kritisk etnografi – Swedish Journal of Anthropology
2024, VOL. 7, NO. 1
https://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-544572
DOI: 10.33063/DIVA-544572

Life in the ruins of a post-mining landscape: The co-constitutive character of human and non-human action in land restoration

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ABSTRACT: In the context of late industrialism, this article analyses the co-constitutive character of human and non-human actions in post-mining landscapes in eastern Germany. It does so by presenting three ethnographic vignettes: the first explores an underwater forest entangled with corroding infrastructure, revealing how human interventions disrupt some non-human activities while enabling others; the second examines the collaborative efforts between humans and non-humans, featuring black locust, white wine and red cattle in landscape restoration, revealing the intricate roles of non-human entities employed by humans; and the final vignette scrutinises the notion of 'feral proliferations' through the bee-eater, highlighting this bird's ability to thrive outside human intention but then leading to nature conservation actions by humans. Inspired by the literature on late industrialism and informed by more-than-human studies, this ethnographic exploration contributes to a better understanding of how human–environment interactions are being shaped in sites characterised by both the remnants of a post-fossil fuel infrastructure and the present infrastructure of renaturation and ecological restoration. This shows how industrial traces and residual infrastructures can catalyse novel engagements. Rather than viewing landscape restoration solely through a human-centred lens, the analysis explores the multifaceted dynamics at play, recognising the interplay of human and non-human actions. Precisely because of the inherent unruliness of non-human elements, both human and non-human forces are essential in restoring post-mining landscapes. The discussion illustrates the complexities of restoration as a socioecological process, one that targets particular species and ecosystems while opening up space to reflect on human–species interactions.

Keywords: late industrialism, post-industrial infrastructure, land restoration, climate crisis, human–non-human relations

Introduction

Light refracts through the dense forest and shimmers between the stems, some of which are 20 metres high. Poplar, black locust and sea buckthorn stand close together, making it difficult to navigate. Yet there are no thick green leaves blocking the view. In fact, none of the trees carries any leaves, but mussels and algae grow on their trunks. It is quiet under water. Only the sound of the breathing diver can be heard, a steady rushing. The underwater forest is his favourite spot in Geiseltalsee, the largest artificial lake in Germany, spanning over 18.5 square kilometres. He says, "This is a real forest only for experienced divers because you can easily lose your orientation. It's also not for those who are claustrophobic because,

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like in a cave, it's difficult to navigate." Further away from the underwater forest, eerie light oozes through the turbid liquid. Still underwater, a 3-kilometre-long cliff of a former mine, a remnant of another past, offers an impressive setting. Power poles protrude from the lake floor accompanied by meandering railway tracks that corrode in the wet environment. A rusty lorry lies overturned next to the tracks. What appear to be relics of the lignite mining that dominated the area for two centuries are actually part of a relatively new infrastructure that shapes the present. These are not inert remains but tenacious traces of recomposition. Now the rusty vehicle offers a settlement place for the water dwellers – overgrown with the life of the lake, which found its afterlife in the ruins of late industrialism. It is a spectral scene that flows *between* the past and the present, between ruination and new life, and we are witnesses to that unsettling of places and selves.

Geiseltalsee (Geisel valley lake) is located in the state of Saxony-Anhalt in eastern Germany and was created in order to restore the land after the closure of opencast mining of lignite (brown coal) in the area for over 150 years. Sixteen villages were demolished in order to reach the lignite below ground, which was pivotal for industry and for domestic heating. An estimated 1.4 billion tons of coal was mined in Geiseltal (Geisel valley) until the pit was decommissioned in 1993 (Geithner 1998). The creation of the lake took several years. Flooding began in 2003 and it was not until 2011 that the lake reached its planned water level. The now underwater forest thus had a few years to grow, teeming with the life that can emerge on the nutrient-poor anthropogenic soil of a post-mining landscape. Yet the decommissioned pit was steadily filled with water, ultimately submerging the young trees.

Inspired by the fields of late industrialism and more-than-human studies, this article examines the co-constitutive character of human and non-human actions within post-mining landscapes, emblematic of what were once dense fossil fuel infrastructures. Despite appearing to be a straightforward proposition, the notion that both human and non-human forces are essential in restoring post-mining landscapes is often overlooked in the literature. Ecological restoration projects are typically viewed as deliberated human interventions with very specific goals (Gann et al. 2019). Meanwhile, studies of post-industrial landscapes often portray biotic life as part of the 'natural' processes reclaiming or repopulating human-modified environments (Poschlod 1997; Tsing 2018). Bringing these perspectives together, the analysis examines *how* landscape restoration involves dynamic interactions with non-human forces. In this context, human interventions can influence these processes, often actively employing specific non-human actors, while the inherent unruliness of non-human elements means they do not always adhere to human-engineered restoration plans, and can thrive independently of human intention. More specifically, the discussion makes use of ethnographic vignettes that illustrate the complexities of interactions between human and non-human entities. The analytical problems at the forefront of this investigation are threefold. First, how can human intention to restore landscapes override some non-human activities yet enable others? Second, what kinds of strategic employment of non-human entities take place in landscape restoration and the creation of a new renatured infrastructure? And third, what can an exploration of 'feral proliferations' or 'feral dynamics' – both product and producer of tensions in the ecosystem itself – tell us about the way non-human entities thrive outside human intention and often in unexpected directions? (Bubandt and Tsing 2018; Tsing et al. 2019)? In other words, what are we left *with* in the aftermath of apparent ruination which is actually a manifestation of *both* decomposition and recomposition.

