and species in Latvia for 2007-2012 (European Commission 2013) because it is a beetle species protected in Latvia (Cabinet of Ministers 2000) and the European Union (European Commission 2009). According to recent studies (Audisio et al. 2007, Audisio et al. 2008) the species Osmoderma eremita represented in Europe, based on molecular research, is divided into four species (Osmoderma eremita, O. barnabita, O.cristinae, O. lassallei) of which only Osmoderma barnabita is found in Latvia. During the preparation of the report, the data on the populations of Osmoderma barnabita, where the species was detected in 2001 - 2013, were used (Figure 1). According to the methodology of the report, the map of species distribution was developed. The gap distance used in the map of species distribution was reduced from 40 km (standard for invertebrates) to 10 km since the species has a very low dispersal capacity. Literature data indicate that Osmoderma barnabita is characterised by weak dispersal capacity; beetles do not normally fly farther than 200-300 m (Ranius et al. 2005), although some specimens could fly longer distances as well (Telnov 2005, Bāra et. al. 2015).

Population size in the Article 17 report is estimated at 350-1000 localities. The number of known trees with the presence of the species was used as the minimum pointer, while the number of trees inhabited by the species - expert assessment - as the maximum pointer (perhaps, a too low assessment). The size of the Figure 1. Localities of Osmoderma barnabita (2001-2012), the distribution and range in Latvia in accordance with the materials of the Article 17 report.
Latvian population was also assessed (10,000 - 30,000 individuals); based on literature data (for example, Tešnovs 2005) and expert opinion, one tree is inhabited by an average of 30 specimens at different stages of development. However, the population assessment of Latvia is rather approximate and it is affected by various factors:

- the quantity classes indicated in the guidelines have a large number interval;
- the registered locality is not in all cases a single tree, but rather part of a larger locality (park, avenue, wooded meadow);
- not all of the inhabited trees have been found/looked for and mapped in parks, avenues, and other tree groups.

The Article 17 report indicates the population size in Natura 2000 areas only by the amount of individuals; however, the population assessment of Osmoderma barnabita by the number of localities is not indicated in the report and originally submitted data on the number of localities has not been preserved as well. By using the dataset of localities (points) of the species used for the preparation of the report, and uniting the localities, which are situated at a distance of 300 m from each other, a total of 71 localities (41 %) are situated within Natura 2000 sites and 103 localities (59 %) are situated beyond Natura 2000 sites. The general principle that the conservation of the species can be ensured by conserving at least 60 % of the population of the species is widely used in nature conservation in Latvia and elsewhere in Europe, especially attributing it to European Union priority species, which also include Osmoderma barnabita (Cabinet of Ministers 2006). The objective of the work was to conduct a feasibility study regarding the development of new Natura 2000 sites for the protection of Osmoderma barnabita, in order to ensure that at least 60 % of Osmoderma barnabita localities in Latvia are situated in the territories with the status of Natura 2000 sites. The following work tasks were set in order to achieve the objective:

- to estimate how many of the known Osmoderma barnabita localities are located within the current SPNT of Latvia, which have not been assigned Natura 2000 status;
- to assess how many and which SPNT that already have the status of Natura 2000 site must be expanded to include the adjacent localities of Osmoderma barnabita, the size of the locality, its distance to the border of the SPNT and other localities of the species within the SPNT, as well as the possible association of the localities and the existing/potential habitats has been assessed.

The number of micro-reserves that are simultaneously Natura 2000 sites, need to be created for the purposes of reaching the objective of Osmoderma barnabita protection;

- to perform analysis on the colonies of Osmoderma barnabita located within the territory of SPNT, which are not Natura 2000 sites, by describing the current status of the localities of species found there.

2. Material and Methods

To assess how many of the known Osmoderma barnabita localities are situated within the SPNT, the records in the LINDA data base of the distribution of Latvian invertebrates, which was developed by Mārtiņš Kalniņš on 15 November 2014, regarding the known localities of Osmoderma barnabita (n=533), have been used. The data base summarises the following data:

- data published in the literature (e.g. Tešnov et al. 2005),
- data of the project “Search for New Localities of the Latvian Population of Osmoderma eremita, Creation of Locality Register and Design of Micro-reserves” funded by the Latvian Environmental Protection Fund (Tešnovs 2006),
- data of the project “Management of Fennoscandian Wooded Meadows and Two Priority Beetle Species: Planning, Public Participation, Innovation” (EREMITA MEADOWS) funded by LIFE+ Programme,
- data of the project “Forest Habitat Restoration within the Gauja National Park” (FOR-REST) funded by LIFE+ Programme,
- data registered in the Nature Observations Diary (Dabas dati 2014),
- other, unpublished data.

Among those, 10 records lack precise coordinates of the locality (no data on the precise or approximate location of the species, questionable accuracy of species identification etc.). These records have not been used for the analysis.

One record in the database refers to one finding on a particular date in a particular place, but, depending on the observer, the site was defined as a single tree, a group of trees, a park or an avenue and the coordinates have been read with varying accuracy - from one to tens of metres. One finding with the same (similar) coordinates can refer to observations made at different times (in such cases the colonies were grouped).

Since varying data on the dispersal capacity of the species exist, two buffers of different size were used for the merging of localities - 300 m and 1000 m buffer (Figure 2). To select SPNT, where the localities of Osmoderma barnabita are situated, a 300 m buffer has been used, the centre of which is included in the SPNT polygon (nature objects - protected trees have not been used in the selection of the data).

In order to assess how many and which SPNT that already have the status of Natura 2000 site must be expanded to include the adjacent localities of Osmoderma barnabita, the size of the locality, its distance to the border of the SPNT and other localities of the species within the SPNT, as well as the possible association of the localities and the existing/potential habitats has been assessed.

The number of micro-reserves that are simultaneously Natura 2000 sites to be created anew, has been determined based on the assumption that Natura 2000 site status shall be determined for those localities of Osmoderma barnabita, which are located within the SPNT, but do not have the status of a Natura 2000 site and/or the changes to the borders of Natura 2000 sites that are situated in the direct vicinity of Osmoderma barnabita localities shall be performed.

In order to perform the analysis of the Osmoderma barnabita localities, each of the selected territories has been initially reviewed in the office on the basis of the orthophoto map (Figure 2). Materials of the project “Search for New Localities of the Latvian Population of Osmoderma eremita, Creation of Locality Register and Design of Micro-reserves” funded by the Latvian Environmental Protection Fund (Tešnovs 2006) have been used as a significant source of information. All potential Natura 2000 sites have been surveyed on site in order to more accurately assess the potential limits of the territory (to ensure that the territory includes the habitats that are currently suitable for the species or will be suitable in the future, and to exclude areas that are not suitable for the conservation of the species or areas of minor significance) by accurately mapping the trees, where Osmoderma barnabita or Liocola lugubris (previous name used in the literature and standard data forms included the newest synonym of the species Liocola marmorata, which was also used to coin the Latvian name for the species) have been found. The survey was carried out taking the largest areas as a priority because it is considered that the minimum area for a sustainable population of Osmoderma barnabita, in terms of the number of trees and the area where the long-term existence of trees that are suitable for the species is possible, is 60 ha (Bāra et al. 2015, Lārmanis et al. 2014).
3. Results and Discussion

Upon the evaluation of the number of localities of Osmoderma barnabita within Natura 2000 sites, in view of the research activities carried out in recent years, it was concluded that the percentage of distribution has not changed significantly (Table 1). Given that the colonies of the species are recorded by using different methods (single tree, group of trees, park, avenue, etc.) and considering the significance of a sustainable habitat for the conservation of species (larger areas with trees suitable for the development of the species currently and in the future), the conservation of the species was evaluated based on the uniting of the localities by means of a 300 m buffer in polygons. Since no precise data on the size of the population of the species in each colony is available, it was assumed that the number of localities (points) and size of localities (polygons) can at least roughly be linked to the size of population.

Only 41 % of the currently known localities (polygons) are located within the territory of Natura 2000 sites. Consequently, the current protection of the colonies of the species cannot be regarded as sufficient, which is further reinforced by the factors that negatively affect the species and its habitat (habitat fragmentation, ageing, felling of old trees, etc.) in the localities of the species, including the territories of Natura 2000 sites (Teljnovs 2005, Teljnovs, Martsuz 2012).

