Best Practice Guidelines

ON THE CREATION OF ECOLOGICAL NETWORK FOR *OSMODERMA EREMITA* AND OTHER SPECIES DEPENDENT ON VETERAN TREES

Life Osmoderma

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Kaunas city museum. KMM PEK7505.
Students at the Kaunas oak forest. Author unknown. (p. 8)
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Content

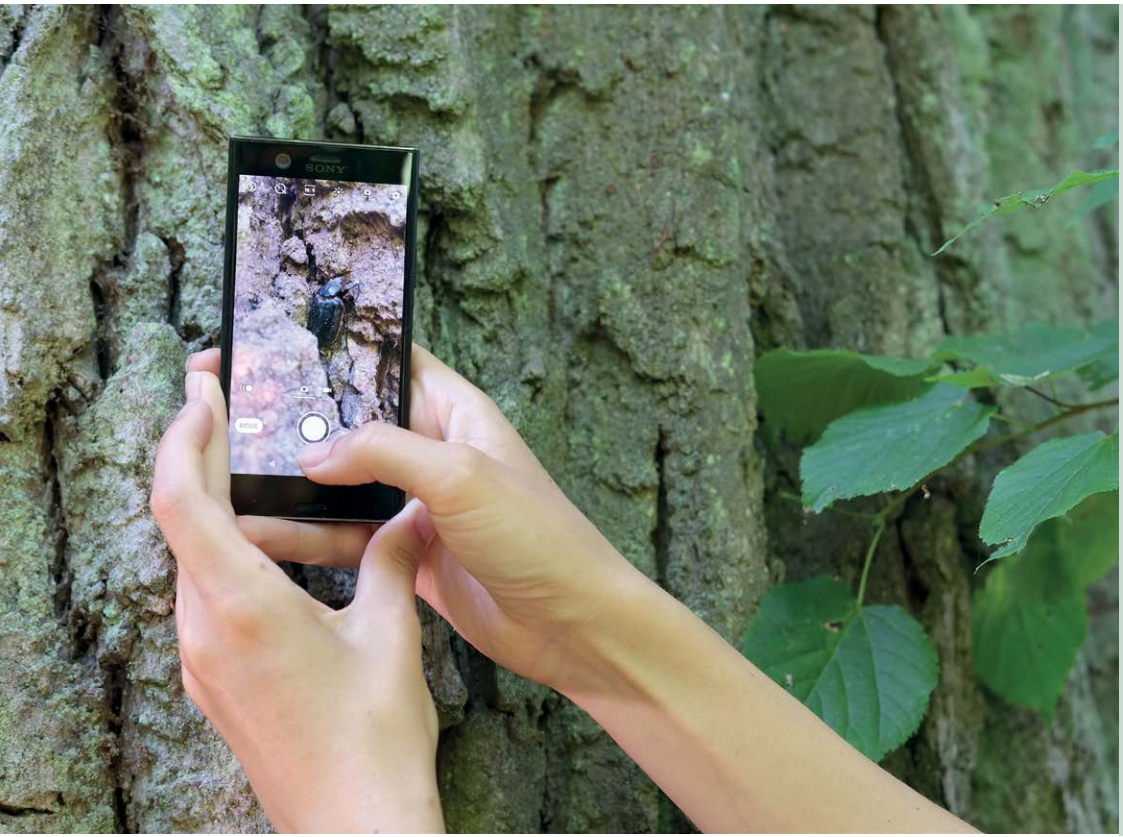

Figure 1. The star of the Project LIFE OSMODERMA – *Osmoderma barnabita*.

Introduction

Over the period from 2017 to 2022, the Lithuanian Fund for Nature, in partnership with Lithuanian Zoological Garden, Daugavpils University Nature Studies and Environmental Education Centre and Kaunas City Municipality, has been implementing a project "Ecological network for *Osmoderma eremita* and other species dependent on veteran trees" (LIFE16 NAT/LT/000701) funded by the European Union environmental financial mechanism „LIFE" (hereinafter referred to as LIFE OSMODERMA). This publication summarizes experience and lessons of the project LIFE OSMODERMA while briefly reviewing different aspects of ecological network creation, arboristic management of ancient trees, importance of deadwood, creation of smart pheromone traps, breeding of the hermit beetle and eradication of invasive tree species. More detailed information can be found on the project website *www.osmoderma.lt* or by directly contacting project team by email *osmoderma@glis.lt*.

Osmoderma barnabita – an umbrella species

The target species of this project is the hermit beetle (*Osmoderma eremita*) included in the List of Protected Fauna, Flora and Fungi Species of the Republic of Lithuania (The Red Book of Lithuania) and ascribed to the vulnerable (VU) category, in annexes II and IV of the EU Habitat Directive (92/43/EEC) on the conservation of natural habitats and of wild fauna and flora (hereinafter referred to as the Habitats Directive). In the Habitats Directive, many other European Union and Lithuanian legal acts and official publications the name O. eremita is in fact used in the meaning of sensu lato. Earlier it was thought that one and the same species, O. eremita, is found all over Europe. However, after having carried out a lot of genetic research, it turned clear that there are several closely related species in Europe, which form the O. eremita complex. A species of this complex dwelling in the Middle and East Europe is *Osmoderma barnabita*. Since in this publication we are talking about the species of the hermit beetle found in Lithuania and Latvia, we will be further using in this publication a name of *O. barnabita*.

Larvae of the beetle develop in decaying wood of live broad-leaved trees, most often host trees are oaks, less often – maples and limes. Duration of development is 2–4 years. The hermit beetle is a thermophilic species, therefore, in the conditions of our climate is more inclined to choose the hollowed oaks with non-shaded and sun-heated trunks. Although the beetle can live in the outskirts of the forests or even in the trees that grow in the forests, but typical habitats of this beetle are wooded pastures. Not only forest flora and fauna is characteristic of this habitat, some rare species typical to open areas are also found in it.

Since this is a beetle, which most of its life spends inside veteran broad-leaved trees, the condition and quantity of such trees, as well as possibilities for the beetles to migrate both between single trees and their groups are directly related to the survival of the hermit beetle. This is also important for other species as *O. barnabita* is one of the so-called umbrella species, which, when protected, provides protection for other

Figure 2. A hermit beetle (*Osmoderma barnabita*) is in particular rare in Lithuania and Europe and it is dependent on the survival of the old, hollow oaks.

Figure 3. Students in the Kaunas oak park. First half of the XXth century.

species occupying the same habitat. Therefore, creation of favourable conditions for the hermit beetle means improvement of the conditions also for other organisms dependant on veteran trees, for example, for bat species western barbastelle (*Barbastella barbastellus*), edible dormouse (*Glis glis*), tawny owl (*Strix aluco*), noble chafer (*Gnorimus variabilis*), pseudoscorpion *Anthrenochernes stellae*, oreange polypore (*Hapalopilus croceus*) and ceramic fungus (*Xylobolus frustulatus*) (see Figure 4).

Figure 4. Ceramic fungus or ceramic parchment (Xylobolus frustulatus).

Importance of veteran trees and project activities

Impressively looking old trees[1] are not only our historical and cultural heritage beautifying the landscape of our country, but a unique habitat for many organisms as well. Oaks older than 100 years growing individually and in groups are in particular valuable. Several hundred species of animals, plants and fungi can be found on one such tree, and in total 1000 species of different organisms are related with veteran trees. Part of these organisms have adapted to live in the old trees only

[1] In this publication, for the purpose of simplicity, we use the words „old tree", „ancient tree", „veteran tree" as synonims.

Figure 5. The species richness a veteran tree supports generally increases with age.

and their survival depends on the fate of such trees.

Since existing places where the beetles are found are in a distance from each another, each tree suitable for a temporary shelter is important for all mentioned species. Although not protected, a single tree can play an important function as a stepping stone between larger suitable habitats. Insects inhabiting such a place or spores of a fungi will be able to spread further, until they find another temporary shelter or protected area. Therefore, inventory, management and protection of old trees, were among the most important activities of the project.

While executing management works of the habitats suitable for the beetle and installing connecting elements and temporary habitats during the project, an ecological corridor was created selecting Natura 2000 sites designated for *Osmoderma barnabita* as the core areas – Kaunas Oak Forest (LTKAU0020), Dūkštos Oak Forest (LTVIN0007)[2] and the Slope of Neris River by Verkiai (LTVIN0012). This ecological network is part of the international Lithuanian–Latvian ecological network in which fragmentation of the populations of the hermit beetle and the evolved gaps for genetic

[2] Later, this Natura 2000 site was connected to another area and named Surroundings of Neris River Loops (LTELE0005).

exchanges between subpopulations have been identified. Restoration of the populations of the hermit beetle has been also implemented in the managed historical places where this beetle was discovered, and, having applied up-to-date technologies, we improved and optimized methods for the monitoring of this beetle.

Figure 6. Kaunas oak forest.

01 Cross-border Ecological network for the species dependent on broad-leaved ancient and veteran trees

This chapter is a summary of publication "Cross-border Ecological network for the species dependent on broad-leaved ancient and veteran trees"[3] that can be found at a full length on project's website *https://www.osmoderma.lt/publications*.

During the development of the Ecological network plan for Lithuania, potentially suitable territories for species occurrence were selected based on criteria elaborated within the LIFE+ EREMITA MEADOWS, project realized in Latvia. In the framework of cooperation, the developed networks are connecting and forming one cross-border ecological network, thus ensuring the possibility to plan species conservation measures on the international scale.

[3] Uldis Valainis, Maksims Balalaikins, Inese Gavarāne, Cross-border Ecological network for the species dependent on broad-leaved ancient and veteran trees, Daugavpils University, Nature Studies and Environmental Education Centre, LIFE16 NAT/LT/000701 data, 2020.

Ecological network plan has been prepared based on known and potential habitats of *O. barnabita* by using results from:

1) analysis of existing biological data in national spatial databases;
2) inventory of the species in the field (project territories);
3) genetic analyses of the target species;
4) GIS modelling and interpolations.

Within the framework of the project, an interactive map has been created, which cartographically depicts all identified potentially suitable habitats of *O. barnabita*. Such an instrument will facilitate the planning of species protection and habitat management measures in specific areas.

1.1. Principles and Sources of Selection of Habitats Potentially Suitable for *Osmoderma barnabita*

All available databases (13 in total) were used while developing the Ecological network plan for the species-dependent on the broad-leaved ancient and veteran trees. The data selection included all available geospatial data that could indicate the occurrence of old broadleaf trees in both forests and opened landscapes. In order to specify the selection criteria *O. barnabita* was chosen as the main target species. This species has very high environmental requirements and reflects the general environmental quality requirements of other umbrella species.