The next section provides the theoretical background that informs this study, drawing on concepts from the literature on late industrialism and more-than-human studies. This framework is essential since it focuses attention not only on the obvious degradation of the old and its attendant set of problems but also the context of the present and portents of the future, and perhaps, then, a model for alternative afterlives. It thereby sets the stage for understanding the co-constitutive interactions between human and non-human forces in ecological restoration associated with renaturation and how they are applied to the case study. The methodological approaches are then briefly detailed, offering insights into the research processes and techniques employed. The following discussion touches on the historical and economic significance of the mining industry in Geiseltal, and the salient legal framework that has shaped the post-fossil fuel infrastructure. This is crucial for understanding the value of the ethnographic vignettes, whose purpose is to demonstrate how the post-mining landscape of Geiseltalsee is being reimagined, restored, and reinhabited by both human and non-human actors.

Late industrialism and more-than-human studies

The narrative of late industrialism, emerging from the stresses associated with (de-) industrialisation, presents a multifaceted stage of development characterised by intricate societal shifts and evolving technological trajectories (Fortun 2012). This perspective, in contrast to the linear and teleological visions of progress inherent in modernist paradigms, emphasises the repercussions of unsuccessful endeavours to establish smooth circulations of technology, goods, and capital. In short, the concept of late industrialism is important in epistemological terms since it eschews a simplistic model and necessarily complicates the usual pre- and post- cleavage. Within the framework of late industrialism, as advanced by Kim Fortun, the landscape unfolds as a canvas marked by exhausted infrastructures, industrial ruins, scarred landscapes and depleted resources. It is a story of an unsettled and unsettling breakdown. In her words,

> Many such problem domains today, in our late industrial times, involve complex conditions, conditions involving many nested systems – technical, biophysical, cultural, economic – and thus a multiplicity of interactions, which keep the parameters of 'the problem' from ever settling down. (Fortun 2012: 451–452)

Both the images of 'nested systems' and the 'multiplicity of interactions' capture the kinds of complexity and contingency that are present in the shifting infrastructures of Geiseltalsee. As Fortun continues, "Complex conditions resist explanation in available terms, producing what I have come to think of as discursive gaps, and discursive risks" (ibid.: 452). It is precisely the wish to fill in these gaps, and to propose new ways of thinking about the problem of infrastructural transformation, that informs the ethnography and interpretation set out here. These visible manifestations of complexity are not mere anomalies but integral components of a system where capitalism, in the form of late industrialism, perpetuates itself by adapting, revising, and restarting, all while preserving its underlying structures (Ojani 2023: 228).

In exploring these problems, the extraction of coal and the subsequent project of

ecological restoration and renaturing introduce another dimension to late industrialism. The mining of coal, absolutely emblematic of resource exploitation, mirrors the challenges and contradictions inherent in this phase of capitalist development. The depletion of natural resources and the transformation of landscapes into industrial sites embody the struggle to sustain seamless circulations in the face of environmental and societal repercussions. Over the last decade and more, the term late industrialism has been associated with something profoundly negative. The characterisation offered by Chloe Ahmann and Alison Kenner (2020: 416) is both brutal and to the point: "Breakdown, trespass, seepage, degradation: this is late industrialism. […] synonymous with collapse, describing everything from crumbling infrastructure to outmoded paradigms." From almost any viewpoint, this should fill us with a sense of unremitting despair. However, Ahmann and Kenner argue that the term 'late' holds transformative potential for several reasons, and this more optimistic turn informs my own analysis, including its theoretical assumptions. First, it signifies a prophetic moment, indicating the end of one era and the emergence of the next. Second, the term carries radical potential, akin to Marx's perception of revolutionary potential in late capitalism's contradictions, presenting opportunities for recombination and the creation of new systems (Ahmann and Kenner 2020: 418). Third, late industrialism offers the chance to 'retrofit' infrastructure, allowing for tinkering with broken systems and actively engaging in transformative practices. And fourth, it encourages experiments in 'living otherwise', promoting alternative principles and discursive frameworks, and the creation of new systems organised around different, more sustainable values. In essence, Ahmann and Kenner persuasively see the term 'late' as holding potential for ushering in radical change, alternative living, and the transformation of existing structures within the late industrialism context. This allows for the prospect of a new world emerging amid places haunted by toxic pasts. In their analysis, this involves people adapting broken systems, forming adaptable alliances, and engaging in creative temporal approaches. As Ahmann (2024: 3-4) states in her recent book *Futures after Progress*, "That these lifeworlds spring from a site more often figured as a relic does not mean they are outmoded. It means that they are prescient: little windows into the shape that hope takes on unstable ground." This shift from the lignite mines of Geiseltal to the spectral and 'artificial' underwater world of Geiseltalsee speaks not of endings but of present realities and uncertain futures.

Taking conceptual clues from Ahmann and Kenner's (2020: 418) assertion that the infrastructures of late industrialism can be reimagined positively – "they are hardly inert ruins. They are alive with residues" – my own argument looks at how people involved with developing something new out of the old in and around Geiseltalsee are finding new infrastructures and sometimes recreating them through interactions with non-human entities. I do so by harnessing more-than-human studies, a theoretical perspective that seeks to move beyond anthropocentrism by acknowledging the agency and importance of non-human entities in shaping sociospatial relations (Panelli 2010; Buller 2014; Fleischmann 2020; Steiner et al. 2022). This perspective challenges the traditional separation between the people and the environment, emphasising the interconnectedness of human and non-human elements. Scholars within more-than-human studies have made persuasive use of new materialist theories in social geography to explore the entanglements and co-constitutions of human and non-human actors, considering the diverse ways in which both contribute to the formation of landscapes, infrastructures and social practices (see, for example, Whatmore

2006; Kirsch 2013; Ash 2020; Salazar et al. 2020). While there was an initial focus on human–animal studies, more recent interventions involve plants (Head et al. 2014; Pitt 2015; Atchison and Phillips 2020), the microbiome (Lorimer 2020), soil (Salazar et al. 2020), technologies (Giaccardi and Redström 2020), and other non-human entities in the production of space and place.