In the Article 17 report the area suitable for the habitat of Osmoderma barnabita has been assessed as 105.6 km². Various data and assumptions have been used for the assessment. Latvia has ~700 parks and their average area is 0.2 km². 38 protected parks, the exact areas of which were known, have been deducted from the total number of parks. So far the Osmoderma barnabita has been found in ~ 40 parks, while, in accordance with the evaluation of the expert, suitable habitats are found in approximately 70% of the parks. So, the approximate area of habitats suitable for the species is ~ 85 km². Latvia has 60 protected avenues and the total area thereof is ~ 1 km². Only some of the avenues are suitable for the development of the species, however, there are suitable avenues, which have not been included in the list of protected avenues. Consequently, an area of 1 km² has been retained in the assessment. The area of protected dendrological plantations in Latvia is 16 km². Approximately 50% of the total areas of plantations are suitable for the species. The area of Wooded meadows is 11.6 km² (data from the Article 17 reporting questionnaire on habitat 6530* Wooded meadows and pastures).

Due to a lack of data, it was not possible to calculate the exact area of habitat suitable for the species among other habitats where the species has been found (oak forests, forests on slopes, screees and ravines, broad-leaved forests in river floodplains, cemeteries and individual large trees). Although the area of oak forests, forests on slopes, screees and ravines, forests, broadleafed forest and river floodplain habitats, as well as the cemetery areas can be calculated, they are not suitable habitats for Osmoderma barnabita habitats throughout their entire area (excessive shade for Osmoderma barnabita, lack of hollow trees, lack of suitable tree species, etc.).

Several solutions are possible while evaluating the possibilities to increase the number of Osmoderma barnabita localities in the territory of Natura 2000 sites, thus providing stronger protection and control of the localities:
- expansion of the existing Natura 2000 sites;
- granting Natura 2000 status to the existing SPNT, territories without Natura 2000 status;
- granting Natura 2000 status to the existing micro-reserves without Natura 2000 status or including such territories into the territory of Natura 2000 sites;
- creating new SPNT, or micro-reserves and granting Natura 2000 status.

Upon the application of any of the aforementioned solutions for the protection of particular localities of the species, the protection of the larger localities (assessed by the area of the habitat suitable for the species) should be prioritised. The mapped localities (inhabited trees) of Liocola lugubris have additionally been used for the assessment of habitat suitability, because this species also inhabits tree hollows (both species are frequently found in the same hollow) and can be used as an indicator of the presence of a habitat suitable for Osmoderma barnabita. Localities that, jointly with the localities incorporated in Natura 2000 sites or parts of such localities, form localities of a large area, are considered the second most important group.

Among the existing SPNT, with Natura 2000 sites, localities of Osmoderma barnabita detected in the direct vicinity of such territories have been found next to 15 SPNT, with Natura 2000 site status (Table 2, Figure 3):
- national parks - 1, the approximate area to be added is 7 ha
- protected landscape territories - 2, the approximate area to be added is 33 ha
- nature parks - 3, the approximate area to be added is 38 ha
- nature reserves - 9, the approximate area to be added is 940 ha

In certain areas re-evaluation of the existing boundaries of the territory would be necessary, in line with the objectives of the establishment and management of the territory. For example, on the basis of the river catchment areas, the territory of the Pедедže river basin should be separated from the nature reserve “Lubāna mitrājs” and a new nature reserve “Pедедže” should be created, containing a part of the current Lubāna Wetland, nature reserves “Mugurves plavas” (Mugurve Meadows), “Sitas un Pедедж益 calie” (Sita and Pедедže Floodplain), as well as the colonies of Osmoderma barnabita and other species and habitats that are currently beyond SPNT, territories. By creating a separate Pедедże river

### Table 1. The number of Osmoderma barnabita localities in especially protected nature reserves with and without Natura 2000 status and beyond them.

<table>
<thead>
<tr>
<th>Data: Article 17 (2013)</th>
<th>Quantity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total number of known colonies (points ) in Article 17</td>
<td>361</td>
<td>100</td>
</tr>
<tr>
<td>The number of known Natura 2000 colonies (points) in Article 17</td>
<td>224</td>
<td>62</td>
</tr>
<tr>
<td>The number of known colonies (points) beyond Natura 2000 in Article 17</td>
<td>137</td>
<td>38</td>
</tr>
<tr>
<td>The total number of colonies-polygons (merging points with a 300 m buffer)</td>
<td>174</td>
<td>100</td>
</tr>
<tr>
<td>The number of Natura 2000 colonies-polygons (merging points with a 300 m buffer)</td>
<td>71</td>
<td>41</td>
</tr>
<tr>
<td>The number of colonies-polygons (merging points with a 300 m buffer) beyond Natura 2000</td>
<td>103</td>
<td>59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data: LINDA 15 November 2014</th>
<th>Quantity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total number of known colonies (points ) in 2014</td>
<td>523</td>
<td>100</td>
</tr>
<tr>
<td>The number of known Natura 2000 colonies (points) in 2014</td>
<td>318</td>
<td>61</td>
</tr>
<tr>
<td>The number of known colonies (points) beyond Natura 2000 in 2014</td>
<td>205</td>
<td>39</td>
</tr>
<tr>
<td>The total number of colonies-polygons (merging points with a 300 m buffer)</td>
<td>215</td>
<td>100</td>
</tr>
<tr>
<td>The number of Natura 2000 colonies-polygons (merging points with a 300 m buffer)</td>
<td>89</td>
<td>41</td>
</tr>
<tr>
<td>The number of colonies-polygons (merging points with a 300 m buffer) beyond Natura 2000</td>
<td>126</td>
<td>59</td>
</tr>
<tr>
<td>The total number of colonies-polygons (merging points with a 1000 m buffer)</td>
<td>162</td>
<td>100</td>
</tr>
<tr>
<td>The number of Natura 2000 colonies-polygons (merging points with a 1000 m buffer)</td>
<td>53</td>
<td>33</td>
</tr>
<tr>
<td>The number of colonies-polygons (merging points with a 1000 m buffer) beyond Natura 2000</td>
<td>109</td>
<td>67</td>
</tr>
</tbody>
</table>

### Table 2. SPNT inhabited by Osmoderma barnabita, where a part of the Osmoderma barnabita locality is situated outside the boundary of the SPNT and territories without Natura 2000 status (LEGEND: AAA-protected landscape area; DL- nature reserve; DP-nature park)

<table>
<thead>
<tr>
<th>Title of the territory, category</th>
<th>Natura 2000 status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augšdaugava, AAA</td>
<td>YES</td>
<td>the approximate area to be added is 12 ha</td>
</tr>
<tr>
<td>Ance swamps and forests, DL</td>
<td>YES</td>
<td>the approximate area to be added is 640 ha</td>
</tr>
<tr>
<td>Bauska, DP</td>
<td>YES</td>
<td>the approximate area to be added is 19 ha (alternatives - 6 or 106 ha)</td>
</tr>
<tr>
<td>Meadows of Lake Burtnieku, DL</td>
<td>YES</td>
<td>the approximate area to be added is 29 ha</td>
</tr>
<tr>
<td>Eglone, DL.</td>
<td>YES</td>
<td>the approximate area to be added is 116 ha</td>
</tr>
<tr>
<td>Guaja National Park</td>
<td>YES</td>
<td>the approximate area to be added is 7 ha</td>
</tr>
<tr>
<td>Mežmuiža Springs, DL</td>
<td>YES</td>
<td>the approximate area to be added is 0.5 ha</td>
</tr>
<tr>
<td>Ogre Valley, DP</td>
<td>YES</td>
<td>the approximate area to be added is 15 – 16 ha, however, the adding of the entire area is not rational, because some localities consist of a standalone tree</td>
</tr>
<tr>
<td>Flood plains of the Sita and Pедедże rivers, DL</td>
<td>YES</td>
<td>the approximate area to be added is 5 ha</td>
</tr>
<tr>
<td>Mugurve grasslands, DL.</td>
<td>YES</td>
<td>the approximate area to be added is 12 ha</td>
</tr>
<tr>
<td>Lubāna wetland, DL</td>
<td>YES</td>
<td>the approximate area to be added is 2 ha</td>
</tr>
<tr>
<td>Pilsalnes Siguldina, DL</td>
<td>YES</td>
<td>the approximate area to be added is 6 ha</td>
</tr>
<tr>
<td>Ukri broad-leaf forest, DL</td>
<td>YES</td>
<td>the approximate area to be added is 30 ha, the addition of only some parts of the area is rational, because a protection mode that considerably differs from the nature reserve is required in the remaining territory</td>
</tr>
<tr>
<td>Vīlce, DP</td>
<td>YES</td>
<td>the approximate area to be added is 5 ha</td>
</tr>
<tr>
<td>Ziemelgauja, AAA</td>
<td>YES</td>
<td>the approximate area to be added is 11 ha</td>
</tr>
</tbody>
</table>
Table 2. Sequel

