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Fungal diversity of the Kellerwald-Edersee National Park – indicator species of nature value and conservation

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With 2 figures and 1 table

Abstract: The UNESCO World Natural Heritage national park Kellerwald-Edersee in Germany was investigated during 10 years for its macromycetes. 613 species have been recorded totally. 31 threatened species are listed on the German red list of fungi. 27 species of interest according to the criteria of the International Union for the Conservation of Nature and Natural Resources (IUCN), 10 species with nature value on a German scale and 5 species of nature value on a European scope have been detected. Compared to other national parks included in the UNESCO World Natural Heritage "Ancient Beech Forests of Germany" and the "Primeval Beech Forests of the Carpathians" the Kellerwald-Edersee National Park has fewer tree species on poor soils thus exhibiting lower species numbers. Based on old tree stands and relict primeval forest fragments the forest ecosystem of the Kellerwald-Edersee National Park will develop to near naturalness within a few decades.

Key words: diversity, fungi, macromycetes, indicator species, beech forest, Kellerwald-Edersee national park, UNESCO World Natural Heritage.

Introduction

The Kellerwald-Edersee National Park (Germany, Hesse) is a part of the UNESCO World Natural Heritage "Ancient Beech Forests of Germany" inscribed on June 25th, 2011 (UNESCO 2013) as an completion of the "Primeval Beech Forests of the Carpathians", inscribed in 2007. Together with the Ukrainian and Slovakian Carpathians the Kellerwald-Edersee clusters a common world heritage site together with the German national parks, Hainich, Serrahn, Grumsin and Jasmund (Fig. 1). Their forests are characterized by old-growth stands dominated by *Fagus sylvatica* L. on different soils

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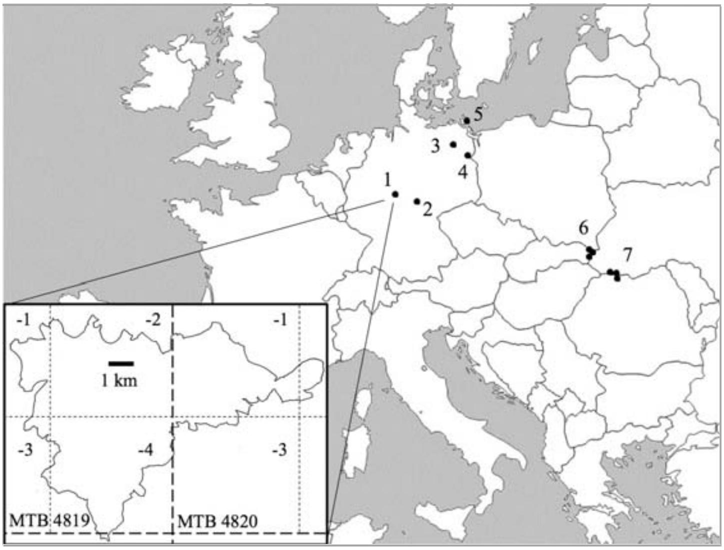

Fig. 1. Map with dots indicating the World Natural Heritage national parks. 1 = Kellerwald-Edersee, 2 = Hainich, 3 = Serrahn, 4 = Grumsin, 5 = Jasmund, 6 and 7 = primeval beech forests of the Carpathians. Detailed map showing the Kellerwald-Edersee National Park with MTB map numbers and quadrants. Map modified from d-maps.com.

representing the natural vegetation of European beech forests from planar to subalpine elevation. High amounts of coarse woody debris (CWD) are a characteristic of these forests (Hahn & Christensen 2004, Christensen et al. 2005, Odor et al. 2006). The vegetation of the Kellerwald-Edersee National Park shows the poor acid form of the European *Luzulo-Fagenion* (Ellenberg 2009) on rubblestone and argillite, mixed with *Quercus robur* L., *Quercus petrea* (Mattuschka) Liebl., sporadic allochthone *Pinus sylvestris* L., *Picea abies* (L.) H.Karst. and *Larix decidua* Mill. The colline to montane character with elevations from 198 to 626 m alt. includes sun-exposed and steep postglacial scree slopes as well as shady slope forests of the type *Tilio-Aceron* Klika 1955, floodplains with *Alnus glutinosa* (L.) Gaertn., oligotrophic meadows and heathers with *Nardus stricta* L. Mean precipitation and temperature vary from 600–900 mm and 6–8°C respectively (Lübcke & Frede 2007).