The hexagonal tessellation has been used for habitats suitability identification for the species dependent on old broad-leaved trees. The dimensions of the hexagon were based on proved information on the flight distance of the hermit beetle, available in the literature. The maximum known *O. barnabita* relocation distance is 2.09 km, which was fixed by the re-capture method. Thus, the distance of 2.09 km was taken as the length of one edge of the hexagon, which also corresponds to the distance from the centre of this figure to each of its angles. The

[4] U. Valainis, M. Nitcis, K. Aksjuta, A. Barševskis, R. Cibuļskis, M. Balalaikins, Avgin SS *Results of using pheromone-baited traps for investigations of Osmoderma barnabita Motschulsky*, 1845 (Coleoptera: Scarabaeidae: Cetoniinae) in Latvia. Baltic J. Coleopterol., 2015 m., 15 (1): p. 37 – 45.

hexagon, as the basis of the network, was taken because it has some advantages from being closer in shape to circles than squares are. Therefore, a hexagon has a shorter perimeter than a square of equal area, which potentially reduces bias due to the edge effects. The value based on the developed criteria of habitat suitability for the hermit beetle occurrence was assigned to each hexagon.

Three main criteria were used to assess the probability of occurrence of the species in the territory of hexagons:

- Criteria 1 – broad-leaved tree species suitability for *O. barnabita*.
- Criteria 2 – age of broad-leaved tree species suitable for *O. barnabita*.
- Criteria 3 – localities of other umbrella species inhabiting old broad-leaved trees.

The effect of each criteria was evaluated separately in both open areas and forest lands. For assigning a value to a specific hexagon, the total value of habitats in forest areas and the full value of open area habitats were compared, which is higher. After comparing one, the most

Figure 7. The principle of hexagon formation.

significant value was assigned to the hexagon. Thus, it was established for each hexagon, whether the most favourable conditions for *O. barnabita* were found in the forest or open landscape. According to this system, the maximum value that can be assigned to one hexagon are 12 points.

1.2. *Osmoderma barnabita* Potential Distribution Model in Lithuania and Latvia

1.2.1. DEVELOPMENT OF A MAP BASED ON HEXAGONS TO IDENTIFY HABITATS SUITABLE FOR O. BARNABITA

The assessment of habitat suitability for species dependent on broad-leaved trees was based on the obtained values of the hexagon. The maximum possible value for a hexagon is 12 points, which is the sum of the maximum values in each of the three matching criteria (the presence of broad-leaved trees, age of broad-leaved trees and umbrella species associated with these trees).

When creating a graphical display of hexagons on the map, according to their value, a certain colour intensity was assigned, increasing the colour intensity with an increase in the value assigned to the hexagon.

To get a general idea of the occurrence possibilities of *O. barnabita* in a particular hexagon, a simplified map was created where all hexagons were divided into three categories depending on suitability for the species. The following categories were used:

- 0 to 3 points – low possibility of *O. barnabita* occurrence;
- 4 to 8 points – medium possibility of *O. barnabita* occurrence;
- 9 to 12 points – high possibility of *O. barnabita* occurrence.

1.2.2. ICREATION OF AN INTERACTIVE MAP AND THE REVIEW OF AVAILABLE GIS DATA LAYERS

For a detailed survey of the territory of Latvia and Lithuania and planning of management measures, an interactive map has been created. To comply with data protection rules, two versions of an interactive map

were created: the first one with free access, where general information is published, and the second version, with restricted access only for specialists of nature conservation and environmental protection, which contains detailed information.

THE PUBLIC ACCESS VERSION CONTAINS THE FOLLOWING DATA:

- Hexagon values map (12 categories);
- Hexagon values map (3 categories);
- Ecological network data:
- *O. barnabita* localities;
- Core areas for *O. barnabita*;
- Ecological corridors between the core areas;
- Gaps between *O. barnabita* populations;
- Results of *O. barnabita* populations' genetic analysis.

Website address: *https://gis.biology.lv/portal/apps/webappviewer/index.html?id=f79a86a88c684596af52f48305932b1c*

THE VERSION AVAILABLE TO SPECIALISTS OF NATURE CONSERVATION AND ENVIRONMENTAL PROTECTION CONTAINS THE FOLLOWING DATA:

- Hexagon values map (12 categories);
- Hexagon values map (3 categories);
- The data selected for the identification of the first criteria: suitable broad-leaved trees for *O. barnabita* in forest stands;
- Parks and manors;
- EU protected habitat Fennoscandian wooded meadows (6530*);
- The data selected for the identification of the second criteria: age of suitable broad-leaved trees for *O. barnabita* in forest stands;
- Broad-leaved ancient trees in open areas;

- The data selected for the identification of the third criteria: localities of umbrella species inhabiting old broad-leaved trees in both forest stands and open landscape;
- Ecological network data:
  - *O. barnabita* localities;
  - Core areas for *O. barnabita*;
  - Ecological corridors between the core areas;
  - Gaps between *O. barnabita* populations;
  - Results of *O. barnabita* populations' genetic analysis.
- Additional factors for planning species protection measures in ecological corridors:
  - Natura 2000 territories;
  - EU protected forest habitats 9180* (Tilio-Acerion forests of slopes, screes and ravines), 9020* (Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes) and 9160 (Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli);
  - Woodland key habitats layer with large-dimensional broadleaf trees (available only for Lithuania);
  - Protected alleys (available only for Latvia);
  - Urban territories.

1.3. Methodology for Identifying the Basic Elements of the Ecological Network

For identification of Ecological network basic elements, the Kernel Density Estimations (KDE) method was used.

Areas with the highest probability of species occurrence according to the KDE method were defined in the Ecological Network as Core areas. The areas between the core sites with the highest probability of identifying potentially suitable habitats for the species were identified as ecological corridors (see Figure 8). Connecting the core areas with corridors, plots

with a low probability of the hermit beetle occurrence were identified. These territories were defined as gaps within the ecological corridors on a global scale. These gaps disrupt gene flow between metapopulations, which leads to a reduction in the genetic diversity. The formation of such gaps should be prevented by the creation of artificial cavities or by veteranisation of trees potentially suitable for the species.

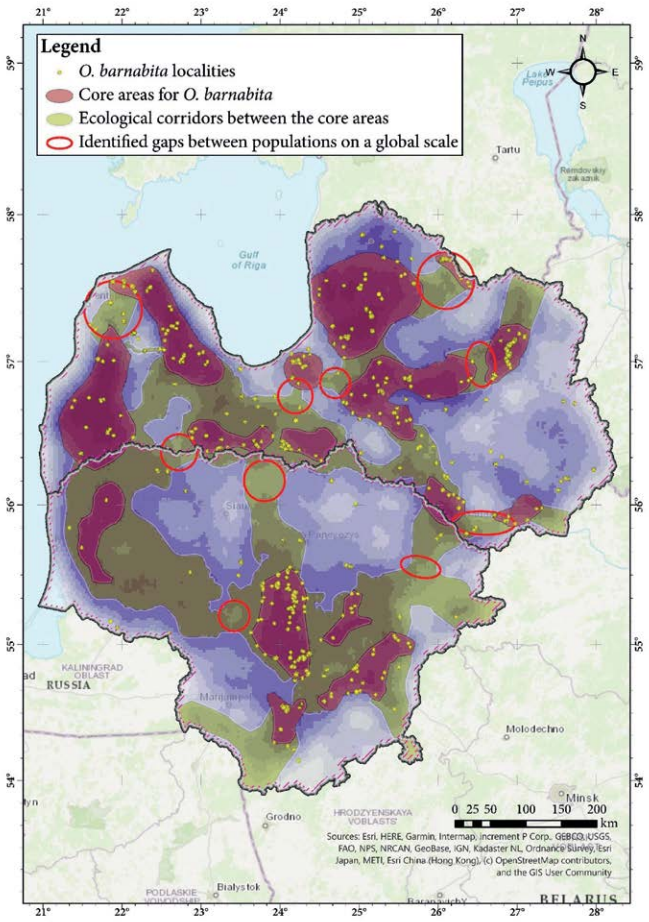

Figure 8. Basic elements of developed Ecological network - core areas, corridors and gaps.

1.4. Interpretation of Performed Genetic Analyses Data

The material required for genetic research was collected from 136 Osmoderma specimens in 28 sites in Lithuania. The samples of hind legs were used for DNA extractions. Overall, 136 DNA samples were isolated, and out of them 134 DNA samples were suitable for analysis. 47 samples from 3 sites were collected in Latvia during the LIFE+ EREMITA MEADOWS project and they were analysed to compare Lithuanian and Latvian metapopulations. Unfortunately, a sufficient number of sampled individuals were represented only by the metapopulations of eastern part of Latvia, therefore the genetic affiliation for the metapopulations located in northern and western parts of Latvia is still unclear.

Principal Coordinate Analysis (PCoA) was used to reconstruct the dissimilarities among metapopulations. Given that a part of the sampling places has been represented by a small number of specimens, samples were analysed by combining the closest metapopulations to each other. PCoA was performed in total in 9 metapopulations in Lithuania and in 3 metapopulations in Latvia (see in Figure 9).

Obtained microsatellite data analysis represents historical data and is demonstrating that connection among metapopulations existed and is indicating that populations have a common ancestor. According to the obtained data (see in Figure 9) all analysed metapopulations are divided into two groups. The first group includes Lithuanian metapopulations 4 and 9, as well as Latvian metapopulations 1, 2 and 3, while the second group includes metapopulations 5, 6, 7, 8, 9, 10, 11 and 14 in Lithuania. Although metapopulations 1 and 2 in Latvia are closer to the first group of metapopulations, they have a specific mixed genetic profile. These two metapopulations have a genetic profile which is sharing alleles with almost all populations. Additionally, the analysis of metapopulation 1 is indicating a probable connection with *O. barnabita* population in Estonia as the genetic profile of some samples differs from others.

The results are showing that metapopulations 4 and 9 in Lithuania have a strong connection and a similar genetic profile. Additionally, obtained results are also demonstrating the similar genetic profile of metapopulations from central part (7 and 14), eastern part (5) and southern part (8 and 10) of Lithuania – by this, it might be considered that these populations had a close connection.