<table>
<thead>
<tr>
<th>Teritorijas nosaukums, kategorija</th>
<th>Natura 2000 status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature monuments - dendrological plantations</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Cēs parks</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Indrāni Park</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Kalēti Park</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Ķeipene Park</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Pammīta Park</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Zīlās Park</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Dabas pieminekļi – aizsargājamās alejas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bēne Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Bukašī Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Citava Linden Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Dīķļ Manor Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Dundaga Linden Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Dzelzava Manor Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Iecava Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Ieriķu Manor Avenue</td>
<td>YES (partially)</td>
<td></td>
</tr>
<tr>
<td>Jaunmērpa Manor Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Kalēti Linden Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Krastīņi Nursing Home Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Lielpļave Manor Linden Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Pope Manor Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Vecauce Avenue</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Vērene Manor Avenue</td>
<td>YES (partially)</td>
<td></td>
</tr>
<tr>
<td>Zūras Manor Avenue</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

basin SPNT, functionally similar territories would be united, which would contribute to their protection and management.

Localities of Osmoderma barnabita were found at 22 SPNT, without Natura 2000 site status - nature monuments (Figures 3, 3.a) - dendrological plantations (6) and avenues (16), but they are relatively small territories sized 1 to 7 ha. Due to the small area of these territories, they are not to be regarded as long-term and stable habitats of Osmoderma barnabita.

Among the existing SPNT, with Natura 2000 site status, localities of Osmoderma barnabita detected in the direct vicinity of such territories have been found next to 15 SPNT, with Natura 2000 site status (Table 2, Figure 3):

- national parks - 1, the approximate area to be added is 7 ha
- protected landscape territories - 2, the approximate area to be added is 33 ha
- nature parks - 3, the approximate area to be added is 38 ha
- nature reserves - 9, the approximate area to be added is 940 ha

In certain areas re-evaluation of the existing boundaries of the territory would be necessary, in line with the objectives of the establishment and management of the territory. For example, on the basis of the river catchment areas, the territory of the Pededze river basin should be separated from the nature reserve “Lūbānas mirājs” (Lūbānas Wetland) and a new nature reserve “Pededze” should be created, containing a part of the current Lūbānas Wetland, nature reserves “Mugurves plāvs” (Mugurve Meadows), “Sītas un Pededzes paliene” (Sīta and Pededze Floodplain), as well as the colonies of Osmoderma barnabita and other species and habitats that are currently beyond SPNT, territories. By creating a separate Pededze river basin SPNT, functionally similar territories would be united, which would contribute to their protection and management.

Localities of Osmoderma barnabita were found at 22 SPNT, without Natura 2000 site status - nature monuments (Figures 3, 3.a) - dendrological plantations (6) and avenues (16), but they are relatively small territories sized 1 to 7 ha. Due to the small area of these territories, they are not to be regarded as long-term and stable habitats of Osmoderma barnabita.

However, the development of these territories is based on other reasons that are not associated with the protection of Osmoderma barnabita, therefore trees inhabited by Osmoderma barnabita or potentially suitable trees are present outside the borders of the SPNT. To ensure the protection of Osmoderma barnabita on the local and regional level, the boundaries and protection mode must be revised by evaluating dendrological value and the requirements for the protection of Osmoderma barnabita.

So far eight micro-reserves for the protection of Osmoderma barnabita have been developed and two more micro-reserves have been developed for...
the protection of habitats - broadleaf forest habitat and the habitat of primary forest in river meanders, but Osmoderma barnabita has been indicated as the species that is present in these micro-reserves. In accordance with the performed calculations on the number of micro-reserves in Gauja National Park, for the long-term existence of trees required for the maintenance of a sustainable population of Osmoderma barnabita, it was assumed that the minimum area is 60 ha (Bīza et al. 2015, Lārmanis et al. 2014). The current regulations on the development and protection of micro-reserves (Cabinet of Ministers 2012) provide that the maximum area of micro-reserve for the protection of Osmoderma barnabita may be 30 ha. Consequently, the solution of micro-reserve development for the protection of the species can be recommended only in certain cases, for instance, if:

• a part of the locality of the species is located in an avenue (Ieriķi Manor Avenue, Vaidavmuža Avenue) outside of an SPNT - Gauja National Park, but the changes to the boundaries of Gauja National Park due to the inclusion of two small objects are not rational and can take a long time (2-5 years);

• a locality, where the existence of the species can be ensured at least in the medium term (20-50 years), exists, but no potential habitats suitable for the species at least in the medium term are present in its vicinity.

In order to achieve the set objective, i.e. - ensuring the protection of at least 60 % of the population of the species, the granting of Natura 2000 status, the amendments to the boundaries of the existing Natura 2000 sites or the development of new sites must be made at approximately 40-50 places. One of the possible solutions is the development of a micro-reserve. If Natura 2000 status is assigned to all SPNT areas without Natura 2000 status, where the localities of Osmoderma barnabita have been detected and the boundaries of these territories, as well as the current Natura 2000 sites, in the direct vicinity of which the localities of Osmoderma barnabita are found are adjusted, the total number of localities - polygons (uniting points with a 300 metre buffer) within Natura 2000 sites will be equal to 125 localities or 58% of the localities. Consequently, in order to reach the objective 10 to 20 micro-reserves will have to be established (reaching the criteria of protecting 63-67% of the localities). If new localities are found either within the existing Natura 2000 sites or beyond them, the number of territories to be established may vary.

Upon the assessment of the condition of Osmoderma barnabita localities that are located in the SPNT, which are not Natura 2000 sites, the localities can be divided into two groups according to their condition. The first group consists of the localities in dendrological plantations (Figure 4). The area of dendrological plantations inhabited by Osmoderma barnabita is 4-7 ha. The potential number of trees suitable for the species is greatly variable - from 30 to 300 trees. However, the current boundaries of dendrological plantations do not coincide with the territory of the potential habitat sites of Osmoderma barnabita, the area of which at the surveyed objects is 7-89 ha.

The second group consists of localities in protected avenues (Figure 5). The area of avenues inhabited by Osmoderma barnabita is 0.7-6 ha. The potential number of trees suitable for the species is greatly variable - from 42 to 725 trees. The current boundaries of protected avenues also do not coincide with the territory of the potential habitat sites of Osmoderma barnabita, the area of which at the surveyed objects is 7-20 ha. The quality of the habitat of the species in both groups of localities can be assessed as average. Although the number of old and hollow trees in these territories is relatively high for trees of various age classes, felling and removal of hollow trees has been detected in all localities. Overgrowth of the territory has been detected in some locality habitats. The relations of the colonies with other localities of the species and habitats varies - from isolated localities occupying island-like territory in agricultural landscapes to administratively separated parts of locality/habitat, for instance, Ieriķi Manor Avenue, Vaidavmuža Avenue, Vērēne Avenue, etc.

A considerable improvement in the protection status of the species can be achieved, if the proposed changes regarding the protective territories of Osmoderma barnabita are implemented and the measures for the management of habitats are carried out.

Table 3. Territories proposed for the protection of Osmoderma barnabita in 2014-2015.

