

# Conservation of saproxylic beetles in the Carpathians

Marian D. Mirea<sup>‡</sup>, Steluta Manolache<sup>‡</sup>, Cristiana M. Pioarca-Ciocanea<sup>‡</sup>, Andreea Nita<sup>‡</sup>, Iulia V. Miu<sup>‡</sup>, Viorel D. Popescu<sup>‡,§</sup>, Bekka S. Brodie<sup>§</sup>, Matei I. Dragomir<sup>¶</sup>, Ion Militaru<sup>¶</sup>, Silviu Chiriac<sup>#</sup>, Laurentiu Rozyłowicz<sup>‡</sup>

<sup>‡</sup> University of Bucharest, Center for Environmental Research, Bucharest, Romania

<sup>§</sup> Ohio University, Athens, United States of America

<sup>|</sup> Association for Biodiversity Conservation, Focsani, Romania

<sup>¶</sup> RNP Romsilva, Putna-Vrancea Natural Park Administration, Tulnici, Romania

<sup>#</sup> Environmental Protection Agency Vrancea, Focsani, Romania

Corresponding author: Steluta Manolache ([aanamanola13@gmail.com](mailto:aanamanola13@gmail.com))

Reviewable

v 1

Received: 02 Feb 2021 | Published: 03 Feb 2021

Citation: Mirea MD, Manolache S, Pioarca-Ciocanea CM, Nita A, Miu IV, Popescu VD, Brodie BS, Dragomir MI, Militaru I, Chiriac S, Rozyłowicz L (2021) Conservation of saproxylic beetles in the Carpathians. Research Ideas and Outcomes 7: e63874. <https://doi.org/10.3897/rio.7.e63874>

## Abstract

Romanian Carpathians are considered a biodiversity hotspot in Europe, with large forested areas, including old-growth forests. Past forestry practices, such as selective logging resulting in forest high grading and removal of ancient or decaying trees, reduced the heterogeneity of forest structure and composition. These practices led to forest habitats with few veteran trees and a small amount of deadwood, which protected saproxylic beetles rely on for completing their complex life cycles. Moreover, saproxylic species are considered pest species under traditional forestry practices, as they reduce the value of timber. As such, Romanian forestry practices have actively sought to reduce the amount of deadwood in an effort to decrease the presence of saproxylic species, thus effectively isolating stands with a high diversity of saproxylic beetles.

The European Commission will finance the project LIFE19 NAT/RO/000023 Conservation of saproxylic beetles in the Carpathians LIFE ROSalia. The project aims to stop and reverse the loss of protected saproxylic beetles (Rosalia longicorn *Rosalia alpina*, the hermit beetle *Osmoderma eremita*, great capricorn beetle *Cerambyx cerdo*, grey beetle *Morimus funereus*, and stag beetle *Lucanus cervus*) in the Carpathians by demonstrating

conservation actions for increasing the connectivity of favorable habitats in the ROSCI0208 Putna-Vrancea (Eastern Carpathians, Romania), and transferring and replicating best management practices in other Romanian Natura 2000 sites.

LIFE ROSalia will be implemented between 2020 and 2025 by the Environmental Protection Agency Vrancea, the Center for Environmental Research at the University of Bucharest, the Putna-Vrancea Natural Park Administration, and the Association for Biodiversity Conservation.

## Keywords

Saproxylic beetles, Habitats Directive, EU Biodiversity strategy for 2030, Natura 2000, Putna-Vrancea Natural Park, LIFE Nature

## Rezumat în limba română

Carpații sunt printre cele mai importante centre de biodiversitate din Europa, datorită gradului mare de împădurire și a prezenței unor suprafețe importante cu păduri seculare. Practicile silviculturale din trecut nu au avut mereu biodiversitatea ca obiectiv central al gospodăririi fondului forestier. De exemplu, arborii seculari sau arborii maturi vătămați au fost recoltați selectiv, rezultând parcele forestiere cu structuri și compoziții lipsite de heterogenitate. În unele zonele, astfel de practici au dus la păstrarea unui număr foarte mic de arbori seculari și cantități reduse de lemn mort, periclitând habitatele unor specii de coleoptere saproxilice protejate. Astfel de specii erau considerate în trecut ca fiind dăunători biotici, astfel că practicile silviculturale căutau să reducă pe cât posibil cantitatea de lemn mort prin tăieri de igienă sau chiar tratamente chimice, izolând sau eliminând parcelele cu diversitate mare de coleoptere saproxilice.

În vederea atingerii obiectivelor Directivei Habitate, Comisia Europeană va finanța proiectul LIFE Nature LIFE19 NAT/RO/000023 Conservarea coleopterelor saproxilice din Carpați LIFE ROSalia. Proiectul va contribui la implementarea unor bune practici de conservare a coleopterelor saproxilice demonstrate în alte zone din Europa, fiind primul proiect LIFE din România care vizează conservarea unor specii saproxilice. Scopul proiectului este stoparea și inversarea tendinței de pierdere a habitatelor speciilor de coleoptere saproxilice cu areal în Carpați protejate prin Directive Habitate (croitorul alpin *Rosalia alpina*\*, gândacul sihastru *Osmoderma eremita*\*, croitorul mare *Cerambyx cerdo*, croitorul cenușiu *Morimus funereus* și rădașca *Lucanus cervus*), prin demonstrarea unor acțiuni de conservare pentru creșterea conectivității habitatelor favorabile în ROSCI0208 Putna Vrancea (Parcul Natural Putna-Vrancea) și replicarea activităților cele mai potrivite în alte situri Natura 2000 din România.

LIFE ROSalia va fi implementat de un consorțiu alcătuit din Agenția pentru Protecția Mediului Vrancea (beneficiar coordonator), Universitatea din București, Centrul de Cercetare a Mediului și de Efectuare a Studiilor de Impact, RNP Romsilva Administrația

Parcului Natural Putna-Vrancea RA și Asociația pentru Conservarea Diversității Biologice (beneficiari asociați).

## Introduction

Romanian Carpathians are considered a biodiversity hotspot in Europe, hosting large forested areas, including old-growth forests (Rey et al. 2007). Past forestry practices such as selective logging resulting in forest high grading and removal of ancient or decaying trees reduced the heterogeneity of forest structure and composition (Munteanu et al. 2016). These practices led to forest habitats with few veteran trees and a small amount of deadwood, which protected beetles such as *Rosalia alpina*, *Osmoderma eremita*, *Cerambyx cerdo*, *Morimus funereus* and *Lucanus cervus* rely on for completing their complex life cycles (Lachat et al. 2012). Moreover, saproxylic species are considered pest species by traditional forestry practices, as they reduce the value of timber. Romanian forestry practices actively sought to reduce the amount of deadwood in an effort to decrease the presence of saproxylic beetles, effectively isolating stands with a high diversity of saproxylic beetles, e.g., by using salvage logging (RNP Romsilva 2019, MAPAM 2003).

LIFE ROSalia project (Fig. 1) aims to stop and reverse the loss of priority and non-priority saproxylic beetle populations in the Carpathians by demonstrating conservation actions for increasing the connectivity of favorable habitats in the ROSC10208 Putna-Vrancea (Eastern Carpathians, Romania), and transferring and replicating suitable actions in other Romanian Natura 2000 sites.



