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## FOREST AS A HABITAT OF SAPROXYLIC BEETLES ON NATURA 2000 SITES IN SLOVENIA

Maja JURC<sup>1</sup>, Nikica OGRIS<sup>2</sup>, Roman PAVLIN<sup>1</sup> & Danijel BORKOVIC<sup>1</sup>

RÉSUMÉ. — *La forêt en tant qu'habitat pour les coléoptères saproxyliques sur les sites Natura 2000 en Slovénie.* — Les sites Natura 2000 représentent presque 36% de la Slovénie ; une grande partie de leur superficie est recouverte de forêts (près de 70%), une grosse portion est dépourvue de végétation et une importante partie consiste en prairies. Les zones Natura 2000 incluent, au titre de la Directive Oiseaux 26 ZPS (zones de protection spéciale) représentant une superficie de 461 819 ha et, au titre de la Directive Habitat, 260 SPIC (sites potentiels d'intérêt communautaire) sur 639 735 ha. La Slovénie a proposé dix types d'habitats forestiers qui incluent près de 265 485 ha de forêts soit 21,62% des forêts du pays. La liste des plantes et des animaux inscrits à l'Annexe II de la Directive Habitat concerne 136 espèces parmi lesquelles on compte 16 espèces de coléoptères: 13 dépendant plus ou moins des forêts (*Bolbelasmus unicornis*, *Buprestis splendens*, *Carabus variolosus*, *Cerambyx cerdo*, *Cucujus cinnaberinus*, *Limoniscus violaceus*, *Lucanus cervus*, *Morimus funereus*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*, *Rhysodes sulcatus* et *Stephanopachys substriatus*) et trois non forêt-dépendantes (*Carabus menetriesi pacholei*, *Graphoderus bilineatus*, *Leptodirus hochenwartii*). Plus de 80% des coléoptères Natura 2000 sont donc forêt-dépendants. Quatre d'entre eux sont des espèces prioritaires de l'Union européenne (*Carabus menetriesi pacholei*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*); ils représentent 25% des coléoptères Natura 2000. Nous présentons la répartition actuelle de six coléoptères (*C. cerdo*, *C. cinnaberinus*, *L. cervus*, *M. funereus*, *O. eremita* and *R. alpina*) sur la base de données récemment accessibles. Une majorité des localisations (145 données) se situe dans 21 ZPS, 99 localisations sont dans 32 SPIC. Même si une majorité des localisations se trouvent dans des ZPS, les SPIC sont un habitat relativement fréquent pour quelques coléoptères, e.g. *M. funereus* et *R. alpina*. 21 sur 26 ZPS sont importantes pour 6 espèces prises en compte dans l'analyse. Il y a aussi 32 SPIC sur les 260 qui hébergent quelques espèces également incluses dans l'analyse. *L. cervus*, *M. funereus* et *R. alpina* se rencontrent plus souvent dans les SPIC que dans les ZPS. Nous présentons les exigences d'une sélection de coléoptères forestiers en particulier pour les communautés végétales et les milieux qu'ils occupent.

*Mots-clés:* Coléoptères saproxyliques, types d'habitats forestiers, communautés, végétales forestières, Natura 2000, Slovénie.

SUMMARY. — Natura 2000 sites represent almost 36% of the Slovenian area; a large part of the area is overgrown with forests (nearly 70%), a big share is without vegetation, an important part is grassland. The areas of Natura 2000 under the Wild Birds Directive include 26 SPA (Special Protection Areas) sites with an area of 461 819 ha and under the Habitat Directive 260 pSCI (potential Sites of Community Interest) sites with an area of 639,735 ha. Slovenia proposed ten forest habitat types and they include nearly 265,485 ha of forests or 21.62% of our forest areas. The number of species from the list of plant and animal species from Appendix II of the Habitat Directive amounts to 138 species, there are 16 species of beetles: 13 more or less forest dependent species (*Bolbelasmus unicornis*, *Buprestis splendens*, *Carabus variolosus*, *Cerambyx cerdo*, *Cucujus cinnaberinus*, *Limoniscus violaceus*, *Lucanus cervus*, *Morimus funereus*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*, *Rhysodes sulcatus* and *Stephanopachys substriatus*) and three not forest dependent species (*Carabus menetriesi pacholei*, *Graphoderus bilineatus*, *Leptodirus hochenwartii*). More than 80% of all Natura 2000 beetles were found to be forest dependent. Four of them are EU priority species (*Carabus menetriesi pacholei*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*),

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they represent 25% of all Natura 2000 beetles. We present the actual wide range for six beetles (*C. cerdo*, *C. cinnaberinus*, *L. cervus*, *M. funereus*, *O. eremita* and *R. alpina*) on the basis of recently accessible data. A majority of location records (145 records) are located in 21 SPA areas, 99 location records are in 32 pSCI areas. Even though a majority of locations lie in SPA areas, pSCI are quite a frequent habitat for some of the beetles, e.g. *M. funereus* and *R. alpina*. 21 out of 26 SPA are important for 6 beetles included into the analysis. There are also 32 of 260 potential pSCI that have locations of some beetles included into analysis. *L. cervus*, *M. funereus*, and *R. alpina* appear more often in pSCI than in SPA areas. We present the stand requirement of selected forest beetles in particular forest plant communities and lands which they actually inhabit.

*Keywords:* Saproxylic beetles, forest habitat types, forest plant communities, Natura 2000, Slovenia.

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Slovenia presents an exceptional species richness. Reasons are extremely complex and involve diverse ecological conditions where the influences of different climatic, tectonic, edaphic, orographic, lithologic and other elements are intertwined; thus Slovenia, as a region of exceptional diversity is called a transitional or ecotonic region. Slovenia is the habitat for more than 15 thousand animal species, 6 thousand plants and 5 thousand fungi species: most of them are silvicolous species. All this now makes part of the joint European heritage.

With a forest cover of 60.56% (1 227 832 ha) Slovenia belongs to the most forested European countries. In only 4.9% of the national territory the distance from one forest to the nearest one exceeds 500 m (Hočendar, 2003). The analysis covering the period since 1875 shows that the forest area in Slovenia is on a constant increase.

The vegetation structure of Slovenian forests is highly diverse. Most forests are located within the area of beech (44%), fir-beech (15%), thermophile deciduous trees and pines (12%) and beech-oak (11%) sites. The forests are relatively well preserved, which is mainly due to the mountainous character of the surface and poor accessibility in the past. There are only 15% of forests in which the share of spruce has considerably increased as a result of spruce planting in the past (Perko, 2004).