1. Bukuši Manor park and avenues. The boundaries of current protected avenues must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 13 ha.
2. Dikļi Manor park and avenues. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 21 ha.
3. Dundaga. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 16 ha.
4. Eglone, DL. To expand the existing nature reserve. The proposed area of the territory to be added is 116 ha.
5. Iecava. New dendrological plantation has to be made. The proposed area of the territory is 27 ha.
6. Ieriķi Manor Avenue The boundaries of the existing protected avenue must be specified.
7. Indrāni (Hincenberga) Manor park and avenue. The boundary of the existing dendrological plantation must be specified. The proposed area of the territory is 8 ha.
8. Kalēti. The boundary of the existing dendrological plantation and avenue must be specified. The proposed area of the territory is 89 ha.
9. Kazdanga Manor Park. New dendrological plantation has to be made. The proposed area of the territory is 40 ha.
10. Dikļi Manor park and avenue. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 19 ha.
11. Lonestā. A new nature reserve must be established. The proposed area of the territory is 119 ha.
12. Mazmežotne (Bauska, DP). To expand the existing nature park. The proposed area of the territory is 19 ha.
13. Pamūļa Manor Park. The boundary of the existing dendrological plantation must be specified.
14. Pope Manor park and avenues. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 23 ha.
15. Ukri broad-leaf forest, DL. To expand the existing nature reserve. The proposed area of the territory is up to 20 ha.
16. Vērēne Avenue (Ogre Valley, DP). The existing nature park must be expanded or the boundary of the protected avenue of Vērēne Manor must be specified. The proposed area of the territory is 8 ha.
17. Zlēkas Park. The boundary of the existing dendrological plantation must be specified. The proposed area of the territory is 9 ha.
18. Dikļi Manor park and avenue. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 7 ha.
19. Vecauce Castle Park. The boundaries of the current protected avenue must be specified and a new dendrological plantation has to be made. The proposed area of the territory is 10 ha.
20. Ance swamps and forests, DL. To expand the existing nature reserve. The approximate area to be added is up to 640 ha. A separate assessment has been drawn up regarding this territory (Vilks 2014).
Current management practices for specially protected habitats and species in Latvia: Forests

Literature


Practical Aspects in the Relocation of Hermit beetle

Osmoderma barnabita Micro-populations

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e-mail: martins.kalnins@biology.lv

Summary

Hermit beetle Osmoderma barnabita is a species of beetle protected in Latvia and Europe. A considerable portion of Latvia’s population inhabits parks, avenues and other plantations of residential areas, where the hollow trees are felled and removed more and more frequently. The objective of the article is to publish the experience of the research on dead trees inhabited by Osmoderma barnabita accumulated to date, methodological aspects of population relocation, as well as to provide recommendations for further research and micropopulation relocation work. The research of the trunks of broken or felled trees by dividing them into shorter spans, sieving the rotten wood, describing the structure of the hollows and counting the detected specimens of Osmoderma barnabita, was used as the main research method.

Varying quantities of dead wood and numbers of Osmoderma barnabita (1 - 83 specimens) and Liocola lugubris (6 - 55 specimens) have been detected in the five examined trees. In two cases it was detected that in the time period from the felling of the tree until examination (20 - 40 days) the number of larvae present in the wood was reduced. The hypothesis was proposed that the internal surface area of the hollow of the tree is a significant factor that determines the number of Osmoderma barnabita specimens in the hollow.

Key words: Osmoderma barnabita, protection of species, artificial habitats, population relocation

1. Introduction

The last assessment of the population of Osmoderma barnabita in Latvia was assessed in 2013, while preparing the report (Article 17 report) to the European Commission on the status of protection of habitats and species in Latvia for 2007-2012 (European Commission 2013) because it is a beetle species protected in Latvia (Cabinet of Ministers 2000) and the European Union (European Commission 2009). According to recent studies (Audisio et al. 2007, Audisio et al. 2008) the Hermit beetle Osmoderma eremita represented in Europe, based on molecular research, is divided into four species (Osmoderma eremita, O. barnabita, O. cristinae, O. lassallei) of which only Osmoderma barnabita is found in Latvia. Population size was estimated at 350-1000 localities or 10000-30000 specimens. The size of population was assessed, based on literature data (for example, Teļnovs 2005) and expert opinion (Teļnovs D., personal communication) - one tree is inhabited by an average of 30 specimens at different phases of development.

A large portion of the Latvian population of Osmoderma barnabita inhabits parks, avenues, dendrological plantations, as well as other plantations in residential areas. The larvae develop in cavities of the trees for three years. Only around 15 % of the adult beetles leave the cavities to search for new habitats. Adult beetles usually do not fly for longer distances than 300 metres, and less frequently 1000 metres (Ranius et al. 2005, Bāra et al. 2015).

The felling and removal of hollow trees is performed with increasing frequency at plantations, including the habitats of Osmoderma barnabita and another protected species of the beetle Liocola lugubris (previous title used in the literature included the newest synonym of the species name Liocola marmorata, which was also used to coin the Latvian title of the species). Such cases have been registered at parks or avenues, for instance in Bēne, Bīriņi, Čere, Dīļi, Dundaga, Mežotne, Rabene, Stende, Stradi and elsewhere. All of the cases listed above have been detected while examining territories that are significant for the conservation of Osmoderma barnabita (Kalniņš 2014), however, there are other cases in addition to these.

Studies have been conducted in Europe on the structure of tree cavities inhabited by Osmoderma barnabita (such as Ranius, Nilsson, 1997), but in Latvia such studies have not been carried out (only information based on the observations of individual researchers is available). There is also no experience in Latvia on the best action in the cases where a broken or felled tree inhabited by Osmoderma barnabita is found, or where the tree must be felled for the reasons of safety of people or property.
The size of population plays a significant role in the protection of rare and endangered species - the larger the population is, the greater the opportunity to preserve the species is. Since many animal species, including Osmoderma barnabita have not been extensively researched, the conservation measures frequently assume the function of experiments as well and may prove to be either successful or unsuccessful. If the animal population is large, the cases of failed experiments would affect the population and its chances of survival to a lesser degree than in the event of small populations. Therefore it is important to obtain knowledge about the species and its protective capabilities while its population is relatively large and the risk of affecting the population of the species negatively by means of the taken action is relatively low.

Based on the aforementioned, the knowledge and experience on the size of micro-populations of Osmoderma barnabita, structure of the tree cavities and the possibilities of micro-population relocation is becoming increasingly topical. The objective of the article is to publish the experience of the research on dead trees inhabited by Osmoderma barnabita accumulated to date, methodological aspects of population relocation, as well as to provide recommendations for further research and micropopulation relocation work.

2. Material and Methods

The factor that unifies research subjects is the random character of selection, namely, felled or broken trees, or parts thereof have been detected where their division or removal for the purposes of cleaning up the territory has already been commenced or planned. Consequently, the time allocated for the planning of the research and work performance was very limited. To make the research as meaningful as possible and the obtaining of scientific and practical information as successful as possible, a written plan of research work was drawn up before the commencement of the works for three research objects (Mežotne mound, Sigulda and Pauži), which was consequently implemented, with the performed works respectively recorded. The work plan included:

1. Definition of the objective of the work (obtaining and counting the specimens of Osmoderma barnabita, development of a new micro-population; obtaining of the material for the creation of the new - partially natural tree cavity; obtaining of practical experience of work planning, organisation and implementation);
2. Receipt of approvals from land owners or legal managers (municipalities, private owners);
3. Obtaining of the permit from the Nature Conservation Agency for the obtaining of specimens of non-hunted species;
4. List of equipment required for work performance;
5. Preparation of the action plan:
   5.1. recording of the time of work commencement;
   5.2. briefing of the involved parties on the objectives of the work and safety measures;
   5.3. fixation of the initial situation, including the undivided tree (photographing, measuring tree size, labelling of size in metres and growth direction);
   5.4. cutting pieces of the appropriate length according to purpose and labelling;
   5.5. collection and packing of dead wood by metre/cavity or other measurement unit and a provisional counting of specimens;
   5.6. measurements of trunk cross-section and longitudinal section areas and photography;
   5.7. cleaning up the workplace.
6. Analysis of the obtained data, including the assessments of work quality and required improvements.