In contrast to the remnants of primeval beech forests of the Ukrainean and Western Carpathians in Slovakia, the German areas of protection had been used heavily by logging, charcoaling and hunting for hundreds of years. Under protection since the 17th century as hunting ground of the sovereign of Waldeck (Bockshammer 1958) many of the relict primeval areas (Frede 2009) in the Kellerwald-Edersee National Park preserved an outstanding diversity. Since its foundation in 2004 many inventories have been undertaken (Schmidt & Meyer 2013) that revealed e.g. 909 species of beetles, 211 mushroom midges, 310 bugs, 301 lichens, 560 higher plants (Frede 2012, Frede & Lehmann 2013), 754 taxa living in marsh sources (Reiss & Zaenker 2012) and 325

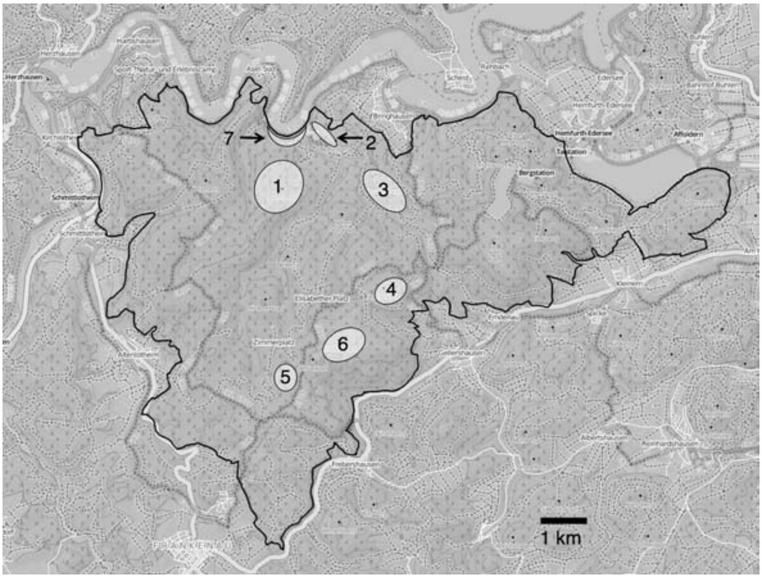

Fig. 2. Map showing the main collection sites with field names. 1 = Arensberg, 2 = Bloßenberg, 3 = Daudenberg, 4 = Locheiche, 5 = Ruhlauber, 6 = Traddelkopf, 7 = Wooghölle. Map modified from OpenStreetMap©.

mosses (Waesch & Preußing 2013). All groups comprised a high amount of indicator species of nature value and conservation.

While primeval beech forests have been investigated thoroughly on higher fungi in the Slovakian Carpathians (Kuthan et al. 1999, Adamčík et al. 2003, Adamčík et al. 2007, Holec 2008, Holec 2013), Ukrainian Eastern Carpathians (Pilát 1940, Holec 2002, 2008, Küffer et al. 2004) and in protected areas in Denmark (Heilmann-Claussen & Christensen 2000), in Germany published data of natural beech forests are available only from the National Parks Hainich (Hainich Nationalpark 2010, 2011), Harz (Schultz 2010) and Bayerischer Wald (Luschka 1993, Nuss 1999).

The aim of this study is to document the diversity of macromycetes in the Kellerwald-Edersee National Park and to compare the abundance of indicator species of nature value (Christensen et al. 2004) with results from two other European beech forest UNESCO World Natural Heritage national parks namely Hainich (Germany, Thuringia) and Poloniny (Slovakia).

Materials and methods

1997 and from 2004 on yearly surveys have been undertaken in autumn to selected areas of interest with a high amount of ancient forest stands including a lot of CWD (Fig. 1). Selected areas with the field names "Arensberg", "Bloßenberg", "Daudenberg", "Locheiche", "Ruhlauber", "Traddelkopf", and the relict primeval site "Wooghölle" have been selected for investigation (Fig. 2). The German grid system (MTB = "Messtischblatt") was used to document the location of records with a four-digit map number followed by the quadrant of the map, e.g. MTB 4819-4. We followed a plot-less sampling strategy according to Mueller et al. (2004) to get a high diversity overview within limited time. Species were identified in the field if possible, and noted as field records. Samples not possible to identify ad hoc were submitted to investigation using an Olympus BX51TF microscope and standard procedures for fungi described in Lee & Langer (2012). For determination literature proposed by Oertel (2003) was used. Names of species follow Mycobank (www.mycobank.org). Voucher specimens are deposited in a satellite collection of the herbarium KAS and in FR (see Index Herbariorum, Thiers 2014).

Results

Within 10 years of inventory 2447 records comprising 613 species (100%) of macromycetes were made. Thereof 1018 vouchers are deposited in KAS and partly in FR. 42% of the total species were wood-decayers, 26% decay leaf or needle litter, 27% were mycorrhizal species and 5% were semi-parasites (Langer & Langer 2013). One special collecting site on the steep scree slope "Wooghölle" with *Tilia* spp., *Acer* spp., *Q. petrea*, *Sorbus aria* (L.) Krantz and *F. sylvatica*, suspected to be relict primeval, revealed 200 species of macromycetes on 0.25 km^2.