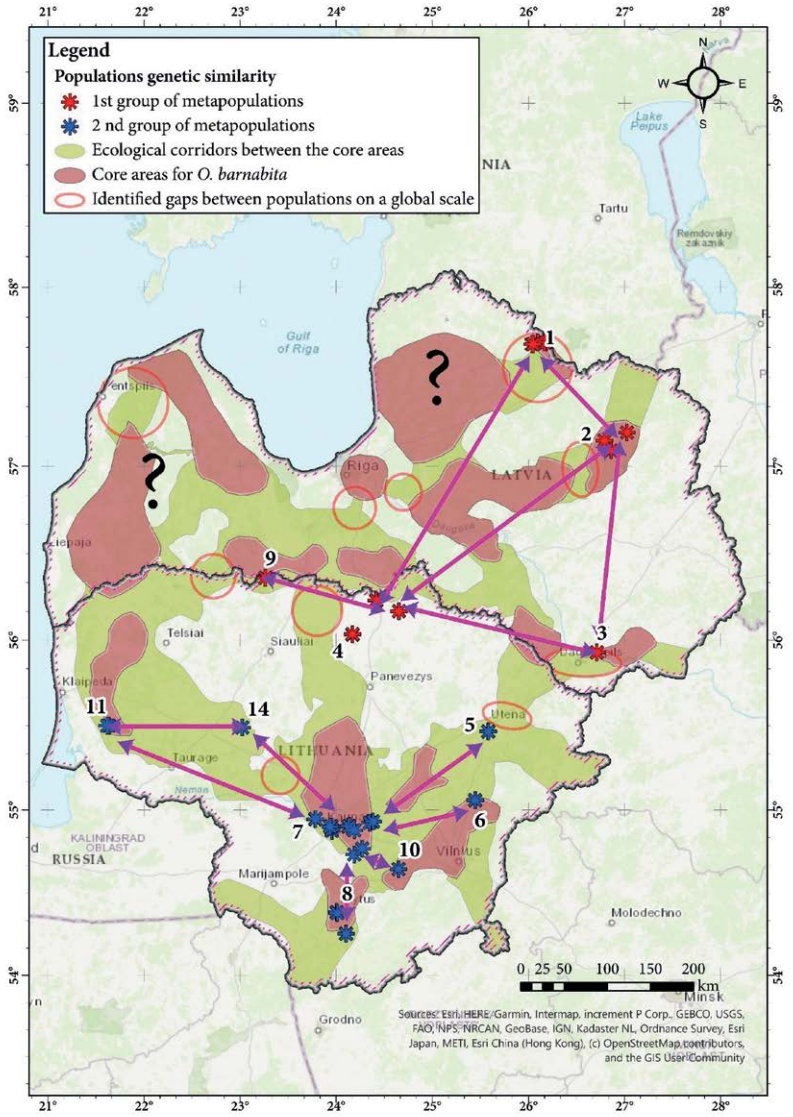

Figure 9. *O. barnabita* metapopulation groups in the Ecological network

Variety of allele number per locus slightly differs among populations, which might indicate relatively recent isolation of populations. However overall genetic profile is showing connection among the populations.

1.5. Recommendations for *Osmoderma barnabita* Conservation Measures

The characteristics of the basic elements of the developed Ecological network and general suggestions for ensuring their functionality are summarized in the Table 1.

Table 1.

CHARACTERISTICS OF THE BASIC ELEMENTS OF THE DEVELOPED ECOLOGICAL NETWORK AND GENERAL SUGGESTIONS FOR ENSURING THEIR FUNCTIONALITY

ECOLOGICAL NETWORK ELEMENTS	CHARACTERISTICS	STRATEGIES
CORE AREAS	Areas where the conservation of suitable habitats takes primary importance, even if the area is not legally protected. Regions where the species localities are concentrated, and the significant number of potentially suitable habitats for the species have been identified. Measures for the management of the hermit beetle habitat and species protection are often already applied in these areas.	· Inventorisation of core areas using both target species and structure-based indicators, such as the presence of old trees. · Identification of factors that could impact species negatively in existing and potential *O. barnabita* habitats. · Planning and implementation of the specific species protection measures (expansion of specially protected nature territories, creation of new ones, etc.) and habitat management measures.

CORRIDORS	Corridors serve to maintain vital ecological connections by supporting physical linkages between the core areas. In principle, linking isolated patches of habitats can help increase the viability of local populations in several ways: · by allowing species individuals access to a larger area of habitat; · by allowing genetic exchange with other local populations; · by offering opportunities for individuals to move away from a habitat that is degrading or from an area that is under threat; · by securing the integrity of physical environmental processes that are vital to the requirements of certain species.	· Identification of potential gaps in O. barnabita distribution corridors and restoration habitats suitable for the hermit beetles. · Implementation of measures to protect the necessary structural elements for O. barnabita. Strict protection of corridors in fragmented landscapes (trees on the roadsides, ancient trees, etc.), including management to keep at least some areas open, e.g., by grazing or selective cutting. · Restoration of stepping stones between core areas, planting trees in places where the continuity of habitat has been disturbed, as well as other measures enhancing the microhabitat continuity in space and time e.g. promoting hollow creation by pollarding trees, veteranisation or fungal inoculation.
GAPS	Gaps are territories where the presence of habitats suitable for hermit beetle is unlikely, but which are essential for the functioning of species distribution corridors. During the development process of the Ecological network plan, gaps between several core areas were identi-fied (see Figure 9). In these territories, species protection measures for the maintenance of existing habitats suitable for the species and creation of new the ones should be implemented as a matter of priority. Gaps on a local scale can be identified using the developed interactive map. In the interactive map, gaps are hexagons where potentially suitable habitats for the species have not been identified.	· Investigation of gaps in the field to find out if it is a gap or lack of data; · Placement of artificial microhabitats – surrogate tree cavities; · Veteranisation of oaks – managing trees to speed up habitat production; · Planting new broad-leaved trees.

2 Creation of the practical ecological corridor Vilnius–Kaunas

Declining number and worsening status of the old trees have been observed not only in Lithuania but all over Europe as well.[5] Seeking to improve conditions for organisms associated with ancient trees, a practical ecological corridor between Vilnius and Kaunas has been created during the project. This network connected a historical habitat of the hermit beetle with the habitat restored during the project - Natura 2000 site, the slope of Neris River by Verkiai was connected with the habitat of the largest population of the hermit beetle in Lithuania, another Natura 2000 site - Kaunas Oak Forest. Creation of the practical ecological corridor consists of several stages.

[5] Helen Read, Veteran Trees: A guide to good management, Veteran Trees Initiative, 2000.

2.1. Inventorisation of the ancient trees

Initial analysis is performed using different data bases (data on the habitats of European interest, Trees – Monuments of Nature, Cadastre of Forests, data of the information system of protected species, etc.). Then a map is designed with potential sites and they are all investigated during the field works.

A form is completed during the field works (an app "MoreApp" was used for filling in the form during the implementation of the project), indicating different tree characteristics and status – location, physical tree parameters, evaluation of the tree and growing site condition. Autumn and spring are the best seasons for the works, when foliage is absent and tree crown and cavities can be better seen.

Since the target species of this project – the hermit beetle – is able to migrate short distances only, efforts have been made to discover and inventory the trees at least every 1–2 km. The total length of the corridor

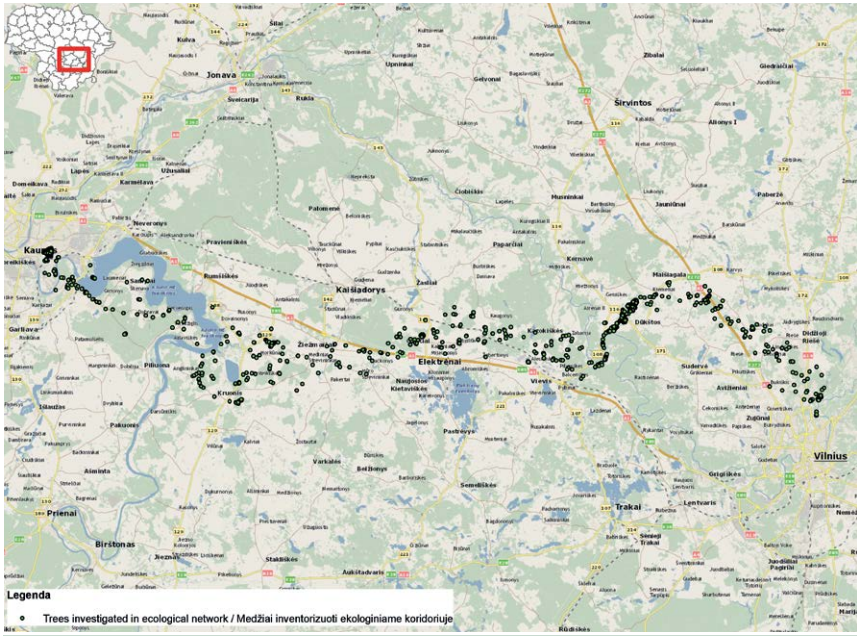

Figure 10. Practical ecological network between Vilnius and Kaunas, designated for species associated with veteran trees.

Vilnius–Kaunas is about 106 km with over 1590 trees that have been counted in it as existing and potential habitats for the hermit beetle and other species associated with old trees.

2.2. Development of an individual protection plan

Over 1000 biologically most valuable trees have been selected from all inventoried trees and assessed with the help of the professional arborists. It has been determined that nearly 700 trees of that number required arboristic management works, for example, cable bracing, crown reduction, mulching under the tree crown projection, removal of the concrete from the hollows, bringing more light to a selected veteran tree by removing young trees. The main purpose of these measures is improvement of the conditions and extension of life of the ancient tree, as well as assuring safety for people. All these measures have been comprehensively described in Chapter 3.

2.3. Agreements with owners, obtaining of permits and execution of works

When individual management plans for ancient trees were developed, tree owners were identified, tree protection agreements were signed and a permit for arboristic management plans was gained.

Pursuant to the land use, majority of the trees were growing on the land of forest and of other use (for example, on the territories of residential buildings, public spaces of urbanized areas) and areas of conservation use. Part of the trees had several owners. In such cases all arboristic works were coordinated and tree protection agreements signed with each of them. First of all, management of trees growing on the private land was coordinated with the owner or owners, afterwards – with a responsible institution or institutions (eldership, municipality or State Forest Service). Management of the trees growing on the state land and gaining of permits have been coordinated with a responsible authority right from the start.

Each owner and responsible institutions were informed about the importance of the ancient tree, threats arising to it and proposed arboristic management measures.

Arboristic tree management works were organized and paid for by the Lithuanian Fund for Nature in the framework of the implementation of LIFE OSMODERMA project, and each owner for his part has committed in writing to the following:

- To abstain from cutting the managed tree,
- To abstain from such radical changes of the growing site as piling up with soil, stones, waste etc., which would result in worsening the growing conditions of a tree,
- To leave a protective area equal to the managed tree crown projection on the ground, avoid such activities as stacking of things, building structures, dumping waste, ploughing and fertilising with mineral fertilizers or intensive grazing.

Not all tree owners undertook to protect a tree (if, for example, they plan to build something or sell the land). However, majority of the owners responded positively to the message that a tree growing on their land was in particular valuable from the biological point of view, investments would be made to carry out arboristic management works, thereby making it safer for people themselves and ensuring a longer tree life. All the trees growing on the land, which was not of the forest use, were included in the register of plants to be protected by the municipality. This ensures even better protection of the tree, because the municipality is a responsible institution which is contacted by people wishing to prune or cut the tree growing on their land.