The latest forest resources inventory shows that deciduous forests cover approximately 39%, coniferous forests 22% and mixed forests 39% of the forested surface. The most often represented tree species in growing stock are Norway spruce (*Picea abies*, 35%), beech (*Fagus sylvatica*, 29%), silver fir (*Abies alba*, 11%), oaks (*Quercus* spp., 8%) and pines (*Pinus* spp., 7%) (Beguš, 1999). The mean growing stock volume was assessed to be 282 m<sup>3</sup>/ha (Hočevnar, 2003). Forest damages are frequently caused by abiotic factors (wind, snow, sleet and fire). Bark beetles outbreaks, mostly on Norway spruce and silver fir, also significantly increase the amount of sanitary cut.

The Act on forests (1993) prescribes how to preserve the productiveness and biodiversity of the forest. The biodiversity of the forests is preserved and increased by planned leaving of dead and dying wood biomass, which is the habitat for saprophytic species of invertebrates, fungi and microorganisms (Speight, 1989). In Slovenia, the prescribed amount of left dead wood biomass in the forest varies between 0.5 and 3% depending on the wood stock in the stands (Jurc, 2004).

After the completion of the process of denationalization, only about 20% of the forests will be owned by the state. The remaining 80% will be in private property. The average private forest estate is small (3 ha) and often divided in separate plots. All the forests are managed by the public forest service. The forest management goals in Slovenia are based on the principles of sustainability, a multifunctional and cognitive close-to-nature approach.

## FORESTS AND NATURA 2000

Presently, the areas of Natura 2000 (a total of 286 sites; adopted on 29th April 2004; OJ RS, No. 49/2004) include under the Wild Birds Directive 26 SPA (Special Protection Areas)

with an area of 461 819 ha representing approximately 22.6% of the country area, and under the Habitat Directive 260 pSCI (potential Sites of Community Interest) with an area of 639 735 ha, which represents about 31.6% of the country area. Over 60% of areas proposed by the Habitat Directive are within the SPA areas proposed by the Wild Birds Directive. A predominant part of the Natura 2000 area is overgrown with forests (nearly 70%), a big share is without vegetation (mainly rocks), and an important part is grassland.

The protected areas (the Triglav National Park, regional and landscape parks, reserves and natural monuments) cover 25% of the joint areas of the Natura 2000 sites.

Proposals of areas that Slovenia defined pursuant to the Habitat Directive, will be adopted by the European Commission following special proceedings, which may take several years.

Ten important forest habitat types were proposed as Natura 2000 areas; they include nearly 265 485 ha of forests (i.e. 21.62% of forest areas in Slovenia). The habitat types were determined on the basis of forest associations and preservation of species composition as registered within the forest management plans of the Slovenian Forest Service (Golob, 2004). There were two criteria for the definition of forest habitat types: the habitat types were defined in relation to the forest communities which ecologically correspond to the EU important habitat types in accordance with habitat types and forest plant communities (Robič, 2002) and the composition of tree species is preserved thus the unnatural species remain below 30% of wood stock (Golob, 2004).

The proposed forest habitat types were: 4070 Dwarf pine forests (*Mugo-Rhododendretum hirsuti*); 9110 Beech forests (*Luzulo-Fagetum*); 9180 Maple forests in the mountain gorge, on slope rubble (*Tilio-Acerion*); 91D0 moor forests; 91E0 riverside willow forests, alder and ash forests (*Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)); 91K0 Illyrian beech forests (*Fagus sylvatica* (*Aremonio-Fagion*)); 91L0 Illyrian oak-hornbeam forests (*Erythronio-Carpinion*); 91R0 Dinaric forests of red pine on dolomite grounding (*Genisto januensis-Pinetum*); 9410 Acidophilous spruce forests from the mountainous to alpine zone (*Vaccinio-Piceetea*) and 9530 (Sub-) Mediterranean forests of Austrian pine. Illyrian beech forests represented 77% of all forest habitat types under the Natura 2000 sites.

In the last years new forest habitat types were added: 91F0 Riverside oak-ash-elm forests (*Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*), along big rivers (*Ulmion minoris*) and 9340 forests with the prevailing species *Quercus ilex* and *Quercus rotundifolia* (see <http://www.natura2000.gov.si>).

Studies from 2003 (Golob) state that 41% of forests in Slovenia qualify as EU habitats, taking into account forest habitat types proposed by Slovenia and adopted by the EC, representing 23% of the Slovenian territory.

## BEETLES AND NATURA 2000

Recent data indicate that the number of species from the list of plant and animal species in Slovenia from Appendix II of the Habitats Directive (Ministry of Environment, 2006, <http://www.natura2000.gov.si>) amounts to 138 species (Plantae and Ferns 27 spp., Briophyta 5 spp., Mammalia 18 spp., Reptilia 7 spp., Amphibia 5 spp., Pisces 34 spp., Invertebrata 42 spp.). From the Invertebrata group we have 16 species of beetles. 13 species of beetles were defined as forest dependent species with regard to ecological requirements and their biological characteristics (*Bolbelasmus unicornis*, *Buprestis splendens*, *Carabus variolosus*, *Cerambyx cerdo*, *Cucujus cinnaberinus*, *Limoniscus violaceus*, *Lucanus cervus*, *Morimus funereus*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*, *Rhysodes sulcatus* and *Stephanopachys substriatus*). Three species are not forest-dependent species (*Carabus menetriesi pacholei*, *Graphoderus bilineatus*, *Leptodirus hochenwartii*). More than 80% (81.25%) of all Natura 2000 beetles were found to be forest-dependent.

Four of them are EU priority species (*Carabus menetriesi pacholei*, *Osmoderma eremita*, *Phryganophilus ruficollis*, *Rosalia alpina*).

FOREST-DEPENDENT NATURA 2000 BEETLES

— *Bolbelasmus unicornis* (Schrank, 1789) (Fam. Scarabaeidae), a stenotopic, subterranean and mycetophagous species. Habitats: grassy pastures, river banks, forest edges and clearings. Niche: in soil on fungi, in dead roots of trees (Koch, 1989b). In Hungary, it lives in light, thermophilic forests of oaks. In Slovenia there are some locations known from literature and collections. EU code 4011. Protecting rank FFH-II, IV.