Examination of the trunks of broken or previously felled trees by dividing them into shorter segments and sieving the dead wood, was the main method of research used. The length of the tree trunk was measured (the distance from the base of the trunk), followed by measurements of non-decayed wood thickness, the internal structure of the cavity was described (smooth walls, cracks, etc.), the volume of the dead wood waste collected in the cavity, its colour and humidity (dry, humid, wet), the presence or absence of bird nests, honeybee Apis mellifera nests or wasp Vespidae nests was recorded. During the sieving of the dead wood all detected specimens of Osmoderma barnabita were counted and divided by the phase of development and larva size, as well as other rare and protected species of invertebrates were registered. All obtained data were registered in a questionnaire designed especially for these purposes. The work was carried out at five objects:

1. Raiskums. Sections from the base of two trunks of Tilia cordata Linden tree – 3.5 m long were cut off (Figure 1, 2). The tree was felled in the autumn-winter season of 2002. The examination was carried out on 15 May 2003 by scraping off the reachable dead wood (without cutting) and sieving it under field conditions. The parts of the tree trunk have been transported from the felling site to another storage location.
2. Mežotne mound. Examination of a 10 m long section of a broken ash tree Fraxinus excelsior (Figure 3, 4). The tree was broken in the autumn-winter season of 2014. The examination was performed in January 2015 by cutting the tree into 1 m and 2 m long sections at the site where the tree had been growing. The sieving of the collected dead wood was performed under laboratory conditions.
3. Dikļi. Collection of the dead wood that was spilled at the site of felling of a *Tilia cordata* Linden tree and the examination of a 2 m long section of the trunk base (Figures 5, 6). The probable size of the cavity - from the base of the trunk to a height of up to ~ 6 m. The tree was felled and the examination was performed in December 2014. The sieving of the collected dead wood was performed under laboratory conditions.

4. Sigulda. Examination of a 9 m long trunk of a felled ash tree *Fraxinus excelsior* (Figures 7, 8). The tree was felled on 17 April 2015, when the initial examination was performed (without cutting) at the site of growing, where the tree was already partially cut into sections. Afterwards the tree (unsawn parts thereof) was transported to another location, where on 8 May 2015 the examination was performed, by cutting the tree into 1 m to 2 m long sections. The sieving of the collected dead wood was performed partially under field conditions and partially under laboratory conditions.

Figure 5. Linden tree with the hollow (left side of the figure) before felling in Dikļi

Figure 6. Fragments of the felled Linden tree at the moment of examination (detection) in Dikļi

Figure 7. Sections of the trunk of the felled ash at the moment of examination (detection) in Sigulda

Figure 8. Longitudinal cross-section of the trunk of the ash at 4 - 6 metres from the base of the trunk with light, dry dead wood that is poorly suited for *Osmoderma barnabita* (Sigulda)

5. Pauži. Examination of the trunk of a felled ash tree *Fraxinus excelsior* (Figures 9, 10). The tree was felled in February 2015, the examination was carried out in April at the site of growing, by cutting the tree into 1 m to 3 m long sections. The sieving of the collected dead wood was performed under laboratory conditions.

The material for genetic studies has been collected from the larvae collected in Dikļi and the beetles collected at Mežotne mound (dead wood with larvae, fragments of the tree trunk) was transported in January and was partially frozen, but the material collected in Sigulda and Pauži was transported in April and was not frozen. The creation of partially natural tree cavities (installation thereof) was conducted in March, April and May. The fragments of the felled tree trunks were installed vertically, fastened with metal plates and screws, the trunks were topped with roofs made of wooden planks, and holes were made in the trunks from the sides, imitating cavity openings. The larvae were placed into tree cavities in May when the average daily temperature was above +10°C, in order to enable the larvae to find the optimum location for their development after placing them into the tree trunks.

Figure 9. Broken ash tree before dividing for research in Pauži

Figure 10. Longitudinal cross-section of the trunk of the ash at 1-3 metres from the base of the trunk with smooth internal cavity inside the bottom of the trunk (Pauži)
Table 1. The parameters of wood structure found at the research objects and the number of specimens of Osmoderma barnabita and Liocola lugubris

<table>
<thead>
<tr>
<th>Site</th>
<th>Measurements</th>
<th>Mežotnes mound (base)</th>
<th>Mežotnes mound (middle)</th>
<th>Dikļi*</th>
<th>Sigulda</th>
<th>Pauži</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of dead wood (litri)</td>
<td>&gt;100</td>
<td>60</td>
<td>30</td>
<td>&gt;100</td>
<td>&gt;50 &lt;100</td>
<td>60</td>
</tr>
<tr>
<td>Osmoderma (larvae)</td>
<td>&gt;28</td>
<td>7</td>
<td>24</td>
<td>83</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Osmoderma (cocoons)</td>
<td>&gt;15</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Liocola (larvae)</td>
<td>? (yes)</td>
<td>31</td>
<td>10</td>
<td>54</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Liocola (cocoons)</td>
<td>? (yes)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

(* only part of the tree was available for research)

3. Results and Discussion

Varying quantities of dead wood, numbers of Osmoderma barnabita and Liocola lugubris have been detected in the examined trees (Table 1).

Since the number of objects researched was small and they differed both in terms of tree species, geographical location and the volume of the trunks of the examined trees, no statistically reliable conclusions can be made currently. However, the cavities of the ash found at Mežotne mound show that there may be situations where a larger quantity of dead wood does not serve as a reliable indicator of higher numbers of larvae in the cavity.

Studies elsewhere in Europe attempted to link the number of larvae with the quantity of dead wood, colour, degree of rotting and humidity (for instance Ranius, Nilsson, 1997). This study, as well as other observations made in Latvia found that the larvae do not occur in cavities or parts of cavities that are dry (dusty) and contain visually whitish-grey dead wood.

Figure 11. Tree cavity with an inner surface that is rich in holes and cracks (increased surface area)

Figure 12. Tree cavity with relatively smooth inner surface (decreased surface area)

Figure 13.

Figure 14.

The cavities were found in the ash at Mežotne mound - one at the base of the tree (0-1 m from the ground), the other in the middle of the trunk (at a height of 8-10 m). The cavity in the middle of the trunk contained the remains of nests of common starling Sturnus vulgaris and common merganser Mergus merganser. The remains of the nests of honey bees Apis mellifera and hornets Vespa crabro were also found there. Studies elsewhere in Europe indicated that birds’ nests positively affect the humidity conditions of the tree cavities inhabited by Osmoderma barnabita (Ranius, Nilsson, 1997). However, it is not currently known whether the presence of birds is a factor that causes a hazard to adult beetles, because, for instance, of Osmoderma barnabita are concentrated in the layer of the wood that is dead, but has not yet decomposed, frequently in fissures and niches. Perhaps the area (and thickness?) of the dead, but not decomposed wood of the tree cavity, which differs in cavities with fissures (Figure 11) and cavities with a relatively smooth inner surface (Figure 12), is one of the factors that affects the number of larvae.

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additional materials are required for the development of the cavity, the adaptation and fastening of which requires additional resources (Figure 15).

By placing the partially natural cavities at the planned site, they should be fastened to the growing trees, buildings or poles made of metal or durable wood that are driven into the ground in order to secure the trunks against falling on people or animals. If the cavity is made from a longitudinally cut section of the tree, it must be fastened with metal plates and screws, which provides the opportunity to easily open and repeatedly inspect it. The gap between sawn parts can be filled with PU foam used for construction. If the section of the tree does not have natural openings into the cavity, it requires additional resources (Figure 15).

In addition to the acquired knowledge about the movement of Osmoderma barnabita and the creation of partially natural cavities, further research of several aspects is required. To date it has been recommended to leave the broken trees on the ground to enable the larvae to fly away in search of new habitats. However, it is not clear how the development of larvae is affected by the changes in the microclimate and the cavity by potential predators that is created when the trunk is on the ground. It is not clear how successfully the development of larvae in partially natural cavities proceeds and how it is affected by the development of ant hills in the trunks. It is also necessary to find out the possible link between the internal surface of the cavity with the number of specimens inhabiting the cavity.

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Figure 15. A partially natural tree cavity from a partially broken tree trunk (M - parts of the tree cavity made of a different material with the purpose of creating the cavity space

Figure 16. Methods of fastening a partially natural tree cavity: 1 - a plate of metal that holds together two longitudinally sawn parts of the trunk; 2 - one of the three tree trunk fastenings to the post that is driven into the ground; 3 - openings in the cavity by the entry and exit of beetles and for humidity control; 4 - filling of the hole with PU foam

Figure 94 95
Areas with Forestry Restrictions in Latvian Forests in 2014

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Summary

By using data from the State Forest Register (SFR), this article summarises and explains statistical information about the amount of protected Latvian forests in various degrees from the current standpoint of nature conservation processes. The data have been collected to the 31 December 2014. According to the data from the Forest Resource Monitoring (hereinafter - FRM), which have been collected by using a sample plot network, the total area of Latvian forests is 3260.8 thousand hectares or 50.5% of the total land area. Complete forest inventory has been carried out in most of the area - 3056.6 thousand ha or 93.7% - by describing each individual forest stand and accumulating the data in the SFR. Along with the data describing forest stands, this database also includes information on economic activity as well as the forestry restrictions imposed on the forests, which is the main subject of this article. Taking into account how the data is gathered and stored in respect to the SFR and FRM, this article has used the data of the SFR as a basis for gathering information about various protected areas and forests protected to different degrees.