In this production of space and place through humans and non-humans 'feral proliferation' play a formative role. 'Feral proliferation' or 'feral dynamics' is a concept introduced by Nils Bubandt and Anna Lowenhaupt Tsing (2018; see also Tsing et al. 2019). The concept explores the dynamic relationships between humans and non-human entities, particularly focusing on the ways in which non-human life forms, often considered feral or wild, adapt and proliferate in anthropogenically impacted environments. Feral typically refers to animals or plants that have escaped domestication and returned to a wild state. However, Bubandt and Tsing extend this concept beyond the individual organism to explore the ways in which entire ecosystems and environments become feral in response to human activities.

Methodologically, more-than-human research calls for new techniques, including mutual ecology, structural ecology and hybrid community studies (Locke 2018; Ameli 2022). In order to explore diverse human relations with non-humans, multispecies ethnography originated in anthropology with Eben Kirksey and Stefan Helmreich's coining of the term (Kirksey and Helmreich 2010; Locke 2018). This approach expands beyond human–animal relations to include all living organisms, aiming to transcend human–species boundaries (Ogden et al. 2013; Buller 2015). As such, multispecies ethnography explores what breaks down human–nature dualisms, emphasising the interconnectedness between humans and other species (Ogden et al. 2013; Tsing 2015). It offers a unique 'mode of attunement' to the complex relationships shaping the world. Laura Ogden et al. (2013: 16) use the term 'mode of attunement' to refer to the ways in which humans and non-human beings become aware of, and responsive to each other's movements and sentience in order to coexist on Earth. This concept emphasises the importance of recognising the agency and subjectivity of non-human beings, as well as the need for humans to develop a sensitivity to their presence and needs. The authors suggest that the 'mode of attunement' can be explored through the lens of multispecies ethnography, which seeks to understand the intricate relationships between humans and non-human beings in various contexts, and this is certainly applicable to the case study of Geiseltalsee and its environs.

Following Ogden et al.'s argument, my own methodological approach aims at exploring the recognition of each other's responses by humans and non-humans. For this ongoing research, I conducted semi-structured interviews with various experts, practitioners, activists, and residents – each deeply committed to creating new possibilities and possessing expertise in knowledge, innovation, design, and infrastructure – in order to capture their perspectives on the role of non-human actors, mainly plants and animals, in the restoration of post-mining landscapes. The interviews focused on themes such as environmental perceptions, relationships with plants, strategies for coping with environmental changes, and the significance of plants in landscape restoration and creating a renatured infrastructure. I used participant observation during various activities such as planting sessions, removal actions, and plant and species counts. I further documented interactions between participants and the surrounding post-mining landscape, with particular attention given to actions indicating a close connection or interaction with plants and other non-human actors. Additionally, I

conducted 'go-along' interviews with natural scientists from various disciplines to be able to observe and participate in their interactions with the post-mining landscape, allowing for spontaneous reactions and emotional connections (Kusenbach 2003). Following the interviews and observations, reflections and field notes were made to record impressions, observations, and thoughts. These served as a basis for later data analysis and assisted in contextualising the collected information. I analysed the data through qualitative content analysis, developing thematic categories to identify recurring patterns, meanings, and connections. The analysis considered a more-than-human perspective to focus on both human and non-human actors by also trying to integrate knowledge from various disciplines on certain species.

Restoring post-mining landscapes is an experimental field, one that my informants describe as characterised by trial and error. Precisely because of the unruliness of non-human actors, post-mining landscapes, as highly engineered spaces, become new arenas for negotiating co-habitability, not just discursively but also materially. These post-mining landscapes, shaped by both ecological forces and human intervention, become dynamic sites where the boundaries between nature and infrastructure are constantly renegotiated. Restoration efforts, which often aim to return the land to a 'natural' state or to repurpose it for new uses, are shaped by unpredictable interactions between species, soil composition, and hydrological systems. As a result, practices of restoration are not only about reclaiming land but also about managing and responding to the emergent behaviours of more-than-human actors. In this process, the notion of control becomes fragmented, as the outcomes of these restoration projects depend on the cooperation—or resistance—of non-human life forms. These complexities make post-mining landscapes a site of continuous experimentation.

While my vignettes often depict my walks through these spaces in the company of human informants, this might seem anthropocentric. However, my interest lies in the co-constitutive character of landscape restoration, which emerges through the actions of both humans and non-humans. When I describe the non-human assemblages in detail, it is always in relation to how humans respond to or engage with these characteristics.

In the next section, I provide some context to the field site through an overview of the historical role of lignite, while also briefly touching on the legal provisions framing restoration measures in German mining districts. The discussion then returns to the opening ethnographic vignette and introduces more in order to investigate the co-constitutive character of land restoration and the creation of renatured infrastructures in post-mining landscapes.