— *Buprestis splendens* Fabricius 1774 (Fam. Buprestidae), a stenotopic, saproxylic, silvicolous and arboricolous species. Habitats: pines and larch forests. Niche: on *Pinus* and *Larix* at the top of the trees with dead branches (Koch, 1989b). According to literature its wide range is exclusively in the European mountainous region. In Slovenia there is only one old citation without a mention of location. The species is on the verge of extinction (Drovenik & Pirnat, 2003).

— *Carabus variolosus* Fabricius, 1787 (Fam. Carabidae), a stenotopic, hygrophilic and paludic species. Habitats: genuine forest species, swampy banks with alder standing trees, at times decayed trees or wet forest meadows up to 1000 m above sea level. Niche: decayed stumps, sometimes under the water (Koch, 1989a). Indicator species for natural forest brook. They hibernate in the decayed wood of small trunks or in stumps near water or in swampland or dug in soft soil. The species is present in the larger part of Slovenia, there are no data for the SW part of the country. Frequent and numerous in some areas (the Krakovski gozd forest), its range is estimated from 6 to 20% of the Slovenian area. The population is stable (Drovenik & Pirnat, 2003). EU code 4014. Protecting rank SI-R; FFH-II, IV.

— *Cerambyx cerdo* Linnaeus, 1758 (Fam. Cerambycidae), a stenotopic (in northern part of his distribution), pholeophilic, xylo-detriticolous, lignicolous, xylophagous, succophagous and saproxylic species. Habitats: old deciduous forests, particularly oaks forests, avenues planted with trees, tree lines in parks and on timber yards. Niche: in an old decaying solitary *Quercus*, particularly in a rough bark, also in fathom wood and on the leaking sap of wounded trees. Damaged trees with dry branches have ethological significance - they attract females. The species was described in Slovenia (*locus typicus* 'circa Labacum' - near Ljubljana, *C. Heros* Scopoli, 1763) (Drovenik & Pirnat, 2003). Range in the paleoarctic region: in Slovenia it appears sporadically in oak stands, the estimated range from 6 to 20% of the area of Slovenia. EU code 1088. Protecting rank SI-E; IUCN-VU; Bern-II; FFH-II, IV.

— *Cucujus cinnaberinus* (Scopoli, 1763) (Fam. Cucujidae), a stenotopic, saproxylic, silvicolous and corticolous species. Habitats: deciduous trees and parks, river banks. Niche: under moist rotten bark, mostly on *Quercus*, *Fagus*, *Populus tremula*, *Populus nigra*, *Acer*, *Salix*, *Ulmus*, also on *Abies* and *Picea*, as well in fathom wood or old wood of railings (Koch, 1989b). Adults and larvae live under the wet bark of standing or lying trees. The species was found and described in the area of Slovenia - *locus typicus* is Carniola (= Kranjska). EU code 1085. Protecting rank SI-E; IUCN-VU; Bern-II; FFH-II, IV.

— *Limoniscus violaceus* (P.W.J.Müller, 1821) (Fam. Elateridae), a stenotopic, saproxylic, silvicolous and xylo-detriticolous species. Habitats: old deciduous trees and old parks. Niche: moldered and rotten wood of deciduous trees, particularly in *Fagus sylvatica* (Koch, 1989b). Found in cavities of trunks, in the necks of roots of *Quercus* spp.; on lowlands and in the mountains of medium height as well as in the submountainous areas. Only one piece of data known from Slovenia, from the XIX<sup>th</sup> century, found in *Juglans nigra* near Lenart in Slovenske gorice. EU code 1079. Protecting rank SI-K; FFH-II.

— *Lucanus cervus* (Linnaeus, 1758) (Fam. Lucanidae), a pholeophilic, at times silvicolous, xylo-detriticolous, succicolous and saproxylic species. Habitats: old deciduous, particularly *Quercus* forests and trees in parks. Niche: especially on the sap leaked out from a tree, particularly of *Quercus*; larvae in big roots and old stumps of deciduous trees as *Quercus*, *Fagus*, *Salix*, *Populus*, *Tilia*, *Aesculus* or in fruit trees in orchards, sporadically in conifers or in compost (Koch, 1989b). In Slovenia it is generally spread, the estimation is that it populates > 51% of area of Slovenia (Brelj, 2001). EU code 1083. Protecting rank SI-E; Bern-III; FFH-II.

— *Morimus funereus* Mulsant, 1862 (Fam. Cerambycidae), a stenotopic, silvicolous, xylo-detriticolous, xylophagous and saproxylic species. Habitats: deciduous and mixed forests. Niche: on and in the rotten, moist stumps, in the wood lying on soil surface and in trunks

with the remaining bark of *Fagus*, *Quercus*, *Populus*, *Castanea* and *Abies* (Koch, 1992). The estimation is that it is present on 21–50% of area of Slovenia (Breljih, 2001). EU code 1089. Protecting rank IUCN-VU; FFH-II.

— *Osmoderma eremita* (Scopoli, 1763) (Fam. Scarabaeidae), a stenotopic, pholeophilic, silvicolous, xylo-detriticolous, phytophagic and saproxylic species. Habitats: forest edges, tree rows in parks, river banks. Niche: particularly in mouldered old hollow trees of *Aesculus*, *Tilia*, *Quercus*, *Salix*, *Fagus*, *Fraxinus* and in fruit trees in orchards, individually on blossoms of *Crataegus*, on shrubs or under the bark of decaying trunks (Koch, 1989b). The species was described in Slovenia - *locus typicus* was Carniola (= Kranjska). The species is spread in the whole of Europe (Ranius *et al.*, 2005). In Slovenia it is present but not frequent. Indicatory, priority and umbrella species. EU code 1084. Protecting rank SI-E; IUCN-VU; Bern-II; FFH-II, IV.

— *Phryganophilus ruficollis* (Fabricius, 1798) (Fam. Melandryidae), a saproxylic, stenotopic, silvicolous and xylo-detriticolous species. Habitats: mostly old deciduous forests. Niche: particularly in rotten soft and fungi decayed or harder wood of *Quercus*, also in old decomposed wood of *Fagus sylvatica*, individually in sawn timber. Indicatory species for a virgin forest. In Slovenia there is one known literature location from the Pohorje. Defined as the priority species in Annexes II of the Habitats Directive (Drovenik & Pirnat, 2003). EU code 4021. Protecting rank FFH-II, IV.