Here we present 121 species including 5 species (0.82%) of interest with nature value according to Christensen et al. (2004) and 10 species (1.63%) with nature value according to Blaschke et al. (2009). We found 25 species listed with IUCN threat categories A to C proposed by Odor et al. (2006): 2 species (0.33%) in category A, 10 species (1.63%) in category B and 15 species (2.45%) in category C. 33 threatened species are specified in the red lists of Germany (Table 1) and 96 threatened species according to the red list of Hesse. 77 species have been collected in old-growth stands with abundant tree individuals with age over 120 years. The presented 121 species are listed below. The complete checklist can be obtained by the corresponding author.

The following list used threat categories introduced by Odor et al. (2006) for species of interest (SSI) in dependence on the IUCN code:

SSI(A) = class A (IUCN "endangered" to "Critically Endangered"); widespread species regarded as very rare and severely threatened.

SSI(B) = class B (IUCN "Near Threatened" to "Vulnerable"); widespread species regarded as rare all over Europe, and threatened in several countries.

SSI(C) = class C (IUCN "Vulnerable" to "Critically Endangered"); threatened in one or several of the covered European countries/regions, but being frequent in others.

Indicator species of nature value follow Christensen et al. (2004) on European scale (I++) and Blaschke et al. (2009) on German scale (I+). Threat categories of fungi in red lists of Hesse (RL He) and Germany (RL Ge) follow Langer (2000) and Benkert et al. (1996) respectively. Red list codes are 1 = critically endangered, 2 = very endangered, 3 = endangered, R = very rare species potentially endangered, D = distribution of species not well known, potentially endangered. Old-growth forest = ogf. MTB = German map grid number. GEL = Herbarium Gitta and Ewald Langer in KAS, L = Langer in FR.

Table 1: Comparison of species numbers of national parks (NLP) with indicator species (I++ for Europe and I+ for Germany), threatened species with red lists categories of IUCN (SSI A to C) and Germany (RL Ge 1 to 3). Numbers in parentheses indicate the percentage of species in respect to total species numbers of the particular national park; n.a. = not applicable.

NLP	**species**	**I++**	**I+**	**SSI(A)**	**SSI(B)**	**SSI(C)**	**RL Ge 1**	**RL Ge 2**	**RL Ge 3**
Kellerwald	613	5(0.82)	10(1.63)	2(0.33)	10(1.63)	15(2.45)	1(0.16)	5(0.82)	26(4.24)
Hainich	1646	11(0.67)	15(0.91)	4(0.24)	21(1.28)	26(1.58)	4(0.24)	46(2.80)	146 (8.87)
Poloniny	1244	15(1.21)	10(0.81)	6(0.48)	11(0.88)	6(0.48)	n.a.	n.a.	n.a.

List of species records from the Kellerwald-Edersee National Park listed in Christensen et al. (2004), Odor et al. (2006) and Blaschke et al. (2009) and in red lists of Germany and Hesse.

Agaricus comtulus Fr., RL He 3, ogf, MTB 4819-2; KAS: GEL 8616.

Albatrellus cristatus (Schaeff.: Fr.) Kotl. & Pouzar, RL Ge 2, RL He 2; MTB 4819-4; KAS: GEL 7677.

Albatrellus ovinus (Schaeff.: Fr.) Kotl. & Pouzar, RL He 2; MTB 4819-2; field record.

Amanita vaginata (Bull.: Fr.) Lam., RL He 3, ogf, MTB 4819-4; KAS: GEL 8216.

Amphinema byssoides (Pers.: Fr.) J. Erikss., RL Ge D, RL He R; MTB 4819-2, 4820-1; KAS: GEL 6899, GEL 7463, GEL 9004, L311.

Astraeus hygrometricus (Pers.) Morgan, RL Ge 3, RL He 3; MTB 4819-2, 4820-1; field record.

SSI(C) *Biscogniauxia nummularia* (Bull.: Fr.) O. Kuntze; MTB 4819-2/4820-1; KAS: GEL 6893, GEL 6894, GEL 7085.

Bolbitius reticulatus (Pers.: Fr.) Ricken, RL He 2, ogf, MTB 4819-4; KAS: GEL 8159.

Boletinus cavipes (Klotzsch: Fr.) Kalchbr., RL He 1, ogf, MTB 4819-2, 4820-1; KAS: GEL 6874.

Boletus edulis Bull.: Fr., RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; field record.

Boletus luridiformis Rostk. in Sturm = *Boletus erythropus* (Fr.: Fr.) Krombh., RL He 3, ogf, MTB 4819-4; KAS: GEL 8221.

Boletus pulverulentus Opat., RL He 3; MTB 4819-2, 4820-1; field record.

I+ *Botryobasidium aureum* Parmasto, ogf, MTB 4819-2; KAS: GEL 7461, GEL 7509, GEL 8525.

Byssocorticium atrovirens (Fr.) Bondartsev & Singer, RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6802, GEL 6887, GEL 8158 , GEL 8313.