Lignite legacy

Germany has long been a leading producer of lignite and in 2022 ranked third in the world behind China and Indonesia and accounted for 44 per cent of lignite production in the European Union. Lignite remains one of Germany's primary fossil energy resources (Schiffer 2023; Garside 2024). Today, there are three active lignite mining districts: the Rhenish mining area in North Rhine-Westphalia, producing 86 million tons per year (t/yr), the largest in the country; Lusatia in Brandenburg and Saxony (60 million t/yr); and the Central German mining district in Saxony, Saxony-Anhalt and Thuringia (19 million t/yr) (Sandau et al. 2021). Predominantly employed for electricity and district heating, around 90% of lignite is utilised in public and industrial power plants, contributing a third of Germany's electricity generation in 2022 (Federal Statistical Office 2023). Its economic

use, characterised by the proximity of mining and power plants, promises a high level of supply and efficiency, a model not driven by the international market, yet potentially with hidden costs (Michel 2005). It has long been recognised that lignite mining significantly alters landscapes, entailing substantial disruptions to human and non-human habitats and the natural environment (Hildmann and Wünsche 1996; Pflug 1998). Since the beginning of mining activities in Germany, lignite extraction has impacted on approximately 177,300 hectares of land, about twice the size of Berlin (Federal Environment Agency 2024).

The tension between exploiting natural resources for economic gain and the ecological consequences of such actions encapsulates the broader dilemmas within late industrialism. Fossil fuel mining is the epitome of what has been labelled 'extractivism'. Of course, human societies have long extracted resources, whether for practical or ceremonial purposes. Extractivism denotes a different order of things. As Louise Nachet et al. (2022: 2) argue,

> when extraction is made into a form of ideology, driven by economic growth–it becomes extractivism, an ideology based firmly in the view of Earth as a resource for humans to master. Extractivism, since connected to economic growth and development, has become an implicit part of our contemporary world.

The extractivism associated with lignite and the subsequent land restoration therefore provides a compelling perspective on late industrialism, exemplifying the intricate interplay between economic systems, ecological sustainability, and the perpetual challenges of navigating the terrain of contemporary political economies, all of which collide in the ethnographic example of Geiseltalsee.

To counteract the adverse impacts of opencast mining, the 1980 Federal Mining Act (Bundesberggesetz, BBergG) mandates that mining companies take measures to transform the affected areas to a 'usable' state once lignite extraction ends (Federal Ministry of Justice 1980). Such measures include agricultural rehabilitation, the conversion of the opencast pits into bodies of water and lakes as well as into local recreation areas, the afforestation of the landscape, the construction of industrial plants or the use of the remaining opencast mining pits as landfills for household waste, power plant ash or hazardous waste. As such, this is not the same as a restoration to the conditions that prevailed prior to mining (Frenz 2010). As a consequence of the law, it is illegal to simply leave the conditions resulting from mining activities to 'rewild' themselves.

Since the Federal Mining Act, mining companies in western Germany have been required to formulate detailed restoration plans as part of their licensing process, ensuring that post-mining landscapes are rehabilitated to a stable and environmentally sustainable condition. Conversely, in the German Democratic Republic (GDR), which operated under a centrally planned economy, state-owned enterprises managed mining activities (Ahlheim 1997; Turner 1997). Following reunification, the Lusatian and Central German Mining Management Company (Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH, LMBV) was established by the German state in 1994 to assume responsibility for the extensive environmental restoration efforts inherited from the GDR, focusing on land rehabilitation of former mining sites. The LMBV was and still is in charge of the restoration and maintenance of the Geiseltal area.

Land restoration after mining presents several significant challenges. Criticisms include the fact that the removal of the loess layers has severely compromised the quality of the new soil. As loess, a loose sediment primarily composed of tiny uniform particles deposited by wind during the ice ages, is highly porous and capable of storing large amounts of water, it contributes to an extremely fertile soil type that optimally supports plant growth (Scheffer et al. 2002: 36). Critics state that removing these layers of loess in the process of mining leads to inevitable losses in natural biodiversity, and the inability of endangered animal species to survive the habitat loss (Gerwin et al. 2023). Such losses cannot be restored. The land left behind is usually characterised by nutrient-poor or even toxic soils, which makes it difficult for vegetation to thrive (Klotz et al. 2000). Restoring soil fertility is a time-consuming process that typically requires the addition of organic material, lime, or fertilisers (Drebenstedt 2000). In addition, mining activities can lead to soil compaction which hinders plant root growth and reduces water infiltration (Durka and Schmidt 2000; Klotz et al. 2000). To address this, soil loosening measures are necessary (Haubold-Rosar 1998). Another major issue is the disruption of natural water flow, such as the lowering of groundwater levels or the diversion of rivers, which requires hydrological interventions to restore the water pathways (Schlenstedt 2017). In some mining areas, acidic water bodies can occur (Geller et al. 1998; Pfeiffer and Nohlen 2000). This acidification must be neutralised, often through liming, to protect and restore the surrounding environment. Another problem with the restoration of post-mining landscapes is the iron hydroxide deposition in the newly created water bodies, the so-called *Verockerung*, of the newly created opencast mining lakes, which manifests itself in the silting of the water bodies (Geller et al. 1998). As a result, these recently created landscapes demand high levels of maintenance.

The Geiseltalsee and its underwater forest

Though Geiseltal is part of the still active Central German mining district, mining there ended in 1993 (Geithner 1998). The collapse of the former GDR in 1989, coupled with sweeping political, economic, and social changes, hastened the cessation of mining operations that were already in an advanced stage of depletion. The shift towards a market-oriented energy sector following the reunification of Germany rendered lignite economically and environmentally unsustainable, leading to a rapid decline in sales. On 30 June 1993 the final lignite train departed from Geiseltal.