After receiving all the permits and the commitment from the tree owner not to harm the tree in the future, a tender to perform arboristic works would be announced and planned measures implemented. Tree protection agreements have been signed and arboristic tree management works have been implemented for more than 600 trees.

03 Arboristic management of ancient trees

Each veteran tree is unique with different circumstances of growing, thus arboristic measures for veteran trees differ from the usual tree management practice. Often veteran trees grow in an urbanized environment (city parks, roadsides) therefore, professional tree management is also beneficial for the safety of people who come as visitors. Maintenance of such trees requires experienced and well skilled arborists who would be able to assess specific needs of each individual tree – to predict arising threats and plan the necessary management measures. Qualification of the specialists was an area of special attention in the project – arborists working with ancient trees were subject to the requirement to have certificates of EAC (European Arboricultural Council), ISA (The International Society of Arboriculture) or VETcert (system developed for the certification of veteran tree management specialists within the VETcert project).

3.1. Main arboristic measures and techniques applied during the project

RESTORATION PRUNING

This method is applied while taking care of the old valuable trees which had lost their characteristic crown form or structure because of branches broken by the storms, inappropriate pruning or mechanical damages. This technique aims at ensuring and maintaining of the good and stable condition of the crown and branches. It is necessary to remove or fasten damaged and drying branches. This technique is combined with other methods, but it should be noted that it is necessary to try and apply the least possible intervention to the crown. Dry branches, if they pose no threat to the safety of the by passers and do not prevent formation of young shoots or branches, must remain in the tree crown. That ensures normal functioning of the ancient tree as a separate ecosystem.

Figure 11. Arboristic management in the Kaunas Oak Forest using an access platform.

CROWN REDUCTION

This measure is used to ensure stability of the tree – the size of the crown is reduced while retaining its natural form. It is mostly used when the tree trunk or main branches are hollow and they may not be able to hold the weight of the crown, the crown is asymmetric or the trunk is leaning downwards a lot. Using this method one can remove no more than 20 % of the foliage. Pruning is divided to the following types:

- Reduction of individual branches – when unproportionally long branches are shortened;
- Reduction of the topmost branches – when upper branches of the tree are removed;
- Reduction of the entire crown– when branches are shortened in the entire crown.

CROWN THINNING

The purpose of this pruning is a healthy and safe tree. Such pruning is carried out with the aim of removing small crown growth problems (for example, crossing branches or branches rubbing together) and clearing extraneous objects or climbing plants from a tree at the right time. These works have no essential influence at the present time, but they allow avoiding expensive management works in future.

REDUCTION OF DRY BRANCHES

The measure is intended to ensure safety of people, vehicles or infrastructure. Dried branches above roads, trails and other frequently visited places are shortened. In forested areas or other remote sites dry branches are left in order to increase biological diversity associated with dead wood. Their removal is carried out only to reduce the tree crown thus decreasing its weight. Then the dry branches are removed first of all, because the tree needs them least. Cuts of the branches are made imitating a natural look of the branch break.

Figure 12.
Dry branches are removed, imitating a natural look of the branch break.

REMOVAL OF THE TREES OVERGROWING AND OVERSHADOWING THE VETERAN TREE

Old trees in the non-forest environment most often would grow in good lighting conditions. The crown form, height and branch distribution of such trees differ from the trees growing in the forest. In the long run, lack of light results in the loss of the lower branches, therefore, young trees must be removed from under the crowns of the old trees leaving flowering shrubs for the pollinating insects. If an ancient tree is growing in suppressed conditions and other trees and shrubs nearby have reached its height, their removal is carried out in several stages, because sudden environmental changes (changed microclimate, humidity and lighting level, resistance to storms) can kill the tree which is being protected. Such removal of trees overgrowing and overshadowing the protected tree must be carried out every 5 to 7 years. The works must be done in autumn or early spring to avoid disturbing the birds.

Figure 13. Removal of the young trees overgrowing the crown of a veteran tree in the Kaunas.

CABLE BRACING

Crowns are fastened by installing dynamic or static bracing using special cables. It is important to ensure prevention of the ingrowth of the cables into the trunk, therefore, every 5–10 years they must be checked to assess if any correction is needed.

- **Dynamic bracing.** Cables are installed in the trees with two or more trunks. In quiet weather conditions the dynamic bracing is not tight, whereas in strong wind special cables adapted for the trees become effective and protect the trunk from cracking and breaking of one of the trunks apart. The dynamic crown bracing system is installed at the height of 2/3, measuring from the area of embranchment to the top of the tree.
- **Static bracing.** Cables are installed in the trees with the trunks which had already split. The aim of the measure is to prevent the trunk from further splitting. The static bracing is installed together with the dynamic bracing. The static crown bracing system is installed in the height of 1/3 at least, measuring from the area of embranchment to the top of the tree.

Figure 14. Dynamic bracing fastening the crown of a tree. Verkiai Manor park.

MANAGEMENT OF CAVITIES

Figure 15. Management of cavities: after removal of a man-made inclusion, cavity is left open or covered with parts from the trunks of the deadtrees.Kaunas Oak forest.

Stonework or concrete in the cavities damage the trunk of the live tree. Most often, the tree tries to heal a cavity, but such man-made inclusions prevent this from happening. Physical properties of the concrete and wood is also different in differing temperatures, so the tree not only cannot heal the crevice but tears that crevice even more. If the cavity is covered, it is not ventilated, which improves conditions to grow for the fungi destroying the wood and causing the tree to age faster. Construction materials must be removed from the cavities where this is possible without damaging a tree. The cavities are left open or covered with parts from the trunks of the dead trees, while installing a wooden supporting construction. Such a cover is used in cases when the cavities are constantly littered, if trees were torched in the past or when there is a high probability of torching the tree in future. For additional protection the cavities having a lot of wood rot and situated near intensive flows of people were equipped with smoke detectors and fire extinguisher balls which, in case of fire, would extinguish the fire right from the start and/or would immediately notify specialists about the fire.

IMPROVEMENT OF THE SOIL UNDER THE CROWN

The measure has been provided to improve tree growing conditions and restore suitable soil characteristics in the places where the soil has been compacted (e.g., near the trails). Hard cover is removed under the crown of the trees, the soil is aerated using an air spade or manually without damaging the active zone of the tree root system. Areas requiring periodic fertilisation and/or watering under the crown are equipped with fertilising wells. Special microbiological preparations are inserted under the tree crown and mulch of the broad-leaved tree wood is spread as a layer of about 8–10 cm thick under entire crown. If the soil under the crown is heavily trampled down, then, in order to ensure longevity of this measure, it is useful to fence the area around the crown, even a small fence would do to redirect the path farther from the root zone.

Figure 16. Soil was improved under the crown of a tree in Kaunas Oak Forest.

CREATION OF THE PROTECTIVE ZONE UNDER THE CROWN

In the areas with intensive development of agriculture, it is important to create a protective area equal to the managed tree crown projection on the ground in which no objects can be stored, structures constructed, waste dumped, soil ploughed and fertilized with mineral fertilizers or intensive grazing practiced. Such a paragraph was also included in the agreements with the tree owners referred to in Chapter 2.

Figure 17. Protective zone under the crown.

4 Dead wood in and outside the boundaries of the city

4.1. Importance of dead wood in natural habitats

Wood is one of the many natural resources creating many ecological niches. The more of the dead wood is in natural habitats, the more diverse it is (degree of decay, standing or fallen, which species of the tree and other aspects), the better is the ability of the habitat to retain more different saprobiontic types. Dead wood is a high-value nature resource, because it is a source of food for many species of animals, fungi, lichen and bacteria, at the same time it is a growth media, nesting and hiding sites for vertebrates and, finally, it provides nutrients for other plants.

Dead wood is also very important for mitigating climate change. While using carbon dioxide, trees “lock” it in their trunks. Forests form an ecosystem accumulating the largest mass of carbon dioxide in the world. Decomposition of the dead trees can last for hundreds of years and, therefore, carbon dioxide is released very slowly. While rotting,

the trunks return back the nutrients to the forest where other trees consume them.

One of the biggest threats to the survival of protected forest species is the lack of dead wood and old trees in the forests. 108 insect species are listed in the Lithuanian Red Data Book, of which 16 species are closely related to dead and damaged wood. Most of the protected mushrooms are relics of old forests, therefore they are found only where the forests have reached natural maturity. Out of 73 species of fungi listed in the Lithuanian Red Data Book, as many as 38 percent (28 species) directly depends on the various stages of decomposition of wood. For some of these fungal species, the greatest threat is posed by the felling of old trees and the scarcity of large-diameter dead wood in forests. 21 rare lichen species are also found on decaying wood, or 48 percent of all lichen species listed in the Lithuanian Red Data Book. Dead wood is also necessary for the existence of 8 rare species of liverwortsand mosses.[6]

Figure 18. Fallen trees create new ecological niches for saprobiontic species and also open windows of light in the crown, this way creating conditions for the young trees to grow. The slope by Verkiai Manor Park, Vilnius.

[6] V. Rašomavičius (ed.) Red Data Book of Lithuania. Animals, plants, fungi. Vilnius, 2021.

Sustainable functioning of forest ecosystems requires appropriate quantities of dead wood to ensure biological diversity of organisms feeding on decaying wood. If a sufficient quantity of it is ensured in the urban green teritories, at least part of saprobiontic species can settle down in them as well.

4.2. Recommendations for leaving dead wood of different types

While leaving dead wood in the urban green areas, it is important to ensure safety of people, diversity of the wood, aesthetic aspects of wood and suitable communication about the actions of the managers of the territories. Leaving of dead wood should be always accompanied by public information actions.

Figure 19. An arborist is cutting a dried branch right above the trail, this way creating a safer environment for people, but, at the same time, leaving part of the solid dead branch for saprobiontic species.

TYPES OF DEAD WOOD

Wood diversity can be defined differently, but in the context of this publication dead wood is divided to three types: dried trees, snags and fallen trees.

- Dried tree – a dead tree which remained standing, has retained a trunk and part of the tree crown. Left close to the trails, playing grounds or other intensively visited places they can pose danger for the safety of people due to a risk of falling or branch break.
- Snag – standing remains of the old tree, most often part of the trunk with remnants of several bigger branches. Left close to intensively visited places they can pose danger for the safety of people, but usually shortening of the remaining branches or of the trunk itself can help and the tree can stand safely for several decades.
- Fallen tree – a fallen live tree, dried tree or a snag. Fallen trees pose no danger to visitors, but they may look not aesthetically.

Figure 20. A fallen tree lying in Dubingiai Castle Hill – being a site of attraction for children is all over polished by the climbers. Inside it flourishes life of diverse life forms and, additionally, it offers another enjoyment or a place for visitors to sit down after climbing the hill.