Calvatia utriformis (Bull.: Pers.) Jaap, RL Ge 3, RL He 3; MTB 4819-2, 4820-1; KAS: GEL 7218.

Camarophyllus virgineus (Wulfen) P. Kumm., RL He 2; MTB 4819-2, 4820-1; KAS: GEL 7222.

Cantharellus cibarius Fr., RL Ge 3, RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7678, GEL 7466, GEL 7485, GEL 8193, GEL 8507, GEL 8577.

Cantharellus cinereus Pers. = *Craterellus cinereus* (Pers.) Pers.: Fr., RL Ge 3, RL He 3, ogf, MTB 4819-4; KAS: GEL 8325, GEL 8327.

Cantharellus tubaeformis Fr., RL He 3, ogf, MTB 4819-4; KAS: GEL 8164, GEL 8201.

Chroogomphus rutilus (Schaeff.: Fr.) O.K.Miller = *Gomphidius rutilus* (Schaeff.: Fr.) S. Lundell, RL He 3; MTB 4819-2; KAS: GEL 6815.

Clitocybe costata Kühner & Romagn., RL He 3, ogf, MTB 4819-2; KAS: GEL 6717, GEL 6782.

Clitocybe geotropa (Bull.: Fr.) Quél., RL He 2; MTB 4819-2/4820-1; field record.

Collybia distorta (Fr.) Quél. = *Rhodocollybia prolixa* var. *distorta* (Fr.) Antonín, Halling & Noordel., RL He 2, ogf, MTB 4819-2; KAS: GEL 7470.

Collybia dryophila (Bull.: Fr.) P. Kumm. = *Gymnopus dryophilus* (Bull.: Fr.) Murrill, RL He 2, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6811, GEL 7413, GEL 7486, GEL 7511, GEL 7518, GEL 7530.

Collybia hariolorum (Bull.: Fr.) Quél. = *Gymnopus hariolorum* (Bull.: Fr.) Antonín, Halling & Noordel., RL He 3, ogf, MTB 4819-2; KAS: GEL 8618.

SSI(C) *Coprinus alopecia* Lasch, RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 8568.

Cortinarius alboviolaceus (Pers.: Fr.) Fr., RL He 3, ogf, MTB 4819-2; KAS: GEL 6743.

Cortinarius anomalus (Fr.: Fr.) Fr., RL He 3, ogf, MTB 4819-4; KAS: GEL 8225.

Cortinarius armillatus (Fr.: Fr.) Fr., RL He 2; MTB 4819-2; KAS: GEL 6862.

Cortinarius cinnabarinus Fr., RL Ge 3, RL He 3, ogf, MTB 4819-4; KAS: GEL 8154.

Cortinarius delibutus Fr., RL He 2, ogf, MTB 4819-4; KAS: GEL 8203.

	Cortinarius multiformis Fr.: Fr., RL He 2, ogf, MTB 4819-2; KAS: GEL 8882.
	Cortinarius olidus J.E. Lange, RL Ge 2 (as *C. cephalixus*), ogf, MTB 4819-2; KAS: GEL 8596.
	Cortinarius traganus (Fr.: Fr.) Fr., RL He 2; MTB 4819-4; field record.
	Craterellus cornucopioides (L.) Pers., RL Ge 3, RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6624, GEL 7540, GEL 8518, GEL 8155.
SSI(C)	*Crepidotus cesatii* (Rabenh.) Sacc., ogf, MTB 4819-2; KAS: GEL 8911.
	Cystolepiota seminuda (Lasch) P. Kumm., RL He 3, ogf, MTB 4819-2; KAS: GEL 8614.
	Entoloma lividoalbum (Kühner & Romagn.) Kubička, RL Ge 3, RL He D, ogf, MTB 4819-4; KAS: GEL 8271.
	Entoloma papillatum (Bres.) Dennis, RL Ge 3, RL He D; MTB 4819-2; field record.
	Fistulina hepatica (Schaeff.) Fr., RL He 3; MTB 4819-2/4820-1; field record.
I+	*Fomes fomentarius* (L.) Fr., MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6746, GEL 7549
SSI(C)	*Gloeophyllum sepiarium* (Wulfen: Fr.) P. Karst., ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6726, GEL 7498, GEL 8322.
I+	*Hapalopilus croceus* (Fr.) Donk = *Aurantioporus croceus* (Pers.: Fr.) Murrill, RL Ge 1, RL He 1; MTB 4819-2/4820-1; KAS: GEL 8558.
	Hebeloma radicosum (Bull.: Fr.) Ricken, RL He 2, ogf, MTB 4819-4; field record.
I++, I+, SSI(B)	*Hericium coralloides* (Scop.: Fr.) Gray, RL Ge 2, RL He 2, ogf, MTB 4819-2, 4820-1; KAS: GEL 6790, GEL 7414, GEL 8604.
I++, SSI(C)	*Hohenbuehelia auriscalpium* (Maire) Singer, ogf, MTB 4819-2; KAS: GEL 8907
	Hydnum repandum L.: Fr., RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7108, GEL 7209, GEL 7465, GEL 8157, GEL 8223.
	Hygrocybe aurantiosplendens R. Haller Aar., RL Ge 3, RL He D; MTB 4819-2/4820-1; KAS: GEL 7225.
	Hygrocybe coccinea (Schaeff.: Fr.) P. Kumm., RL Ge 3, RL He 2; MTB 4819-2/4820-1; KAS: GEL 7221.
	Hygrocybe conica (Scop.: Fr.) P. Kumm., RL Ge 3, RL He D; MTB 4819-2, 4820-1; KAS: GEL 6776, GEL 6892, GEL 7217, GEL 8584.
	Hygrocybe glutinipes (J.E. Lange) R. Haller Aar., RL Ge 2; MTB 4819-2/4820-1; KAS: GEL 7220.