Mining in Geiseltal, as elsewhere, left behind huge pits with steep embankments at risk of landslides and sites contaminated by the chemical industry. Due to the large mass deficit – the volume of the lignite that is now missing from the ground – most of the remaining pits could not be filled with overburden. The greater part was flooded and today forms Geiseltalsee. After the last lignite train left, it took another decade until the flooding of the immense decommissioned pit could start to create the artificial lake. It then took eight years for the pit to be replenished with filtered water sourced from the Saale and Geisel rivers, resulting in a water body holding over 420 million cubic metres of water and reaching depths of up to 78 metres (Oldorff et al. 2021). The site now hosts a distinctive ecosystem with diverse flora and fauna. At the same time, the lake has transformed into a popular recreational spot featuring a yacht marina, vacation homes and permanent camping facilities. Along its southern shore, several boat rental services operate, offering opportunities to rent houseboats for exploration.

Despite the seemingly idyllic appearance of Geiseltalsee, a discerning eye sees points of intrigue that belie its 'natural' facade. A nuanced reading of the landscape reveals subtle disruptions, where conventional biological norms seem suspended. An elder tree, typically rooted at the base of hills due to its affinity for wet soil, emerges incongruously in the middle of the hill – an anomaly suggesting a haphazard blend of soil compositions spilled from the overburden during mining activities. Beneath the water's surface, other anomalies demand further exploration. As depicted at the outset, the underwater realm harbours an intriguing mixture of submerged forests and corroded infrastructure, remnants of the past. The lake's peculiar characteristics are not lost on enthusiasts, as evidenced by the presence of a diving school explicitly promoting the exploration of this post-mining landscape under water. In the short introductory vignette, we briefly heard from the diver, who is in fact running the diving school. His cautionary note about the difficulty of navigating the underwater forest emphasises the unpredictable character of non-human responses to human interventions. The submerged trees, originally growing on anthropogenic soil, faced an unforeseen fate as the pit was filled with water. The intentional restoration involved the manipulation of water levels, and the consequences unfold as the underwater forest becomes a challenging environment even for experienced divers. The mining cliff and the remnants of industrial infrastructure, including submerged power poles and railway tracks, serve as reminders of past human activities. Meanwhile, the rusted lorry overturned next to the tracks has become a settlement for water dwellers, mussels, and algae, showcasing the adaptability of non-human life in transformed landscapes.

The underwater forest of Geiseltalsee vividly illustrates the intersection of human efforts in land restoration with the agency of non-human actors. This forest, emerging on the decommissioned pit with nutrient-deficient soil, discloses the characteristics of birch and poplar, which are renowned in ecology as 'pioneers' in post-mining landscapes. Such pioneer tree species excel at colonising open spaces, ecologists observe, a phenomenon not exclusive to mining activities but also arising from events like clear-cutting after bark beetle infestations, storm damage, landslides, volcanic eruptions, meteorite impacts, or wildfires (Begon et al. 2016; Kadereit et al. 2021). In environments marked by nutrient deficiencies or imbalances, as often found in the underdeveloped soils of post-mining landscapes, pioneer tree species demonstrate superior adaptability compared to other tree species. The conditions of these landscapes create favourable circumstances for the rejuvenation of light-demanding species like poplar and birch, highlighting their capacity to thrive in challenging ecological scenarios. The appearance of the pioneer forest might as such suggest a natural occurrence, seemingly untouched by human intervention, yet the reality is more complex.

In fact, the forest appeared while submerged pumps from the mine remained beneath the tranquil surface of the lake, diligently preventing the landscape from succumbing to the rising groundwater level. The pumps were initially installed for the mining operation to pump the groundwater out of the pit (see Stoll et al. 2008). Once mining ceased, the pumps continued to operate to prevent uncontrolled flooding, which could lead to erosion or landslides. Only after some years of preparation did the controlled flooding of the pit begin, stopping the pumps, letting the groundwater rise and also diverting water from nearby rivers. What might seem like a natural process of forest regrowth, then, is actually the result of an intricate interplay between ongoing human management and natural processes, adding another layer to the intricate entanglements of non-human and human actions.

With the intentional flooding of Geiseltalsee the pumps draining the landscape were stopped. This human endeavour to restore the landscape had an unforeseen impact on the emerging forest. Despite the inundation, the young trees that had established themselves on the decommissioned pit died, yet their remnants proved remarkably resilient beneath the water's surface. The vignette at the beginning of the article depicts this submerged forest, where algae and mussels now thrive on the dead trunks, aesthetically taking on a role akin to leaves in the aquatic environment. To truly grasp the depth of this scene, one can consider an insight offered by Elaine Gan et al. (2017: 5): "To track the histories that make multispecies livability possible, it is not enough to watch lively bodies. Instead, we must wander through landscapes, where assemblages of the dead gather together with the living. In their juxtapositions, we see livability anew."

Within the dynamic interplay of human intent and the adaptability of non-human entities, the underwater forest represents non-human actions within a landscape with submerged pumps run by people. Although the non-human actions of growing trees are overridden by human efforts to restore the landscape and the trees die, the vignette also demonstrates, through the remnants of the trees (even though dead) as well as through other species such as the algae, the adaptability and persistence of non-human entities in newly formed ecosystems, even in the face of transformative interventions. It also resembles what Gan et al. (2017: 7) call "our weedy hope," which suggests that even in environmental degradation there are spaces for unexpected forms of life and possibilities for coexistence.

Black locust, white wine and red cattle

In the heart of what was once an industrial scar on the land, a captivating scene unfolds as I step into a flourishing black locust forest on the slope of Geiseltalsee, accompanied by a biologist. In May the air is filled with the sweet fragrance of blooming flowers, mingling with the subtle earthiness of the soil beneath the canopy. Row upon row of black locust trees (*Robinia pseudoacacia*), their trunks tall and sturdy, stand as sentinels against the backdrop of a post-mining landscape. They were planted here in order to avoid erosion and enrich the soil quality.