Figure 1. [doi](#)

LIFE19 NAT/RO/000023 Conservation of saproxylic beetles in the Carpathians LIFE ROSalia (<https://liferosalia.ro/>)

The project **objectives** are:

- to increase the connectivity between patches of old-growth forest in the Romanian Carpathians by creating 22 stepping-stone habitats in Putna-Vrancea Natura 2000 site, suitable for *Rosalia alpina*<sup>\*</sup>, *Osmoderma eremita*<sup>\*</sup>, *Cerambyx cerdo*, *Morimus funereus*, and *Lucanus cervus*;
- to increase the understanding of the role and ecosystem services provided by the saproxylic beetle communities and associated habitats for biodiversity and forest resilience, and strengthening the involvement of stakeholders and the local communities in the conservation of these species in Romania;

- to update the knowledge regarding concrete conservation of priority and non-priority protected saproxylic beetles among stakeholders from the project area and Romania, by active knowledge transfer and replicating the techniques demonstrated during the project;
- to create and legally bind a national action plan for saproxylic beetles (*Rosalia alpina*, *Osmoderma eremita*, *Cerambyx cerdo*, *Morimus funereus*, and *Lucanus cervus*) as a method to unlock the use of concrete conservation of saproxylic species at the national level in the medium and long term.

## Species targeted by the project

The project targets five saproxylic beetles' species, protected by EU Habitats Directive (\* indicate a priority species Directive 92/43/EEC 1992).

### **Rosalia Longicorn *Rosalia alpina*\* – Natura 2000 code 1087**

Listed in Annex II of Habitats Directive (Directive 92/43/EEC 1992), in Unfavourable-Inadequate status in RO Alpine biogeographical region (European Commission 2018), Least Concern according to IUCN RedList Europe (Nieto and Alexander 2010). The project area covers an important region to *Rosalia longicorn* in Romania and Europe (Rozyłowicz et al. 2019, APNPV 2020, Miu et al. 2020), as Romania hosts one of the largest populations of Europe and habitats in the area can host a large population and unfragmented (European Commission 2018). The adults of *Rosalia longicorn* can be observed mainly between July and August. Females lay eggs about 2-4 cm deep in the crevices of deciduous trees such as Beech (*Fagus sylvatica*), but also *Ulmus*, *Carpinus*, *Tilia*, *Castanea* spp. The larval development lasts 2-3 years and begins in decaying wood, exposed stumps, standing or fallen trunks, avoiding contact with the ground. The xylophagous larvae drill galleries and feed on the xylem. The pupation occurs in spring or early summer, the adults emerging between June and August when they can be seen on the host plants (Gîdei and Popescu 2014, Lachat et al. 2012, Campanaro et al. 2017). The *Rosalia longicorn* relies on low-density stands or forest edges (while avoiding shaded microhabitats), wood pastures (with isolated trees), sun and rain exposed trees, pastureland with very old trees and dead branches. The continuity of the deadwood recruitment is essential for dispersal. The mature individuals can disperse up to 1.6 km (Campanaro et al. 2017). It is considered pest species by forestry professionals (RNP Romsilva 2019), but is generally accepted as a species without a significant negative impact on forestry and forest products.

### **The Hermit Beetle *Osmoderma eremita*\* – Natura 2000 code 1084**

Listed in Annex II of Habitats Directive (Directive 92/43/EEC 1992), in Unfavourable-Bad status in RO Alpine biogeographical region (European Commission 2018), Near Threatened according to IUCN RedList Europe (Nieto and Alexander 2010). *Osmoderma eremita* species complex is included in the latest Standard Data Form (SDF) of ROSCI0208 as data deficient (MMA 2019). The hermit beetle adults can be observed from June to early September, during the daytime. They have a range up to 250 m in radius. The females lay

up to 90 eggs inside the wood mould or in the hollow trees, with a larval development taking about 2-3 years or even longer if the climatic conditions are not optimal. In the last year of larval development, the larvae construct a cocoon made of their excrements and wood mould. The adult males produce a fruity-odor pheromone to attract females (Gîdei and Popescu 2012, Iorgu 2015, Maurizi et al. 2017). The hermit beetle habitat is restricted to veteran, mature trees with decaying heartwood and a moderate sun exposure located in shrub free areas within forests (Iorgu 2015, Jansson et al. 2009, Carlsson et al. 2016, Maurizi et al. 2017). *Osmoderma eremita* may occupy mature broad-leaved woodland with wood mould in the project area, at the base of hollow living trees, especially trunks with large cavities resulting from natural fungal decay of the dead heartwood (Iorgu 2015, MMAP 2019).

### **The Great Capricorn beetle *Cerambyx cerdo* - Natura 2000 code 1088**

Listed in Annex II of Habitats Directive (Directive 92/43/EEC 1992), in Unfavourable-Bad status in RO Alpine biogeographical region (European Commission 2018), Near Threatened according to IUCN RedList Europe (Nieto and Alexander 2010). Not included in SDF of ROSCI0208 (MMAP 2019) but included in the latest inventories carried out by the Putna-Vrancea Natural Park administration. The adults of this species can be observed between May and September, being generally active at twilight. Between May and September, the female can lay up to 300 eggs in deadwood part of living, very old and unshaded trees (e.g., injuries on the trunk or in branches of very old trees) (Drag and Cizek 2018, Gîdei and Popescu 2014). In the project area, *Cerambyx cerdo* can be found in deadwood of standing veteran oak trees (*Quercus* spp.) and other deciduous species, selecting very old oaks and decaying trees that have a diameter larger than 40 cm (APNPV 2020). The species is marginally present in the area due to the limited availability of oak forests, however, when present is abundant. The species is considered a pest by foresters (MAPAM 2003, RNP Romsilva 2019).

### **The Grey Beetle *Morimus funereus* – Natura 2000 code 1089**

Listed in Annex II of Habitats Directive (Directive 92/43/EEC 1992), Unfavourable-Inadequate status in RO Alpine biogeographical region (European Commission 2018), Vulnerable according to IUCN RedList ver 2.3. Not included in SDF of ROSCI0208 (MMAP 2019) but present in the latest inventories carried out by the park administration. The adults of this species can be observed between March and September, mostly active at twilight and night hours but can also be seen during the day, depending on climatic conditions. The females lay eggs in the tree trunks, with larvae developing under the bark of decayed wood in the first stage, while in the ultimate stage, they develop in the heart of the trunk. The larval development takes 3-5 years (Hardersen et al. 2017, Gîdei and Popescu 2014, Leonarduzzi et al. 2017). In the project area, *Morimus funereus* can be found in well-structured forest habitats abundant in deadwood, large standing tree trunks and also in-ground trunks and large logs or large branches. The species is informally considered a pest by foresters (RNP Romsilva 2019).

### **The Stag Beetle *Lucanus cervus* – Natura 2000 code 1083**

Listed in Annex II of Habitats Directive (Directive 92/43/EEC 1992), in Unfavourable-Bad status in RO Alpine biogeographical region (European Commission 2018), Near Threatened according to IUCN RedList Europe (Nieto and Alexander 2010). Not included in SDF of ROSCI0208 (MMAP 2019) but present in the latest inventories carried out by the park administration. The adults of this species can be visible from mid-April to September. The females are digging down in the dead tree bark crevices, but also in the roots of rotten trees, preference for oak, apple, ash, or cherry trees to lay their eggs, selecting warm places on sandy or light soils. They are mostly active in the evening, being able to fly 1 to 3 km. As larvae, depending on weather conditions, they spend up to five-six years tunneling through and consuming rotting wood and building up fat reserves (Bardiani et al. 2017, Gidei and Popescu 2012, Lachat et al. 2012). The species is marginally present in the area due to the limited availability of oak forests, however, when present, it is abundant (APNPV 2020).