ZONING OF TERRITORIES

We offer to zone the territories in which dead wood will be left based on the following principle: intensively visited territories by official trails, territories close to other objects and the remaining places where visiting is less intensive. Safe distance from official trails should make 1,5 of the trunk's length. For example, if a dried tree of 10 m height is left, distance from the nearest path or another object visited by people should be 15 m. Recommended retention of wood by types and zones is provided in Table 2.

Table 2.

PROPOSED RETENTION OF WOOD BY TYPE AND LOCATION

TYPE	NEAR THE TRAILS OR OTHER OBJECTS	OTHER PLACES
DRIED TREES	It is recommended not to retain dried trees, unless they are at the distance exceeding 1,5 of the trunk's length from the trails and other objects, or unless they are trimmed to the snag level.	Quantity needed to achieve the volume that has been set
SNAGS	Impressive size, posing no danger	
FALLEN TREES	Large diameter, without branches or with big branches only	

QUANTITY OF THE LEFT WOOD

Ideally, the quantity of the volume of dead wood per hectare should be provided in the territory's nature management plan. Nevertheless, quite often the territories do not have any nature management plans or the volume of dead wood is not indicated in the plan. In such cases we offer to leave at least 10 m3/ha of dead wood in city forests and parks. This is half of the recommended minimal quantity for the forests of our climate zone. If only possible, there should be left a similar quantity of all three types of dead wood in order to increase the diversity of dead wood and possibilities for the associated species to establish themselves on that territory. While calculating the volume one should not forget that part of deadwood is found also in veteran trees, which have dried branches and decaying wood inside the trunk. It is allowed to leave less of the dried trees, snags and fallen trees on the territories where old trees are abundant. Nevertheless, if equal distribution of the types of dead wood is preferred, the priority while leaving the wood on such territories should be left to snags and fallen trees.

Figure 21. Snags remain stable for many years and pose no actual danger for by passers, but offer a shelter for a variety of species. However, it is recommended to assess the degree of decay and stability of the snags situated near the trails every several years. (On the left - the slope by Verkiai Manor Park, Vilnius; on the right – Kaunas Oak Forest).

AESTHETIC AND OTHER IMPORTANT ASPECTS OF TREE RETENTION

The simplest way to accumulate a required quantity of dead wood while retaining a beautiful aesthetic look of the territory is to leave wood of large diameter. One trunk of the large-diameter tree can be equal in its volume to ten small trees, therefore, while selecting which of the dead trees should be removed, start from the smallest trees first of all. If dead wood is left by the trails and visited sites, it is important to do this in an aesthetic way. For example:

- To leave snags of impressive size or appearance as sites of attraction.
- To remove majority of the branches of the fallen trees and to leave just a trunk and several large branches. This way, a simpler access for visitors or mowing in the territory will be ensured.
- Branches can be taken away or left, but it is important not to stack them under the trunk of the fallen tree.

- Dead wood is left and information activities are carried out for promotion.

Environmental protection measures are not always welcomed by the public. One of the main reasons for that – lack of knowledge. Therefore, we recommend to install informational boards of several sizes for public

Figure 22. This pile of dead wood nearby intensively visited trails does not create an aesthetic look, but left in a more remote site of the park or city forest it will be useful to nature for many years to come. Kaunas Oak Forest.

information in environmentally important city forests. The following information is provided on large boards:

- Information on the importance of veteran trees and dead wood for the forests from the points of biological diversity, climate change and public well-being;
- A message that parks managers are concerned about biological diversity;
- Information on how much and in what way dead wood and old trees are left;
- Warning about danger of visiting in windy weather.

We offer to use small boards in the visited sites too:

- Interesting ancient trees – telling how a specific tree is important from historical, cultural or natural points of view.
- Large diameter fallen trees and snags – showing that they have been left intentionally and informing of their value for nature.

Figure 23. A small-diameter sign informing park visitors that this fallen tree has been left intentionally, not because park managers are inactive.

05 Breeding of the hermit beetle and restoration of the population

Stages of breeding and population restoration of the hermit beetle are briefly described in these guidelines, whereas a comprehensive breeding and rearing methodology is provided in a separate publication „Methodology for Rearing and Breeding the Hermit Beetle (*Osmoderma barnabita*)“[7].

The aim of breeding a hermit beetle is creation of ex situ population which would be used to restore species in historical habitats. This aim is reached over several stages:

- Restoration of the favourable status for the habitats of the hermit beetle;
- Collection of the individuals of the hermit beetle in nature;
- Establishment of ex situ population;
- Releasing individuals of the hermit beetle to restored habitats;
- Monitoring of the restored population.

[7] Kristina Guzaitienė, *Methodology for Rearing and Breeding the Hermit Beetle (Osmoderma barnabita)*, Kaunas, 2021 (in Lithuanian and English languages).

5.1. Restoration of the favourable status of the habitats of the hermit beetle

It would be the best to restore populations of the hermit beetle in the territories which are known to have historical data on the presence of this species, however, due to the worsening conditions of the habitat, it is not found there anymore. One of the aims of the project was to restore a viable population precisely in a place of the said type: Natura 2000 site, the slope of Neris River by Verkiai. Although this Natura 2000 area has been designated for the conservation of the hermit beetle, this species has not been discovered there for more than ten years.

Since the hermit beetle is a thermophilic species, favourable status of the habitat is restored by reopening of the old hollow broad-leaved trees which had been once growing on the open sites (wooded pastures, woodland edges, old manor parks, around farmsteads) by clearing the shading undergrowth. In many cases the condition of old trees themselves must be also improved: to avoid any break of the trunk or trunk branches, the trees must be fastened by bracing, the weight of their crowns are reduced by partial crown reduction, the soil beneath the crown is aerated, fertilised or mulched, and where a tree grows in a place visited by people, – a risk for human safety is lowered.[8] These measures have been described in more detail in Chapter 3.

Restoration of favourable habitat conditions for the hermit beetle at the same time recreates possibilities for the restoration of the population of the hermit beetle in the site.

5.2. Collection of individuals of the hermit beetle in nature

Implementation of this breeding stage requires to select genetically suitable individuals for the establishment of ex situ population – they should not be genetically too far apart from the beetles, which lived in the restored areas, and their genetic variability should not be too low.

[9] Helen Read, *Veteran Trees: A guide to good management*, Veteran Trees Initiative, 2000.

Collection of adult beetles, larvae or cocoons in nature can be done only with permits obtained from a responsible institution (in Lithuania – Environmental Protection Agency). Adults are captured using pheromone traps in known and stable populations of the species and up to 2 % of adult individuals are collected. Since adult beetles are short-lived, they are transferred to the breeding boxes in the laboratories as soon as possible where they will be able to mate and lay eggs.

Larvae and cocoons of the hermit beetle discovered in fallen (for example, after a storm) or logged trees can be collected and, together with the substrate, transferred to the laboratory for breeding. Such collection of larvae and cocoons from nature is also subject to a receipt of the permit from the Environmental Protection Agency.

Figure 24. A female hermit beetle captured in a pheromone trap.

5.3. Establishment of *Ex situ* population

During the project, ex situ population was successfully embedded in Lithuanian zoological garden. It is important to create in a laboratory environment conditions suitable for rearing and breeding the hermit beetle and similar to those in nature.

PREPARATION OF BREEDING CONTAINERS AND OF THE SUBSTRATE IN THE LABORATORY

Hermit beetles are reared in ventilated plastic 40–60 l containers. The containers are filled with substrate made of:

Figure 25. Oak wood rot of fine fraction.

- 50–60 % of the leaves composted for 6–12 months and of mechanically shredded leaves of the pedunculated oak (Quercus robur);
- 40–50 % of the mould of the pedunculated oak affected by the wood rot. The rot is collected from old hollow or fallen oaks. Large parts are mechanically shredded to smaller fractions.

Both components of the substrate are well mixed and watered so that relative air humidity in the containers reaches 75–85 %. Later suitable humidity is maintained using a plant sprayer. It is convenient to use a digital thermometer-hygrometer for the measurement of humidity and temperature. Containers are stored in darkness.

TRANSFER OF ADULT BEETLES TO THE BREEDING CONTAINERS AND REARING THEREOF

10–15 individuals are reared in each breeding container, ratio of the females and males is 3:1. Optimal temperature is from +18 °C to +22 °C and it is maintained by an air conditioning system. Adult beetles are fed with fruit pieces (oranges, kiwi, bananas and grapes). In average, mated females lay 20–30 eggs deep in the substrate and 14–20 days later hatch larvae. Eggs and young larvae are in particular sensitive

Figure 26. A female hermit beetle (on top) and a male (bellow).

Figure 27. Larvae after the second wintering.

to disturbance, therefore, breeding containers are inspected (young larvae are counted, measured in length and sorted based on the size) 60–90 days after the beetles have been settled in the containers, but no later than in September. From the month of October, substrate is not disturbed and larvae are allowed to prepare for the wintering season.

TRANSFER OF LARVAE AND COCOONS TO BREEDING CONTAINERS AND REARING THEREOF

Substrate of the rearing containers for larvae is prepared in the same way as for adult beetles. Additionally, each container is filled with substrate taken from that tree where larvae or cocoons were collected. Larvae live in such substrate for 2–4 years depending on the time when eggs were hatched and on individual development features. It is important to keep breeding containers in optimal, close to natural conditions all over the year (Table 3).

Table 3.

OPTIMAL TEMPERATURE FOR THE BREEDING OF THE HERMIT BEETLE

MONTH	TEMPERATURE	COMMENTS
JUNE–AUGUST	From +20 °C to +22 °C	-
SEPTEMBER	+15 °C	Larvae are checked
OCTOBER–NOVEMBER	+10 °C	Larvae form a "wintering chamber"
DECEMBER–FEBRUARY	From 0 °C to +5 °C	-
MARCH–APRIL	Gradual increase to +15 °C	-
MAY	+20 °C	At the end of May larvae are checked

During the most intensive larvae feeding and growing time in May–August, substrate reduces by about one fourth, therefore, it is refilled with composted, shredded leaves of the pedunculated oak 1–3 times a season, so that growing larvae would be able to subsist. Part of larvae form cocoons already in the second year of life, others – in the third. During June–July, adult hermit beetles hatch from cocoons. They are used for further breeding in a laboratory.

Figure 28. Larvae are bred in containers.

5.4. Release of the individuals of the hermit beetles to restored habitats

Larvae and cocoons are transferred to the wood mould boxes specially designed for the hermit beetles and filled with wood rot (wood mould boxes are described in Section 5.5.) and placed in historical habitats of the species. Larvae are transferred in May–June, when average air temperature reaches +12 °C and above. Cocoons are relocated to nature in May–June, when air temperature is from +12 °C to +16 °C.