According to the data of the SFR (as of 31 December 2014), 2193.8 thousand ha or 71.8% of the forest area (34% of the inland area) are commercial forests which are subjected to the legal regulations governing general forest management and its application. However, 862.8 thousand ha or 28.2% of the total forest area (13.4% of the inland area) are composed of various protected territories, which are subjected to special management conditions. Most of the territories subjected to the special conditions are national level specially protected nature areas (hereinafter - SPNA), including, the North Vidzeme Biosphere Reserve, protection zones for environmental and natural resources, and micro-reserves. It should be pointed out that the conditions in respect to forest management in these protected areas are very different: from the prohibition of forestry in the strict and regulated nature reserves or micro-reserves to open wood extraction in the North Vidzeme Biosphere Reserve or other neutral zones of the SPNAs.

Depending on the permissible forestry activity or restriction degree in respect to the conditions of final felling, the SFR data in this article are divided into 6 groups by producing the following results which characterise the overall economic activity restrictions in forests: 1) forestry prohibited - 3.3% of the forests (1.6% of the inland area); 2) prohibited thinning from a certain age of the trees and final felling - 2.3% of the forests (1.1% of the inland area); 3) final felling prohibited - 1.2% of the forests (0.6% of the inland area); 4) clear felling prohibited – 6.9% of the forests (3.3% of the inland area); 5) none of the aforementioned prohibitions, but the territory is located in any of the protected areas - 14.5% of the forests (6.9% of the inland area); 6) commercial forests outside of the protected areas - 71.8% of the forests (34% of the inland area). The same data grouped by the permissible applications of the forest provides the following overview: In 93.2% of the forests there are no restrictions in respect to forest management with an aim to extract wood; in 3.5% of the forests some certain thinning work is allowed until the trees have reached a age, which is followed by a wood extraction prohibition; in 3.3% of the forests any kind of wood extraction is prohibited for the purpose of nature conservation, except for those carried out as a part of specific species or habitat protection measures or within the framework of other specific activities.

Keywords: Protected areas, Forest Resource Monitoring, State Forest Register, forestry restrictions, forest, Latvia
1. Introduction

When making decisions or having public discussions in respect to nature conservation, it is important to use as accurate as possible statistical information on the forest management restrictions imposed in the country. When it comes to forests and especially public discussions on this topic, it often includes exaggerated and rather incorrect data, in this way restricting the possibilities of having a constructive discussion and making unbiased decisions. Since 2001, the State Forest Service published detailed annual reports and summarized data, in the form of the SFR data on its website (the State Forest Service 2015). By using data from the SFR, this article summarises and explains statistical information about the area of protected Latvian forests to various degrees from the current standpoint of the nature conservation process as of 31 December 2014.

2. Material and Methods

2.1. Structure of the Forest Information System in Latvia

The condition of Latvian forests is studied within the framework of two state-organised processes - Forest Resource Monitoring and forest inventory. The FRM gathers information using a systematically developed sample point network. This data is then extrapolated and referred to the whole of Latvia (Silava 2014). The FRM data is used to describe the overall condition of forests in the country. The work was carried out by the Latvian State Forest Research Institute Silava in accordance with Cabinet Regulation No. 238 National Forest Monitoring Regulations of 3 April 2012. The SFR in turn covers 93.7% of the forest area which is included in the FRM (Silava 2014).

According to Section 1, Paragraph 34 of the Forest Law, a forest is defined as an ecosystem in all of its developmental stages where the main producers of organic mass are trees, which in the respective location may reach at least 5 m in height and have or potentially may have a crown projection area of at least 20 percent of the total area of the forest stands. According to Annex 1 to Regulation No. 88 Regulations on Information Circulation of the Forest Inventory and State Forest Register of 2 February 2013 (hereinafter - Cab.Reg. No. 88), the SFR shall keep records of forest stands, destroyed forest stands, clearings, and seed production plantations.

The SFR is a national information system which gathers and maintains information about forests and forestry activities carried out therein, adjacent swamps, forest infrastructure objects as well as clearings, swamps, and glades within the forests. The SFR is maintained by the State Forest Service (hereinafter - the SFS) and the procedure for its maintenance is laid down in Cab. Reg. No. 88. The SFR was launched on 1 January 2002 when the SFS took over a number of databases, the most significant of which for the SFS functions and industry planning was the Forest Fund database (SFS 2001). The SFR includes information about forest areas which have undergone the forest inventory. Section 29, Paragraph one of the Forest Law has imposed an obligation on the forest owners or legal possessors to carry out the forest inventory at least once every 20 years.

2.2. Types of Specially Protected Forests

The SFR also maintains information on various protected areas - specially protected nature areas, micro-reserves, and protected zones of environmental and natural resources, genetic resource forests, scientific objects etc. These are territories, the protection of which is imposed by law, Cabinet Regulations, or administrative provisions. Objectives for the designation of such protected areas may be different - species and habitats conservation, conservation of genetic diversity, water resource conservation, etc.

One of the most significant types of protected areas are the SPNAs, which are under special national protection restrictions. This is territory - rare and typical natural ecosystems, habitats of protected species, peculiar and beautiful landscapes typical to Latvia, dendrological plantations and secular trees as well as areas important to the recreation, education, and research purposes (Nature Conservation Agency (NCA) 2015). According to Section 38 of the Forest Law, SPNAs are a part of the National Forests which are created to conserve and protect the rare and typical natural ecosystems, habitats of protected species, peculiar and beautiful landscapes typical to Latvia, dendrological plantations and secular trees as well as areas important to the recreation, education, and research purposes.

Objectives for the designation of such protected areas may be different - species and habitats conservation, conservation of genetic diversity, water resource conservation, etc.

Information on the restricted areas in this article is gathered and analysed based on the textual part of the SFR without directly using the graphical data of protected areas. Some certain restrictions in respect to the conditions to be met for final felling described above are registered in the SFR as restrictions in the protected areas. The analysis does not separately highlight the areas which are subject to specific sanitary felling restrictions, when the felling is carried out in respect to trees harmed by diseases, pests, animals, wind, or any other phenomena. The legal definition of the different types of protected areas is very different and this kind of information is not specifically accumulated by the SFR as it does not directly affect the determination of the land’s cadastral value or extent of compensation for

2.3. Degrees of Restrictions on Forestry Activities

Various restrictions are imposed in respect to the protected areas - from the complete prohibition of forestry activities throughout the whole calendar year to felling prohibitions for specific months of the year or specific felling conditions. The large amount of forestry restrictions makes their systematisation and registration in information systems very difficult. This article divides the data of forestry restrictions into 6 groups:

- Prohibition of felling from a certain age of the trees and final felling, meaning, both prohibition of forest felling when the age or diameter of final felling laid down in the Forest Law has been reached and prohibition of forest felling, most often by trees reaching a certain age, for example, in nature reserves.
- Felling prohibition consisting of prohibition of felling when the age or diameter of final felling laid down in the Forest Law has been reached.
- Clear felling prohibition, meaning that the forest stand may be felled gradually over a period of several years when it has reached the final felling age or diameter.
- None of the aforementioned restrictions is present, even though the forest lies within a protected area. These areas are often subjected to seasonal forestry restrictions, reconstructive felling (type of felling for nonproductive forest stands) restrictions, or final felling restrictions in respect to the diameter.
- None of the aforementioned final felling restrictions are present and the area is subject to the general legal regulations governing forest management and use.

Areas with Forestry Restrictions in Latvian Forests in 2014

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the restrictions on forestry activities. Sanitary felling in various protected areas is carried out based on the respective situation in the forest after some certain natural disturbances and the respective legal framework regulating this protected area.

The SFR is currently the most accurate data source for ascertaining the extent of areas subject to forestry restrictions.

3. Results
The SFR data from 2014 shows that forest inventory has been carried out in 3056.6 thousand ha of forests registered in Latvia which composed 47.3% of the inland area. Various types of protected areas accounted for 862.8 thousand ha or 28.2% of the total forest area (Table 1). The largest proportion of the protected areas consisted of SPNAs, protection zones of environmental and natural resources, and micro-reserves (SFS 2015).