### **Area targeted by the project**

#### **Putna-Vrancea Natural Park, Vrancea Mountains NATURA 2000 Code ROSCI0208 Putna-Vrancea**

Putna-Vrancea Natural Park was established in 2004 by Government Decision 2151 regarding establishing the protected natural area regime. The area conservation status was elevated as Natura 2000 area, i.e., Site of Community Importance ROSCI0208 Putna-Vrancea and Special Protection Area ROSPA0088 Vrancea Mountains (APNPV 2020, MMAP 2019).

Putna-Vrancea Natura 2000 site overlaps the central and northwestern sectors of the Vrancea Mountains (Fig. 2). The site is part of the external group of Curvature Carpathians, overlapping the Putna river catchment area. The main relief units within the Putna-Vrancea Natura 2000 site are Lăcăuți-Goru, Coza, Lepșa, and Zboina Neagră. The Lăcăuți-Goru area unfolds on the general direction NV-SE, between Basca Mare and Zăbala rivers. The maximum elevation of the Vrancea Mountains and in Putna Basin - Goru Peak (1784 m) and Lăcăuți Peak (1776 m). Coza Mountain extends at the north of Zboina Frumoasa and is bounded by rivers Putna at the north, Zăbala (southwest), and Năruja (southeast) (APM Vrancea 2009).

#### **Flora**

To date, researchers described over 650 vascular plants, a high species richness for a mountain area. Species of conservation interests include the lady's-slipper orchid (*Cypripedium calceolus*), the dwarf mountain pine (*Pinus mugo*), the common yew (*Taxus baccata*), the globeflower (*Trollius europaeus*), and the edelweiss (*Leontopodium alpinum*) (APNPV 2020, MMAP 2019).

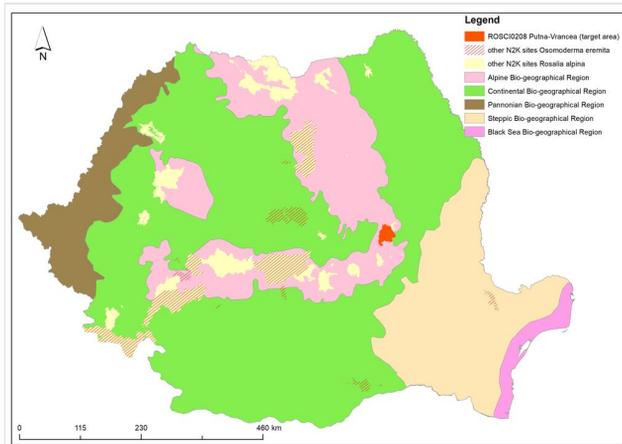


Figure 2. [doi](#)

Location of ROSCI0208 Putna-Vrancea in Romania

## Fauna

In Putna-Vrancea Natura 2000 were identified over 180 vertebrates species, many of them protected by Habitats Directive, Birds Directive, Romanian Government Emergency Ordinance 57/2007 (regarding protected area and conservation of species and habitats), Bern Convention (Conservation of European Wildlife and Habitats) and Bonn Convention (Convention for the Protection of Migratory Species). Ten vertebrates species, other than birds, are strictly protected (APNPV 2020, MMAP 2019).

Fauna of Putna-Vrancea Natura 2000 site is a typical one for an Eastern European mountain area. The most common mammals in the area are red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), tree marten (*Martes martes*), fox (*Vulpes vulpes*), badger (*Meles meles*), wildcat (*Felis silvestris*), chamois (*Rupicapra rupicapra*). Moreover, there are also a high number of small and medium-sized mammals species such as rodents: the bank vole (*Myodes glareolus*), the common vole (*Microtus arvalis*), the short-tailed vole (*Microtus agrestis*), the yellow-necked mouse (*Apodemus flavicollis*), the common dormouse (*Muscardinus avellanarius*), Eurasian red squirrel (*Sciurus vulgaris*) (APNPV 2020).

Large carnivores (bear, wolf, lynx) and otter are key wildlife species in the area (APNPV 2020). So far, LIFE financed three projects for the conservation of large carnivores in Putna-Vrancea Natural Park (see [www.carnivoremari.ro](http://www.carnivoremari.ro)), and the area is a donor for lynx individuals for a reinforcing Slovenian population in the frame of an ongoing LIFE project (LIFE16 NAT/SI/000634).

A large number of bird species inhabits Putna-Vrancea, many of them being species protected by national and international legislation: the western capercaillie (*Tetrao urogalus*), the hazel grouse (*Tetrastes bonasia*), the lesser spotted eagle (*Aquila pomarina*), the golden eagle (*Aquila chrysaetos*), the common buzzard (*Buteo buteo*), the common kestrel (*Falco tinnunculus*), the red-footed falcon (*Falco vespertinus*), the Eurasian sparrowhawk

(*Accipiter nisus*), the Ural owl (*Strix uralensis*), brown owl (*Strix aluco*), the Eurasian eagle-owl (*Bubo bubo*), the long-eared owl (*Asio otus*), raven (*Corvus corax*), white-backed woodpecker (*Dendrocopos leucotos*), the great spotted woodpecker (*Dendrocopos major*) (APM Vrancea 2009, APNPV 2020).

Herpetofauna is also specific to the mountain area, being represented by species such as the fire salamander (*Salamandra salamandra*), the alpine newt (*Triturus alpestris*), the northern crested newt (*Triturus cristatus*), the yellow-bellied frog (*Bombina variegata*), the agile frog (*Rana dalmatina*), the adder (*Vipera berus*), the wall lizard (*Podarcis muralis*), the viviparous lizard (*Zootoca vivipara*), the slowworm (*Anguis fragilis*), the smooth snake (*Coronella austriaca*) (APM Vrancea 2009).

### Habitats

The environmental factors in Putna-Vrancea Natura 2000 site favor the presence of deciduous trees (APM Vrancea 2009, APNPV 2020, Gafta and Mountford 2008, MMAP 2019):

#### Luzulo-Fagetum beech forests

On acidic soils from Putna-Vrancea Natura 2000 dominates *Fagus sylvatica*, however, at a higher elevation (over 1200 m), the prevailing species are *Abies alba* and *Picea abies* (*Fagus sylvatica-Abies alba* or *Fagus sylvatica-Abies alba-Picea abies* forests). The understory is dominated by *Luzula luzuloides*, *Polytrichum formosum*, *Deschampsia flexuosa*, *Calamagrostis villosa*, *Vaccinium myrtillus*, *Pteridium aquilinum*.

#### Asperulo-Fagetum beech forests

On neutral or near-neutral soils from Putna-Vrancea Natura 2000 dominates *Fagus sylvatica*, however, at a higher elevation (over 1200 m) the prevailing species are *Abies alba* and *Picea abies* (*Fagus sylvatica-Abies alba* or *Fagus sylvatica-Abies alba-Picea abies* forests). The understory includes species such as *Anemone nemorosa*, *Lamium galeobdolon*, *Galium odoratum*, *Melica uniflora* and *Dentaria* spp.

Alluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)

Acidophilic forests with *Picea* from the mountain zone to the alpine (Vaccinio-Piceetea), on a small area on Goru and Lacauti ridge. The forests are dominated by *Picea abies* and are divided into subalpine spruce forests and lower elevation spruce forests in areas unfavorable to *Fagus sylvatica* and *Abies alba*. Such forests are found in a small area in Putna and Zabala rivers.

### Socio-economic environment

Putna-Vrancea Natural Park includes three communes (Nistorești, Tulnici, Păulești) with four villages (Coza, Tulnici, Greșu, Lepșa). The area is inhabited by 10,000 people. The local economy is dominated by subsistence agriculture, livestock, and forestry (70%).