— *Rosalia alpina* (Linnaeus, 1758) (Fam. Cerambycidae), a stenotopic, silvicolous, xylo-detriticolous, lignicolous, xylophagous and saproxylic species. Habitats: old beech forests on limestone. Niche: on and in decaying trees and trunks and also on hollow stumps of *Fagus sylvatica*, also in fathom wood, rarely on *Acer* and other deciduous trees. Development on a sunny position on beech trees with rotten wood (Koch, 1992). Females deposit eggs in freshly cut trees and in stumps. Not long ago it was a frequently found species in Slovenia, now the abundance of population has decreased. It is estimated to inhabit from 21 to 50% of the Slovenian area (Breljih, 2001). Priority and vulnerable species. EU code 1087. Protecting rank SI-E; IUCN-VU; Bern-II, FFH-II; IV.

— *Rhysodes sulcatus* (Fabricius, 1787) (Fam. Rhysodidae), a stenotopic, silvicolous, saproxylic and corticolous species. Habitats: old coniferous and deciduous trees in forests. Niche: under the bark and in moulded wood of *Fagus sylvatica* and *Quercus* (Koch, 1989a). Indicatory species for a stable virgin mixed forest with large quantities of dead wood. Heavily threatened in Europe and on the wide scale (Speight, 1989). EU code 4026. Protecting rank FFH-II.

— *Stephanopachys substriatus* (Paykull, 1800) (Fam. Bostrichidae), a stenotopic, silvicolous (amylophilic, corticolous), lignicolous (xylophagous) and saproxylic species. Habitats: conifer forests, moors, also near sawmills. Niche: conifers, particularly young trees damaged by fire, under the bark and in sapwood of *Pinus*, rare under the bark of dried up stumps and trunks of *Picea* and *Abies*, under the accumulated bark of *Picea* and in sawn wood of conifers (Koch, 1989b). From a Holarctic species, of which some locations in the northern part of Slovenia are found, one specimen was found in a pheromone trap for scolytides on the location Rečice near Bled (Drovenik & Pirnat, 2003). EU code 1927. Protecting rank SI-K; FFH-II.

The aim of our study was to present the actual wide range of six selected saproxylic beetles (*C. cerdo*, *C. cinnaberinus*, *L. cervus*, *M. funereus*, *O. eremita* and *R. alpina*) based on recently accessed data. The percentage of localities of the mentioned beetles which are actually in the Natura 2000 sites, their forest plant communities and lands which they actually inhabit were also studied.

## MATERIAL AND METHODS

Data used for the analysis have been taken from two references of Drovenik & Pirnat (2003) and CKFF (2006). Altogether 619 locations for 6 beetles were gathered (57 records were gathered from CKFF, 2006, the rest from Drovenik & Pirnat, 2003). Table I shows the number of localities gathered for each beetle. For example there are 252 known localities for *L. cervus*, and only 6 records for *C. cinnaberinus*. Data are of various accuracies as well (Table II). Generally, data are of high accuracy when the real locality is within a 2 km radius from the location. An average accuracy means around 5 km radius error, low accuracy about 10 km or more radius error. The main reason for this coarseness of the data is the way of digitizing the locations, i.e. from geographical and local names.

TABLE I

Number of records for each beetle taken into analysis

Species	Number of records
<i>Cerambyx cerdo</i>	39
<i>Cucujus cinnaberinus</i>	6
<i>Lucanus cervus</i>	252
<i>Morimus funereus</i>	192
<i>Osmoderma eremita</i>	40
<i>Rosalia alpina</i>	90

TABLE II

Accuracies of the data (in number of records)

Species	Low accuracy	Average accuracy	High accuracy
<i>Cerambyx cerdo</i>	3	11	25
<i>Cucujus cinnaberinus</i>	1	3	2
<i>Lucanus cervus</i>	7	86	159
<i>Morimus funereus</i>	19	95	78
<i>Osmoderma eremita</i>	2	30	8
<i>Rosalia alpina</i>	13	25	52

We made three analyses to present the actual wide range of six selected saproxylic beetles, to find out the percentage of localities of the mentioned beetles which are actually in the Natura 2000 sites, their forest plant communities and lands which they actually inhabit.

The first analysis was made in Natura 2000 potential Sites of Community Interest (pSCI) and Natura 2000 Special Protection Areas (SPA) which were accepted by the Slovenian Government with a special ordinance (Ordinance of Special Areas of Conservation - the Natura 2000 areas, 2004). The second analysis was made with the help of a forest community's background layer (Marinček & Čarni, 2002). The third analysis was made with land use categories (MKGP, 2003). The analyses have been made in the ESRI ArcInfo 9.1 software. Because the data are not exact we used the forest plant community and land use that took the largest area around a particular locality. We assume this is the most probable location where a beetle was found.

## RESULTS

### BETLES IN NATURA 2000 AREAS

The analysis of the locality records for 6 beetles shows that the percentage of records in the Natura 2000 areas is 17.9% for *C. cerdo*, 50% for *C. cinnaberinus*, 49.6% for *L. cervus*, 46.4% for *M. funereus*, 32.5% for *O. eremita* and 56.7% for *R. alpina*.

The locations of *L. cervus* are generally almost evenly distributed across Slovenia (Fig. 1).

There are much more locations in the north-eastern part of Slovenia, i.e. Goričko, because a special research project was performed in that area in which *L. cervus* was caught in special traps within a systematic grid of 2 km (CKFF, 2006).

Figures 2 to 6 show locations for other 5 beetles analysed: *C. cerdo*, *R. alpina*, *M. funereus*, *C. cinnaberinus* and *O. eremita*.

The locations of *C. cerdo* do not belong to the Alpine region, but are bound to oak regions. Locations of *R. alpina* are mainly bound to the Alpine and central parts of Slovenia. There are no records of *R. alpina* in sub-Mediterranean and sub-Pannonian regions. In Slovenia, *M. funereus* is found predominantly in western regions, including the sub-Mediterranean and Alpine regions. There are a few records for *C. cinnaberinus* and cannot be considered to have a distribution rule. *O. eremita* is found all over Slovenia.