	Hymenochaete rubiginosa (Dicks.: Fr.) Lév., RL He 3, ogf, MTB 4819-2; KAS: GEL 6655.
	Hymenochaete tabacina (Schwein.: Fr.) Lév., RL He 3, ogf, MTB 4819-2; KAS: GEL 7474.
	Hypocrea citrina (Pers.: Fr.) Fr., RL He 2, ogf, MTB 4819-2; KAS: GEL 8902.
I+, SSI(C)	*Hypsizygus tessulatus* (Bull.) Singer 1947 = *Hypsizygus ulmarius* (Bull.: Fr.) Redhead, Blaschke; MTB 4819-2; field record.
	Inocybe adaequata (Britzelm.) Sacc., RL He 3, ogf, MTB 4819-2; KAS: GEL 8903.
	Inocybe cookei Bres., RL He 3, ogf, MTB 4820-1; KAS: GEL 8998.
I++, I+, SSI(B)	*Inonotus cuticularis* (Bull.: Fr.) P. Karst., RL He 2, ogf, MTB 4819-2, 4819-4; KAS: GEL 8262 , GEL 8517, GEL 8572.
	Inonotus hastifer Pouzar, RL Ge 3; MTB 4820-1; KAS: GEL 8893.
SSI(C)	*Inonotus nodulosus* (Fr.) P. Karst., ogf, MTB 4819-2, 4819-4, 4820-1; field record.
I++, I+, SSI(B)	*Ischnoderma resinosum* (Fr.) P. Karst., ogf, MTB 4819-2, 4819-4; field record.
I+, SSI(B)	*Kavinia himantia* (Schwein.: Fr.) J. Erikss., Blaschke; MTB 4819-2; field record.
	Lactarius camphoratus (Bull.) Fr., RL He 3, ogf, MTB 4819-4; KAS: GEL 8179, GEL 8191.
	Lactarius chrysorrheus Fr., RL He 3; MTB 4819-2, 4820-1; field record.
	Lactarius lignyotus Fr., RL He 2, ogf, MTB 4819-4; field record.
	Lactarius vellereus (Fr.) Fr., RL He 2, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6837, GEL 8177, GEL 8285, GEL 8286.
	Lactarius vietus (Fr.) Fr., RL He 3; MTB 4819-2, 4820-1; field record.
SSI(C)	*Lenzites betulina* (L.: Fr.) Fr., ogf, MTB 4819-2, 4819-4; KAS: GEL 8280.
	Macrolepiota mastoidea (Fr.) Singer, RL He 3; MTB 4819-2/4820-1; KAS: GEL 7180, GEL 8552.
	Macrolepiota procera (Scop.: Fr.) Singer, RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 8541.
	Macrotyphula filiformis (Bull.: Fr.) Paechn. ex Rauschert, RL He 2; MTB 4819-2/4820-1; KAS: GEL 7114.
SSI(C)	*Meripilus giganteus* (Pers.: Fr.) P. Karst., ogf, MTB 4819-2, 4819-4, 4820-1; field record.
	Micromphale foetidum (Sowerby: Fr.) Singer, RL He 3, ogf, MTB 4819-4; field record.
SSI(C)	*Mutinus caninus* (Huds.: Pers.) Fr., ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 8599.