Tourism is a growing industry, especially in Lepşa and Greşu. Putna-Vrancea Natural Park receives over 40,000 tourists/year, mostly on weekends and public holidays (APM Vrancea 2009, APNPV 2020).

## Conservation issues

### Lack of suitable habitats for saproxylic beetles

The abundance of protected saproxylic species is heavily influenced by habitat conditions, such as the amount of deadwood, presence of old trees, diversity of tree species, and amount of light penetrating the forest stands (Lachat et al. 2012, Larrieu et al. 2018, Nieto and Alexander 2010). Putna-Vrancea Natural Park is one of the most compact forested areas in the Romanian Carpathians, with over 90% forest cover. Past forestry management practices such as selective extraction of valuable trees (beech, oak, maple) and the removal of veteran trees simplified the forest structure and dramatically decreased saproxylic insects (MMAP 2019, APNPV 2020). Furthermore, saproxylic insects, including the protected species, are considered pests by forest authorities and their populations were actively reduced in the past by sanitation harvest and insecticide spraying (RNP Romsilva 2019, MAPAM 2003).

When compared to their potential distribution in Romania, *Rosalia alpina* and *Osmoderma eremita* are found in few forest stands and are disconnected from highly valuable populations in old-growth forests stands (e.g., the Southern Carpathians) (Iorgu 2015, Gidei and Popescu 2014, Gidei and Popescu 2012, Brodie et al. 2019). While the practice of selective logging diminished after the designation of the project area as a Natura 2000 site, the presence of large stands of young forest and lack of deadwood and veteran trees (APNPV 2020) hinder the increase and expansion of saproxylic insects populations, such as *Rosalia longicorn* and the hermit beetle. Other species, such as *Cerambyx cerdo*, *Morimus funereus*, and *Lucanus cervus* are in the same unfavorable situation (APNPV 2020, Iorgu 2015). For example, in the project area, we inventoried 50 km<sup>2</sup> suitable habitats for *Rosalia alpina* out of ~200 km<sup>2</sup> potentially suitable (considering tree host species). To speed up the creation of suitable habitats and avoid losing key population nuclei, we will work in 22 stepping stone suitable habitats by creating veteran-like trees and sun-baked snags, install wood mould boxes and wood piles and remove understory vegetation that keeps deadwood in shade (LIFE08 NAT/E/000075 2008, LIFE11 NAT/IT/000252 2011, LIFE14 GIE/IT/000812 2014, LIFE14 NAT/IT/000209 2014, LIFE16 NAT/LT/000701 2016, Jansson et al. 2009, Carlsson et al. 2016). These actions will help to recover the target insect populations but also act as a demonstration area for forest and protected area managers from Romania and the EU. Furthermore, we will develop a legally binding action plan as a tool for the replication of activities. The demonstrated actions will be assessed by the state of the art monitoring activities and disseminated in order to reach major stakeholders in forest, agriculture and protected area management.

### **Lack of understanding of the value of saproxylic beetles' communities**

Saproxylic beetles can inflict economic damage to the timber industry, which is the main reason why they are considered forest pests (Brodie et al. 2019). However, the population sizes of many saproxylic beetle species are not very large (relative to other beetles such as the pest bark beetles), but the fact that many species are large and conspicuous, and often seen around oviposition sites around deadwood or live trees (Gîdei and Popescu 2012, Gîdei and Popescu 2014), is often interpreted as a sign of infestation. This has typically led to forest sanitation measures (LIFE11 NAT/IT/000252 2011), such as application of insecticides or removing biologically-valuable deadwood and decaying trees. The main reasons for neglecting saproxylic species' conservation are the fear of infestation and subjective perception of species biology (Carpaneto et al. 2017). This is confirmed by the fact that few management plans in Romania include concrete activities for these species, and most Natura 2000 site managers avoid including such species in the Standard Data Forms (SDF) of the respective sites. An actual example well illustrates the designation as pest species and the lack of understanding of the value of saproxylic beetles for biodiversity and ecosystem services: after submission by Road Authorities of documentation for financing a highway in the Southern Carpathians, European Commission asked for clarification, including management measures for mitigating the impact on *Morimus funereus* population. The main message from media and forest authorities was negative towards beetle conservation (e.g., the title of a media article was *A bug stopped the highway*). We will build a participatory monitoring tool designed to involve foresters and forest owners in data collection to change this negative perception. This will increase their understanding of species biology (LIFE11 NAT/IT/000252 2011) and role in the forest ecosystem. Moreover, to prevent persecution of saproxylic beetles that are considered pests, we will demonstrate the use of semiochemicals as an environmentally-friendly forest sanitation method (Cook et al. 2007, Howse et al. 1998). These methods allow the manipulation of insects to alter their distribution and abundance in forest habitats to meet both forestry goals (high-quality timber, free of galleries bored by saproxylic beetle larvae) and conservation goals (protection of these keystone species).

### **Lack of awareness regarding suitable actions for promoting favorable conservation status for saproxylic beetles**

Even the species are protected under Habitats Directive, Romanian Natura 2000 and forest managers do not always promote concrete conservation activities (Iorgu 2015, Manolache et al. 2017). While some forest managers incorrectly designate these species as a pest, Natura 2000 managers are not aware of concrete conservation methods and wrongly believe that retaining a few old-growth trees will guarantee saproxylic species conservation. Most Natura 2000 management plans include the prescription to leave 5 old trees/ha when logging (APNPV 2020), which is not recommended when the available habitat is limited. Furthermore, several managers do not report these species to avoid measures considered as harmful for productivity and against silvicultural norms. For example, *Cerambyx cerdo* is mentioned in Ministry Order 454/2003 for approval of technical norms of forest protection as pest species and, when present is compulsory to step in and remove the individuals (MAPAM 2003). This order contradicts the legal norms

governing biodiversity and protected areas; to avoid contravening with forestry and biodiversity legislation, protected area managers with forestry background tend to minimize the presence of saproxylic species. This threat affects not only the project area, but all Natura 2000 sites in Romania. To address these issues, we will demonstrate the implementation of concrete conservation actions, such as the creation of veteran trees and snags, installing wood mould boxes, creating wood piles, managing understory, participative monitoring and use of semiochemicals as conservation methods, evaluate the results, create a national action plan, and disseminate best-fitted communication methods (Brodie et al. 2019, Cook et al. 2007, Howse et al. 1998, LIFE08 NAT/E/000075 2008, LIFE11 NAT/IT/000252 2011, LIFE14 NAT/IT/000209 2014, LIFE16 NAT/LT/000701 2016).

## **Methodology**

To solve identified conservation issues in Putna-Vrancea ROSCI0208 and unlock the conservation of saproxylic insects in Romania, we will implement the following activities:

### **Preparatory actions**

To ensure a smooth implementation of project activities and to comply with various legal requirements, we will carry out several preparatory activities, necessary to develop the implementation plans to the necessary level of details: Detailed work plans for conservation activities (Preliminary inventory of forest structure and communities related with deadwood; Update ownership list; Produce technical plans for implementation of concrete conservation actions; Produce detailed intervention maps; Produce methodologies for monitoring concrete conservation activities; Produce a buying green guide); Ex-ante survey and planning for awareness and educational activities (Questionnaires for sociologic investigation; Producing the implementation and replication strategy; Establishing the final monitoring indicators); Project and regional kick-off meetings and training of team; Obtaining EIA and Natura 2000 permits; Action plan for target species (Studies for conservation status at Romanian level, elaboration of plan, public debates; legal approval); Legal advising for contracts with landowners (to safeguard a 20-years sustainability).