The soil, once barren and scarred, now hosts grass and wildflowers, their colours contrasting vividly with the charcoal tones of the tree trunks. The black locusts, with their delicate yet resilient compound leaves, extend their branches upwards, their deep-reaching root systems now stabilising the anthropogenic ground. In this soil, invisible to the human eye, the black locust not only helps to stabilise the ground, the biologist explains, but also engages in a fascinating process called nitrogen fixation through a symbiotic relationship with nitrogen-fixing rhizobia (*Rhizobium* spp.) or root nodule bacteria.

The tree releases organic compounds such as flavonoids into the soil. These flavonoids act as signalling molecules, attracting specific rhizobia bacteria from the soil. The rhizobia bacteria enter the root hairs of the black locust through infection threads. Once inside, the bacteria induce the formation of nodules, a specialised structure on the roots, creating a symbiotic relationship. This process is controlled by a complex exchange of signals between the plant and the bacteria. Within the nodules, the rhizobia bacteria convert atmospheric nitrogen (N^2) into ammonia (NH^3). Nitrogen, abundant in the air but inaccessible to many plants, thus becomes a usable form for the black locust and surrounding plants. In return for fixing nitrogen, the bacteria receive carbohydrates and other nutrients from the black locust.

This mutualistic exchange thus benefits both partners. The ammonia produced by nitrogen fixation is converted into ammonium (NH^{4+}) and can be used by the black locust for its growth and development. Further, when the tree sheds its leaves, the nitrogen-rich material contributes to the soil's fertility. This symbiotic relationship allows the black locust to thrive in nitrogen-poor soils, a trait that contributes to its success as a pioneer species in 'disturbed environments' (Begon et al. 2016; Kadereit et al. 2021). The ability to fix nitrogen enhances soil fertility and supports the growth of other plants in the vicinity, making the black locust a valuable species in ecological restoration and soil improvement projects.

The black locust's adaptability, fast growth, and beneficial properties contributed to its widespread cultivation in Europe, including Germany. In 2020 the German Dr. Silvius Wodarz Foundation (Silvius Wodarz Foundation 2020) chose the black locust as the 'Tree of the Year', primarily due to its properties, some of which are particularly valuable at a time of climate crisis. The black locust withstands heat and drought, and even tolerates aggressive road and highway de-icing salt residues. Its flowers are considered true bee pastures, abundant with nectar.

However, the tree also raises concerns among conservationists because once the species establishes itself it is challenging to eradicate. Depending on the location, the black locust is classified as an invasive tree species, despite its positive properties, because these can become problematic (see also Vítková et al. 2017). "Black locust is well adapted to nitrogen-poor soils, as nitrogen accumulates at its roots," explains the biologist walking with me through the post-mining landscape. "However, this makes it a potential threat to nitrogen-poor natural areas like sandy grasslands. Species specialised in nutrient-poor and dry soils have a tough time alongside the black locust; they get displaced by it." It is precisely its special characteristics that make the black locust favourable and problematic from the perspective of conservationists, depending on the specific location of the tree. "The black locust is undemanding and thrives even under lean conditions. However, naturally nutrient-poor landscapes have become rare and should be preserved due to their specific biodiversity" (Biologist, Interview, May 2023).

Despite the tree's invasive capacities, in the face of drought-induced forest dieback, forestry scientists are proposing a novel approach to reforestation by planting a mix of foreign trees as a risk diversification strategy. Leading this initiative is the black locust, celebrated as the new beacon of hope in the era of climate crisis due to its exceptional resilience to drought and heat (Hofmann et al. 2020). For most German foresters, the North American tree is a newcomer, but not for foresters in Saxony-Anhalt. Here, entire forests of black locust were planted on reclaimed mining areas during the GDR era, such as in Geiseltal or in Goitzsche near Bitterfeld (Baumert 2023). Around 1960, a third of the forests in these post-mining landscapes comprised black locust – eastern Germany has 60 years of experience with this tree. As noted above, the tree was intentionally planted for the restoration of the post-mining landscape at Geiseltalsee to fix the nitrogen content and as such improve the soil. The extensive root system of black locusts also makes them effective for erosion control. Planting them in areas prone to soil erosion like the slope from the heap down to Geiseltalsee helps stabilise the ground. However, during a recent walk with one of the LMBV employees responsible for the maintenance of the area, he explained that the LMBV decided to not bring in the black locust tree artificially anymore, "because it is so hard to control and spreads really rapidly. It makes it more difficult to incorporate more diversity in

the planted forests" (LMBV employee, Interview, May 2024).

Near the black locust forest at Geiseltalsee, nestled on a formerly desolate wasteland, a vineyard sprawls across six hectares, as yet another example of the human and non-human capacity to reclaim post-mining landscapes. Rows of 30,000 grapevines now adorn the once towering heaps of discarded earth. The terrain, a meticulously engineered slope, situated to capture sunlight, serves as the nurturing ground for the flourishing vines.

> We thought, if we are already creating the landscape here, why not make it perfect? The perfect vineyard has an inclination of about 27 degrees and faces the sun. We seized the opportunity to materialise this, so to speak, as an epiphany of reclamation. (Winegrower, Interview, August 2023)

Below the perfectly angled vineyard hill, the human-made lake, repurposed to retain warmth during harsh winter months, dutifully imparts its accumulated heat to the hillside, shielding the delicate roots of the vines from impending frost. Amid the vines, pockets of vibrant life thrive. Thoughtfully positioned green spaces and strategically placed straw conserve rainwater, fostering a delicate equilibrium within the ecosystem. A herd of red cattle (*Rotes Harzer Höhenvieh*), a nearly extinct breed, roams adjacent to the scene. These cattle graze with purpose, contributing to the preservation of this reimagined landscape. Beyond their grazing duties, their weight assists in condensing the anthropogenic ground, while the cattle's manure, a potent source of nourishment, blends with the earth, sustaining the vines in a cyclical intermingling of life – each step infusing the soil, each vine absorbing their bounty and the hillside steadfast against potential erosion. The soil, itself a blend of compacted detritus and discarded overburden, echoes the remnants of industry.

A sunny October day in 2023. Some volunteers and I trudge up to the vineyard to help with the hand-harvesting of the youngest grapevines. The rest had already been harvested by machines. "The machine harvests in two hours the same amount 40 people can pick in a day," the winegrower explains. The grapes we are supposed to gather that day grow on the youngest plants of the vineyard, too delicate and small to be efficiently harvested by a machine. Each of the rows is about 250 metres long with a 60-metre change of elevation. Our hands are sticky with grape juice as we meticulously pick the ripening fruit, grappling with the 27-degree slope that takes a toll on hips and backs. A sudden yelp punctuates the air when someone unsuspectedly becomes the target of a wasp's intrusion, one that had eaten its way inside a grape. A quirky remark floats in the air, suggesting that wine might not be vegetarian after all, considering the insects that find their way into the vineyard's bounty. Amid the banter, the winegrower interjects, steering the conversation towards a more profound reflection and pragmatic insight. In a world "increasingly buzzing about biodiversity," he asserts that this concern has always been paramount for vintners. "We've formed a partnership with a local beekeeper, allowing their bees to forage on the black locust trees and wine blossoms, contributing not just honey but essential pollination around the vineyard" (Winegrower, October 2023).

The black locust forest and vineyard at Geiseltalsee demonstrate the creation of a new landscape within a historical backdrop shaped by mining, encapsulating the profound interplay between human creativity and more-than-human entanglements. This

transformed expanse, once marked by the scars of heavy industry, now hosts a thriving 6-hectare vineyard strategically positioned on a 27-degree slope, capturing sunlight with precision to support 30,000 grapevines against the backdrop of a heavy industrial history and its afterlives. We indeed 'see livability anew.' Informed by the transformative potential attributed to late industrialism, the deliberate interplay between human and non-human actors in the restoration of this post-mining landscape vividly exemplifies the possibilities of reimagination and encapsulation. The post-mining landscape is 'alive with residues' and, more than that, with something new. The vineyard's success is intricately tied to the innovative use of an artificial lake that includes exhausted infrastructures and underwater industrial ruins. This aligns with Ann Laura Stoler's (2008: 194) notion of ruins as active agents shaping the more-than-human landscape: "ruins are also sites that condense alternative senses of history. Ruination is a corrosive process that weighs on the future and shapes the present." The intentional placement of beehives, contributing to pollination, fosters a multispecies environment that extends to the nearby black locust forest, echoing the more-than-human perspective. The collaborative relationship between black locusts and bacteria, enriched by the anthropogenic ground, narrates a history rooted in industrial processes and represents, in the words of Ahmann and Kenner, an opportunity for experiments in living otherwise. The soil, a product of waste material once extracted during mining, tells a story of life in the ruins of a damaged planet (Gan et al. 2017). This assemblage of the black locust forest, vineyard, and red highland cattle embodies life intertwined with industrial legacies, serving as a living history that transcends the observable present while condensing 'alternative senses of history.' The vibrant greenery signifies these landscapes, not only as symbols of reclamation but living embodiments of hope and resilience amid late industrial ruins. The intentional interplay between human and more-than-human actors in post-mining landscape restoration unveils complex, reciprocal relationships. The histories and futures of multispecies livability are inscribed not just in lively bodies but in the assemblages of the past, present, and the 'weedy hope' sprouting from the remnants of extractivism.

However, a high amount of human effort is put into the control of unintended 'feral proliferation' or 'feral dynamics' (Bubandt and Tsing 2018; see also Tsing et al. 2019). The black locust, for instance, once intentionally planted in order to enhance soil quality and prevent erosion, spreads rapidly and is difficult to control. While picking grapes, I noticed young sprouts of black locust among some rows of the plants and asked the winegrower about it, to which he passionately replied, "black locust is like the plague, it spreads and is difficult to control. You have to observe it and make sure it doesn't continuously reseed itself. I need to remove the seedlings soon, otherwise I cannot get rid of it." A seedling forms roots up to 3 metres in length from the first to the third year. Later, the roots of the black locust can even reach 7–8 metres in length. As a post-catastrophe tree, a proper pioneer species, the black locust reproduces more rapidly under stress. It exhibits root sprouting, allowing the generation of multiple trees not only from seeds but also from the roots of a single tree. Exploring the multifaceted relationship between the black locust and its environment also compels an understanding of the ecological, cultural, and historical dimensions of this tree, questioning its role as a symbol of hope while acknowledging the potential ecological challenges it may pose. In doing so, a more-than-human perspective enables us to recognise the interconnectedness of human and non-human entities in shaping landscapes and ecosystems.

Feral proliferations and nature conservation

Accompanied by a dedicated ornithologist, I stroll along Geiseltalsee into the part which today is a nature reserve. Opposite the vineyard and the black locust forest lies a roughly 2-kilometre-long peninsula, where Möckerling, one of the 16 villages displaced due to mining, was once located. The depleted topsoil has given way to calcareous sandy and gravelly soils, fostering flower-rich dry meadows and xerothermic grasslands. This environment becomes a suitable habitat for numerous insects, creating ideal conditions for the bee-eater (*Merops apiaster*), which has dug its breeding burrows into the steep slopes formed by mining.