	Mycena polygramma (Bull.: Fr.) Gray, RL He 3, ogf, MTB 4819-4; KAS: GEL 8195, GEL 8213.
	Mycena renati Quél., RL Ge 3, RL He 2, ogf, MTB 4819-2; KAS: GEL 8521.
SSI(B)	*Ossicaulis lignatilis* (Pers.: Fr.) Redhead & Ginns, RL Ge 3, RL He 2, ofg, MTB 4819-2, Mayr (1991).
	Otidea onotica (Pers.) Fuckel, RL Ge 3, RL He 3, ogf, MTB 4819-2, 4820-1; KAS: GEL 8573.
	Oudemansiella mucida (Schrad.: Fr.) Höhn., RL He 3, ogf, MTB 4819-2, 4820-1; KAS: GEL 6741.
	Panaeolus papilionaceus (Bull.: Fr.) Quél., RL He 2, ogf, MTB 4819-2; KAS: GEL 8901.
	Paxillus panuoides Fr. = *Tapinella panuoides* (Fr.: Fr.) Gilb., RL He 3, ogf, MTB 4819-4; KAS: GEL 7663.
	Peziza micropus Pers.: Fr., RL He 3, ogf, MTB 4819-2; KAS: GEL 6654.
	Phellinus ferreus (Pers.) Bourdot & Galzin = *Fuscoporia ferrea* (Pers.) G.Cunn., RL He 3, ogf, MTB 4819-2; KAS: GEL 6734.
I+	*Phellinus pini* (Brot.: Fr.) A. Ames = *Porodaedalea pini* (Brot.) Murrill, RL Ge 3; MTB 4819-2, 4820-1; field record.
SSI(B)	*Pholiota flammans* (Fr.) P. Kumm.; MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7699, GEL 8549.
	Phylloporus pelletieri (Lév.) Quél., RL Ge 3, RL He 1; MTB 4819-4; KAS: GEL 7676.
	Physisporinus vitreus (Pers.: Fr.) P. Karst., RL He 3; MTB 4819-2; KAS: GEL 7449.
SSI(C)	*Pleurotus dryinus* (Pers.: Fr.) P. Kumm., RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7390, GEL 7473, GEL 7501, GEL 8178.
	Pluteus ephebeus (Fr.: Fr.) Gill., RL He 3, ogf, MTB 4819-2; KAS: GEL 8884.
SSI(B)	*Pluteus leoninus* (Schaeff.: Fr.) P. Kumm., RL He 3, ogf, MTB 4819-2; KAS: GEL 8519.
SSI(B)	*Pluteus petasatus* (Fr.) Gillet, ogf, MTB 4819-2; KAS: GEL 7510.
	Pluteus salicinus (Pers.: Fr.) P. Kumm., RL He 3, ogf, MTB 4819-2; KAS: GEL 8896.
	Pluteus thomsonii (Berk. & Broome) Dennis, RL He 2, ogf, MTB 4819-2; KAS: GEL 8880.
I+, SSI(C)	*Polyporus badius* (Pers.) Schwein. = *Royoporus badius* (Pers.) A.B. De, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7468, GEL 8581, EL 8897.
	Polyporus squamosus Huds.: Fr., RL He 3, ogf, MTB 4819-2; KAS: GEL 8520, GEL 8527.

Psathyrella leucotephra (Berk. & Broome) P.D. Orton, RL Ge 3, ogf, MTB 4819-2; KAS: GEL 8595.

SSI(B) *Pseudoclitocybe cyathiformis* (Bull.: Fr.) Singer; MTB 4819-2/4820-1; KAS: GEL7119, GEL 7150.

Pseudocraterellus sinuosus (Fr.) Corner, RL Ge 3, RL He R; MTB 4819-2; KAS: GEL 8994.

SSI(C) *Pycnoporus cinnabarinus* (Jacq.: Fr.) P. Karst., ogf, MTB 4819-2, 4819-4; KAS: GEL 6849, GEL 7503.

Ramaria flava (Schaeff.: Fr.) Quél., RL Ge 3, RL He D, ogf, MTB 4819-4; KAS: GEL 8202.

Rozites caperatus (Pers.: Fr.) P. Karst., RL Ge 3, RL He 3, ogf, MTB 4819-4; KAS: GEL 8189.

Russula adusta Fr., RL He 3; MTB 4819-2/4820-1; KAS: GEL 7416.

Russula anthracina Romagn., RL Ge 3, ogf, MTB 4819-4; KAS: GEL 8186.

Russula badia Quél., RL He 3; MTB 4819-2, 4820-1; field record.

Russula farinipes Romell, RL Ge 3, RL He D, ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7072, GEL 7102.

Russula paludosa Britzelm., RL He 3, ogf, MTB 4819-2; KAS: GEL 8514.

Russula puellaris Fr., RL He 3; MTB 4819-2, 4820-1; field record.

Russula rosea Pers., RL He 3, ogf, MTB 4819-2, 4820-1; KAS: GEL 7400, GEL 7534.

Sarcodon imbricatus (L.) P. Karst., RL Ge 3, RL He 2; MTB 4819-2/4820-1; field record.

SSI(C) *Schizophyllum commune* Fr., ogf, MTB 4819-2, 4819-4, 4820-1; KAS: GEL 4623.

Serpula himantioides (Fr.: Fr.) P. Karst., RL He 2; MTB 4819-2, 4819-4, 4820-1; KAS: GEL 7094, GEL 7164, GEL 7490.

SSI(A) *Spongipellis pachyodon* (Pers.) Kotl. & Pouzar; MTB 4819-2/4820-1; field record.