### **Concrete conservation actions**

Planned conservation actions cover different methods for improving the habitats for the 5 target species: speeding-up decaying habitats, increase the amount of deadwood, improve the availability of light, participatory monitoring and demonstrative use of semiochemical. We will work in 22 intervention areas (12 km<sup>2</sup>), which will result in improving at least 380 km<sup>2</sup> and spillover in other Natura 2000 sites. The planned actions are: Creating standing deadwood to promote decaying habitats: Creation of 625 veteran-like trees by veteranisation of young trees and of 303 sun-exposed snags by modifying existing snags; Provisions of deadwood for saproxylic beetles: Creating and installing 171 custom-made wood mould boxes and of 508 wood piles as microhabitats ready to be colonized; Follow-up activities; Shrubs removal for improving saproxylic beetles habitats mostly around

veteran-like trees, Participatory monitoring and demonstrative use of semiochemicals as a conservation method by developing of a participatory monitoring app designed for forest owners and managers and a demonstrative use of pheromones as non-lethal a sanitation method.

### **Monitoring actions**

To evaluate the effectiveness of concrete conservation activities and their social impact and correct the actions if necessary, we planned a comprehensive set of monitoring actions: Monitoring of saproxylic insects within intervention areas; Monitoring of saproxylic insects and forest structure within the entire site (as a benchmark); Monitoring of ecosystem services and of social / economic impact; Monitoring of awareness activities, and Monitoring key project indicators. The actions foresee deliverables at regular time intervals to inform on time the experts working on concrete conservation on the outcome of their interventions.

### **Communication actions**

To effectively replicate the conservation actions, we also planned a complete set of communication activities: Dissemination of project objectives and activities leaflets, Press conferences, web site, information panels, posters; Layman report (incl video); Awareness activities for local inhabitants; educational nature trail; small display area, exhibitions with children drawings, photo exhibitions and guided fieldwork for children, postcards, flyers for local inhabitants, Meetings with local stakeholders. Dissemination of technical solutions and scientific outreach; Handbook with best practice examples of conservation activities (for foresters / Natura 2000 managers), movie on “How to maintain forest health without losing biodiversity”, Participation to scientific events, Publishing articles, Guided field visits; Networking with other projects and closing event Visits to other LIFE projects in Europe and Romania, Receiving visits from other LIFE projects.

### **Management actions**

We planned a set of management actions to facilitate the technical and administrative implementation of the proposal: Technical and financial project management, After-LIFE, and External audit.

## **Expected results and impacts**

The main impacts of the proposal are improved conservation statuses at the end of the project for *Rosalia alpina*\*, *Osmoderma eremita*\* and other co-benefiting species (*Morimus funereus*, *Cerambyx cerdo*, *Lucanus cervus*) in ROSCI0208 Putna-Vrancea and ensuring medium and long term conservation of saproxylic insects in Romania. The proposal will improve 200 km<sup>2</sup> of *Rosalia alpina* and *Lucanus cervus* occupied habitats in Romania, and 100 km<sup>2</sup> of favourable habitats to *Osmoderma eremita*\*, *Morimus funereus* and *Cerambyx cerdo* ranges. We estimate that this will lead to an increase of 10-20% of suitable habitats and population abundance in Romania. Furthermore, by creating a national action plan for

the five endangered species, the proposal will positively impact these species at the national level, while avoiding costly conflicts with forest owners and managers. Lastly, the proposal will contribute to changing the paradigm of conservation of saproxylic beetles, from passive conservation (keeping some mature trees in the logged area) to concrete conservation (actively seeking to create veteran trees and keep large quantities of deadwood in the forest).

The expected results are:

- 1) demonstrating the creation of the next generation of veteran trees for *Rosalia alpina*\*, *Osmoderma eremita*\*, *Morimus funereus*, *Cerambyx cerdo*, *Lucanus cervus* in areas lacking suitable habitats by altering 625 trees from 22 intervention areas in ROSCI0208 Putna-Vrancea, covering 1200 ha.
- 2) producing 303 sun-exposed snags near veteran-like trees to act as a reproduction habitat for *Rosalia longicorn* and other saproxylic beetles living in sun-exposed areas.
- 3) providing artificial and natural deadwood habitats to attract saproxylic insects and facilitate reproduction and dispersal in the 22 stepping-stone intervention areas by creating 171 custom made wood mould boxes and 508 wood piles.
- 4) clearing of overgrowth near the newly provided deadwood for improving *Osmoderma eremita*\*, *Rosalia alpina*\*, *Morimus funereus*, *Cerambyx cerdo* and *Lucanus cervus* habitats (clearing understory on ~ 20 ha).
- 5) developing participatory monitoring of insects by involving forest owners and managers to change the perception of saproxylic insects as pest species and decrease harmful forest management techniques such as removing deadwood.
- 6) introducing the use of semiochemicals (pheromones) as an environmentally-friendly forest sanitation method to prevent harming protected saproxylic beetles.
- 7) actively involving over 1,000 professionals (forestry managers, forest owners, Natura 2000 managers) and over 15,000 members of the general public from Romania and EU in the conservation of saproxylic beetles.
- 8) ensure the medium and long-term conservation of saproxylic insects by legally binding a national action plan for the five target species.

## Expected risks and constraints

The project LIFE ROSalia is implemented in an area where all partners have good connections and developed other conservation projects, including those financed by LIFE. This project is a follow-up of a small pilot grant ([The Romanian Longicorn beetle project](#)) aiming at testing efficient methods for conservation of insects and during the preparation, we identified several expected risks, constraints, and mitigation measures. The project

actions and proposed management have been designed to allow efficient control of the project's technical and financial aspects.

**Availability of intervention areas** / Likelihood - unlikely / Impact moderate. We selected the intervention areas based on a connectivity model, aiming at providing core populations for the Carpathians. The land is private property, and we confirmed the availability with the owners. During the project, we will explore 6 more backup areas in the region.

**Delays in obtaining permits** / Likelihood - unlikely / Impact moderate. The beneficiary is the environmental authority in charge of issuing permits in Vrancea. The permits will be issued by NEPA, and our expertise will allow us to achieve the results on time. For this, we foresee a 3-month extra time.

**Delays due to weather** / Likelihood - likely / Impact moderate. Extreme events such as floods can occur and block the roads. To minimize the risks, we selected intervention areas close to roads to expect an opening in a short time. We also foresee buffer time for each planned activity, including the entire project. We also choose to purchase off-road cars to have access to intervention areas in the case of such events.

**Contractual issues** / Likelihood - unlikely / Impact high. It is possible that some of the contractors will not fulfill the targets specified within the contracts. In order to avoid these situations, the contracts will include strict stipulations related to interim and progress reports and the management team will enforce the law.

**Availability of stakeholders** / Likelihood - unlikely / Impact medium. The most important constraints associated with the involvement of stakeholders are related to identifying a convenient date for most of the participants. To avoid inadequate scheduling, we have foreseen a larger period of time in which to organize the events. Due to the long term projects and interests of the different partners, we also have access to a very significant database of experts, stakeholders and interested NGOs members, which will represent the selection base for the participants to become the replication agents.

## **EU added value of the project and its actions**

### **Contribution to the specific objectives of the priority areas**

The project will significantly contribute to priority areas as set out in Article 12 of LIFE Regulation. More specifically, will improve the conservation status of five endangered and neglected saproxylic beetles' population and dependent habitats.

Currently, SDF for Putna-Vrancea ROSCI0208 reveals little about the target saproxylic species (MMAF 2019), as many SDFs in Romania (Manolache et al. 2017). The project area belongs mostly to the Alpine biogeographical region (99%) (APNPV 2020, MMAF 2019).