According to the SFR, the area of SPNA in forests was 602.7 thousand ha, including, the Northen Vidzeme Biosphere Reserve of 233.1 thousand ha, protection zones of environmental and natural resources covered 338.2 thousand ha (including, the coastal protection zone of the Baltic Sea and the Gulf of Riga 77.5 thousand ha, protection zones of surface water bodies 131.1 thousand ha, protection zones around cultural heritage objects 53.6 thousand ha, protection zones around drinking water abstraction sites 1.0 thousand ha, forest protection zones around cities 21.8 ha, protection zones around swamps 37.1 thousand ha, and forests within the administrative territories of cities 16.1 thousand ha), while the micro-reserves covered 39.2 thousand ha and their buffer zones - 37.8 thousand ha. The scientific objects were registered with a total area of 1.2 thousand ha, specifically protected forest sites 12.6 thousand ha, and local level SPNAs - 1.1 thousand ha (SFS 2015). Taking into account that these protected areas partially overlap, the total area of protected forest areas registered in the SFR is 862.8 thousand ha, not the arithmetic sum of the aforementioned protected areas (SFS 2015).

The SFR data shows that 71.8% of the country area was covered by commercial forests, which were subject to the general regulations governing forest management and use and were not the subject of any final felling restrictions. Forestry activities were prohibited in 3.3% of the forests, thinning from a certain tree age and final felling in 2.3% of the forests, final felling in 1.2% of the forests while clear felling in 6.9% of the forests. Overall, 13.7% of all forests were subject to the aforementioned final felling restrictions. At the same time, 14.5% of the forests were included in a certain protection area, but were not subject to the aforementioned forestry restrictions (for example, the landscape protection zone or neutral area of the North Vidzeme Biosphere Reserve). It should be pointed out that the latter value, viewed from the standpoint of protected areas, shows that even if any seasonal restrictions are imposed, complete timber extraction is possible in 51.4% of the protected forest areas. Forest in the North Vidzeme Biosphere Reserve makes up for a large proportion of the areas which are not subject to the 4 aforementioned final felling restrictions while at the same time being situated in a protected area. 233.1 thousand ha of forest have been registered in the Biosphere Reserve, of which around 14.6 thousand ha (6.3% of the total forest area in the North Vidzeme Biosphere Reserve) are included in other SPNAs - 25 nature reserves and 1 nature park which are subject to forestry prohibition or other final felling restrictions. Based on this, around 218.5 thousand ha or 93.7% of the forests in the North Vidzeme Biosphere Reserve are not subject to any restrictions in respect to tree felling, which would be imposed by legal regulations governing the conservation and use of specially protected nature areas. Overall, final felling is prohibited in 6.8% of Latvian forests, while in 93.2% it is allowed.

<table>
<thead>
<tr>
<th>Areas with Forestry Restrictions in Latvian Forests in 2014</th>
<th>Thousand ha</th>
<th>% from total forest area</th>
<th>% of the country area (6457.3 thousand ha (SFR 2015))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Total forest area (FRM 2014)</td>
<td>3260.8</td>
<td>100</td>
<td>50.5</td>
</tr>
<tr>
<td>B: Invented forest area (SFR 2015)</td>
<td>3056.6</td>
<td>100 (93.7 % no A)</td>
<td>47.3</td>
</tr>
<tr>
<td>From C: Forest area with and without forestry restrictions</td>
<td>3056.6</td>
<td>100</td>
<td>47.3</td>
</tr>
<tr>
<td>Commercial forests that are subject to the general regulations of forest management</td>
<td>2193.8</td>
<td>71.8</td>
<td>34</td>
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<tr>
<td>Forests with forestry restrictions</td>
<td>862.9</td>
<td>28.2</td>
<td>13.4</td>
</tr>
<tr>
<td>From D: Forests with forestry restrictions divided into 6 groups</td>
<td>100.3</td>
<td>3.3</td>
<td>1.6</td>
</tr>
<tr>
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<td>1.2</td>
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<td>6.9</td>
<td>3.3</td>
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<tr>
<td>Clear felling prohibited</td>
<td>443.5</td>
<td>14.5</td>
<td>6.9</td>
</tr>
<tr>
<td>None of the aforementioned prohibitions, but the territory is located in any of the protected areas</td>
<td>2193.7</td>
<td>71.8</td>
<td>34.0</td>
</tr>
<tr>
<td>Commercial forests outside of the protected areas</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

4. Discussion
Based on the results from Stage 2 of the FRM (Forest Resource Monitoring), the total area of forests in Latvia was 3260.8 thousand ha (Silava 2014), while the SFR accumulated information about 3056.6 thousand ha of forests in 2014 (SFS 2015). Taking into account that the data accumulated by the SFR, due to methodological conditions, include only forest areas which have undergone forest inventory and do not include the overgrown areas which comply with the definition of the Forest Law (other land categories with an area of 0.5 ha or larger with the average height of the trees in the forest stand of at least 5 m and where the basal area of the forest stand is equal to or larger than the minimum required basal area for a forest stand, and which has not undergone forest inventory, etc.), we may conclude that the actually restricted forest areas are larger than shown in the SFR. The FRM methods also provides analysis of forest areas in respect to restrictions on economic activities and protected areas, however defines that, the data on protected and restricted areas are collected from the SFR forest site data and, thus, they face the same methodological problems as described in relation to the SFR (Silava 2013). The publicly available reports on the results of the FRM do not include information on restricted areas.

It should be noted that the SFR does not register and this article does not include the areas which have been identified and protected by certain forest owners or legal possessors on a voluntary basis, for example, within the framework of forest certification. One of the largest forest managers which is carrying out voluntary forest conservation is Laniķis valsts mežu AS (hereinafter - LVM) which is in charge of 1.41 million ha of state forest areas.

Since 2011, the identification and mapping of Latvian and European protected habitats has been carried out in the areas managed by the LVM, which lie outside of the legally protected nature areas (LVM 2015). It is carried out both in the Ecoregion areas determined by the LVM and the rest of the LVM lands before planning any economic activities, by carrying out an environmental impact assessment and in respect to the planned forest infrastructure construction projects and the evaluation of potential felling areas. The data recorded on site are registered into the LVM database which is used by the LVM employees in charge of forest management activities on a daily basis.
Forest Fires in Latvia from 1990 to 2014

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Summary
This article summarises information about the number and area of forest fires in Latvia from 1990 to 2014. The State Forest Service carries out wildland firefighting work and keeps the forest fire inventory. All of the identified and extinguished forest fires are inspected on site and surveyed with a GPS receiver. The results are registered in the State Forest Register. From 1990 to 2014, forest fire has broken out on average 753 times per year, affecting 990 ha of forests. The annual number of registered forest fires and affected areas may vary significantly - in certain cases it may even differ by ten times the amount. The most common cause for forest fire is careless human activity with fire. From 2007 to 2014, 77.2% of fires were caused by careless human activity with fire, 8.7% by malicious burning, 6.7% by the burning of the last year’s grass, 2.9% by the interaction of various vehicles, 1.3% by the burning of logging residues, 0.8% by lightning, and 2.5% by various other factors. Most of the fires are concentrated around Riga and Daugavpils.

From 1998 to 2014, prescribed burning was carried out in around 289.7 ha of Latvian forest land, with an aim to conserve the natural values. Of the whole area, 288.5 ha were moorland and only 1.2 ha were forests.

Keywords: forest, fire.

1. Introduction
Forest fires historically have always played a larger role in the formation and existence of forest ecosystems. A number of wild species and species communities are dependent on them. Today the distribution, frequency, and ecological effect of fire most likely differ from what it could be if untouched by human hands. Due to the fact that the majority of fires are caused by human activity, the forest fires are usually successfully suppressed, the wood damaged during the fire is often removed, and the majority of the burnt areas also include man-made forest structures.