Strobilomyces floccopus (Vahl: Fr.) P.Karst. = *Strobilomyces strobilaceus* (Scop.: Fr.) Berk., RL He 3; MTB 4819-2, 4819-4, 4820-1; KAS: GEL 6600, GEL 6723, GEL 6732, GEL 7496, GEL 8168, GEL 8174.

Stropharia aeruginosa (Curtis: Fr.) Quél., RL He 3, ogf, MTB 4819-2, 4819-4, 4820-1; field record.

Tricholoma scalpturatum (Fr.) Quél. = *Tricholoma argyraceum* (Bull.) Gillet, RL He 3; MTB 4819-2, 4820-1; field record.

Tricholoma sejunctum (Sowerby: Fr.) Quél., RL Ge 3, RL He 3; MTB 4819-2/4820-1; KAS: GEL 7411.

Tricholomopsis rutilans (Schaeff.: Fr.) Singer, RL He 3, ogf, MTB 4819-1, 4919-2/4820-1; KAS: GEL 6787.

SSI(C)	*Volvariella bombycina* (Schaeff.: Fr.) Singer, ogf, MTB 4819-2/4820-1; KAS: GEL 8501, GEL 8553.
	Volvariella surrecta (J.A. Knapp) Singer, RL Ge R, RL He 2, ogf, MTB 4819-2; KAS: GEL 8612.
	Xerocomus rubellus (Krombh.) M.M. Moser, RL He 3; MTB 4819-2/4820-1; field record.
	Xylaria longipes Nitschke, RL He 2; MTB 4820-1; KAS: GEL 8888.
I+, SSI(A)	*Xylobolus frustulatus* (Pers.: Fr.) Boidin, RL Ge 2, RL He 1, ogf, MTB 4819-2, 4819-4; KAS: GEL 7544.

Discussion

Compared with published data from other beech forest World Natural Heritage national parks it is obvious that the species record of the Kellerwald-Edersee National Park is still incomplete and needs further investigation. Nevertheless we found a respectable number of species with nature value according to Christensen et al. (2004) and Blaschke et al. (2009) assuming that the wood-decaying species recorded reflect the nearly naturalness of this forest ecosystem. The amount of dead wood in the German beech forests with protection status is comparatively low to the primeval beech forests of the Carpathians (Harmon et al. 1986, Christensen et al. 2004, Jakoby et al. 2010). Nevertheless Christensen et al. (2004) showed by the comparison of 106 natural or semi-natural beech forest that the amount of CWD is not crucial for the amount of indicator species. The quality of woody debris is far more important than its amount (Abrego & Salcedo 2013). Although the Kellerwald-Edersee National Park was used by humans intensively in the past, governmental protection plans since 1986 have increased its naturalness in previously managed areas. Vandekerkhove et al. (2005) showed that previously managed beech forest can come to nearly natural status within 20 years in means of assemblage of species if a stock of old tree species is available. This is especially true for our selected collecting sites "Arensberg", "Bloßenberg", "Daudenberg", "Locheiche", "Ruhlauber" and "Traddelkopf", while in the relict primeval site "Wooghölle" (Frede 2009) an absence of management over the centuries accumulated ca. 150 m^3/ha of CWD in different stages of decay from 12 tree species. At the latter side we recorded 200 fungal species in only ca. 25 ha. While the Hainich and Poloniny National Park with their rich soils on lime stone and flysh have up to 53 tree species (Nationalpark Hainich 2010), the Kellerwald-Edersee National Park provides only 32 (Meyer & Steffens 2009). While *Abies alba* Mill. and *P. abies* are allochthone in the Kellerwald-Edersee National Park, they are frequent autochthone elements in higher elevations in the Carpathians. Differences in the numbers of species records are therefore explained not only by the time period of inventory but also by the diversity of tree species available as substrate and its diversity of CWD. It has been shown that a high diversity of tree species favours fungal diversity (Heilmann-Clausen et al. 2005), also a high diversity of different CWD (Heilman-Clausen & Christensen 2003, Heilman-Clausen & Christensen 2004).

From 21 European species with nature value analysed by Christensen et al. (2004) *Hericium coralloides, Hohenbuehelia auriscalpium, Inonotus cuticularis, Ischnoderma resinosum* and *Ossicaulis lignatilis* have been recorded in the Kellerwald-Edersee National Park. They are also present in the Hainich National Park (except for *H. auriscalpium* and *O. lignatilis*) and the Poloniny National Park (except for *I. cuticularis*). While *H. coralloides* is on the red lists of various European countries and therefore of great importance in conservancy assessment (Boddy et al. 2011), *I. resinosum* is described as common as soon as a high amount of CWD is available (Krieglsteiner 2000). *H. auriscalpium* is a very rare saprotrophic species on beech wood and also of high interest for conservancy assessment (Ainsworth 2004). Holec & Kolařík (2013) differentiated *Ossicaulis lachnopus* (Fr.: Fr.) Contu from *O. lignatilis* using molecular methods. While they found *O. lachnopus* mainly in natural habitats, *O. lignatilis* seems to grow in more man-influenced habitats. From the species analysed by Odor et al. (2006) as IUCN class A "very rare and severely threatened" we recorded *Spongipellis pachyodon* and *Xylobolus frustulatus*. In the Hainich National Park *Aurantioporus fissilis* (Berk. & Curt) Jahn, *Ceriporiopsis pannocincta* (Rom.) Gilb. & Ryv., *Flammulaster muricatus* (Fr.: Fr.) Watl. and *Psatyrella populina* (Britzelm.) Kits van Wav. have been recorded from the IUCN class A species set and in the Poloniny National Park in addition *Ionomidotis irregularis* (Schwein.) Durand, *Spongipellis delectans* (Peck) Murrill and *Steccherinum murashkinsky* (Burt) Maas Geest. (Hainich Nationalpark 2011, Adamčík et al. 2007).

Comparing the percentage of species of interest in respect to total species numbers found hitherto in the Hainich National Park with that of the Kellerwald Edersee it can be summarized that the latter one has a higher proportion of species with nature value (Cristensen et al. 2004, Blaschke et al. 2009) and IUCN threat categories (Table 1). In contrast the Hainich National Park has the higher proportion of threatened species according to the red list of Germany. The Poloniny National Park has the highest proportion of species with nature values according to Christensen et al. (2004).

Attempts to answer the question if a macromycete can be used as an indicator for nature value have been undertaken using statistical analysis (Christensen et al. 2004, Odor et al. 2006) or by empirical studies (Blaschke et al. 2009, Fichtner & Lüderitz 2013). Our records of *I. resinosum, I. cuticularis* and *X. frustulatus* reflects the situation that species suspected to indicate a natural forest ecosystem also are frequently found in old parks, cementeries and former grazing-forests, e.g. the nature reserve "Urwald Sababurg" in Gemany (Hesse). Species lists from such important protection areas in Germany, like nature reserves, are rarely published (e.g. Langer & Bernauer 2009).

Looking to assigned thread categories of the German red list of fungi (Benkert et al. 1996), that of IUCN (2012) proposed by Odor et al. (2006) for fungi and local lists from the German states (e.g. Langer 2000) shows the limits of comparability. From the German red list there is only one species, *Hapalopilus croceus*, with threat category "critically endangered" and five species with category "very endangered" (*Albatrellus cristatus, Cortinarius olidus, H. coralloides, Hygrocybe glutinipes* and *X. frustulatus*). From these two top categories only *C. olidus* and *H. coralloides* have been recorded in the Hainich National Park besides 50 other species not found in the Kellerwald-Edersee National Park. From the latter species set in the Poloniny National Park, Adamčík et al.

(2007) mentioned only *H. coralloides*. But 26 species of the category "endangered", after the German red list, were recorded in Poloniny National Park. In contrast to this, 146 "endangered" species have been recorded in the Hainich National Park.

Many of the threatened macromycetes create diverse habitat structures for the fauna. It was shown that different age classes of trees, tree species composition and quality of CWD induced by fungi influence the diversity of spiders (Hsieh & Linsenmair 2011), beetles (Müller et al. 2008, Nilsson & Baranowski 1997), gastropods (Kappes 2005) or bats (Celuch & Kropil 2008). We recorded *Fomes fomentarius*, *Hypsizygus tessulatus*, *I. cuticularis*, *Pholiota flammans*, *Volvariella bombycina* on *Fagus sylvatica* and *Fistulina hepatica* and *X. frustulatus* on *Quercus* spp. in high abundance on the lower parts of standing trees, while *Oudemannsiella mucida* was frequently recorded in upper parts. All these species were associated with a high number of different niches like hollow stems, holes and cracks confirming the findings of the above mentioned authors fostering diversity of different organisms. Therefore some of the most endangered species like the xylotrophic violet click-beetle *Limoniscus violaceus Müller*, the hermit beetle *Osmoderma eremita* Scopoli or the Bechstein's Bat *Myotis bechsteinii* Kuhl are present in the Kellerwald-Edersee National Park because of niches supplied by fungi (Hessen Forst 2012).

Sunny rock slopes and screes with records of the thermophilic fungi *Astraeus hygrometricus* and *Biscognauxia nummularia* harboure also very rare plant species like *Dianthus gratianopolitanus* Vill. and *Asplenium septentrionale* (L.) Hoffm. indicating thermo- and acidophilic conditions (Becker et al. 1996).

Ongoing natural processes like small gap dynamics and storms (Standovár & Kenderes 2003) will push the development of diversification of tree age classes and CWD in the Kellerwald-Edersee National Park significantly in the next decades. Therefore a continuation of the inventory especially of macromycetes must be carried on every year until the species accumulation curve will come to an equilibrium.

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