*Rosalia longicorn* is included in the SDF of Putna-Vrancea ROSCI0208 as present (MMAP 2019). A recent study of Putna-Vrancea Natural Park administration confirmed the species on app. 50 km<sup>2</sup> with under 20 individuals per ha. Based on host tree species, we consider as suitable over 200 km<sup>2</sup> of the project area. *Rosalia longicorn* is in U1 Unfavourable-Inadequate conservation status on the Romanian Alpine region (article 17 Habitats Directive reporting period 2007-2012) and the presence confirmed on 2000 km<sup>2</sup> (European Commission 2018). Thus, after the project ends, we will add 150 km<sup>2</sup> of habitats with a viable population. Habitat enhancement in Putna-Vrancea represents 10% of suitable habitats and population abundance in the Romanian Alpine region. We based our estimation on the number of veteranized trees and sun-exposed snags to be created in the 22 intervention areas. Taking a dispersal distance of 500 m (cautionary estimate as this species can disperse over 1.5 km, Campanaro et al. 2017), one veteranized tree can provide 0.25 km<sup>2</sup> of suitable habitat. The addition of sun-exposed snags and wood piles will create even more suitable habitats, and the use of pheromones will speed up the colonization process.

*Osmoderma eremita* is included in the SDF of Putna-Vrancea as data deficient (MMAP 2019). The hermit beetle in U2 Unfavourable-bad conservation status on the Romanian Alpine region and was confirmed only on 300 km<sup>2</sup> (European Commission 2018). In project area, *Osmoderma eremita* complex was sporadically observed (app. on 10 km<sup>2</sup>), but the distribution is certainly higher because the species is difficult to observe without specific skills or dedicated monitoring sessions (Maurizi et al. 2017). Taking the limited dispersal capabilities, we will improve the habitats on about 100 km<sup>2</sup> (e.g., veteranized trees, wood piles, wood mould boxes), which will add more than 20% of suitable habitats and population abundance in the Romanian Alpine region.

*Cerambyx cerdo*, *Morimus funereus*, and *Lucanus cervus* are not included in the SDF of Putna-Vrancea but present according to the Putna-Vrancea Natural Park Administration. *Lucanus cervus* is in U2 Unfavourable-Bad in Alpine region and present in 1000 km<sup>2</sup>, *Cerambyx cerdo* is in U2 Unfavourable-Bad and present in 400 km<sup>2</sup> and *Morimus funereus* is in U1 Unfavourable-Inadequate and present in 300 km<sup>2</sup> (APNPV 2020, European Commission 2018, MMAP 2019). The concrete conservation activities (veteranized trees, wood piles, wood mould boxes, sun-exposed snags) will add more than 20% of suitable habitats and population abundance in the Romanian Alpine region.

The proposal will demonstrate actions novel for Romania, which can then be implemented by projects financed by other EU and national programmes, such as the European Regional Development Fund and Common Agricultural Policies environmental measures. The project can also greatly contribute to Biodiversity Strategy for 2030 if more areas from Putna-Vrancea will become strictly protected (European Commission 2020, Miu et al. 2020). If the actions will be demonstrated as efficient ones, the Natura 2000 managers can update the management plans of their sites and apply for ERDF funds (e.g., the replacement for *Programul Operational Infrastructura Mare POIM*), which in Romania can finance only concrete conservation actions (no preparatory and monitoring activities, or education actions). The project will not only contribute to implementing Habitats Directive in Romania, but will also contribute to updating forestry and agricultural policies at the national level, as we aim to affect forest / agricultural management practices by developing

a legally-binding a national action plan for saproxylic protected species. The project targets relevant stakeholders via a mix of actions (visits at demonstration sites, handbooks, mobile application, presentations, replication plans), culminating with a legally binding national action plan for the five saproxylic insects.

### **Synergies and integration of environmental objectives into other Union policy areas**

Our project approach demonstrates how insects improve forest health and gain the trust of forest managers in proposed conservation activities, thus avoiding conflicts between promoters of conservation measures (i.e., Natura 2000 managers) and forest owners and managers. There are no large-scale conservation initiatives targeting saproxylic insects in Romania, due to the poor knowledge of species requirements and forest managers' opposition. Because saproxylic insects lower trees' market value, they are perceived as pest species and persecuted by forestry practices. However, stakeholders' biodiversity value can be positively perceived if the role in ecosystems is demonstrated and presented in layman terms and accessible to the general public (Hartel et al. 2020). We designed a multi-purpose strategy to improve the conservation status of saproxylic insects by providing decaying wood/forest habitats, while working with forest managers to change the forestry practices. These actions will contribute to implementing and updating EU policies on forest management and keeping the timber industry's competitiveness while complying with EU rules for biodiversity. Thus, we aim to raise awareness about these species by creating a tool for participatory monitoring and by demonstrating the use of semiochemicals to manipulate insect populations in forest stands with high commercial value. In this way, we intend to demonstrate that the protected insects contribute limited losses to the timber industry and deliver a method to deter harmful insects without comprising protected saproxylic insect habitats. We will involve all relevant decision-makers (forestry authorities, environmental authorities, forest owners, scientists, landowners associations). We will use interactive communication methods, such as field trips to demonstration sites, workshops, presentations at events, scientific and popular publications, in-person discussions, and we will work beyond simple dissemination, i.e., legally binding a national action plan for these species and planning replication in 10 other Natura 2000 sites (concrete actions, grant advising, Rozyłowicz et al. 2017). Methodologies will be included in public reports and educational/transfer materials such as brochures and participatory monitoring mobile application, available in Romanian and English.

### **Adopting Green public procurement**

Newly adopted Romanian legislation (Law 69/2016 on green public procurement) encourages green procurement to minimize the impact of purchased items on the environment. The law complies with EU Buying Green Guide. Vrancea Environmental Protection Agency (APM VN) as a representative of environmental authority in the region will apply GPP rules for items purchased during the project and will implement activities with a minimal impact on the local environment. Thus, we have foreseen the elaboration of a guide for green public procurement, specifically designed for proposed items. APM VN will adopt this guide as the standard for procurement during the project. A special provision regarding GPP will be inserted in the partnership agreement between APM VN and

associated beneficiaries. Moreover, we will publish the guide on the project webpage in order to contribute to a better implementation of GPP in Romania. The proposal will also use the Ministry of Environment's experience on GPP (LIFE14 GIE/IT/000812 2014).

### **Uptake of the results of other EU-financed projects**

The project has been prepared by our staff by using examples from other EU-financed projects adapted to the local situation. Specifically, we included actions demonstrated as efficient in other countries such as pollarding, installing wood mould boxes, participatory monitoring, etc. (LIFE08 NAT/E/000075 2008, LIFE11 NAT/IT/000252 2011, LIFE14 NAT/IT/000209 2014, LIFE16 NAT/LT/000701 2016). We also included methods evaluated during FP projects such as Keeping Europe's forests healthy and Coarse Woody Debris (CDW) and plant/fungal biodiversity (demonstrate the value of veteranization and provided wood piles), and [FP7SCALES](#) - Securing the Conservation of biodiversity across Administrative Levels and spatial, temporal, and Ecological Scales (demonstrate the necessity of speeding up the creation of decaying habitats and the manipulation of species). Reports from these projects (published in scientific articles and project webpages) were evaluated, and the best suited for our proposal were included. In these scientific articles were presented methods such as: creating veteran-like trees, creating tree snags, installing wood mould boxes, installing wood piles, trimming bushes and participatory monitoring.