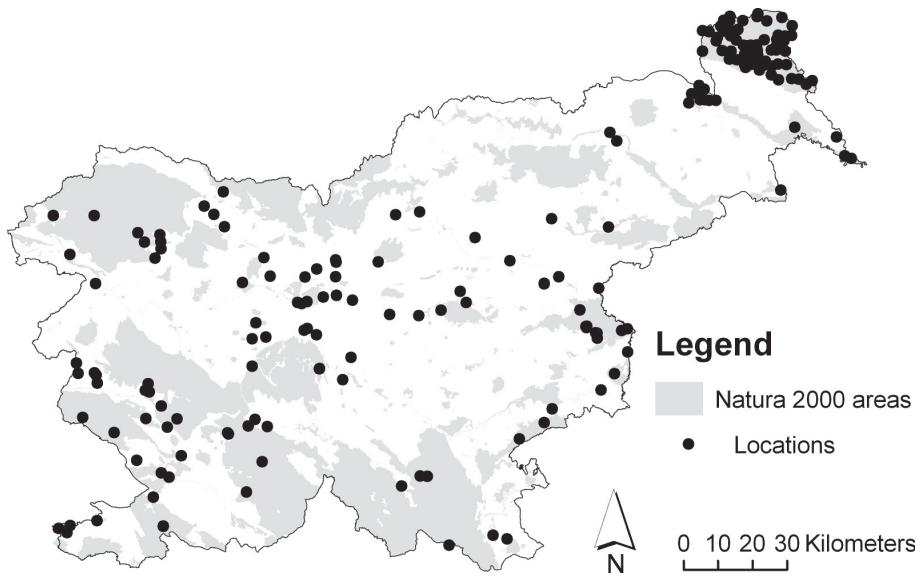


Figure 1. — Locations of *Lucanus cervus* and Natura 2000 areas in Slovenia

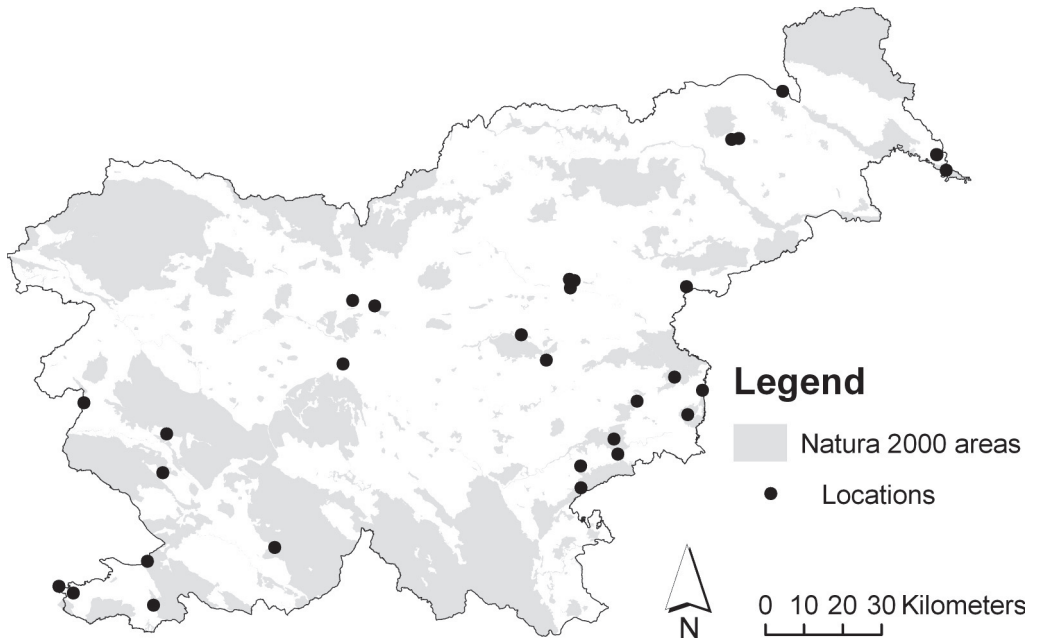


Figure 2. — Locations of *Cerambyx cerdo* and Natura 2000 areas in Slovenia.



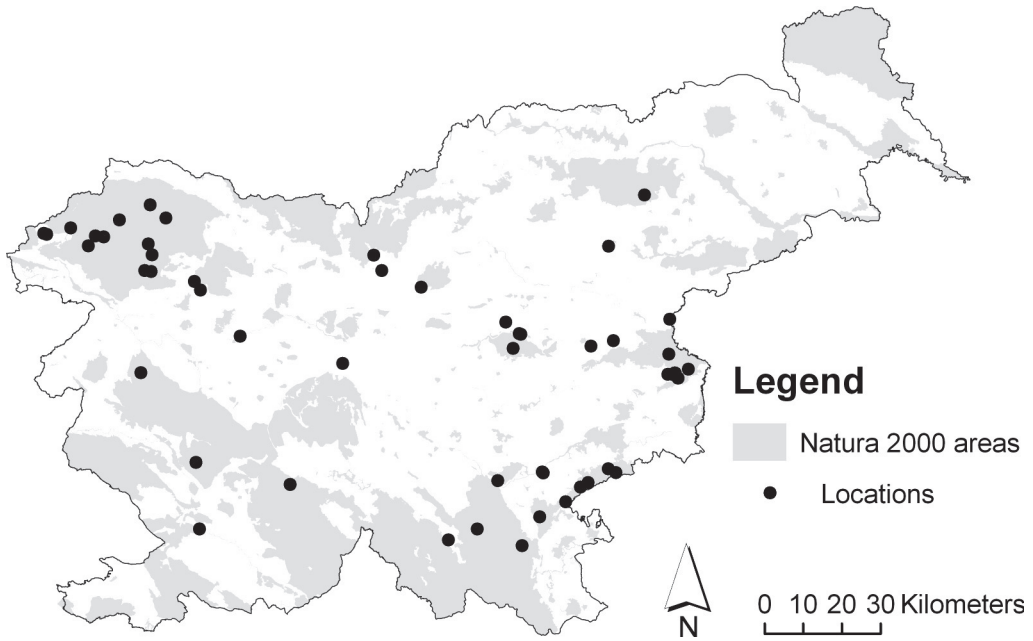


Figure 3. — Locations of *Rosalia alpina* and Natura 2000 areas in Slovenia.