At the time of transfer the box is additionally filled with 20–40 litres of substrate from the breeding container in which larvae were growing and cocoons were formed. If larvae and cocoons are transferred at the same time, first go larvae which burrow deep in the substrate immediately after they are lodged, and only after that cocoons are carefully placed one after another (they are fragile and if the cocoon is affected the beetle can perish) and they are covered by a layer of substrate of about 10–20 cm thick. If good results of reintroduction are sought, it is recommended to lodge about 500 units of larvae and cocoons per one territory over the period of 2–5 years.

At the time of the project, larvae and cocoons of the hermit beetle were released to the nature in 2020 and 2021. 441 larvae and 80 cocoons have been settled to the wood mould boxes over the both years. In 2021, the first adult beetles have been noticed in the boxes and around them. And also in summer of 2021, an adult beetle has been captured by a pheromone trap in the slope of Neris River by Verkiai. The beetle could have flown from the wood mould box to a natural hollow in a tree. This shows that breeding and relocation were implemented successfully and it is probable that the population of the hermit beetle in the Natura 2000 site, the slope of Neris River by Verkiai, will successfully be restored.

Figure 29. Larvae and cocoons of the hermit beetle being released in the wood mould boxes at the slope of Neris River by Verkiai in 2021.

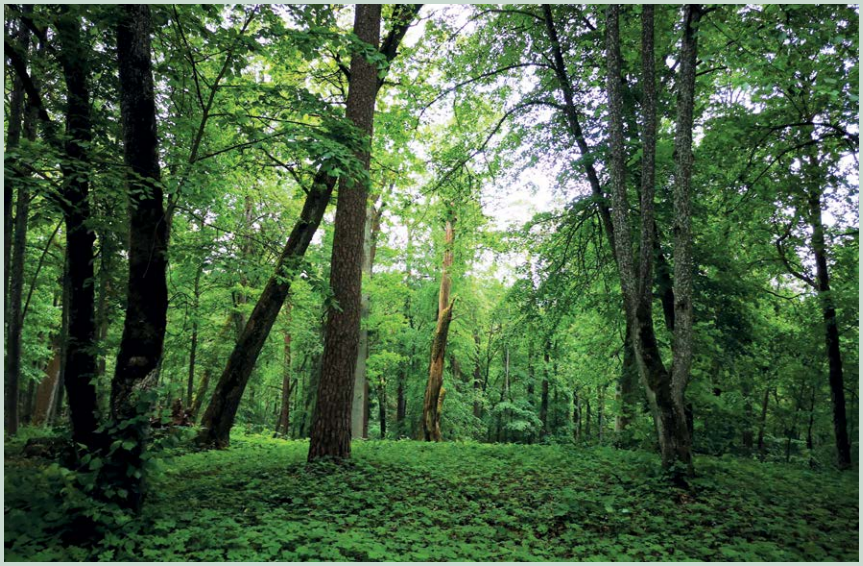

Figure 30. The slope of Neris River by Verkiai.

5.5. Wood mould boxes for the hermit beetle

Special wood mould boxes designed for the release of the hermit beetles to nature were produced in Sweden based on experience of „LIFE – Bridging the Gap" project carried out in Sweden, and this experience was adapted for the conditions of the specific territory (for example, there are many black woodpeckers in the slope of Neris River by Verkiai, therefore, a wood mould box was plated with a protective metal mesh). A detailed scheme for the construction of the wood mould box can be found on the web site *www.osmoderma.lt*. Wood mould boxes mimic an ecosystem of the natural cavity, they can be inhabited by different saproxilic insects, as well as by birds and bats (small vertical barriers have been constructed for them). A wood mould box is of 2,5 m height and 0,5 m width. From inside it is filled with oak leaves (about 50 %), sawdust of a larger fraction (up to 50 %) of broad-leaved trees (oak, maple, lime) and natural wood rot collected from nature. A big volume of the filling enables to maintain quite stable conditions inside the wood mould box, even in high freezing temperatures in winter. The wood mould box is placed in a sun-lit place in order to create favourable conditions for this thermophilic species.

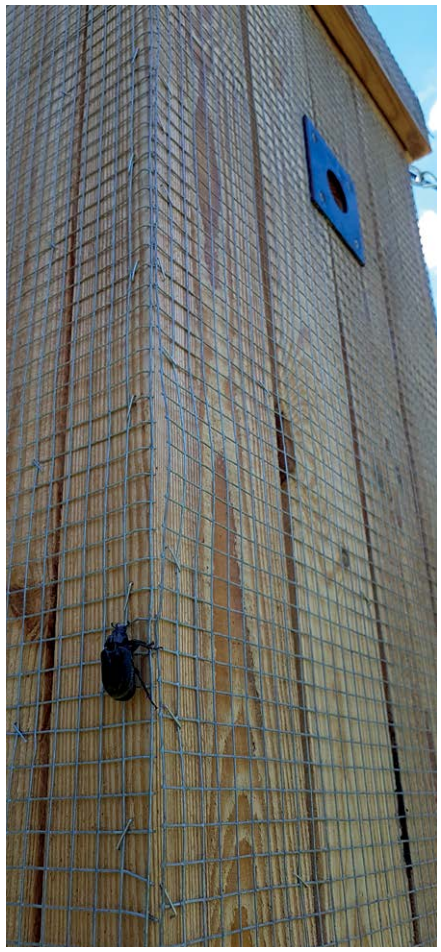

Figure 30. The slope of Neris River by Verkiai.

Figure 32. A wood mould box standing in Verkiai Manor Park and an information board nearby.

The wood mould box is filled with substrate moistened with about 30 l of water and from then on humidity is maintained naturally by the rain getting inside through the holes in the roof. In cases of droughts, it is possible to water additionally based on the need. During the implementation of the project, two such wood mould boxes have been placed in Neris Regional Park, in the Natura 2000 site, the slope of Neris River by Verkiai.

[9] J. Rimšaitė (ed.), *Europos bendrijos svarbos rūšių monitoringo metodikos. Žinduoliai, žuvys, varliagyviai, ropliai, moliuskai, vabzdžiai ir augalai. [Methodologies for monitoring species of European interest. Mammals, fish, amphibians, reptiles, molluscs, insects and plants]* Vilnius: Nature Research Centre, State Service for Protected Areas under the Ministry of Environment, 2016.

5.6. Monitoring of the restored population

The restored population can be easily affected, therefore, it is necessary to choose methods for monitoring it carefully. Checking occupancy and content of the cavity may result in the harm to the larvae and eggs of the hermit beetle. Monitoring performed with pheromone traps can cause disturbance to mating processes of the hermit beetles. Therefore, it is recommended to perform monitoring of the restored population every 5 years according to the monitoring methodology described in the publication on monitoring methods for the species of European interest.[9]

5.7. Action to save the hermit beetle – a case of Strėvininkai forest

In November 2019, specialists of the Lithuanian Fund for Nature discovered a woodland of 1,5 hectares which has been recently cut clear in Strėvininkai forest, Kaišiadorys region. Strėvininkai forest has been designated as a special area of conservation for the protection of the hermit beetle and Cucujus cinnaberinus. Based on Resolution No. 276 „On the approval of general provisions for the areas important for the protection of habitats or birds“ adopted by the Government of the Republic of Lithuania on 15 March 2004 „It is prohibited to log old hollow and drying trees in the habitats of the hermit beetle (*Osmoderma eremita*)“.

The Lithuanian Fund for Nature contacted responsible institutions in order to clarify whether the logging was done legally (several months later a reply was received that the logging was carried out legally). In order to prevent similar situations in future, the Lithuanian Fund for Nature has also contacted a forest owner concerning a possibility to donate several valuable logs containing larvae of the hermit beetle. It has been agreed to donate 4 logs with larvae to the Lithuanian Fund for Nature and transport them to Verkiai Regional Park, the Natura 2000 site - the slope of Neris River by Verkiai. This measure has been undertaken in order to save at least part of the population of the hermit beetle which lived in the felled oaks.

Figure 33. Logs with larvae of the hermit beetle and an information board nearby.

Figure 34. In summer of the same year when the transfer was done, several individuals of the hermit beetle crawled out from Strėvininkai logs.

06 Development of smart pheromone traps for the hermit beetle

One of project's objectives was to improve monitoring techniques and equipment by applying smart technologies and enhance understanding of ethology of the hermit beetle. It was accomplished by developing smart pheromone traps. Biggest advantage of such an improvement is a very fast response time after successful catch of a beetle. Also, if all traps are working efficiently, number of unnecessary traveling and extra fuel costs are reduced to a minimum.

Trial and error method was key in the development of the smart pheromone traps. It took several attempts until the right solutions were made. The first trap prototype (Figure 35) was developed in the summer of 2018. The trap efficiency and accuracy were low due to the problems related with the transducer (it records the beetles falling in the trap), data transfer, usage of instant data transfer through radio frequency, and a short time of autonomous operation. Experiments have shown that the most optimal results can be obtained with camcorder built in the trap, which records the beetles falling in the trap while using the video processing technology.

The second trap version (Figure 35) was equipped with a full-time recording video camera. In this trap data transmission was implemented using the GSM network. Due to the changes made in the trap structure, the trap controller had to be remade as well. Therefore, industrial controller was replaced by a single-board computer resulting in the necessity to reprogramme the device. To control electricity consumption, electricity charging/discharging currency sensor was installed in the trap. As a result of the above changes, energy efficiency of the trap was increased, and the time of autonomous operation was extended up to 21 days. The second version of the traps was tested in the field works of summer 2019. The developed prototype of traps operated in accordance with the expectations, however, as a result of the modification, the weight of the trap reached 11 kilograms, making it difficult to deliver the traps to remote places. Moreover, this trap had an irregular shape, which made the transportation even more difficult. After evaluating the functional aspects of the trap, it was decided to develop a new prototype.

The following requirements were established for the development of the third version of the traps: to reduce the weight and size, while maintaining the ability to receive data from the trap at least twice a day. Compliance with these requirements would provide easier movement and installation of the trap, as well as a quick release of trapped insects. To reduce the power consumption of the trap, it was decided to replace a full-time record video camera with a part time photo camera. This

Figure 35. Different trap versions.

led to a significant reduction in electricity consumption. To reduce the weight and the size of the trap, acid/lead batteries were replaced with lithium batteries resulting in the reduction of the weight of the trap to 1.5 kilograms, and their size was also significantly reduced (Figure 35). The chronology of the development of smart traps is shown in Table 4.

Table 4.