### **Replicability and transferability**

We planned our proposal as a demonstration case with a high transferability value and a clear replication strategy. The replicability and transfer activities go beyond continuation, dissemination, and networking and actively seek to multiply the project's impacts and mobilize a wider uptake during and after the project at the national level. In Romania, concrete conservation activities rarely target saproxylic insects due to their designation as pest species before creating Natura 2000. While most protected area managers are looking to improve these species' status, few are aware of effective conservation measures such as those tested in other parts of the EU. We included in our proposal activities matching as much as possible the conditions from other Natura 2000 sites in Romania. We will veteranize trees to speed up the colonization of habitats with limited availability of deadwood (such as young forests), create habitats for the reproduction of species dependent on sunny areas (sun exposed trees snags, clearing the understory), create artificial habitats for species depending on deadwood (wood mould boxes and wood piles), and demonstrate a push and pull strategy for reducing the number of saproxylic insects when necessary.

Demonstrated conservation activities will be replicated using the following tools:

1. Reports and information materials including information about how the demonstrated method might be applied in other geographic areas and habitats: a manual for stakeholders on how semiochemicals as an environmentally friendly sanitation method;

Handbook with best practice examples of conservation activities for saproxylic insects; a movie on "How to maintain forest health without losing biodiversity".

2. Demonstration visits organized for stakeholders from other geographic areas and habitats field trips with 40 forest owners and PA managers to promote demonstrating an environmentally-friendly sanitation method and change the attitude toward the saproxylic insects.

3. Creating a mobile application for the identification of protected saproxylic insects by stakeholders.

5. Producing scientific materials: participating in scientific events with presentations, publishing scientific articles.

6. Elaborating and legally binding the first national action plan for the five saproxylic insects targeted by the project, including a detailed description of actions and areas suitable for replication.

7. Creating a replicability plan for five other areas: e.g., Soveja, Făgăraș, Râul Putna, Dălhăuți, Lunca Siretului Inferior.

The replicators of our activities will be forest owners and managers (for example, ROMSILVA - protected areas office, communal owners Hăulișca, Păulești, Tulnici, county forestry offices from Vrancea, Bacău, Buzău), Natura 2000 managers (for example, The National Agency for Protected Natural Areas from Buzău, Sibiu, Vrancea, Bacău counties, Iron Gates Natural Park Administration, Domogled Valea Cernei National Park Administration, Microregional Association Pogány-Havas), consultants for the development of Natura 2000 management plans, local community (for example, local inhabitants from Soveja, Greșu, Ojdula, Tulnici, Negrilești, Bârsești, Păulești, Hăulișca), conservationists (to transfer the examples to students). Replicators were already contacted and agreed to take part in the proposal when requested by the beneficiary. The Ministry of Environment agreed to legally bind the plan until the project end. The process will include a nationwide consultation of stakeholders.

These activities will lead to improved habitats for saproxylic insects and the creation of the next generation of conservation professionals, adopting novel conservation methods and changing the formal and informal silvicultural practices in Romania.

## Funding program

[LIFE19 NAT/RO/000023](#) Conservation of saproxylic beetles in the Carpathians LIFE ROSalia (2020 - 2025) is co-financed by the [LIFE programme 2014-2020](#), the EU's funding instrument for the environment and climate action (75% of eligible costs). The balance is provided by the Ministry of Environment, Waters, and Forests (APM VN contribution to the project), University of Bucharest (UNIBUC contribution to the project), RNP Romsilva

Putna-Vrancea Natural Park Administration (PVNP contribution to the project), and Association for Biodiversity Conservation (ACDB contribution to the project).

## Grant title

LIFE19 NAT/RO/000023 Conservation of saproxylic beetles in the Carpathians LIFE ROSalia (2020 - 2025).

## Hosting institution

### Coordinating beneficiary

Vrancea Environmental Protection Agency (APM VN, [Agenția pentru Protecția Mediului Vrancea](#), Romania)

### Associated beneficiaries

University of Bucharest, Center for Environmental Research and Impact Studies (UNIBUC, Universitatea din București, [Centrul de Cercetare a Mediului și de Efectuare a Studiilor de Impact](#), Romania)

Putna-Vrancea Natural Park Administration (PVNP, [RNP Romsilva Administrația Parcului Natural Putna-Vrancea RA](#), Romania)

Association for Biodiversity Conservation (ACDB, [Asociația pentru Conservarea Diversității Biologice](#), Romania)

## Author contributions

### Grant concept, writing, and technical revision

Steluta Manolache, Cristiana M. Pioarca-Ciocanea, Andreea Nita, Viorel D. Popescu, Bekka S. Brodie, Laurentiu Rozyłowicz

### Grant revision

Silviu Chiriac, Matei I. Dragomir, Ion Militaru

### Article writing and revision

Marian D. Mirea, Iulia V. Miu, Steluta Manolache, Andreea Nita, Viorel D. Popescu, Bekka S. Brodie, Laurentiu Rozyłowicz

## Conflicts of interest

The authors declare that there is no conflict of interest.

## References

- APM Vrancea (2009) Planul de management al Parcului Natural Putna-Vrancea. Agentia pentru Protectia Mediului Vrancea, Focsani, 193 pp. [In Romanian].
- APNPV (2020) Planul de management al Parcului Natural Putna-Vrancea, siturilor ROSCI0208 Putna-Vrancea și ROSPA0088 Munții Vrancei. RNP Romsilva Administrația Parcului Natural Putna-Vrancea RA (APNPV), Tulnici, 247 pp. [In Romanian].
- Bardiani M, Chiari S, Maurizi E, Tini M, Toni I, Zauli A, Campanaro A, Carpaneto GM, Audisio P (2017) Guidelines for the monitoring of *Lucanus cervus*. *Nature Conservation* 20: 37-78. <https://doi.org/10.3897/natureconservation.20.12687>
- Brodie B, Popescu V, Iosif R, Ciocanea C, Manolache S, Vanau G, Gavrilidis A, Serafim R, Rozyłowicz L (2019) Non-lethal monitoring of longicorn beetle communities using generic pheromone lures and occupancy models. *Ecological Indicators* 101: 330-340. <https://doi.org/10.1016/j.ecolind.2019.01.038>
- Campanaro A, Redolfi De Zan L, Hardersen S, Antonini G, Chiari S, Cini A, Mancini E, Mosconi F, Rossi de Gasperis S, Solano E, Bologna M, Sabbatini Peverieri G (2017) Guidelines for the monitoring of *Rosalia alpina*. *Nature Conservation* 20: 165-203. <https://doi.org/10.3897/natureconservation.20.12728>
- Carlsson S, Bergman K, Jansson N, Ranius T, Milberg P (2016) Boxing for biodiversity: evaluation of an artificially created decaying wood habitat. *Biodiversity and Conservation* 25 (2): 393-405. <https://doi.org/10.1007/s10531-016-1057-2>
- Carpaneto G, Campanaro A, Hardersen S, Audisio P, Bologna M, Roversi PF, Peverieri GS, Mason F (2017) The LIFE Project “Monitoring of insects with public participation” (MIPP): aims, methods and conclusions. *Nature Conservation* 20: 1-35. <https://doi.org/10.3897/natureconservation.20.12761>
- Cook S, Khan Z, Pickett J (2007) The Use of Push-Pull Strategies in Integrated Pest Management. *Annual Review of Entomology* 52 (1): 375-400. <https://doi.org/10.1146/annurev.ento.52.110405.091407>
- Directive 92/43/EEC (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Council of European Communities, Bruxelles. URL: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043>
- Drag L, Cizek L (2018) Radio-Tracking Suggests High Dispersal Ability of the Great Capricorn Beetle (*Cerambyx cerdo*). *Journal of Insect Behavior* 31 (2): 138-143. <https://doi.org/10.1007/s10905-018-9669-x>
- European Commission (2018) Conservation status of habitat types and species: datasets from Article 17, Habitats Directive 92/43/EEC reporting. [https://www.eea.europa.eu/ds\\_resolveuid/78a8fdf22fa14fdbb8ff218071aeb5d8](https://www.eea.europa.eu/ds_resolveuid/78a8fdf22fa14fdbb8ff218071aeb5d8). Accessed on: 2018-10-02.
- European Commission (2020) EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the

Regions. COM/2020/380 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380>. Accessed on: 2021-1-15.