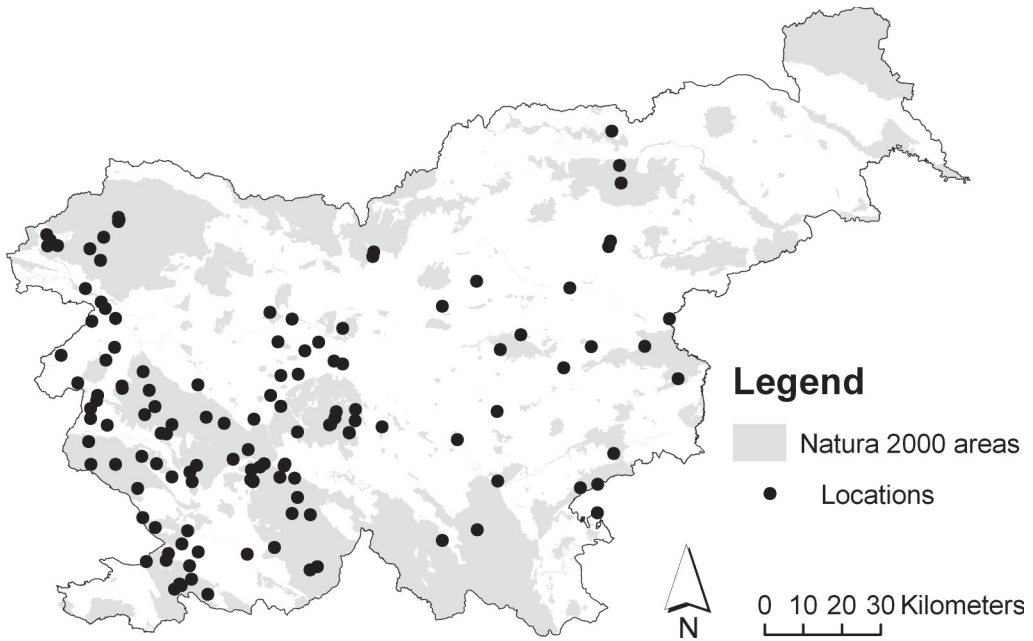


Figure 4. — Locations of *Morimus funereus* and Natura 2000 areas in Slovenia.

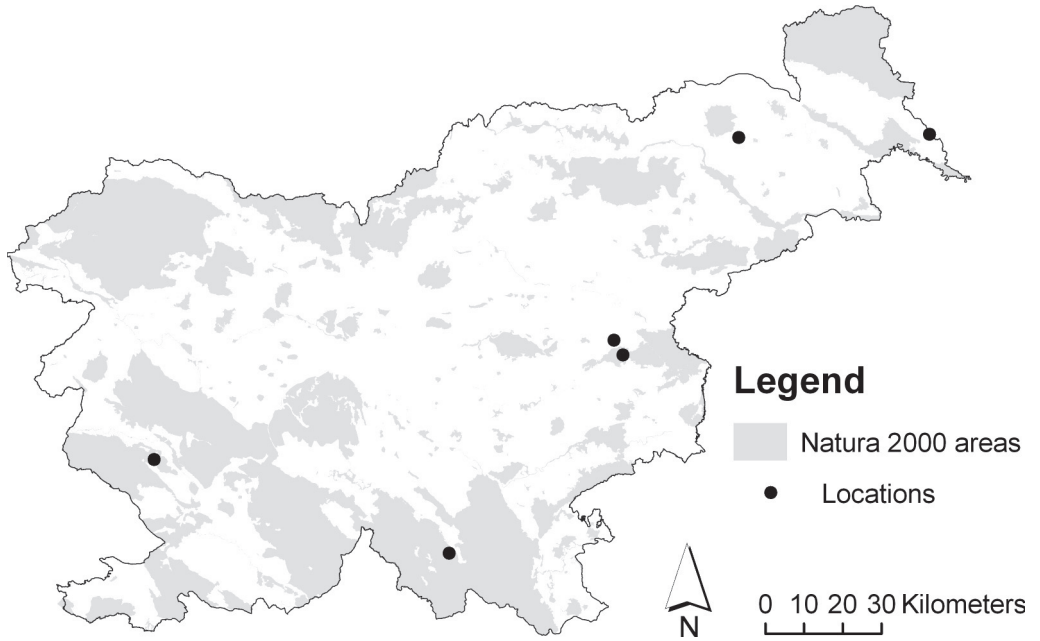


Figure 5. — Locations of *Cucujus cinnaberinus* and Natura 2000 areas in Slovenia.

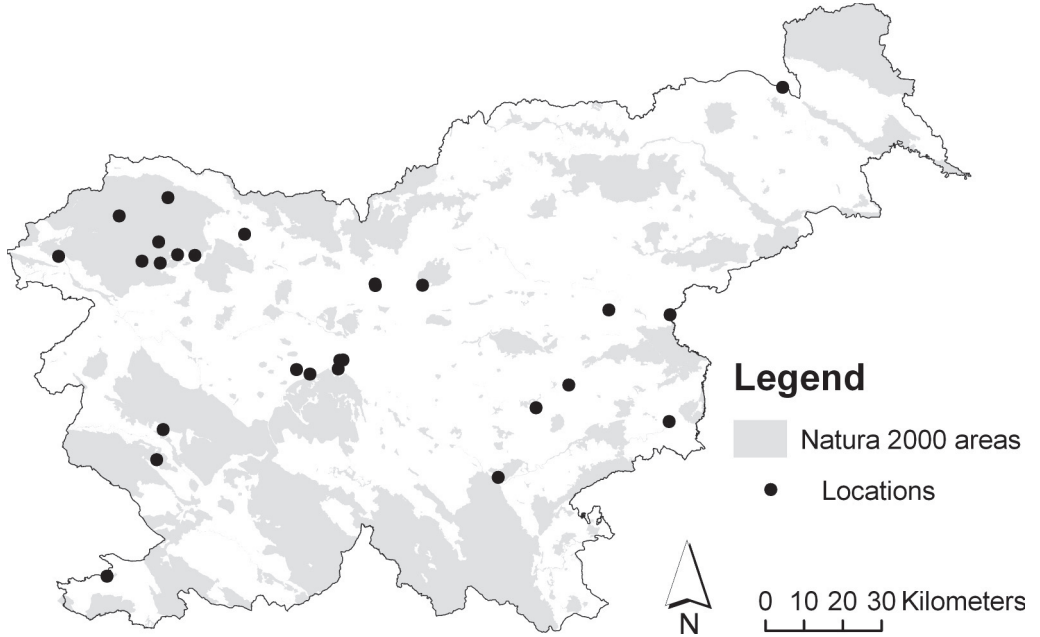


Figure 6.— Locations of *Osmoderma eremita* and Natura 2000 areas in Slovenia.

There are 260 pSCI sites covering 639 735 ha (31.5% of Slovenia) and 26 SPA sites covering 461 819 ha (22.8% of Slovenia). Less than half of the records (244 of 619) are located in SPA or pSCI Natura 2000 sites (Table III).