In recent years, more and more people are discussing the application of prescribed burning for the purpose of nature conservation in Latvia. It has been recommended in several forest biodiversity planning materials, especially in reference to the Boreal forests (Johansson 2005, Brūmelis, Jankovska 2013, Lārmanis 2013, Lārmanis at al2014). Some small-scale prescribed burning has already been carried out in Latvia (Cirulis 2002, State Forest Service (SFS) 2005, State Defence Property Agency (SDPA) 2009, SFS, State Centre for Defence Military Objects and Procurement (SCDMOP) 2010, 2011, 2012, 2013, 2014). Other countries such as Sweden, Finland, and several Central European countries have much broader experience in the use of prescribed burning both in terms of research and practical application (FAO 2007, GFMC 2009, Montiel, Kraus 2010, Similä, Junninen 2012). When discussing the application of prescribed burning in nature conservation, it is important to know the context of the distribution and intensity of uncontrolled fires.

This article summarises information about forest fires in Latvia from 1990 to 2014.

2. Material and Methods
The article is based on the information on forest fires from the State Forest Service (hereinafter - the SFS) since 1990. In accordance with the external legal regulations, the SFS supervises compliance with the fire safety requirements, carries out wildland firefighting activities (except for the administrative territories of Riga, Jurmala, and Daugavpils), as well keeps the forest fire inventory. The procedure for the inventory of forest fires is laid down in Cabinet Regulations No.279 Regulations on Inventory of Forest Fires and Firefighting Works(14 April 2012).

After each forest fire, it is inspected by a SFS forester who carries out a survey of the fire with a GPS receiver. All of the fires with an area larger than 1 ha are surveyed as polygons; fires with an area of less than 1 ha may be surveyed both as polygons or points. Measurements from the GPS receiver and descriptive indicators, including causes for the forest fire, are registered in the State Forest
Register (hereinafter - the SFR). The SFR is a national information system which gathers, stores, and updates information on forests and forestry activities carried out therein. The SFR also maintains and stores information on forest land - land under forest vegetation objects, overflowing clearings, swamps and glades, as well as adjacent swamps. Data on all identified fires within the forest land is registered in the SFR. Taking into account that the graphic data on forest fires has only been collected since 2007, this article includes information in respect to the layout of the forest fires for the period of 2007 - 2014. Data on causes of forest fires are also displayed for the period from 2007 - 2014. Information about the causes of forest fires is registered by the SFR officials after the inspection of the forest fire sites, based on the data identified during the inspection, methodology approved by the European Commission (EC 2012), and personal experience. The causes of forest fires are registered in the SFR and the European Forest Fire Database.

The article also includes information on areas which have undergone prescribed burning for the restoration and maintenance of protected habitats. The first prescribed burning in Latvia was carried out within the framework of the Mežole Project in Mežole in 1998 (Cīrulis 2002). According to the available information, the following prescribed burning for the purpose of the conservation of species and habitats was carried out in Taurkalne in 2005 within the framework of the Management of Natural Forest Habitats in Latvia project (SFS 2005). For several years, habitat management activities have been carried out in Ādaži Military Training Area, for example, the Restoration of Biodiversity in the Military Training Area and NATURA 2000 Site Ādaži in 2009, activities under the agreements entered into between the State Centre for Defence Military Objects and Procurement and the SFS from 2010 to 2013, and the Birds in Ādaži project (Improvement of the Conservation Status for Protected Bird Species in the Natura 2000 Site Ādaži) in 2014 (SDPA 2009, SFS, SCDMOP 2010, 2011, 2012, 2013, 2014). Prescribed burning activities were carried out on the heath of Ādaži Military Training Area which according to Annex 1 to Cabinet Regulations No. 88 Regulations for Forest Inventory and Information Circulation of State Forest Register of 12 February 2013 is considered to be a type of forest land. The areas which underwent prescribed burning in the Ādaži Military Training Area in 2009 and 2014 was determined by carrying out on-site measurements. Calculations were carried out in respect to the areas that have undergone prescribed burning in 2010, 2011, 2012, and 2013.

3. Results

Break out and expansion of forest fires are related to the meteorological conditions, forest characteristics - soil type, tree species, their age, etc., and presence of humans in the forest. For this reason the number and areas of forest fires each year are very different. Since 1990, the largest number of forest fires have been recorded in 1992 and 2006 (Figure 1). In 1992, in total there were 1510 forest fires which affected 8412 ha of forests, while in 2006 there were 1929 fires affecting 3790 ha respectively. In 2014, there were 698 forest fires covering an area of 591 ha which is more than in the four previous years (Figure 2). Since 1990, the average annual area of forest fires in Latvia has been around 1.3 ha; during the years of low fire hazard level, the average fire area has been less than 1 ha.

From 2007 to 2014, the most common cause of forest fire has been careless human activity with fire - 77.2% of all instances - by leaving cigarette butts, improperly extinguished campfires, etc. 9.7% of forest fires have been caused by malicious burning, while 6.7% were due to the burning of the last year’s grass. 2.9% of the forest fires were caused due to the improper use of various vehicles, for example, locomotives. Natural causes of fire, for example, lightning, have been recorded a total of 30 times over the last 8 years (0.8%) affecting 4.1 ha of forest land, which is a fairly small area (Table 1). The causes of forest fires in terms of their proportion and also the proportion of the affected area, has been quite similar for the analysed period (SFS 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015).

Results over a longer period of time have shown that most forest fires tend to break out in the forest of Riga and Daugavpils. This is largely related to the fact that there are a number of frequently visited forests suitable for recreation as well as mushroom and berry picking nearby (Figure 3; Donis et al 2014). The aforementioned figure displays the break out points of forest fires from 2007 until 2014 as since 2007 forest fires sites are surveyed with GPS receivers and registered in the SFR.

The first time any literature source mentions prescribed burning as a nature conservation measure carried out in Latvia goes back to 1998, when an area of 0.2 - 0.25 ha was set on fire within the Mežole Project (Cīrulis 2002). Prescribed burning in relation to the management of natural forest habitats was also carried out in Taurkalne in 2005 in a total area of 1.0 ha (SFS 2005). In total, prescribed forest burning has been applied to an area of 1.2 - 1.25 ha which is a very low indication. A relatively larger forest area has been burned for the purpose of heath restoration from 2009 - 2014 at the Ādaži Military Training Area. By gathering various data sources, it may be concluded that in the Ādaži Military Training Area the prescribed burning method has been applied to an area of around 288.5 ha (Table 2) as a part of the heath restoration measures (SDPS 2009, Mārdega 2014, SFS, SCDMOP 2010, 2011, 2012, 2013, 2014) which is a many times larger area compared to the treated forests.

4. Discussion

In practice the actual burned forest areas may be slightly larger than those registered in the SFR, as some individual forest fires may be extinguished by volunteers without notifying the State Forest Service or the State Fire and Rescue Service or burn out due to natural causes. However, generally the information on forest fires from the SFR may be considered as unbiased and reliable and the accumulated data may be used in further scientific research work.

One of the general arguments against the need for prescribed burning is an assumption that today there are already enough forest fires in order to maintain the
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Figure 3. The geographical layout of the burnt out areas from 2007 to 2014

tendencies of fire dynamics over a longer period in this region as well. Due to investments in forest protection system as well as the creation and maintenance of its infrastructure, the average size of forest fires in Latvia has been fairly low - 1.3 ha during the period of 1990 - 2014. More than 99% of the forest fires have been caused by careless human activity or malicious burning. Similar statistics may also be seen in other countries of our region (Schmuck et al. 2014). The human impact on the outbreak of forest fires in Latvia is also reflected in the geographical layout of the burnt out areas: the majority of them have taken place around the two largest cities - Riga and Daugavpils (Donis et al 2014, Figure 3) where you can observe intense human recreation. By assessing the effects of the forest fires, we should also take into account the forestry tendencies in Latvia, when in most cases the aftermath of the forest fires includes removal of the remaining stands by sanitary clearing and restoration measures of forest stands due to forest conservation and economic purposes, thus decreasing the amount of structures in the forest affected by the natural disturbance. As an individual positive example we may mention the leaving of the burnt areas to natural processes in Slītere and Ķemeri national parks.

Table 2. Number of forest land in Latvia where prescribed burning was used as a nature conservation measure

<table>
<thead>
<tr>
<th>Year</th>
<th>Area, ha</th>
<th>Moorland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>0,2-0,25</td>
<td>Forest</td>
</tr>
<tr>
<td>2005</td>
<td>1,0</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>~ 67</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>~ 81</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>~ 82</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>~ 32</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>3,5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,20-1,25</td>
<td>to 288,5</td>
</tr>
</tbody>
</table>
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Presentation: