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Long-term development of ant assemblages of recultivated woodland and free-succession open-land habitats in a former strip mining area

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Abstract

Ant assemblages in two woodland recultivations, one semi-natural forest and three open habitats in free succession were investigated in the former strip mining area of Berzdorf near Görlitz / Germany in 1997 / 98 and 2017. Seven structural and six physico-chemical habitat parameters, including mean and maximum calibrated soil temperatures were recorded numerically. Vascular plants, bryophytes and lichens were collected for estimation of soil moisture, nutrient and calcium figures. A four-partite search method (integrating scrutiny-, quick-, spot-inspection- as well as large-scale search) resulted in 373 ant nests, belonging to 9 genera and 23 species. Fourty five years after afforestation, ant assemblages in afforestions on spoil heaps showed 74 % typical woodland species and 5 % typical open-land species remaining from earliest successional stages. The long survival of the latter appears remarkable as epigaean habitat structure and microclimate of the plots showed a clear woodland character already 22 years after afforestation. Sixty five years after afforestation, typical woodland species had increased their share to 93 % and typical open-land species had completely vanished. The retarded immigration of typical woodland species after 65 years is explained through restrictions by dependent colony foundation, requirement for increased tree trunk diameters, and a weaker long-range dispersal capacity. The two afforestation plots showed 65 years after initiation only 50 % of the species richness and nest density of the semi-natural woodland which indicates the long time span needed for completion of ant assemblages. Within 20 years of observation, the development of ant assemblages on the study plots left in free succession from an open-land situation was largely determined by physico-chemical factors and to a lesser degree by structural changes. High soil moisture, good nutrient supply and low soil temperatures reduced species richness. The opposite conditions, as found in the strongly sun-exposed erosion area on basaltic tuff, prevented shrub encroachment and the upgrowth of a high and dense herb layer and allowed a development from a very poor ant-assemblage with few pionier species into a very rich open-land ant community of high value for nature conservation.

Keywords Ant ecology | habitat succession | species richness | nest density | species conservation

1. Introduction

There is a general interest to find robust bioindicators for monitoring and assessment programs (Noss 1990, McKenzie et al. 2012). Such studies mainly focussed on terrestrial invertebrates (Disney 1986, Williams 1993), such as carabids (Reinio & Niemelä 2003) or ants (Andersen & Majer 2004, King et al. 1998) but have extended the scope to vertebrates within the last years, e.g. bats (Jones et al. 2009). Among invertebrate bioindicators ants were believed to be of highest rank (Brown Jr 1997) and have been used in this sense for evaluation of anthropogenic disturbances on habitats (Majer 1983, Majer 2005). Such disturbances include logging, fire, grazing, or mining activities with following restoration (Andersen 1993, 1997). Strong anthropogenic

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disturbances leading to destruction of natural or semi-natural habitats, as reported for mining sites in Australia by Majer (1983), may result in impoverishment of species assemblages. On the other hand, anthropogenic interventions for conservation of cultural landscape – such as mowing or grazing – could lead to an increase of species richness (Dauber et al. 2006).

There are several studies on the post-mining development of invertebrate communities in former strip mining areas on reclaimed (afforested) sites and sites in free (spontaneous) succession. Andersen et al. (2003) used ants as indicators for post-mining restoration in Australia. Majer et al. (2007) investigated successional data in ants and spiders in Australia. They found, when measured by species richness and composition, that reassembly trajectories tracked toward unmined reference areas. Hendrychova et al. (2008) investigated ground-dwelling beetles (*Carabidae*), bugs (Heteroptera), slugs and snails in NW Bohemia. They found a higher species diversity in non-reclaimed sites under spontaneous succession which also provided more suitable habitats for rare species and indicate a higher value for species conservation. Comparable results were found by Holec & Frouz (2005) who studied ant successions on reclaimed and unreclaimed soils of strip mine spoil heaps in NW Bohemia 8 to 32 years after their initiation. Overall abundance and species number increased with succession age in open sites whereas these parameters did not change significantly over time in forest sites.

The area between Görlitz, Hagenwerder and Berzdorf has been used as opencast mining site from 1835 to 1996. Large central parts of the mining site were flooded in 2003 and the resulting lake grew to an area of 9.6 km^2 and depth of 72 m and represents one of the largest water-bodies in Saxony. The southern part of the area was used as spoil heap ('Langteichhalde', established between 1951 and 1955). This plot was primarily afforested with *Alnus glutinosa, Populus sp.* (hybrid)*, Robinia pseudoacacia* and *Pinus sylvestris* from 1952 to 1961 (Dunger et al. 2001). This recultivation area was target of several studies, investigating the initial colonization by invertebrates, such as collembolans, myriapods and carabids or of a bioindication survey considering the status of renaturation (Dunger et al. 2001, 2002, Voigtländer et al. 2016). A massive landslide, moving about 50 ha of ground 340 m southeast and called 'Landslide P', occurred at the northwestern flank of the mining area in 1981. It remained in stable position since about 1997. Ground movement resulted in strong fissures and upheavals. Over hundred ha of the western and northwestern area, including the landslide, became a nature reserve in 1997 (Heinrich et al. 2014, Seifert 2017 digital supplement).

We monitor here 20 years of habitat development from 1997 to 2017 of two study plots on the Langteichhalde and four study plots within the Landslide P: a mixed pine forest recultivation and a mixed popular forest recultivation in the first area and an oat-grass meadow, a semi-natural forest, an erosion area on basaltic tuff and a young alder carr in the second area. One aim of the study is comparing the dynamics of free (spontaneous) succession starting from three landslide-disturbed open-land habitats with most different physico-chemical conditions. The other aim is comparing the development of a semi-natural disturbed woodland on natural ground and of two forest recultivations on heaped soil.

2. Methods

We studied the development of ant assemblages and habitat structures in the two forest recultivations on heaped soil 46 and 65 years after afforestation – i.e, in 1998 and 2017. Four study plots in the area of Landslide P were studied 16 and 36 years after movement of the ground – i.e., in 1997 and 2017.

2.1. Evaluation of physico-chemical habitat parameters

Soil temperatures were measured in 35 mm depth at 6 to 10 measuring spots depending on habitat heterogeneity. Maximum and mean calibrated soil temperatures (T_{MEAN} and T_{MAX}) were calculated using the program *CalibSoil* which allows the characterization of the thermic conditions in the top soil of a habitat independently from short- or medium-term weather fluctuations (Seifert & Panier 2007, Seifert 2017). Determination of indicator plants for soil moisture, nutrient and calcium content of soil was done by Petra Gebauer (vascular plants) and Volker Otte (bryophytes and lichens) – both belonging to the Botany Department of Senckenberg Görlitz. Moisture, nutrient, and calcium figures were calculated as unweighted average of all indicator values given in Ellenberg et al. (2001) and supplemented by data in Jäger et al. (2005). Mechanical stress on top soil (M) was assessed according to Seifert (2017).

2.2. Evaluation of habitat structure

The study site was subdivided into 3–6 plots of 3 m edge length with fewer plots in case of a homogenous habitat stratum and more numerous plots in case of a heterogenous stratum. The following structural

parameters were recorded as average from these plots: the cover of the tree, shrub, herb and bryophyte-lichen layers, the cover of dead wood, litter, stones and bare ground and cumulative phytodensity in the bryophyte-lichen and herb layer. Details of methodology are given in Seifert (2017).

2.3. Collecting methods

Ant collecting was done as described by Seifert (2017). This was direct search for nests as a combination of scrutiny search (S-search), quick search (Q-search), spot inspection (SI-search) or large scale search (L-search). This allows for a given time limit a more comprehensive recording of the species present. Furthermore this sequential method provides comparability of nest density data of species with poorly and easily detectable nests by calculation of integrated species-specific densities.

3. Study sites

Detailed information on the development of habitat parameters and ant assemblages is given in the annex. We provide here only a short characteristics.

3.1. Mixed pine forest

The study plot was a mixed pine forest located on the former spoil heap Langteichhalde (51.0645°N, 14.9296°E).

Situation in August 1998 (for details see annex SP 134, data according to Seifert 2017 digital supplement):

The plot was characterized by a tree cover of 45% consisting of poorly growing *Pinus sylvestris* and a shrub cover of 20% composed of *Acer pseudoplatanus*, *Fraxinus excelsior, Prunus padus, Quercus robur, Sambucus nigra*, *Rubus idaeus* and *Symphoricarpus albus*. A strong herb layer with coverage of 100% – mainly a thick and dense coat of *Carex brizoides* – was present. Cover percentage was 1% in the bryophyte and lichen layer and 5% in the litter layer. Mean and maximum calibrated soil temperatures T_{MEAN} and T_{MAX} were calculated as 13.91 °C and 16.01 °C. Mechanical stress was assessed to have degree 2 which means a weak pressure and seldom, occasional visits of larger mammals.

Situation in June 2017 (for details see annex SP 237):

The plot developed into a stand of up to 25 m high pine trees (*Pinus sylvestris*), mixed with 15–20 m high slim beech trees (*Fagus sylvatica*), with the tree cover having increased to 97.4%. The structure of the lower habitat strata had changed dramatically. Herb layer was reduced to scattered, poorly growing plants with a total cover of only 0.25%. As result, the epigaean phytodensity value PD reduced from 4000 to 2. The cover of the bryophyte and lichen layer did not change significantly – recently being 0.1%. A litter layer of approximately 3.6 cm thickness – consisting of leafs, needles and pine cones – covered 97.6% of the surface. Some pieces of dead wood (0.07 pieces/m^2), pine stumps and some larger basaltic stones (0.01 items/m^2) were present. The physico-chemical parameters of soil did not change with the following exceptions: T_{MEAN} raised to 14.3°C due to global warming and there was a strong increase of soil acidity – indicated by reduction of Ellenberg' R values from 5.11 to 4.67. The latter is explained by the strong development of pine needle litter. Mechanical stress increased to degree 3 mainly due a strong growth of the wild boar population.

3.2. Mixed poplar forest

The study plot was a mixed poplar forest located on the former spoil heap 'Langteichhalde' (51.0652°N, 14.9312°E).

Situation in August 1998 (for details see annex SP 133, data according to Seifert 2017 digital supplement):

The tree layer had a coverage of 75% and contained equal portions of *Populus* sp. (hybrid) and *Robinia pseudoacacia.* Some smaller *Alnus glutinosa* and *Betula* pendula trees were present. Few shrubs – mainly some *Sambucus nigra* and young *Acer pseudoplatanus* – formed a cover of 15%. The strong herb layer of 90% cover mainly consisted of *Galium aparine.* Cover percentage was 15% in the bryophyte and lichen layer, 50% in the litter layer and 5% in dead wood on ground. T_{MEAN} and T_{MAX} were calculated as 14.01°C and 16.42°C. Mechanical stress was assessed with degree 2 meaning a very low level of pressure.

The Situation in June 2017 (for details see annex SP 236):

The site developed into a stand of large popular trees (*Populus* sp. (hybrid)) with a mean height of 25 m and 50–70 cm-diameter at breast height, mixed with smaller trees of *Robinia pseudoacacia*, *Acer pseudoplatanus*, *Alnus glutinosa* and *Betula pendula,* forming a tree cover of 81%. The shrub layer decreased to 7.2% and

the formerly strong herb layer to 13.4% cover with an average height of 5 cm. As result, the epigaean phytodensity value PD diminished from 3000 to 72. On the other hand, litter layer increased to 69.8%, having a mean thickness of approximately 2 cm. Cover percentage was 3% in bryophytes and lichens, 8.4% in of dead wood (with 0.9 pieces/m^2) and 8.2% of the silt-sand-loam soil remained uncovered. The physico-chemical parameters of soil did not change with the following exceptions: T_{MEAN} raised to 14.31°C due to global warming whereas T_{MAX} slightly decreased to 16.06°C. The mechanical stress was classified as degree 4 due to the strongly increased population especially of wild boars.

3.3. Semi-natural forest

This study plot, situated in the center of Landslide P at 51.0903°N and 14.9279°E, is closely neighboring the former carrot-oat-grass meadow.

Situation in July 1997 (for details see annex SP 105):
This forest was moved 340 m south-eastwards from its original position by the landslide in 1981 and was in a stable position in 1997. About 10% of the area became inundated by Lake Berzdorf in 2009. The faults and irregular inclination of the big clods caused by the landslide generated a heterogeneous, distorted relief with up to 1-meter deep cleft ruptures, faults and inclinations. Big clods of 4–10 m diameter, kept together by the root plates of the trees, showed no ruptures. Tree cover was 90%, formed by a mixture of of mainly old *Acer pseudoplatanus*, *Tilia cordata*, *Carpinus betulus*, *Quercus robur*, *Fraxinus excelsior*, *Salix rubens* and *Tilia platyphyllos*. A strong leaf litter layer of 40% and a high number of dead wood items with 8% surface cover was found. Cover percentage of the shrub layer, consisting of mainly *Corylus avellana* and young *Fraxinus excelsior*, was 20%, that of herb layer, mainly composed of *Poa nemoralis* and *Carex brizoides*, 20%, and that of bryophyte-lichen layer 15%. T_{MEAN} and T_{MAX} were 13.78°C and 15.52°C. Furthermore, mechanical stress M was classified as level 2 due to a lower density of big mammal populations.

The Situation in June 2017 (for details see annex SP 235):
The structure of upper phytostrata of the plot did not change considerably during 20 years. The tree layer – still composed by the same species – had a cover of 93% with an average height of 15 m and 30 cm average diameter at breast height. Instead, the lower habitat strata changed strongly. The former coat of *Poa nemoralis* and *Carex brizoides* nearly vanished and was replaced by a more diverse but sparse herb layer of 25% cover and 18 cm mean height. The shrub cover, formed by a few young *Fraxinus excelsior* and *Corylus avellana*, decreased to 6% and bryophyte-lichen cover halved to 7%. The large and aging trees resulted in a high amount of dead twigs and stems of up to 15 cm diameter – 4.5% ground cover and 2.2 items/m^2 were recorded. The total of 6.3% bare soil cover in the plot largely results from the surfaces of the up to 1-meter high scarps of big clods that were basically in the same condition as 20 years ago. The leaf litter layer was strongly developed, covering 65.6% of the total surface with an average thickness of 2.8 cm. The situation was heterogenous: the tops of clods were sparsely covered with litter whereas up to 5-cm thick litter layers accumulated in the hollows. The physico-chemical parameters of soil did not change with the following exceptions: T_{MEAN} and T_{MAX} rose to 14.54°C and 15.93°C due to climate change, nutrient figure N rose from 5.54 to 6.06 and epigaean phytodensity value PD decreased from 800 to 457. The mechanical stress increased to level 3 due to increased visiting rates by larger mammals – mainly roe deer and wild boar.

3.4. Young alder carr

The investigated plot was located at the western margin of Lake Berzdorf at 51.0914°N and 14.9271°E.

Situation in August 1997 (for details see annex SP 108):
The original site (51.0911°N, 14.9290°E) was a former open land of unclear management – probably arable land – that was transferred by the landslide 340 m south-eastwards of its original position in 1981. The drifted ground developed first into a moist tall herb community with few xerothermous spots. In 1997 it was under fast succession into an alder carr. The tree cover of 85% was formed by 4 to 6-meters high and 10 to 15 years-old *Alnus glutinosa*. Cover percentage was 15% in the herb layer, 8% in the bryophyte-lichen layer and 5% for the small leaf litter layer. T_{MEAN} and T_{MAX} were 13.65°C and 14.93°C. Mechanical stress was assessed at level 2.

The Situation in June 2017 (for details see annex SP 239):
Because the original plot SP 108 was flooded by Lake Berzdorf in 2009, the follow-up study was done in a replacement site situated at 51.0914°N and 14.9271°E – a shift 140 m to the west and 9 meters up. This was the only remaining unflooded area showing in 1997 a condition comparable to SP 108. This plot adjoined a birch forest

in the northwest and a frequently used gravel road in the southeast and was characterized by a strong and diverse herb layer of 86 % cover and 34 cm average height. Bare ground covered 18.5 % of surface, caused by daily and frequent movements of roe deer or wild boar next to steep slopes of a spring. The trees had developed into a 20 m high stand of alder trees with 82% cover and 20 cm mean diameter (chest height). The decreased shrub layer – covering 1.6 % and having a mean height of 2.5 m – was formed by young alder trees with sparse foliage. The stone embankment of the spring caused a stone cover of 0.1 % (0.3 items/m^2). Litter cover was 1.2 % and dead wood cover rose to 2.8 % with 4.3 items/m^2. T_{MEAN} and T_{MAX} were 14.60°C and 16.20°C, nutrient and calcium figures 5.64 and 5.33 respectively. Epigaean phytodensity increased from 1500 to 2950 and mechanical stress rose to level 4 due to high visiting rates of roe deer and wild boar.

3.5. Former carrot-oat-grass meadow

The study plot is located in the area of Landslide P (51.0898°N, 14.9277°E).

Situation in August 1997 (for details see annex SP 107):

This highly heterogeneous habitat was a former cut-meadow and pasture before it became transferred by the landslide in 1981. Sequential series of fissures up to 80 cm depth, 10–100 cm width and 10–15 m length and steep fault scarps of up to 80 cm height were observed. Striking small-scale sun exposure differences between the bare soil on top of scarps and the deep bottom of the fissures led to an extreme microclimate differentiation: maximum calibrated soil temperature was 31.0 °C on top of a scarp and 14.8°C in a 60-cm deep fissure. The plot was characterized by a strong herb layer of 90 %, mainly dominated by *Daucus carota* and *Arrhenaterum elatius*. A bryophyte and lichen layer with 10 % coverage as well as a sparse grass litter cover of 1 % was detected. T_{MEAN} and T_{MAX} as average over all microhabitats were 15.09°C and 20.88°C. The mechanical stress was estimated as 2 due to occasional visits of larger mammals.

The Situation in June 2017 (for details see annex SP 234):

Twenty years of meteorological and organismic influence led to a complete vanishing of fissures and scarps and the habitat was no longer a carrot-oat-grass meadow. One large *Fraxinus excelsior* of 40 cm diameter at breast height, growing on the southern margin of the plot formed a beginning tree layer of 8.6 % cover. The formerly strong herb layer cover decreased to 57.2 % and a strong shrub layer of 56.5 % cover had developed which is mainly formed by 15 years-old *Prunus cf. cerasifera* with 5 to 20 cm basal stem diameter. A bryophyte layer of 19.7 % of *Brachythecium rutabulum* formed under the grass cover and a grass litter layer of 37.7 % and 2.8 cm mean thickness was recognized. Yet, a clearly developed Ah-horizon was still missing. Furthermore, 3 % of soil remained uncovered. The physico-chemical parameters of soil changed as follows: T_{MEAN} rose to 15.74°C, T_{MAX} decreased slightly to 20.65°C, moisture figure F increased from 4.63 to 5.0. The nutrition figure N increased from 5.75 to 6.10 whereas calcium (reaction) figure decreased slightly from 5.94 to 5.69. The mean epigaean phytodensity value PD diminished from 2400 to 1315 – mainly caused by absence of any herb layer plants under the cherry plums. Mechanical stress was estimated at level 4 due to the highly increased population size, especially of wild boars.

3.6. Erosion area on basaltic tuff

This plot, characterized by bare soil exposed during the break-off of land, is situated at the northwest margin of Landslide P (51.0922°N, 14.9262°E).

Situation in August 1997 (for details see annex SP 106):

Former B and C horizons exposed by the landslide covered large parts of the surface and consisted of loamy to claylike weathered material of basaltic tuff, mixed with 5–50 cm thick edge-rounded to rounded blocks of basaltic tuff. About 20 % of the surface was covered with unweathered basaltic tuff containing 10–20 % xenocrysts (nepheline, olivine). The total cover was 70 % in bare ground, 15 % in the herb layer and 15 % in the bryophyte-lichen layer formed by *Cladonia fimbriata*, *Cladonia c*f. *subulata* and *Ceratodon purpureus*. The mean and maximum calibrated soil temperatures were calculated as 17.09°C and 29.23°C. Mechanical stress was assessed as 2 because of only few visits of larger mammals..

The Situation in June 2017 (for details see annex SP 238):

The plot was flanked in the northeast by 20-m high trees and in the southwest by a 8-m high wood. This led to a coverage of dead wood on ground of 2 % (0.01 items/m^2). The herb cover increased to 20 % with an average height of 60 cm. The total cover of bare ground decreased slightly to 65 % – that of the characteristic basaltic tuff stones to 15 %. The bryophyte and lichen layer decreased dramatically to 1 %. Furthermore, a small grass litter

cover of 6% with an average thickness of 0.8 cm had developed. The physico-chemical parameters of soil did not change with the following exceptions: Mean and maximum calibrated temperatures rose to 17.91°C and 30.05°C due to climate change. The nutrient figure N diminished from 5.06 to 4.36. The calcium (reaction) figure increased from 5.43 to 6.16 and the epigaean phytodensity value PD from 500 to 1200. Mechanical stress was classified as 4 due to increased visiting rates by larger mammals – mainly roe deer and wild boar the tracks of which crossed the plot.

4. Results and discussion:

A synoptic information on integrated species-specific nest densities and species richness of the study plots is provided by Tab. 1. Details of findings are given in the annex.

4.1. Mixed pine forest (SP 134/237)

The follow-up investigation in 2017 resulted in the finding 33 nests of 7 ant species (Tab. 1). The most abundant species was *Temnothorax crassispinus* with 20.8 nests / 100 m². The density of *Myrmica ruginodis*, being the most abundant species with 19.3 nests / 100 m² in 1998, decreased to 8.5 nests / 100 m². Total nest density increased from 27.7 nest / 100 m² to 35.4 nests / 100 m². Species richness S_{100} rose from 3.53 to 5.05 species per 100 m² due to immigration of *Lasius brunneus, Lasius fuliginosus, Temnothorax crassispinus* and *Stenamma debile* which were lacking 19 years ago. This increase of species richness is largely explained by three strong changes in habitat structure: (1) the complete disappearance of the thick *Carex brizoides* coat allowed foraging and nesting of *Temnothorax crassispinus*, (b) the development of a litter layer generated the main stratum of foraging for *Stenamma debile* and (c) the increase in diameter of tree stems improved nesting conditions of *Lasius brunneus*. Time is also a considerable factor: establishment of socially parasitic ant species always needs a longer time because attempts of parasite queens to invade a host colony usually have a low success rate and chances to colonize a new site increase when sufficiently dense host populations have developed (SEIFERT 2017). This situation is exacerbated in *Lasius fuliginosus* because it is the only social hyperparasite known in the European ant fauna. Accordingly, it took this species 65 years after heap afforestation to found a beach head in this study plot.

4.2. Mixed poplar forest (SP 133/236)

The follow-up investigation in 2017 resulted in the finding 56 nests of 6 ant species. The most abundant species was *Myrmica ruginodis* with 20.2 nests / 100 m² (Tab.1). Nineteen years ago, *M. ruginodis* and *M. rubra* had a nearly equal abundance with 9.3 and 9.9 nests / 100 m² respectively. Species richness was basically the same: the two open-land species *Lasius niger* and *Lasius flavus* – both relics from earlier successional stages – vanished, whereas the two typical woodland species *Lasius brunneus* and *Temnothorax crassipinus* immigrated. The formation of a population of *Lasius brunneus* is explained by improved nest site availability caused by higher diameter of the tree stems and strong increase of dead wood due to aging of poplar trees. Similarly, the increased density of *Lasius platythorax* and *Myrmica ruginodis* is explained by a richer supply with dead wood on ground offering suitable nest space. The strong reduction of the herb layer, did not have such a striking effect on spatial resistance and microclimate as in the adjacent mixed pine forest. Sixty five years after afforestation, the site has developed an ant assembly typical for broad-leafed Central European forest but a good number of species present in natural or semi-natural woodland with longer developmental history is still missing (compare with Seifert 2017, digital supplement). The plot achieved in 2017 about half the species richness of the semi-natural forest (SP 105/235).

4.3. Semi-natural woodland (SP 105/235)

The follow-up investigation in 2017 resulted in the finding of 134 nests of 9 species (Tab. 1).

Compared with 1997, there was a reduction of nest density in each *Myrmica*, *Lasius* and *Formica* species whereas *Temnothorax crassispinus* enormously increased its density from 10 to nearly 160 nests / 100 m². Three species found in 1997 were no longer recorded and only one species appeared as new. As result, the species richness index S_{100} reduced from 11.76 to 9.91. These relatively strong changes appear puzzling. Competitive displacement of *Myrmica*, *Lasius* and *Formica* by the raise of *T. crassispinus* appears extremely unlikely. The latter species is clearly subordinate in interspecific encounters and its different food and nest site selection results in a low overlap of fundamental niche spaces and low level of competition which favors peaceful coexistence (Seifert 2017). The physico-chemical and structural parameters of the plot did not change basically during 20 years. It seemed that

Table 1. Integrated species-specific nest densities of 23 ant species in nests / 100 m² in the six study plots surveyed in 1997/98 and 2017. The acronym 'F' indicates finding of only foragers.

	Mixed pine forest		Mixed poplar forest		Semi-natural forest		Young alder carr		Former oat-grass meadow		Erosion area on basaltic tuff	
	1998	2017	1998	2017	1997	2017	1997	2017	1997	2017	1997	2017
Camponotus fallax (Nylander, 1856)						1.99						F
Camponotus ligniperda (Latreille, 1802)												F
Formica cinerea Mayr, 1853									4.50		0.40	F
Formica cunicularia Latreille, 1798							2.60		7.50			
Formica fusca Linnaeus, 1758		F			13.30	4.99			7.50			F
Formica sanguinea Latreille, 1798												4.46
Lasius brunneus (Latreille, 1798)		1.82		6.46	6.70	1.99						
Lasius emarginatus (Olivier, 1792)									0.70			
Lasius flavus (Fabricius, 1782)			2.40						14.90	8.50		19.31
Lasius fuliginosus (Latreille, 1798)		0.07			0.20	0.06						
Lasius niger (Linnaeus, 1758)			0.30		3.30	1.00	10.50		100.00	2.83	34.70	2.97
Lasius platythorax Seifert, 1992	5.90	0.61	2.70	8.88	36.70	4.99	5.30	1.25		3.78		
Lasius umbratus (Nylander, 1846)					0.20							
Leptothorax acervorum (Fabricius, 1793)					16.70					1.10		
Myrmica rubra (Linnaeus, 1758)	2.50	0.61	9.90	5.66	16.70	1.99	92.10	45.65	6.00	39.64		
Myrmica ruginodis Nylander, 1846	19.30	8.47	9.30	20.20	26.70	2.99	5.30					
Myrmica rugulosa Nylander, 1849												1.49
Myrmica sabuleti Meinert, 1861												1.49
Myrmica scabrinodis Nylander, 1846					3.30		2.60		3.00			
Myrmica schencki Viereck, 1903												4.46
Ponera testacea Emery, 1895												1.49
Stenamma debile (Foerster, 1850)		3.03	4.80	1.61								
Strongylognathus testaceus (Schenck, 1852)												2.97
Temnothorax crassispinus (Karavaiev, 1926)		20.75		5.79	10.00	159.61				3.29		
Tetramorium caespitum (Linnaeus, 1758)												4.46
Tetramorium impurum (Foerster, 1850)											1.40	35.65
Total nest density	27.70	35.36	29.40	48.60	133.80	179.61	118.40	46.90	144.10	59.14	36.50	78.75
S_{100} in species per 100 m²	3.53	5.05	6.04	5.45	11.76	9.91	7.40	2.09	7.60	6.81	2.34	10.84
Moisture (F)	5.38	5.25	5.94	5.59	5.33	5.29	6.07	5.83	4.63	5.00	4.13	4.13
T_{MAX} in °C	16.01	15.97	16.42	16.06	15.52	15.93	14.93	16.20	20.88	20.65	29.23	30.05

the trees in particular were under much lower stress in 2017 than in 1997 because of advanced recovery from the rupture of the root system of the trees caused by the landslide in 1981. Furthermore, the hydroregime of the plot became probably stabilized since 2009 due to the constant water level of Lake Berzdorf which is located 3–6 m below the plot. However, the extreme drought in August 2015 could have temporarily affected a number of hygrophilous species such *as Lasius platythorax*, *Myrmica ruginodis* and *Myrmica rubra*. Reduction of phytodensity in the herb layer may provide a partial explanation for the raise of *Temnothorax crassispinus* but this cannot explain a masive, 16fold density increase – unknown population cycles, reduced parasite load or accidental patch effects in connection with inaccurate recording of geographic coordinates in 1997 appear possible. The advent of *Camponotus fallax*, which was a rather rare species in the Görlitz region in the 1980s, is explained by a general abundance increase in Saxony and the higher amount in the plot of dead wood remaining in situ.

4.4. Young alder carr (SP 108/239):

The follow-up investigation in 2017 resulted in the finding of 30 nests of only 2 species (Tab. 1).

The current plot is situated 140 m westwards of the now inundated study plot of 1997. It is by orography, water supply and tree composition the only remaining patch in the whole area of Lake Berzdorf supposed to show a condition into which SP 108 probably would have developed. The change in habitat structure since 1997 is mainly a strong increase in height and stem diameter of alder trees and an increase in herb layer plant diversity and epigaean phytodensity. The 1.1° C increase of maximum and mean calibrated soil temperatures since 1997 is stronger than predicted by global warming. The insolation index (Seifert & Panier 2007) – determined by orography and habitat structure and calculated by the *CalibSoil* software – was basically the same in 1997 and 2017: 0.047 vs. 0.036. Because of the unchanged irradiation conditions of the soil and a basically similar water regime, the temperature differences are either artefacts due to a measuring error in 1997 or true differences explained by edge effects of the sun-exposed gravel road which is immediately adjacent to the plot. The much higher species richness in 1997 – 7.4 against 2.1 species per 100 m² in 2017 – is reasonably explained by the effect of disturbance by the landslide and habitat history before 1981. Before the landslide, the transferred land mass included areas formerly representing south-facing open cultural land and small woodland spots. In 1997, xerothermous areas with sun-exposed scarps and crests of ground ruptures were nearby north of this spring valley *in statu nascendi*. There was either accidental immigration from these xerothermous spots or survival of translocated nests founded earlier under more xerothermous conditions. This may explain the temporal presence of *Lasius niger*, *Formica cunicularia* and *Myrmica scabrinodis* in the cold and moist habitat spot of SP 108. The constancy of these conditions after 1997 then led to a massive loss of ant diversity and to a 'monocenosis' formed by the highly adaptive *Myrmica rubra*.

4.5. Former oat-grass meadow (SP 107/234):

The follow-up investigation in 2017 resulted in the finding of 62 nests of six species (Tab. 1).

There was a moderate decrease of overall species richness from 7.6 to 6.8 species per 100 m² but a drastic change of species composition due to strong shrub and tree encroachment and surface homogenization. In 1997, there was an extreme microclimate variance due to ground ruptures caused by the landslide. This generated a small-scale wave pattern of very xerothermous microhabitat spots alternating with oligothermous and moist spots. Thus, T_{MAX} was 32.6°C on crests and S-facing fronts of fault scarps but only 16.9°C on the bottom of clefts. Shrub encroachment and the complete leveling of surface relief by meteorological and organismic influences led to an equalization of microhabitat temperatures at a rather low level and to a complete vanishing of the xerothermophilous open-land species *Formica cinerea*, *F. cunicularia*, *Lasius emarginatus* and *Myrmica scabrinodis*. The beginning succession to woodland is indicated by immigration of *Lasius platythorax*, *Temnothorax crassispinus* and *Leptothorax acervorum*.

4.6. Erosion area on basaltic tuff (SP 106/238):

The follow-up investigation in 2017 resulted in the finding of 55 nests of ten species and of foragers of further four species (Tab. 1). Within 20 years, there was a very strong increase of ant species richness from 2.34 to 10.84 species per 100 m² and a strong increase of total nest density from 36.5 to 78.8 nests / 100 m². Physico-chemical and structural parameters of the habitat

basically did not change but phyto-diversity increased considerably. In 1997, only 16 years after exposition of the geological raw material by the landslide, only few pioneer species with strong dispersal ability and big source populations in the region were able to colonize the spot – namely *Lasius niger* and *Formica cinerea*. In 2017, the plot had developed to a valuable habitat from the perspective of ant species conservation with 50 % of nesting species listed in the Red Data Book of Germany (Seifert 2007). It is the only site for *Ponera testacea* in Upper Lusatia (Fig. 1) and the only finding of the social parasite *Strongylognathus testaceus* in the hill county of Upper Lusatia. Despite offering a low diversity of microhabitats and a low nutrient supply, the rich ant assemblage in the habitat is explained by the xerothermous conditions in the soil which are close to the optimum values for species richness and biomass of ants (Seifert 2017). Higher species richness in non-reclaimed post-mining sites under spontaneous succession was also found in investigations of carabid beetles and spiders (Hendrychova et al. 2008) and ants (Holec & Frouz 2005) in NW Bohemia.

5. Comparative discussion

The development of ant assemblages in the two study plots (SP 134/237 and SP 133/236) in afforestions of strip-mine heaps initiated in 1952 showed the following temporal pattern. Forty six years after afforestation, typical woodland species formed 74 % of the ant nests found whereas this figure was 5 % in typical open-land species that remained from earliest successional stages. The long survival of the latter appears remarkable as epigaean habitat structure and microclimate of the plots showed a clear woodland character already in 1985 (Dunger et al. 2001). Sixty five years after afforestation, typical woodland species had increased their share to 93 % and typical open-land species had completely vanished. The retarded immigration of three typical woodland species after 65 years is explained through restrictions by dependent colony foundation (*Lasius fuliginosus*), requirement for increased tree trunk diameters (*Lasius brunneus*) and a weaker long-range dispersal capacity (*Temnothorax crassipinus*). The two afforestation plots showed 65 years after initiation only 50 % of the species

Figure 1: Head of the blind subterranean ant *Ponera testacea* Emery 1895 which colonized the basaltic tuff erosion area 36 years after initiation of the succession. It is the only known finding of this species in the region of Upper Lusatia.

richness and nest density found within the semi-natural woodland (SP 105/235). These figures may provide an idea of the long time span needed for completion when source populations of these woodland species are not nearby. The direct comparison of the afforestation plots with the semi-natural woodland plot is justified because all three plots are most similar in soil moisture and soil temperature – the top-ranking factors determining richness and biomass of ant assemblages also in woodland sites (Seifert 2017).

The three study plots left in a free succession from an open-land situation showed a most different development and it was obvious that physico-chemical factors were deciding factors. Plot SP 108/239 – having a rich water supply, good nutrient supply and weak sun-exposure – transformed from a moderately rich open-land ant community into a 'monocenosis' of the most eurypotent species *Myrmica rubra* which has the biggest fundamental niche space among all Central European congeneric species (Seifert 2017). The ant population on plot SP 106/238, with a soil having a sufficient water and nutrient supply and good sun-exposure, was after 20 years on the way to transform from a moderately rich open-land community into that of a deciduous-woodland. It will be most interesting to see into which state the plot will have developed in the year 2037 relatively to that of the immediately adjacent semi-natural woodland. The erosion area on basaltic tuff (SP 106/238) contrasted from the other free-succession plots by weak water supply, extreme sun-exposure and low nutrient supply. These conditions prevented both shrub encroachment and the upgrowth of a high and dense herb layer. As a result, the plot developed from a very poor ant-assemblage with few pioneer species into a very rich open-land ant community of high value for nature conservation. To ensure the further development of this plot towards a rich assemblage of endangered insect species with preference for oligotrophic and xerthermous habitats, a number of trees in the strongly growing adjacent woodland should be cut.

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Annex

SP 105: Semi-natural woodland in Landslide P

Habitat type: landslid sycamore-linden-hornbeam wood
Date of investigation and investigatore: 31 July 1997
Situation: 8 km SSE Görlitz, 51.0903°N, 14.9279°E, 189–194 m
Plot size: S-area 30 m² (6 subareas of 5 m²), L-area 500 m², habitat size 7000 m²
Orography (slope and orientation of surface): overall slope 10° E, faults and irregular inclination of the big clods during the landslide caused a heterogenous, distorted relief
Soil conditions: authochtonous loess-loam, yellowbrown silt, free of calcium, up to 1-m deep cleft ruptures, faults and inclinations of big clods of 4–10 m diameter (kept together by the root plates of the trees).
Comments: The wood was transferred by landslide to 340 m SE from its original position in 1981 and was in a stable position in 1997. 10 % of the area have been inundated by Lake Berzdorf in 2009.
Vegetation: (survey by Bräutigam and Gebauer, not fully given here but completely considered for calculation of indicator values)
– tree layer (cover 90 %, mainly old trees):
Acer pseudoplatanus 4, *Tilia cordata* 4, *Carpinus betulus* 3, *Quercus robur* 1, younger *Fraxinus excelsior* 1, younger *Prunus padus* +, *Salix rubens* +, *Tilia platyphyllos* +
– shrub layer (cover 20 %):
Corylus avellana 2, *Fraxinus excelsior* 1, *Crataegus* spec., *Prunus padus*, *Quercus robur*, *Evonymus europaea*, *Sambucus nigra*, *Rubus idaeus* all +
– herb layer (cover 70 %):
Poa nemoralis 5, *Carex brizoides* 2, *Anemone nemorosa* 1, *Convallaria majalis* 1, *Majanthemum bifolium* 1, *Melampyrum nemorosum* 1, *Polygonatum multiflorum*, *Galium schultesii*, *Moeringia trinerva*, *Scrophularia nodosa*, *Solidago virgaurea*, *Stellaria holostea*, *Asarum europeum*, *Corydalis cava*, *Dactylis glomerata*, *Dryopteris filix-mas*, *Epilobium montanum*, *Festuca gigantea*, *Lamium galeobdolon*, *Milium effusum*, *Holcus mollis*, *Holcus lanatus*, *Senecio ovatus*, *Taraxacum officinale*, *Viola reichenbachiana*, *Aegopodion podagraria*, *Anthriscus sylvestris*, *Gnaphalium sylvaticum*, *Hieracium sabaudum*, *Luzula pilosa*, *Pulmonaria obscura*, *Achillea millefolium*
– bryophyte and lichen layer (cover 15 %):
Atrichum undulatum 2, *Dicranella heteromalla* 2, *Politrichum formosum* +
– litter layer (cover 40 %)
– dead wood on ground (cover 8 %)
– physico-chemical factors, plant and stone density:
T_{MAX} 15.52°C, T_{MEAN} 13.78°C, F (moisture) 5.33, N (nutrients) 5.54, R (Ca^{++}) 5.71, M 2, PD 800, S 0.05

Ant species		nests / 100 m²
Lasius platythorax		36.70
Myrmica ruginodis		26.70
Leptothorax acervorum		16.70
Myrmica rubra		16.70
Formica fusca		13.30
Temnothorax crassispinus		10.00
Lasius brunneus		6.70
Lasius niger		3.30
Myrmica scabrinodis		3.30
Lasius fuliginosus		0.20
Lasius umbratus	11.	0.20
total		**133.80**

Species richness index S_{100} 11.76 species / 100 m².
The ant assemblage is basically the same as it is expected for an undisturbed forest of the same structure and tree composition – i.e. the huge ruptures and deformations during the landslide did not have a significant influence. The typical, and apparently stable, faunal composition of this small woodland patch was also not influenced by the dynamic development in the adjacent areas of SP 107 and SP 108.

SP 106: Erosion area on basaltic tuff

Habitat type: Erosion area on volcanic (basaltic) tuff
Date of investigation: 1 and 2 August 1997
Situation: 8 km SSE Görlitz, 51.0922°N, 14.9262°E, 220–225 m
Plot size: S-area 72 m², Q-area 254 m²
Orography (slope and orientation of surface): 35° SE
Soil conditions: Loamy to claylike weathered material of basaltic tuff, mixed with 5- to 50-cm thick edge-rounded to rounded blocks of basaltic tuff. About 20 % of surface

is covered with unweathered basaltic tuff containing 10 % to 20 % xenocrysts (nepheline, olivine).
Comments: very steep area on basaltic tuff. The geological raw material was exposed by a landslide in 1981. There is strong splash erosion and no soil formation.
Vegetation:
– herb layer (cover 15 %):
Artemisia vulgaris 1, *Dactylis glomerata* 1, *Erigeron acris* 1, *Festuca ovina* 1, *Festuca rubra* 1, *Linaria vulgaris* 1, *Medicago lupulina* 1, *Achillea millefolium* +, *Daucus carota* +, *Festuca brevipila* +, *Salix caprea* +, *Tanacetum vulgare* +, *Taraxacum officinale* +, *Agrostis capillaris* r, *Lactuca serriola* r, *Plantago lanceolata* r, *Trifolium pratense* r, *Tussilago farfara* r, *Lotus corniculatus*, *Conyza canadensis*
– bryophyte and lichen layer (cover 15 %):
Cladonia fimbriata r, *Cladonia* cf. *subulata*, *Ceratodon purpureus*
– physico-chemical factors, plant and stone density:
T_{MAX} 29.23°C, T_{MEAN} 17.09°C, F (moisture) 4.13, N (nutrients) 5.06, R (Ca^{++}) 5.43, M 2, PD 500, S 5

Ant species		nests / 100 m²
Lasius niger		34.70
Tetramorium impurum		1.40
Formica cinerea	3.	0.40
total		**36.50**

Species richness index S_{100} 2.34 species / 100 m².

SP 107: Oat-grass meadow with ruderal component

Habitat type: carrot-oatgrass meadow with strong ruderal influence
Date of investigation: 4 August 1997
Situation: 8 km SSE Görlitz, 51.0898°N, 14.9277°E, 188–190 m
Plot size: S-area 67 m²
Orography (slope and orientation of surface): 9° S
Soil conditions: autochthonous loess-loam, yellowbrown, dusty silt without calcium. Ground much more ruptured by the landslide than in SP 105, distance of fissures perpendicular to their length extension 50–150 cm, fissures up to 80 cm deep, 10–100 cm wide and 10–15 meters long. Bare soil is exposed at steep fault scarps of up to 80 cm height.
Comments: Immediately adjacent to SP 105. The plot was a former cut-meadow and cattle pasture before it was transferred by landslide 340 m SE of its original position in 1981 and was in a stable position in 1997. The fissures and faults cause a small-scale change of very xerothermous (crests and S-facing fronts of fault scarps) with cool and moist microhabitats (bottom of clefts and N-facing fronts of fault scarps).
Vegetation:
– herb layer (cover 90 %, very heterogeneous, the mainly grassy area is interspersed with almost vegetation-free spots and tall herb patches):
Daucus carota, *Arrhenaterum elatius*, *Artemisia vulgaris*, *Dactylis glomerata*, *Erigeron acris*, *Festuca rubra*, *Achillea millefolium*, *Tanacetum vulgare*, *Agrostis capillaris*, *Trifolium pratense*, *Tussilago farfara*, *Conyza canadensis*, *Epilobium hirsutum*, *Cirsium vulgare*, *Tripleurospermum perforatum*, *Geranium palustre*, *Solidago canadensis*, *Conyza canadensis*, *Crepis capillaris*, *Vicia hirsuta*, *Vicia tetrasperma*, *Hypericum perforatum*, *Humulus luppulus*, *Hieracium sabaudum*, *Rumex thyrsiflora*, *Leucanthemum vulgare*, *Epilobium ciliatum*, *Epilobium tetragonum tetragonum*, *Crepis tectorum*, *Trifolium hybridus*, *Campanula patula*, *Alchemilla monticola*, *Urtica dioica*, *Calamagrostis epigejos*
– bryophyte and lichen layer (cover 10 %)
– litter layer (cover 1 %)
– physico-chemical factors, plant and stone density:
T_{MAX} 20.88°C, T_{MEAN} 15.09°C, F (moisture) 4.63, N (nutrients) 5.75 R (Ca^{++}) 5.94, M 2, PD 2400, S 0
T_{MAX} 32.6°C at crests and S-facing fronts of fault scarps, 22.8°C in grassland with PD 2400 and 16.9°C at the bottom of fault clefts.

Ant species		nests / 100 m²
Lasius niger		100.00
Lasius flavus		14.90
Formica cunicularia		7.50
Formica fusca		7.50
Myrmica rubra		6.00
Formica cinerea		4.50
Myrmica scabrinodis		3.00
Lasius emarginatus	8.	0.70
total		**144.10**

Species richness index S_{100} 7.60 species / 100 m².
There was complete scrub encroachement on the plot in 2016.

SP 108: Tall herb community with alder upgrowth

Habitat type: moist tall herb community developing into an alder carr
Date of investigation: 10 August 1997
Situation: 8 km SSE Görlitz, 51.0911°N, 14.9290°E, 177–182 m
Plot size: S-area 38 m²
Orography (slope and orientation of surface): 10° ENE, heterogenous relief due to ground deformation by landslide.
Soil conditions: autochthonous loess-loam, yellowbrown, dusty silt. Vertikal faults of 0.5–1 m height but former fissures have vanished because of instability of the moist to wet soil material. Rushing out slope water.
Comments: immediately NE of SP 105. The plot was a former openland of unclear management (probably arable land) and was transferred by a landslide 340 m SE of its original position in 1981. The drifted ground developed first into a moist tall herb community with few more xerothermous spots. In 1997 it was under fast succession into an alder carr. The plot was inundated by Lake Berzdorf in 2009.
Vegetation:
– tree layer (cover 85%, 4–6 m high, 10–15 years):
Alnus glutinosa 4, *Fraxinus excelsior* +, *Carpinus betulus* +, *Salix* spec., *Corylus avellana*
– herb layer (cover 15%):
Urtica dioica, *Chaerophyllum aromaticum*, *Tussilago farfara*, *Galeopsis speciosa*, *Cirsium oleraceum*, *Glechoma hederacea*, *Pulmonaria obscura*, *Dactylis glomerata*, *Dryopteris filix-mas*, *Festuca gigantea*, *Anthriscus sylvestris*, *Ajuga reptans*, *Agrostis gigantea*, *Heracleum spondylium*
– bryophyte and lichen layer (cover 8%):
– litter layer (cover 5%)
– physico-chemical factors, plant and stone density:
T_{MAX} 14.93°C, T_{MEAN} 13.65°C, F (moisture) 6.07, N (nutrients) 6.57, R (Ca^{++}) 6.88, M 2, PD 1500, S 0.05

Ant species		nests / 100 m²
Myrmica rubra		92.10
Lasius niger		10.50
Lasius platythorax		5.30
Myrmica ruginodis		5.30
Myrmica scabrinodis		2.60
Formica cunicularia	6.	2.60
total		**118.40**

Species richness index S_{100} 7.40 species / 100 m².
Lasius niger, *Myrmica scabrinodis* and *Formica cunicularia* are relics of earlier successional stages with higher sun-exposure.

SP 133: Mixed poplar forest Langteichhalde ('A-Pappel')

Habitat type: 46-years-old heap afforestation with deciduous mixed forest
Date of investigation: 5 August 1998
Situation: Schönau-Berzdorf-3.5 km E, 51.06526°N, 14.93102°E, 239 m
Plot size: S-area 41 m² (4 x 8, 1 x 9 m²), Q-area 182 m²
Orography (slope and orientation of surface): 0°
Soil conditions: quaternary heap soil, silt-sand-loam
Comments: Long-term study plot on a high heap. Afforested in 1952 in equal percentages with poplar, robinia and black alder, the plot had developed in 1960 into a dense, almost impenetrable shrub. Pitfall trapping by Natural History Museum Görlitz in 1985 and 1997/98.
Vegetation:
– tree layer (cover 75%):
Populus spec. 3, *Robinia pseudoacacia* 3, *Acer pseudoplatanus* 2, *Alnus glutinosa* +, *Betula pendula* +
– shrub layer (cover 15%):
Acer pseudoplatanus 1, *Fraxinus excelsior* +, *Prunus padus* +, *Quercus robur* +, *Sambucus nigra* 2, *Rubus idaeus* +, *Symphoricarpus albus* +
– herb layer (cover 90%):
Galium aparine 4, *Moeringia trinerva* 2, *Poa nemoralis* 2, *Stachys sylvatica* 2, *Urtica dioica* 2, *Geum urbanum* 1, *Holcus mollis* 1, *Impatiens parviflora* 1, *Rubus fructicosus* 1, *Brachypodium sylvaticum*, *Geranium robertianum*, *Glechoma hederacea*, *Festuca gigantea*, *Rubus idaeus*, *Elymys canina*, *Humulus lupulus*, *Quercus robur*, *Fraxinus excelsior*, *Ribes rubrum* s.l., *Silene dioica* each +
– bryophyte and lichen layer (15%)
Brachythecium rutabulum 2, *Brachythecium velutinum* 1, *Brachythecium populeum* +, *Brachythecium salebrosum* r, *Atrichum undulatum* 1, *Amblystegium serpens* +, *Dicranella heteromalla* +, *Eurhynchium striatum* +, *Pohlia nutans* +, *Ceratodon purpureus* r, *Plagiothecium denticulatum* r
Sphagnum
– litter layer (cover 50%)
– dead wood on ground (cover 5%)
– physico-chemical factors, plant and stone density:
T_{MAX} 16.42°C, T_{MEAN} 14.01°C, F (moisture) 5.94, N (nutrients) 6.53, R (Ca^{++}) 5.83, M 2, PD 3000, S 0.5

Ant species		nests / 100 m²	individuals in pitfall traps
Myrmica rubra		9.90	43
Myrmica ruginodis		9.30	40
Stenamma debile		4.80	4
Lasius platythorax		2.70	3
Lasius flavus		2.40	0
Lasius niger	6.	0.30	1
total		**29.40**	**91**

Species richness index S_{100} 6.04 species / 100 m².
Nest density and species richness are similar to the conditions in comparable deciduous forests on natural soil. The higher abundance of *Myrmica rubra* compared to SP 134 is probably explained by the absence of conifers and slightly higher soil temperatures. The single observed worker of *Lasius niger* should indicate a nest surviving within the shady and cool habitat as more open areas with significant source populations are 200 m away. The trapping data of 1985 show that the same species were already present in that time.

SP 134: Mixed pine forest Langteichhalde ('L-Kiefer')

Habitat type: 46-years-old heap afforestation with pines later supplemented by beach
Date of investigation: 6 August 1998
Situation: Schönau-Berzdorf-3.4 km E, 51.06482°N, 14.92993°E, 239 m
Plot size: S-area 54 m² (18+18+18 m²), Q-area 119 m²
Orography (slope and orientation of surface): 0°
Soil conditions: quaternary heap soil, silt-sand-loam
Comments: Long-term study plot on a high heap. Afforested in 1952 with Pinus sylvestris. Pines were poorly growing and placed underneath with Fagus sylvatica in about 1990. Pitfall trapping by Natural History Museum Görlitz in 1985 and 1997/98.
Vegetation:
– tree layer (cover 45 %):
Pinus silvestris 3
– shrub layer (cover 20 %):
Fagus silvatica 3, *Carpinus betulus* 2, *Quercus robur*, *Prunus serotina*, *Betula pendula*, *Acer negundo*, *Acer platanoides*, *Betula pendula*, *Rubus idaeus*, *Sambucus nigra*, *Prunus mahaleb*, *Prunus padus*, *Prunus avium*, *Corylus avellana*, *Sorbus aucuparia*, *Tilia cordata*
– herb layer (cover 100 %):
Carex brizoides 3, *Poa nemoralis*, *Dactylis glomerata*, *Pyrola minor*, *Silene dioica*, *Prunus serotina* 1, *Agrostis capillaris*, *Arrhenaterum elatius*, *Brachypodium sylvaticum*, *Calamagrostis epigejos*, *Convolvulus arvensis*, *Deschampsia flexuosa*, *Deschampsia caespitosa*, *Epilobium angustifolium*, *Epilobiumm montanum*, *Equisetum arvense*, *Festuca rubra*, *Festuca brevipila*, *Fragaria vesca*, *Galium album*, *Galium aparine*, *Geum urbanum*, *Hieracium sabaudum*, *Holcus lanatus*, *Humulus lupulus*, *Moehringia trinerva*, *Othilia secunda*, *Quercus robur*, *Rubus idaeus*, *Rubus fructicosus*, *Rumex acetosella*, *Sorbus aucuparia*, *Stachys silvatica*, *Taraxacum officinale*, *Acer pseudoplatanus*, *Alopecurus pratensis*, *Athyrium filix-femina*, *Betula pendula*, *Chaerophyllum aromaticum*, *Cirsium vulgare*, *Dryopteris dilatata*, *Frangula alnus*, *Lapsana communis*, *Larix decidua*, *Lathyrus pratensis*, *Poa pratensis*, *Picea abies*, *Prunus avium*, *Prunus mahaleb*, *Scrophularia nodosa*, *Senecio ovatus*, *Symphoricarpus albus*, *Viburnum opulus*, *Urtica dioica*, *Impatiens parviflora*
– bryophyte and lichen layer (cover 1 %):
Brachythecium rutabulum 2, *Atrichum undulatum*, *Dicranella heteromalla*, *Lophocoela heterophylla*, *Pohlia nutans*
– litter layer (cover 5 %)
– physico-chemical factors, plant and stone density:
T_{MAX} 16.01°C, T_{MEAN} 13.91°C, F (moisture) 5.38, N (nutrients) 5.66, R (Ca^{++}) 5.11, M 2, PD 4000, S 0.5

Ant species		nests / 100 m²	individuals in pitfall traps
Myrmica ruginodis		19.30	195
Lasius platythorax		5.90	10
Myrmica rubra	3.	2.50	9
total		**27.70**	**214**

Species richness index S_{100} 3.53 species / 100 m².
Nest density and species richness are clearly below data from pine forests on natural soils which is explained by the very dense *Carex brizoides* turf causing lower soil temperatures. 85 % of ant nests were in thick deadwood exposed above the *Carex* and 15 % near to surface of more sun-exposed grass pads. The trapping data of 1985 show that the same species were already present in that time.

SP 234 (→ SP 107): Former oat-grass meadow

Habitat type: former Dauco-Arrhenateretum, now with strong shrub encroachment
Date of investigation: 8 and 9 June 2017 (A. Prosche, B. Seifert)
Situation: 8 km SSE Görlitz, 51.0898°N, 14.9277°E, 188–190 m
Plot size: S-area total 91.32 m² (meadow 46.46, large Prunus 31.45, small Prunus 13.38), habitat size: 350 m²
Orography (slope and orientation of surface): 3° S
Soil conditions: autochthonous loess-loam, yellowbrown, dusty silt without calcium. Fissures caused by the landside of 1981 complety closed. Ah horizon in 2017 not clearly developed. No top layer of raw humus.
Comments: Immediately adjacent to SP 235 (→ SP 106). The plot was a former cut-meadow and cattle pasture before it was transferred by landslide 340 m SE of its original position in 1981 and was in a stable position in 1997. Strong scrub enroachment in 2017. The plot is adjacent to a pond of 650 m² in the west, to the expanding broad-leafed wood SP 235 (→SP 106) in the east and northeast, and by a dirt road with shrub margins in the south. The water table of Lake Berzdorf is 2 m below the level of the plot and begins 25 m south.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):
– tree layer (cover 8.6%, mean height 14 m, diameter breast height 44 cm):
One tree of *Fraxinus excelsior* at southern margin of plot covering 8 m² of the plot
– shrub layer (cover 56.5%, mean height 6 m):
Prunus cf. cerasifera, several up to 15-years old bushes of Cherry Plum with 5 to 20 cm basal stem diameter; *Carpinus betulus* (3 m high).
– herb layer (cover 57.2%, mean height 23 cm):
Acer pseudoplatanus, *Agrostis stolonifera, Alliaria petiolata, Arrhenaterum elatius, Calamagrostis epigejos, Dactylis glomerata*, *Dryopteris carthusiana, Dryopteris filix-mas, Epilobium montanum, Equisetum arvense, Fraxinus excelsior, Galium aparine*, *Geum urbanum, Holcus lanatus, Poa nemoralis, Poa trivialis, Solidago canadensis, Urtica dioica*, *Quercus robur, Rubus idaeus*
– bryophyte and lichen layer (cover 19.7%, mean height 1.5 cm) (det. Dr. Volker Otte 30.06.17)
Brachythecium rutabulum, Hypogymnia physodes, Physcia tenella, Xanthoria polycarpa
– litter layer (cover 37.7%, mean height 2.8 cm)
Grass and tall herb litter
– dead wood on ground (cover 0%)
– stone cover (cover 0%m²)
– bare ground (cover3%)
loess loam
– physico-chemical factors, plant and stone density:
T_{MAX} 20.65°C, T_{MEAN} 15.74°C, F (moisture) 5.00, N (nutrients) 6.10, R (Ca^{++}) 5.69, M 4, PD 1315, S 0

Ant species	nests / 100 m²	nests S-area 91.32 m²	nests SI-search
Myrmica rubra	39.64	36	6
Lasius flavus	8.50	7	2
Lasius platythorax	3.78	4	
Temnothorax crassispinus	3.29	3	
Lasius niger	2.83	3	
Leptothorax acervorum	1.10	1	
Formica fusca	0	2 foragers	
total	**59.14**	**54**	**8**

Species richness index S_{100} 6.81 species / 100 m².
Myrmica rubra has polydomous colonies. The only place without nests was a 20 m² spot without any herb layer below a very dense *Prunus*. Accordingly, the *M. rubra* density in the grassy parts of the ground was about 50 nests / 100 m².

SP 235 (→ SP 105): Semi-natural woodland in Landslide P

Habitat type: semi-natural, landslid sycamore-linden-hornbeam wood
Date of investigation and investigators: 9–12 June 2017 (A. Prosche, B. Seifert)
Situation: 8 km SSE Görlitz, 51.0903°N, 14.9279°E, 189-194 m
Plot size: S-area 70.2 m², L-area 1670 m², habitat size 2500 m²
Orography (slope and orientation of surface): overall slope 10° SE, faults and irregular inclination of the big clods during the landslide caused a heterogenous, distorted relief.
Soil conditions: authochtonous loess-loam, yellowbrown silt, free of calcium, up to 1-m deep cleft ruptures, faults and inclinations of big clods of 4–10 m diameter (kept together by the root plates of the trees).
Comments: The wood was transferred by landslide to 340 m SE from its original position in 1981 and was in a stable position in 1997. 10% of the area have been

inundated by Lake Berzdorf in 2009. The water table of Lake Berzdorf is 3–6 m below the level of the plot. The basic structure of ground was unchanged in 2017 with exception of a thicker litter and humus layer in the hollows.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):
– tree layer (cover 93 %, mainly old trees, mean height 15 m, mean diameter breast height 30 cm):
Acer pseudoplatanus, *Tilia cordata*, *Carpinus betulus*, *Quercus robur*, *Fraxinus excelsior*, *Salix rubens*, *Tilia platyphyllos*
– shrub layer (cover 6 %, 1.6 m):
Corylus avellana, *Fraxinus excelsior*
– herb layer (cover 25 %, mean height 18 cm):
Acer pseudoplatanus, Alliaria petioloata, Anemone nemorosa, *Athyrium filix-femina, Atrichum undulatum, Brachypodium sylvaticum, Campanula patula, Carex brizoides*, *Carpinus betulus, Convallaria majalis*, *Corylus avellana, Crataegus spec., Dactylis glomerata*, *Dryopteris filix-mas*, *Epilobium montanum, Euphorbia dulcis*, *Festuca gigantea, Fraxinus excelsior, Galeopsis cf. bifida, Galium aparine, Galium intermedium=schultesii*, *Geum urbanum, Glechoma hederacea, Hieracium sabaudum*, *Holcus mollis*, *Humulus lupulus*, *Lamium galeobdolon*, *Moeringia trinerva, Picea abies, Poa nemoralis*, *Polygonatum multiflorum*, *Populus tremula, Primula elatior, Pulmonaria obscura*, *Rosa spec*., *Rubus idaeus, Scrophularia nodosa, Senecio ovatus*, *Sorbus aucuparia, Stellaria holostea*, *Taraxacum officinale, Urtica dioica, Viburnum opulus, Viola reichenbachiana*
– bryophyte and lichen layer (cover 7 %, mean height 1 cm) (det. Dr. Volker Otte 30.06.17)
Brachythecium rutabulum, Atrichum undulatum
– litter layer (cover 65.6 %, mean height 2.8 cm)
leaf litter
– dead wood on ground (cover 4.5 %, 2.2 items / m²)
Many small pieces of twigs; also laying stems and branches of up to 10 cm diameter
– stone cover (cover 0 %, number of items / m²: 0)
– bare ground (cover 6.3 %)
Mainly at the up to 1 m high scarps of big clods.
– physico-chemical factors, plant and stone density:
Temperatures maximum 8 June 2017 15.77°C (n=6); minimum 9 June 13.62°C (n=6)
T_{MAX} 15.93°C, T_{MEAN} 14.54°C, F (moisture) 5.29, N (nutrients) 6.06, R (Ca^{++}) 5.93, M 3, PD 457, S 0

Ant species	nests / 100 m²	nests S-area 70.2 m²	nests SI-search	nests L-search 1670 m²
Temnothorax crassispinus	159.61	112	1	
Lasius platythorax	4.99	2	3	
Formica fusca	4.99	4	1	
Myrmica ruginodis	2.99	3		
Lasius brunneus	1.99	2		
Camponotus fallax	1.99	1	1	
Myrmica rubra	1.99	2		
Lasius niger	1.00		1	
Lasius fuliginosus	0.06			1
total	**179.61**	**126**	**7**	**1**

Species richness index S_{100}: 9.91 species / 100 m².
One small *Lasius fuliginosus* nest in an area of about 1600 m². Density in hollows with strong litter layer much lower than on crests. Pseudo-area calculated from from S- and SI-search of *Lasius+Myrmica+Camponotus*: 20/14*70.2 = 100.3 m²

SP 236 (→ SP 133): Mixed poplar forest Langteichhalde ('A-Pappel')

Habitat type: 65-years-old heap afforestation with deciduous mixed forest
Date of investigation: 14 and 15 June 2017 (A. Prosche), 27 June 2017 (Seifert)
Situation: Schönau-Berzdorf-3.5 km E, 51.06526°N, 14.93102°E, 239 m
Plot size: S-area 86.4 m², Q-area 0 m², habitat size: 7000 m²
Orography (slope and orientation of surface): slope 0°
Soil conditions: quaternary heap soil, silt-sand-loam, Ah horizon 20 cm in 2017
Comments: Long-term study plot on a high heap. Afforested in 1952 in equal percentages with poplar, robinia and black alder, the plot had developed in 1960 into a dense almost impenetrable shrub. Pitfall trapping by Natural History Museum Görlitz in 1985 and 1997/98, 2017. Some large Populus have fallen down. Dead wood increased strongly compared to 1998.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):

– tree layer (cover 81 %, mean height 25 m, mean diameter breast height 50 cm, some *Populus* 75 cm and 30 m high and in danger to break down):
Populus spec., *Robinia pseudoacacia*, *Acer pseudoplatanus*, *Alnus glutinosa*, *Betula pendula*
– shrub layer (cover 7.2 %, mean height 2.55 m):
Populus, Robinia, Acer
– herb layer (cover 13.4 %, mean height 5 cm):
Agrostis cf. trivialis, Allium cf. oleraceum, Athyrium filix-femina, Brachypodium sylvaticum, Carex brizoides, Deschampsia caespitosa, Dryopteris carthusiana, Dryopteris dilatata, Dryopteris filix-mas, Evonymus europaea, Festuca gigantea, Ficaria verna, Fraxinus excelsior, Galium aparine, Geranium robertianum, Geum urbanum, Hedera helix, Impatiens parviflora, Poa nemoralis, Poa trivialis, Prunus padus, Quercus robur, Rubus caesius cf., Sambucus nigra, Silene dioica, Stachys silvatica, Ulmus glabra, Urtica dioica, Tilia cordata.
– bryophyte and lichen layer (cover 3 %, mean height 1.5 cm) (det. V. Otte)
Brachythecium rutabulum, Lecanora dispersa, Phaeophyscia orbicularis, Physcia adscendens, Xanthoria parietina
– litter layer (cover 69.8 %, mean height 2 cm)
Leaf litter
– dead wood on ground (cover 8.4 %, 0.9 items / m²)
Laying stems of up to 25 cm diameter, one strong Populus in SI-area
– stone cover (cover 0.2 %, 0.06 items / m²)
– bare ground (cover 8.2 %)
Silt-sand-loam
– physico-chemical factors, plant and stone density:
T_{MAX} 16.06°C, T_{MEAN} 14.31°C, F (moisture) 5.59, N (nutrients) 6.44, R (Ca^{++}) 6.29, M 4, PD 72, S 0

Ant species	nests / 100 m²	nests S-area 86.4 m²	nests SI-search
Myrmica ruginodis	20.20	21	4
Lasius platythorax	8.88	8	3
Lasius brunneus	6.46	2	6
Temnothorax crassispinus	5.79	5	
Myrmica rubra	5.66	4	3
Stenamma debile	1.61	2 gynes	
total	**48.61**	**40**	**16**

Species richness index S_{100}: 5.45 species / 100 m² [mean of S- and Pseudo-area].

Calculation of pseudo-area combining *Lasius* + *Myrmica* + *Stenamma* : 53 nests /(37 nests / 86.4 m²) =123.9 m²
*Note: no nests of *Stenamma* were found on the S-area but only two gynes at two different spots. Because the nuptial flight of *Stenamma* occurs in September and October, movements of gynes before this period may be interpreted as indication for presence of nests in the habitat. In order to avoid a density overestimation, *Stenamma* was allocated (deviating from the ususal procedure) to recording group 3 together with *Myrmica* and *Lasius*, finally assuming 2 nests /124 m².