TABLE III  
Number of Natura 2000 areas and locations where a beetle was found

Species	Natura 2000 area group	No. of rec.	No. of Natura 2000 areas
<i>Cerambyx cerdo</i>	pSCI	3	3
	SPA	3	3
<i>Cucujus cinnaberinus</i>	pSCI	1	1
	SPA	1	1
<i>Lucanus cervus</i>	pSCI	28	11
	SPA	82	6
<i>Morimus funereus</i>	pSCI	38	12
	SPA	36	7
<i>Osmoderma eremita</i>	SPA	5	1
<i>Rosalia alpina</i>	pSCI	29	5
	SPA	18	3
	SPA	145	21
Total	pSCI	99	32
	Total	244	53

Most of those records (145 records) are located in SPA sites that have been already accepted as valid. Even though the majority of records are in SPA sites, pSCI sites constitute a quite frequent habitat for some beetles, e.g. *M. funereus* and *R. alpina*. 21 of 26 SPA sites are important for 6 beetles included into the analysis, in particular for *L. cervus* and *O. eremita*. There are also 32 of 260 potential pSCI sites that have locations of treating beetles. *M. funereus*, and *R. alpina* appear more in pSCI than in SPA areas.

#### BEETLE DISTRIBUTION ACROSS DIFFERENT FOREST PLANT COMMUNITIES AND DIFFERENT LANDS (LAND USE CATEGORIES)

The results of the analysis of the beetle location data according to forest plant communities indicate potential beetle preference for defined forest plant communities. Even though most of the *C. cerdo* data are in different beech type communities, this beetle is the most frequently found in different oak type communities. *C. cinnaberinus* was found mostly in different *Fagetum* type forest communities and also other types. This is significant for *C. cinnaberinus* as it is a polyphagous beetle. *L. cervus* data show its ecological niche for a wide variety of old decomposed stump. *M. funereus* generally lives in broadleaved and mixed forests and this is reflected in its locations in forest plant communities, being usually found in different types of beech and oak type communities. *O. eremita* appears in a wide variety of forest plant communities. The results for *R. alpina* show that this beetle prefers beech-based stands.

#### Beetle preference for forest plant communities

— *Cerambyx cerdo*: *Castaneo sativae-Fagetum* (13 records), *Vaccinio myrtilli-Pinetum sylvestris* (5), *Molinio litoralis-Quercetum pubescentis* (4), *Arunco-Fagetum* (2), *Lamio orvalae-Fagetum* (2), *Vicio oroboidi-Fagetum* (2), *Seslerio autumnalis-Quercetum pubescentis* (2), and other with 1 record: *Ostryo-Fagetum*, *Seslerio autumnalis-Quercetum petraeae*, *Seslerio autumnalis-Ostryetum carpinifoliae*, *Piceo abietis-Quercetum roboris*, *Ostryo carpinifoliae-Quercetum pubescentis*, *Melampyro vulgati-Quercetum petraeae*, *Blechno-Fagetum* and *Pseudostellario europaeae-Carpinetum*;

— *Cucujus cinnaberinus*: *Ostryo-Fagetum* (1 rec.) and others with one record: *Vicio oroboidi-Fagetum*, *Castaneo sativae-Fagetum*, *Omphalodo-Fagetum*, and *Seslerio autumnalis-Quercetum petraeae*;

— *Lucanus cervus*: *Castaneo sativae-Fagetum* (75 records), *Blechno-Fagetum* (32), *Ostryo-Fagetum* (30), *Anemono trifoliae-Fagetum* (14), *Seslerio autumnalis-Ostryetum carpinifoliae* (13), *Omphalodo-Fagetum* (10), *Galio rotundifolii-Pinetum sylvestris* (8), *Ostryo carpinifoliae-Quercetum pubescentis* (7), *Hacquetio epipactidis-Fagetum* (6), *Lamio orvalae-Fagetum* (5), *Molinio litoralis-Quercetum pubescentis* (5), *Vaccinio myrtilli-Pinetum sylvestris* (4) and other *Piceo abietis-Quercetum roboris* (3), *Seslerio autumnalis-Fagetum* (3), *Arunco-Fagetum* (3), *Seslerio autumnalis-Quercetum petraeae* (2), *Salicetum albae* (1), *Helleboro nigri-Carpinetum betuli* (1), *Pteridio-Betuletum pendulae* (1), *Galio rotundifolii-Abietetum albae* (1), *Quercu-Ostryetum carpinifoliae* (1), *Carici umbrosae-Quercetum petraeae* (1), *Avenello flexuosae-Piceetum* (1), *Alnetum glutinosae s. lat.* (1), and *Vicio oroboidi-Fagetum* (1);

— *Morimus funereus*: *Omphalodo-Fagetum* (49 records), *Blechno-Fagetum* (21), *Anemono trifoliae-Fagetum* (19), *Arunco-Fagetum* (15), *Ostryo carpinifoliae-Quercetum pubescentis* (13), *Castaneo sativae-Fagetum* (11), *Seslerio autumnalis-Quercetum petraeae* (11), *Ostryo-Fagetum* (10), *Seslerio autumnalis-Fagetum* (9), *Lamio orvalae-Fagetum* (7), *Seslerio autumnalis-Ostryetum carpinifoliae* (4) and other *Hacquetio epipactidis-Fagetum* (3), *Galio rotundifolii-Abietetum albae* (3), *Ranunculo platanifoliae-Fagetum* (3), *Vaccinio myrtilli-Pinetum sylvestris* (2), *Carici umbrosae-Quercetum petraeae* (2), *Seslerio autumnalis-Quercetum pubescentis* (2), *Abio albe-Carpinetum betuli* (2), *Melampyro vulgati-Quercetum petraeae* (1), and *Cardamino savensi-Fagetum* (1);

— *Osmoderma eremita*: *Anemono trifoliae-Fagetum* (14 records), *Blechno-Fagetum* (11), *Castaneo sativae-Fagetum* (7), *Homogyno sylvestris-Fagetum* (2), *Seslerio autumnalis-Quercetum petraeae* (1), *Molinio litoralis-Quercetum pubescentis* (1), *Omphalodo-Fagetum* (1), *Ostryo-Fagetum* (1), *Seslerio autumnalis-Ostryetum carpinifoliae* (1), and *Lamio orvalae-Fagetum* (1);

— *Rosalia alpina*: *Ostryo-Fagetum* (19 records), *Anemono trifoliae-Fagetum* (18), *Lamio orvalae-Fagetum* (16), *Arunco-Fagetum* (9), *Omphalodo-Fagetum* (5), *Blechno-Fagetum* (4), *Castaneo sativae-Fagetum* (4), *Hacquetio epipactidis-Fagetum* (4), *Vaccinio myrtilli-Carpinetum betuli* (4), *Homogyno sylvestris-Fagetum* (1), *Ostryo carpinifoliae-Quercetum pubescentis* (1), *Ranunculo platanifoliae-Fagetum* (1), *Rhodothamno-Rhododendretum hirsute* (1), and *Abio albe-Carpinetum betuli* (1).