TIMELINE OF THE SMART TRAP DEVELOPMENT PROGRESS

TRAP PARAMETERS	2018 SUMMER TRAP VERSION (tested in field work)	2019 SUMMER TRAP VERSION (tested in field work)	2020 SUMMER TRAP VERSION (tested in field work)
DATA TRANSFER	Radio frequency Instant data transfer	GSM Instant data transfer	GSM Periodical data transfer
SOURCE OF POWER	Solar panel + lead acid battery	Solar panel + lead acid battery	Lithium ion battery
BATTERY LIFE (Time of autonomous operation)	3 days	21 days	30-40 days
MOTION DETECTOR	Light interruption detector	Full time record video camera	Periodical recorded photo camera
TRAP CONTROLLER	Industrial controller	Single board computer	Single board computer
ADDITIONAL OPTIONS	· humidity sensor · temperature sensor · electricity charging/ discharging current sensor	· humidity sensor · temperature sensor · electricity charging/ discharging current sensor	· humidity sensor · temperature sensor · clogging sensor
TRAP BODY WEIGHT SIZES	6 kg 35cm X 65cm X 40 cm	11 kg 35cm X 65cm X 40cm	1.5 kg 30cm X 30 cm X 24cm

THE FINAL VERSION OF THE TRAP CONSISTS OF 4 MAIN PARTS:

- Frame
- Funnel with a cover and a cotton swab inside containing pheromone
- Watertight case with a photo camera and electronic components.
- Plastic case with sawdust to collect fallen beetles.

TRAP CASES WITH ELECTRONIC COMPONENTS CONSIST OF:

- Two 7,30 V Li-Ion batteries, with 8 Ah rated capacity for each battery – 16 Ah in total.
- 7,5 A fuse
- Switch
- Charging port XT-60
- Adafruit TPL5110 Low Power Timer Breakout
- DC-DC "buck" converter, that constantly provides 5 V.
- Raspberry Pi zero GPIO microcontroller
- SIM800 GSM modem
- GSM Antenna
- Photo camera
- IR LED and it's sensor
- Temperature and humidity sensor
- Connecting wires

After turning on, power from the batteries powers up DC-DC converter, which provides constant 5 V for whole system. Then immediately turns on Low Power Timer Breakout, which then turns on a Raspberry Pi zero GPIO microcontroller. The timer works up to 2 minutes or until the confirmation is received from the microcontroller. Then it goes into a "sleep" mode for two hours, wakes up and repeats the process over and over again. When the Raspberry microcontroller boots up, it makes pictures and connects to GSM provider through GSM modem. If light in the beetle collecting case is insufficient, IR sensor and LED provide light during the night time. All the pictures are also stored in a 16 GB MicroSD card together with a program code. Together with the picture, the trap sends temperature and humidity data to the database which is accessible via www.biology.lv/traps.

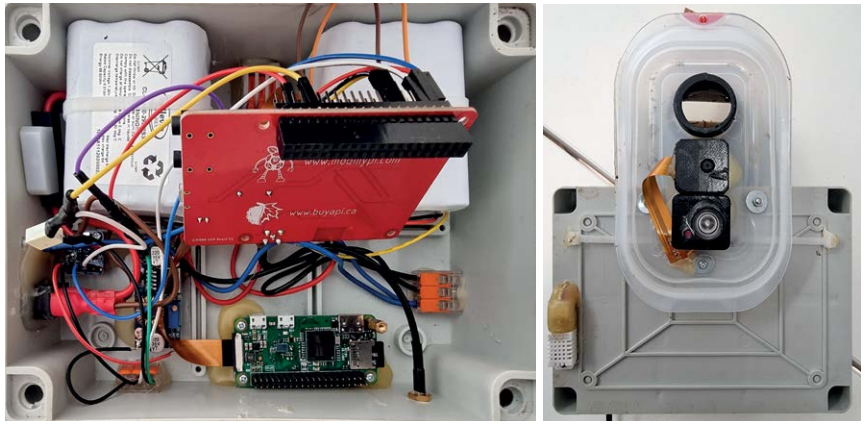

Figure 36. Inside view of a smart trap with electronic components visible.

If GSM coverage is insufficient and microcontroller cannot send out data in 2 minutes, it goes to a "sleep mode" and when it "wakes up" in 2 hours it will firstly try to send new pictures and other stored but not uploaded pictures.

A total cost of the electronic parts per trap is around 200 €, the price for the mobile data ~10 € for 2 months. Assembling time is also much longer when compared to a conventional trap. Occasionally, some of the electronic components might be bogus and compromise the whole system of the trap, most commonly – the GSM modems and DC-DC converters.

In conclusion, the smart pheromone traps are a great option for the monitoring in remote areas or when having many distant places, where traveling time might be saved. For small-scale and local investigations this option might become too expensive or require unproportionally long time for preparation.

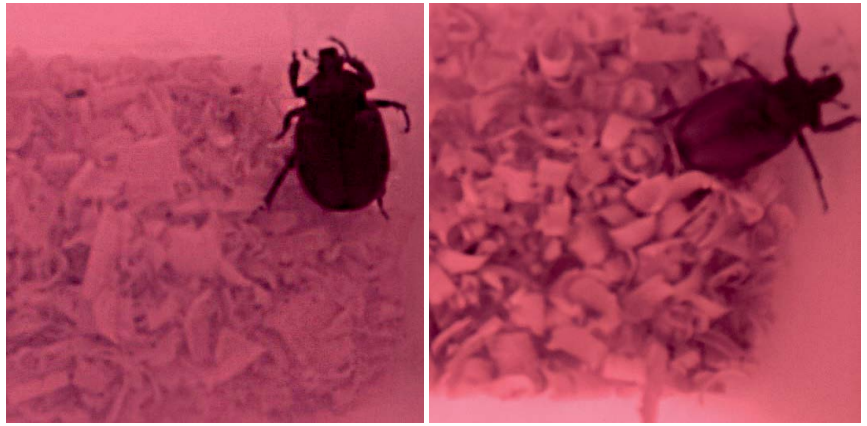

Figure 37. After receiving a picture like this to the database, you can be sure that travelling to the monitoring site will not be in vain.

07 Eradication of invasive tree species

An ash-leaved maple (*Acer negundo L.*) is one of the tree species included in the List of Invasive Species of Lithuania. This species of maple is naturally found only in North America. It is a very aggressive and easily spreading species in Lithuania overgrowing local plant species, changing habitats and thus destroying natural biodiversity of Lithuania. An ash-leaved maple is a adaptive species characterized by high tolerance to the lack of water and nutrients making it able to adapt and grow in different conditions: flooded meadows, mixed forests, pine woods, river banks, urbanized territories, abandoned fields, roadsides, areas around railway lines, landfills and even on the roofs of the buildings. Ash-leaved maples reach their fruiting age relatively fast. Their fruiting age depends on the conditions of the area where the tree grows: in open and sufficiently fertile areas seed production can start as soon as after five years, whereas in the forest, where there is more shade, it can last for 15 and more years. The number of produced seeds depends on the quantity of the light falling on the ash-leaved maple. One mature female ash-leaved maple (this species is dioecious) can produce huge quantities of seeds – 100–500 thousand units or even more. Dispersal speed of the species of the ash-leaved maple reaches 0, 6–1 m/year, when seeds are spread by the wind, however, accidental spreads by cars, trains or water increase the rate of dispersal up to 100 m/year.

Ash-leaved maples cause the biggest threat to natural flooded meadows and habitats of the riverside shrubs where, just in several years, it becomes a dominating plant species. Ash-leaved maples, usually growing along riparian areas, tend to lean down until they eventually fall down or break during the ice-drift or storm. A fallen trunk up-roots and produces new suckers giving rise to new leaning trees which, in the long run, fall down again. In this way a vegetation complex uncharacteristic to local conditions is formed dominated by ash-leaved maples, while previously customary willows and aspens are deprived of the possibility to grow. The “jungle” unusual to the local landscape becomes a desert in terms of biodiversity and not attractive for recreation. Such a stand of the ash-leaved maples forms millions of seeds which, dispersed by the wind and water, establish themselves in new territories. The threat posed by the ash-leaved maple is increased by the fact that outside the boundaries of its natural range it has no usual pathogens which make it quite sensitive in Northern America.

Apart from the damage caused by them to Lithuanian nature, ash-leaved maples are marked by other negative aspects as well. They are among the trees that are earliest to spread pollen in Lithuania. Large amounts of the pollen, which typically reach the highest concentrations

Figure 38. A new abundant generation of the ash-leaved maple is maturing.

in the city green areas, are produced by ash-leaved maples causing a hay-fever for people prone to allergies. Disorderly sprouted shoots in the urban green territories distort the aesthetic look and this requires additional funds for the management. Besides that, they often break or tumble down thus causing danger to the safety and property of people.

Due to these characteristics, it has been chosen to perform eradication of this invasive tree species on several territories during the implementation of the project LIFE OSMODERMA – in the Natura 2000 sites: Kaunas Oak Park and the slope of Neris River by Verkiai.

7.1. Methods of eradication

Measures for the eradication of the ash-leaved maple are divided to physical and chemical measures. Physical eradication measures include the following: pulling or digging out of young plants, cutting of young or mature trees and removal of re-shooting suckers by cutting them off. Chemical measures are based on the effect of herbicides. The problem that is most often faced when eradicating an ash-leaved maple is a large number of suckers regrowing after cutting this tree down. If, before cutting an ash-leaved maple, it is not processed with chemical substances from the very beginning, it may be necessary to remove

Figure 39. Shortly after cutting down the trunks of the ash-leaved maple in the warm period of the year, plenty of suckers appear from the sleeping buds.

the suckers for a number of times each year and repeat this for several years. The best results are obtained by combining different measures of eradication depending on the age, growing conditions, habitat location and sensitivity to eradication measures.

UPROOTING AND EXCAVATING OF THE ASH-LEAVED MAPLES.