SP 237 (→ SP 134): Mixed pine forest Langteichhalde ('L-Kiefer')

Habitat type: 65-years-old heap afforestation with pines later supplemented by beach
Date of investigation: 19 and 20 June 2017 (A. Prosche), 27 June (Seifert)
Situation: Schönau-Berzdorf-3.4 km E, 51.06482°N, 14.92993°E, 239 m
Plot size: S-area 48.2 m², L-area 1400 m², habitat size: 6300 m²
Orography (slope and orientation of surface): 0°
Soil conditions: quaternary heap soil, silt-sand-loam; pine litter causes higher acidity than in SP 236. 3.6 cm litter, 2 cm raw humus, 11 cm Ah horzion, then heap substrate.
Comments: Long-term study plot on a high heap. Afforested in 1952 with Pinus sylvestris. Pines were poorly growing and placed underneath with Fagus sylvatica in about 1990. Pitfall trapping by Natural History Museum Görlitz in 1985 and 1997/98. The Fagus have grown to 8 m height in 2017. The remaining Pinus were in a rather good condition in 2017.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):
– tree layer (cover 97.4 %, mean height 14 m, *Pinus* 20 m, mean dbh 25 cm, *Pinus* 40 cm):
Pinus sylvestris, Fagus sylvatica, Robinia pseudacacia
– shrub layer (cover 0.6 %, mean height 5.0 m):
Robinia pseudacacia
– herb layer (cover 0.25 %, mean height 8 cm):
Acer pseudo-platanus, Betula pendula, Carpinus betulus, Dryopteris carthusiana, Dryopteris filix-mas, Fraxinus excelsior, Impatiens parviflora, Prunus padus, Quercus robur, Quercus rubra, Ribes rubrum, Symphoricarpos albus
– bryophyte and lichen layer (cover 0.1 %, mean height 1 cm) (det. Dr. Volker Otte 30.06.17)
Brachythecium rutabulum, Lophocolea heterophylla
– litter layer (cover 97.6 %, mean height 3.6 cm)
Leaf and needle litter, pine cones

– dead wood on ground (cover 1.4 %, 0.07 items / m²)
Branches of up to 4 cm diamer, 0.6 pine stumps / 10 m²
– stone cover (cover 0.2 %, 0.01 items / m²)
– bare ground (cover 0 %)
– physico-chemical factors, plant and stone density:
T_{MAX} 15.97°C, T_{MEAN} 14.30°C, F (moisture) 5.25, N (nutrients) 5.62, R (Ca^{++}) 4.67, M 3, PD 2, S 0

Ant species	nests / 100 m²	nests S-area 48.2 m²	nests SI-search	L-search 1400 m²
Temnothorax crassispinus	20.75	10	1	
Myrmica ruginodis	8.47	5	9	
Stenamma debile	3.03	1	4	
Lasius brunneus	1.82	1	2	
Myrmica rubra	0.61		1	
Lasius platythorax	0.61		1	
Lasius fuliginosus	0.07			1
Formica fusca	0		1 dG	
total	**35.36**	**17**	**15**	**1**

Species richness index S_{100}: 5.05 species / 100 m² [mean of S- and pseudo-area].
Calculation of pseudoarea excluding *Temnothorax* and *L. fuliginosus*: 24 nests / (7 nests /48.2 m²)= 165.26 m².

SP 238 (→ SP 106): Erosion area on basaltic tuff

Habitat type: Erosion area on volcanic (basaltic) tuff
Date of investigation: 20, 21, 22 and 27 June 2017 (A. Prosche)
Situation: 8 km SSE Görlitz, 51.0922°N, 14.9262°E, 220–225 m
Plot size: S-area 67.32 m², Q-area 0 m²,
habitat size: 280 m²
Orography (slope and orientation of surface): 35° SE
Soil conditions: Loamy to claylike weathered material of basaltic tuff, mixed with 5- to 50-cm thick edge-rounded to rounded blocks of basaltic tuff. About 20 % of surface is covered with unweathered basaltic tuff containing 10 % to 20 % xenocrysts (nepheline, olivine).
Comments: very steep area on basaltic tuff. The geological raw material was exposed by a landslide in 1981. There is moderate splash erosion and weak soil formation. Flanked in the northeast by 20 m high wood and in the southwest by 8 m high wood.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):
– herb layer (cover 20 %, mean height 60 cm)
Acer cf. pseudoplatanus, Achillea millefolium, Arrhenaterum elatius, Artemisia vulgaris, Betula pendula, Calamagrostis epigeios, Campanula patula, Cichorium intybus, Dactylis glomerata, Daucus carota, Epilobium tetragonum, Erigeron acris, Erigeron annuus ssp. septentrionale, Festuca brevipila, Festuca rubra, Hieracium sabaudum, Hieracium umbellatum, Hippophae rhamnoides, Hypericum perforatum, Hypochoeris radicata, Leontodon hispidus, Linaria vulgaris, Lotus corniculatus, Medicago lupulina, Pilosella piloselloides, Pilosella vulgaris, Poa angustifolia, Populus tremula, Prunus spec., Prunus spinosa, Quercus robur, Rosa cf. canina, Solidago canadensis, Taraxacum officinale, Trifolium aureum
– bryophyte and lichen layer (cover 1 %, mean height 0.2 cm) (det. Dr. Volker Otte 30.06.17)
Brachythecium rutabulum, Brachythecium velutinum, Cladonia cf. rei, Grimmia pulvinata, Lecanora muralis
– litter layer (cover 6 %, mean height 0.8 cm)
Grass litter
– dead wood on ground (cover 2 %, 0.01 items / m²)
Several branches of 8 cm, detached by storms from adjacent wood
– stone cover (cover 15 %, 1.2 items / m²)
– bare ground (cover 65 %)
Loamy to claylike weathered material of basaltic tuff
– physico-chemical factors, plant and stone density:
T_{MAX} 30.05°C, T_{MEAN} 17.91°C, F (moisture) 4.13, N (nutrients) 4.36, R (Ca^{++}) 6.16, M 4, PD 1200, S 2

Ant species	nests / 100 m²	nests S-area 67.32 m²	nests SI-search
Tetramorium impurum	35.65	24	
Lasius flavus	19.31	13	
Formica sanguinea	4.46	3	1
Myrmica schencki	4.46	3	
Tetramorium caespitum	4.46	3	
Lasius niger	2.97	2	1
Strongylognathus testaceus	2.97	2	
Myrmica rugulosa	1.49	1	

Ant species	nests / 100 m²	nests S-area 67.32 m²	nests SI-search
Myrmica sabuleti	1.49	1	
Ponera testacea	1.49	1	
Camponotus ligniperda	0	x	
Camponotus fallax	0	x	
Formica fusca	0	x	
Formica cinerea	0	x	
total	**78.76**	**53**	**2**

Species richness index S_{100}: 10.84 species / 100 m².
Foragers of *C. fallax*, *C. ligniperda* from nests near the western margin of the plot.

SP 239 (→ SP 108): Young Alder Carr

Habitat type: 30-35-years old alder carr along a spring
Date of investigation: 22 and 27 June 2017 (A. Prosche)
Situation: 8 km SSE Görlitz, 51.09140°N, 14.92712°E, 189 m
Plot size: S-area 61.34 m², Q-area 80 m²,
habitat size: 80 m²
Orography (slope and orientation of surface): slope 7°, azimuth 0°, on both sides of the eastwards-directed spring steep S- and N-facing slopes
Soil conditions: very loamy [autochthonous loess-loam, yellowbrown, dusty silt].
Comments: 140 metres W of the inundated SP 108. Only remaining area showing a condition into which SP 108 probably would have developed if not inundated.
Vegetation (recording of herb layer largely by Petra Gebauer 21 June 2017):
– **tree layer** (cover 82 %, mean height 20 m, diameter breast height 20 cm):
Alnus glutinosa
– **shrub layer** (cover 1.6 %, mean height 2.5 m):
Alnus glutinosa
– **herb layer** (cover 86 %, mean height 34 cm):
Acer pseudoplatanus, Agrostis stolonifera, Alliaria petiolata, Alnus glutinosa, Athyrium filix-femina, Betula pendula, Brachypodium sylvaticum, Calamagrostis epigejos, Dactylis glomerata, Deschampsia caespitosa, Dryopteris filix-mas, Epilobium montanum, Equisetum arvense, Euphorbia dulcis, Festuca gigantea, Fraxinus excelsior, Galium aparine, Galium intermedium,Geranium robertianum, Geum urbanum, Hieracium sabaudum, Holcus mollis, Juncus effusus, Poa nemoralis, Poa trivialis, Prunus avium, Quercus robur, Rubus idaeus, Stellaria alsine, Stellaria holostea, Taraxacum spec., Urtica dioica, Veronica beccabunga,
– **bryophyte and lichen layer** (cover 25.9 %, mean height 1 cm) (det. Dr. Volker Otte 30.06.17)
Atrichum undulatum, Brachythecium rutabulum, Plagiomnium undulatum, Polytrichum formosum
– **litter layer** (cover 1.2 %, mean height 0.5 cm)
Leaf and tall herb litter.
– **dead wood on ground** (cover 2.8 **%,** 4.3 items / m²)
Alder twigs of up to 3 cm diameter
– **stone cover** (cover 0.1 %, 0.01 items / m²)
The stone embankment of the inflow of the lake reaches 3 metres into the plot.
– **bare ground** (cover 18.5 %)
An animal path (roe deer, wild boar); steep slopes of spring with only sparse plant cover.
– **physico-chemical factors, plant and stone density:**
T_{MAX} 16.20°C, T_{MEAN} 14.60°C, F (moisture) 5.83, N (nutrients) 5.64, R (Ca^{++}) 5.33, M 4, PD 2950, S 0

Ant species	nests / 100 m²	nests S-area 61.34 m²	nests Q-search 80.0 m²
Myrmica rubra	45.65	28	0
Lasius platythorax	1.25	0	2
total	**46.90**	**28**	**2**

Species richness index S_{100}: 2.09 species / 100 m².
M. rubra polydomous population. *L. platythorax* nest close to adjacent *Betula*, *Populus*, *Acer* stand.