#### *The appearance of different species of beetles analysed on different lands (land use categories)*

The results show that different species of beetles are often found on urban land, like *C. cerdo*, *O. eremita*, and *R. alpina*. Other beetles (*L. cervus*, *M. funereus*, and *C. cinnaberinus*) are mostly found in forests. A single tree or a group of trees in an agricultural land can be enough for *C. cerdo*, *L. cervus*, *M. funereus*, *O. eremita*, and *R. alpina* to live there.

The results of the analysis of preference of particular saproxylic beetles to land use are:

— *Cerambyx cerdo*: Urban land (18 records), Agricultural land (11), Forest land (10);

— *Cucujus cinnaberinus*: Forest land (4 records), Urban land (2);

— *Lucanus cervus*: Forest land (131 records), Urban land (82), Agricultural land (38), Wetland (1);

— *Morimus funereus*: Forest land (74 records), Urban land (63), Agricultural land (54), Dry open land (1);

— *Osmoderma eremita*: Urban land (25 records), Forest land (11), Agricultural land (4);

— *Rosalia alpina*: Urban land (42 records), Forest land (31), Agricultural land (17).

## DISCUSSION

Natura 2000 areas do not cover the habitats of 6 species of beetles analysed that are suitable: 17.9% of records of *C. cerdo* are found in Natura 2000 areas, the percentage is 50%

for *C. cinnaberinus*, 49.6% for *L. cervus*, 46.4% for *M. funereus*, 32.5% for *O. eremita* and 56.7% for *R. alpina*. We are talking about the Natura 2000 areas which are now under the process of being accepted by the EC and they might well turn out to be different at the end of the process.

In Slovenia over 60% of the areas proposed under the Habitat Directive are located within the proposed SPA areas under the Wild Birds Directive. Less than half (244 out of 619) of the records for analysed species are located in SPA or pSCI Natura 2000 areas. Most of them (145 out of 244) are located in SPA that have already been accepted as valid. 21 of 26 SPA are important for 6 beetles included in the analysis, in particular for *L. cervus* and *O. eremita*. There are also 32 of the 260 potential pSCI where the analysed species live. *M. funereus* and *R. alpina* appear more in pSCI than in SPA areas.

The stand preferences for the six analysed species are similar. All beetle species require very similar forest plant communities, above all old beech or oak forest as follows: *C. cerdo* appears in 15 different plant communities, above all in six beech and six oak plant communities; *C. cinnaberinus* in five plant communities: in four beech and one oak plant communities; *L. cervus* appears in 25 different plant communities, above all in 10 beech plant communities, seven oak plant communities and others; *M. funereus* appears in 20 different plant communities, above all in 11 beech and five oak plant communities; *O. eremita* appears in 10 different plant communities, above all in seven beech and three oak plant communities; *R. alpina* appears in 14 different plant communities, above all in ten beech and one oak plant communities.

Three of six analysed forest-dependent species like *C. cerdo*, *O. eremita* and *R. alpina* show preference for urban land. This could be explained by the fact that important habitats for these species are old trees in parks, by riversides or solitary. The other three species *C. cinnaberinus*, *M. funereus* and *L. cervus* prefer a forest land.

The area of the Slovenian Natura 2000 sites represents only a small contribution to the protected areas in EU25. On the other hand, if the SPA and pSCI areas are compared to the total terrestrial area of the country, the view is different.

The European average for SPA is 9.6% of the terrestrial area. Only three European countries have more than 15% of the surface declared as SPA: Slovakia (25.2%), Slovenia (22.6%) and Spain (18.2%) (<http://biodiversity.eionet.europa.eu>).

The European average for pSCI is 12.2% of the terrestrial area. The Slovenian proposal of 6397 km<sup>2</sup> represents the highest percentage of a country's terrestrial area in Europe. The three European countries with the largest percentage of pSCI compared to the total terrestrial area are Slovenia (31.6%), Spain (22.6%) and Portugal (17.4%) (<http://biodiversity.eionet.europa.eu>).

## CONCLUSIONS

Data accuracy is coarse; therefore, results are not entirely reliable but only probable.

Natura 2000 areas are important for the preservation of rare and endangered beetle species. Our analysis shows there is great potential in pSCI sites for *L. cervus*, *M. funereus*, and *R. alpina*.

The proportion of beetle locations in Natura 2000 areas could show the quality of defined SPA and pSCI Natura 2000 areas for the protection of selected, rare and endangered beetle species. Therefore, we could make an assertion that Natura 2000 areas provide good protection for *R. alpina*, *C. cinnaberinus*, *L. cervus*, and *M. funereus*; and less for *O. eremita* and *C. cerdo*.

Beetle distribution across different forest plant communities shows which forest plant communities indicate potential beetle preference for the forested habitat type. *C. cerdo* is the second most frequently found in different oak type communities, *C. cinnaberinus* was found mostly in different *Fagetum* type forest communities, *L. cervus* was mostly found at *Castaneo sativae-Fagetum*. Beetles of the species *M. funereus* generally live in broadleaved and mixed forests (beech-oak type communities). *O. eremita* appears in a wide variety of forest plant communities. The results for *R. alpina* shows that this beetle prefers beech-based stands.

Beetle occurrences on different land use categories give the somewhat unusual result that *C. cerdo*, *O. eremita*, and *R. alpina* are often found on urban land even though they basically live in forests. This could be explained in a way that single trees or groups of trees can be enough for their full cycle development.

We have determined that forest management that works with nature, and which is enforced both in the theory and practice of Slovenian forestry, is the necessary foundation for conserving the forest and saproxylic forest species. Slovenian forestry legislation and adopted EU legal regulations (Natura 2000) regarding the protection of forest biodiversity ensure the preservation of saproxylics now and in the future.

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