This is the most effective way to eradicate ash-leaved maples, but it requires a lot of hard physical work making this method rather costly in larger areas. Uprooting and excavating have a very low negative effect on the plants of other species and on the animals, that is why this method suits perfectly in protected and sensitive natural areas high in biological diversity. It is best to remove ash-leaved maples when they are easily recognized and distinguished from other trees and bushes – from the mid of June to the mid of August. Young ash-leaved maples are most effectively removed when their size ranges from the span to the human height, they are uprooted while grasping them by the trunk close to the root neck. If the roots are harder or the soil is heavier, the roots can be undercut with the spade. Ash-leaved maples removed in this way regrowvery rarely. It is in particular important not to cut the stem above the ground to prevent formation of a denser overgrowth from the re-shooting of the new suckers. It is not allowed to throw down the torn ash-leaved maples directly on the ground, because, if the soil is humid, they can easily re-root. Therefore, it is advisable to clear them off from the area or

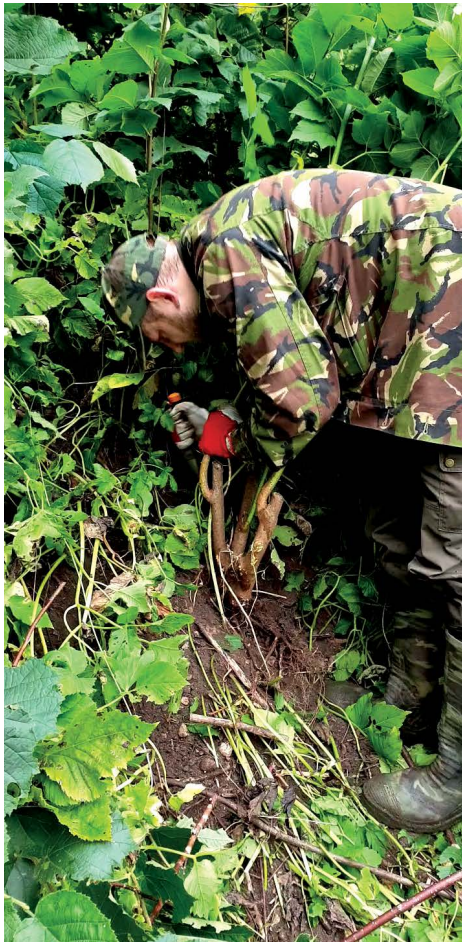

Figure 40. Uprooting an ash-leaved maple on the slope of Neris River by Verkiai.

hang them up on the shrubs or trees growing nearby, or, in the worst case, to leave them lying in the sun on the grass after removal of the soil from the roots in order they dry out and die as soon as possible.

LOGGING OF ASH-LEAVED MAPLES

Ash-leaved maples, which are too big to pull or excavate, can be cut with benzine chainsaws or shrub-cutters (depending on the thickness of the trunk). This is not a very complicated measure and work costs are usually similar to those of the management of the abandoned fields, track cleaning or logging of the selected forest trees (depending on the density of the ash-leaved maples and local conditions). Lumber and waste produced after the logging can be used for biofuel or rendered to the owners of the managed land plots. It is best to discuss this question in advance, before starting eradication of these invasive trees. After the ash-leaved maples are felled, dispersal of the seeds and pollen is halted for at least five years. However, cut stumps of the ash-leaved maples sprout a plenty of new suckers. This measure is recommended only if a possibility to remove sprouting suckers at least 1-2 times a year is ensured, for example, in the managed water sites, lawns, mown hay meadows and similar places. In all other cases this can be used as a secondary measure for managing the territory and removing ash-leaved maples that dried out after processing with herbicides.

ERADICATION OF ASH-LEAVED MAPLES USING HERBICIDES

Ash-leaved maples are sensitive to the herbicides of the glyphosate group. Sprayed with the herbicide solution the tree is weakened but not killed. To prevent it from re-shooting it is necessary to apply herbicides to the trunk or stump of the ash-leaved maple. This can be done in several ways:

- Remove the bark and apply the herbicide solution to the trunk,
- Brush herbicides onto the freshly cut stump,
- Use applicators to fill in the herbicide solution into the holes drilled into the trunk,
- Hammer capsules with the herbicide granules into the drilled holes.

All four methods are relatively expensive, because every single ash-leaved maple has to be affected on the whole territory, which demands a lot of time and efforts, special tools and special preparation. Although herbicides are used for the chemical eradication, this method is of little damage to the environment, because just a trunk of an individual tree is affected, no spraying is done on the invasive tree and foliage

of the surrounding vegetation. The first two methods (brushing of the herbicides) are not very effective, because just less than 60 % of the trees die from such a treatment, the remaining trees survive and continue dispersing their seeds.

A much effective and faster method is injecting of the herbicides directly into the trunk at the stump level. This method can be applied for the ash-leaved maples with trunks of the diameter exceeding 25 cm. This method allows effective eradication of quite large patches of the ash-leaved maples. The measure of hammering special capsules with glyphosate granules into the drilled holes is somewhat more costly. This is due to the price of the capsules which, as compared to other herbicides, is quite high. This measure proved to be useful when single ash-leaved maples have to be eradicated or when repetitive eradication is expensive. Efficiency of injecting herbicides into the trunk reaches about 90 %, therefore, willing to eradicate ash-leaved maples completely, the works must be done repetitively (in this case the scope of works is usually much smaller than at the beginning of eradication).

Figure 41. Marks of the holes drilled in the stump of the cut ash-leaved maple and filled with the herbicides are visible. This will prevent dispersal of seeds for good and all.

7.2. Conditions for the execution of works while applying chemical elimination

Herbicides must be used in accordance with all environmental and personal work safety requirements. The worker must be equipped with special clothes, footwear, gloves, respirators and eyeglasses. Persons working with herbicides on the territory of Lithuania must complete the courses intended for the professionals using plant protection products. It is desirable that they have skills and experience of work with plant protection measures.

Eradication of invasive plants must be carried out in accordance with the legal acts. In Lithuania, this is regulated by the Description of the Procedure for the Control and Eradication of Invasive Species. Prior to the start of the works, at least 10 working days before the start of eradication, it is necessary to notify private or state land owners about the plans to use invasive species' eradication measures on their land and about the specific date of work execution.

Eradication works of ash-leaved maples can be carried out only by the workers capable of distinguishing ash-leaved maples from other trees. Before the work is started, it is necessary to instruct the workers and introduce them to the methods of recognition of the ash-leaved maples of the different age, tools of eradication and procedure for the work execution. If workers are hired for the eradication of invasive species, it is useful to check the course and quality of the works, deployed tools, measures of protection and work efficiency at any time.

It is best if chemical processing is done after the sap flow in June–August, when the trees are in full foliage, frosts are not probable, ambient temperature is not higher than +25 °C, and the weather is not rainy. Holes of 8–10 mm in diameter and 5–6 cm in depth are drilled in the trunk of the ash-leaved maple as close to the ground surface as possible and spaced at least every 4 cm around the entire trunk. If the tree diameter is bigger than 20 cm, two rows of the holes are drilled, if the diameter is bigger than 30 cm – three rows are drilled and so on and so forth. A 9 mm diameter drill is of an optimal size, because a 10 mm diameter drill needs more of accumulator energy resources and a hole made by an 8 mm diameter drill is more difficult to fill in with the herbicide.

The holes must be immediately filled with the glyphosate solution applying 3–5 ml of the solution per each hole. A preparation containing 450 g of the active substance per 1 litre is used. The preparation is diluted with water at the ratio of 1:2. If the amount of the active substance is bigger or smaller than 450 g/l, the norm of diluting with water must be adjusted accordingly, but by no means can the prescribed concentration be reduced. Herbicides are carefully injected into the holes using manual applicators or small manual sprayers to spray the solution at a moderate flow and jet. It is necessary to prevent herbicides from dropping and drifting on the adjacent plants. It is required to spread a protective sheet on the place where the herbicides are mixed and poured (if that is done on the ground surface) to prevent the herbicide from getting into the environment.

Special capsules containing glyphosate active substance are hammered into the evenly drilled holes of the trunks 30–35 mm in depth and 13 mm in width. Holes must be spaced from one another no more than 6–8 cm. The number of drilled holes is indicated in the manuals of the producers. This work requires to use a specially prepared drill or another method ensuring an accurate depth of the drilled holes. The number of capsules must be chosen based on the producer's instructions. If no instructions are provided specifically with respect to the ash-leaved maples, a parameter calculated for the aspens and multiplied by 1,5 times shall be used.

Trees treated with chemical preparations display stripes of bright colours around the tree perimeter. Paints of one colour only should be used for all the trees to facilitate their identification. This facilitates discovery of treated trees at a later stage, when 2–3 weeks later effect of the preparation is checked and dried trees are felled. Trees that are found not to have dried are once again treated with glyphosate through the additionally drilled holes. After this treatment, the trees are marked with a stripe of the bright-coloured paints around the entire trunk using the paints of a different colour than those used to treat the tree for the first time, or a new stripe can be used beside the previous marking. The procedure is repeated until not a single viable ash-leaved maple is left on the territory.

COMPLEX MEASURES FOR THE ERADICATION OF THE ASH-LEAVED MAPLES

All methods for the eradication of the ash-leaved maple have different advantages and drawbacks, thus the biggest impact over the shortest period of time at the least cost is gained only by combining different measures. Young ash-leaved maples are best eradicated by uprooting them, and if they are spread in abandoned meadows or soils and are still young – by cutting them. The best option for trees which cannot be uprooted is to treat them with herbicides and cut them down after they have dried.

Summary

Activities of the project LIFE OSMODERMA embraced management of one of the biggest organisms in Lithuania – ancient trees, and restoration of the population for one of the smallest organisms – the hermit beetle. Chances of survival for the hermit beetle, which spends majority of its life in the cavities of mature broad-leaved trees, directly depend on the age, condition and abundance of such trees. Each ancient tree whose life is prolonged contributes to the halt of the loss of many species. In this publication we have reviewed only the main measures implemented during the project and we hope they will help veteran trees and species dependent on them to live and flourish long. We wish to promote a broader dissemination of this good practice and practical application of the described measures, because part of organisms associated with the veteran trees have adapted to live only in them and every tree suitable for a shelter, even if that shelter is just temporary, is important for such species.

All these activities would not be possible without public involvement. Consciousness of tree owners (more than 600 owners have agreed to permit arboristic maintenance works and signed the commitments to protect the trees), information boards on importance of dead wood, undertaken arboristic tree management or information boards containing facts about ancient trees and species living in them received a lot of attention from people. The sites chosen by the project are the Natura 2000 sites, which are intensively visited by the people, part of them are city parks, therefore, we have been constantly subject to human attention not only during arboristic works, but also while arranging events or promoting information in social networks and on the project web site. We are glad that people are increasingly in favor of veteran trees being managed by professional arborists and that ancient trees are less and less deemed as posing a threat, as our three-year survey of visitors to Kaunas Oak Forest, Dūkštos Oak Forest and Verkiai Manor Park has showed. However, public awareness on environmental issues is just getting pace and with this publication we aim to support the idea that you can never have too much of ecological education.

Figure 42. Looking for traces of hermit beetle activity during the event „Secrets of Nature“ in the Verkiai Manor Park.

Figure 43. During the event in Kaunas Oak Forest, the participants were able to test the arboristic equipment themselves by climbing a tree.

Life Osmoderma

OTHER PUBLICATIONS ISSUED IN THE COURSE OF THE PROJECT

METHODOLOGY FOR REARING AND BREEDING THE HERMIT BEETLE (*OSMODERMA BARNABITA*)(LT, EN)

MAINTENANCE AND MANAGEMENT GUIDELINES FOR VETERAN TREES AND DEADWOOD (LT, LV, EN)

CROSS-BORDER ECOLOGICAL NETWORK FOR THE SPECIES DEPENDENT ON BROAD-LEAVED ANCIENT AND VETERAN TREES

They can be all found on the web site
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