- Gafta D, Mountford O (Eds) (2008) Manual de interpretare a habitatelor Natura 2000 din România. Risoprint, Cluj-Napoca, 10 pp. [In Romanian].
- Gîdei P, Popescu EI (2012) Ghidul Coleopteleror din România. volum 1. Editura PIM, Iași, 533 pp. [In Romanian].
- Gîdei P, Popescu EI (2014) Ghidul Coleopteleror din România. volum 2. Editura PIM, Iași, 531 pp. [In Romanian].
- Hardersen S, Bardiani M, Chiari S, Maura M, Maurizi E, Roversi P, Mason F, Bologna M (2017) Guidelines for the monitoring of *Morimus asper funereus* and *Morimus asper asper*. Nature Conservation 20: 205-236. <https://doi.org/10.3897/natureconservation.20.12676>
- Hartel T, Nita A, Rozyłowicz L (2020) Understanding human–nature connections through value networks: the case of ancient wood-pastures of Central Romania. Sustainability Science 15 (5): 1357-1367. <https://doi.org/10.1007/s11625-020-00811-z>
- Howse PE, Stevens IDR, Jones OT (1998) Insect Pheromones and their Use in Pest Management. Springer, Dordrecht, 369 pp. <https://doi.org/10.1007/978-94-011-5344-7>
- Iorgu ȘI (Ed.) (2015) Ghid sintetic pentru monitorizarea speciilor de nevertebrate de interes comunitar din România. Asocieria S.C. Compania de Consultanță și Asistență Tehnică S.R.L. și S.C. Integra Trading S.R.L., Bucharest, 164 pp. [In Romanian].
- Jansson N, Ranius T, Larsson A, Milberg P (2009) Boxes mimicking tree hollows can help conservation of saproxylic beetles. Biodiversity and Conservation 18 (14): 3891-3908. <https://doi.org/10.1007/s10531-009-9687-2>
- Lachat T, Wermelinger B, Gossner M, Bussler H, Isacsson G, Müller J (2012) Saproxylic beetles as indicator species for dead-wood amount and temperature in European beech forests. Ecological Indicators 23: 323-331. <https://doi.org/10.1016/j.ecolind.2012.04.013>
- Larrieu L, Paillet Y, Winter S, Büttler R, Kraus D, Krumm F, Lachat T, Michel A, Regnery B, Vandekerckhove K (2018) Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators 84: 194-207. <https://doi.org/10.1016/j.ecolind.2017.08.051>
- Leonarduzzi G, Onofrio N, Bardiani M, Maurizi E, Zandigiaco P, Bologna M, Hardersen S (2017) Attraction of different types of wood for adults of *Morimus asper* (Coleoptera, Cerambycidae). Nature Conservation 19: 135-148. <https://doi.org/10.3897/natureconservation.19.12659>
- LIFE08 NAT/E/000075 (2008) BIODIVERSIDAD Y TRASMOCHOS - Management and conservation of *\*Osmoderma eremita*, *\*Rosalia alpina* and other saproxylic habitats of Community interest in Gipuzkoa. [https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=3575](https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3575). Accessed on: 2021-1-14.
- LIFE11 NAT/IT/000252 (2011) MIPP - Monitoring of insects with public participation. [https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=4295](https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4295). Accessed on: 2021-1-14.
- LIFE14 GIE/IT/000812 (2014) LIFE GPPbest - GPPbest - Best practices exchange and strategic tools for GPP. [https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=5352](https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5352). Accessed on: 2021-1-14.
- LIFE14 NAT/IT/000209 (2014) LIFE EREMITA - Coordinated actions to preserve residual and isolated populations of forest and freshwater insects in Emilia-Romagna.

- [https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=5332](https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5332). Accessed on: 2021-1-14.
- LIFE16 NAT/LT/000701 (2016) LIFE OSMODERMA - Ecological network for Osmoderma eremita and other species dependent on veteran trees. [https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=6294](https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=6294). Accessed on: 2021-1-14.
  - Manolache S, Ciocanea CM, Rozyłowicz L, Nita A (2017) Natura 2000 in Romania – A Decade of Governance Challenges. *European Journal of Geography* 8 (2): 24-34.
  - MAPAM (2003) Ordin nr. 454 din 14 iulie 2003 privind aprobarea Normelor tehnice pentru protecția pădurilor și a Îndrumărilor privind aplicarea Normelor tehnice pentru protecția pădurilor. Ministerul Agriculturii, Pădurilor, Apelor și Mediului. Monitorul oficial al României 564 din 6 august 2003.
  - Maurizi E, Campanaro A, Chiari S, Maura M, Mosconi F, Sabatelli S, Zauli A, Audisio P, Carpaneto G (2017) Guidelines for the monitoring of *Osmoderma eremita* and closely related species. *Nature Conservation* 20: 79-128. <https://doi.org/10.3897/natureconservation.20.12658>
  - Miu I, Rozyłowicz L, Popescu V, Anastasiu P (2020) Identification of areas of very high biodiversity value to achieve the EU Biodiversity Strategy for 2030 key commitments. *PeerJ* 8 <https://doi.org/10.7717/peerj.10067>
  - MMAP (2019) Ministerul Mediului, Apelor și Pădurilor. Natura 2000 Standard Data Form ROSCI0208 Putna-Vrancea. <https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSCI0208>. Accessed on: 2021-1-14.
  - Munteanu C, Nita MD, Abrudan IV, Radeloff V (2016) Historical forest management in Romania is imposing strong legacies on contemporary forests and their management. *Forest Ecology and Management* 361: 179-193. <https://doi.org/10.1016/j.foreco.2015.11.023>
  - Nieto A, Alexander KN (2010) European Red List of saproxylic beetles. Publications Office of the European Union, Luxembourg, 45 pp.
  - Rey V, Groza O, Ianos I, Patroescu M (2007) Atlas de la Roumanie. La Documentation Française, Paris. [In French].
  - RNP Romsilva (2019) Dăunători biotici ai pădurilor. [https://web.archive.org/web/20190120114819/http://www.rosilva.ro/articole/daunatori\\_biotici\\_ai\\_padurilor\\_p\\_113.htm](https://web.archive.org/web/20190120114819/http://www.rosilva.ro/articole/daunatori_biotici_ai_padurilor_p_113.htm). Accessed on: 2021-1-14.
  - Rozyłowicz L, Nita A, Manolache S, Ciocanea C, Popescu V (2017) Recipe for success: A network perspective of partnership in nature conservation. *Journal for Nature Conservation* 38: 21-29. <https://doi.org/10.1016/j.jnc.2017.05.005>
  - Rozyłowicz L, Nita A, Manolache S, Popescu V, Hartel T (2019) Navigating protected areas networks for improving diffusion of conservation practices. *Journal of Environmental Management* 230: 413-421. <https://doi.org/10.1016/j.jenvman.2018.09.088>