Ornithologists have been actively involved for several years in preserving and maintaining the crucial breeding sites of the bee-eater across various districts in central Germany. One of the most important breeding colonies lies in the Geiseltal mining landscape, now under protection. To safeguard the species, no roads or paths can be constructed in this area, and reforestation is prohibited on the peninsula since the migratory bird requires open landscapes. While the climate crisis may play a role, the bee-eater has been found in Germany since at least 1964 (Dellwisch et al. 2022). It disappeared and was considered extinct in Germany just 25 years ago and found only in south-eastern Europe. One of the largest populations of bee-eaters in Germany today is in Saxony-Anhalt's (post-)mining landscape, with Geiseltal being the largest breeding area for the bee-eater in the country. Due to the relatively recent renaturing measures, the trees on the Geiseltalsee peninsula are still young and thus not very tall. Away from the paths, there are frequently overgrown mounds, likely to have been piled up due to mining. In the steep earth mounds, the ornithologist and I eventually discover fist-sized cavities, the first signs of the bee-eaters.

The steep walls formed by lignite mining became essential habitats for the bee-eater's nesting. These colourful migratory birds typically arrive in Geiseltal around May and stay until August or September, depending on the weather. They excavate 1–2-metre-long nesting burrows, removing up to 7 kilograms of soil, sometimes causing their long bills to shorten by up to 0.5 cm. Being the first to return from their winter quarters in the West African savannas, stretching from Senegal to Ghana, as well as East Africa and southern Africa, secures better prospects, as 50–60 per cent of existing nesting burrows are reused later, requiring only cleaning instead of digging. For their habitat and reproduction, bee-eaters need warm and structurally rich natural spaces with open areas, trees, and most importantly, long steep walls. Additionally, other species such as the kingfisher, the sand martin, the house sparrow, and wild bees benefit from the steep cliffs created by extraction as their habitat. Just a few metres further, we stumble upon another bee-eater colony. A huge earthen wall dotted with nesting holes rises directly next to the path. Numerous colourful bee-eaters circle above us, perch on the trees and feast on bumblebees. We settle into one of the bushes, and my companion begins taking photographs.

As lignite mining alters the landscape by creating steep sandy cliffs, mining unintentionally provided a habitat that suits the nesting preferences of bee-eaters. In the conventional sense, lignite mining is a human activity with significant environmental impact. However, in the context of feral proliferation, it becomes an unintended facilitator of new ecological opportunities. The bee-eater demonstrates an unpredictable adaptation to the altered environment created by mining activities. Feral proliferation, in this case, refers to the unexpected expansion of the bee-eater's habitat range due to the availability of suitable nesting sites, challenging traditional expectations of their migratory patterns. This

example highlights the complex interactions between human activities and non-human life forms. The alterations made by humans in the landscape, driven by industrial activities like mining, inadvertently create conditions that favour certain species, allowing them to proliferate in unexpected ways. Feral proliferation therefore suggests that the consequences of human interventions such as mining go beyond mere disturbance and can lead to the emergence of novel ecological configurations. In fact, most of the species present in post-mining landscapes are there not *despite* the disturbance but *because* of it.

Conclusion

This article explores a post-mining landscape through three ethnographic vignettes, emphasising human ingenuity, environmental adaptation, and the co-constitutive character of humans and non-humans in landscape restoration. By integrating insights from recent research on late industrialism and more-than-human studies, the analysis demonstrates how practices can expand our understanding of experiments in 'living otherwise' to include non-human actors. Geiseltalsee stands as a living example of the dynamic interplay between human engineering and environmental restoration, echoing the broader significance of more-than-human entanglements for ecosystems and the dependences on one another.

The submerged forest in Geiseltalsee epitomises dynamic interactions between human interventions, environmental changes, and non-human agency. This underwater ecosystem, teeming with pioneer trees, algae and mussels, demonstrates how landscapes transform, sometimes even when dead, through the resilience and adaptability of non-human elements in response to anthropogenic disturbances. The narrative underscores the adaptive strategies of plant species in nutrient-deficient soils and highlights the coexistence of human technologies. The submerged pumps, at first actively preventing the landscape from succumbing to rising groundwater levels, exemplify the coexistence of human technologies and natural processes in shaping landscapes. When these pumps were stopped and the landscape further transformed through intentional flooding, the complexity of plant responses to human interventions was brought to the fore. The underwater environment, now including dead trees, became a novel space for the thriving of algae and mussels on tree trunks. While originally aimed at restoration, the intentional flooding introduced an element of unpredictability, emphasising the need for a nuanced understanding of non-human actions. In the critical discourse on more-than-human studies, this narrative underscores the co-constitutive relationships between human activities, non-human life, and the broader ecological dynamics, contributing to a deeper understanding of the interconnectedness of human and non-human entities in shaping landscapes.

The deliberate planting of black locust trees to stabilise soil and the establishment of a vineyard on an engineered slope are examples of how human ingenuity can leverage natural processes for ecological restoration. This interaction aligns with Ahmann and Kenner's perspective on late industrialism, emphasising the potential for repurposing exhausted landscapes and infrastructures into sites of innovation. Furthermore, the black locust's role in nitrogen fixation and soil enrichment highlights the symbiotic relationships emphasised in more-than-human studies, where the agency of non-human entities is crucial in reshaping sociospatial relations. However, the trees also exemplify feral proliferations to which humans try to respond in order to harness their initial plans. The vineyard's reliance on human care, and the integration of red cattle for land management, underscore a multispecies approach

to landscape restoration, reflecting the interconnectedness and co-constitutive character of human and non-human actors.

The transformation of Geiseltal's topography due to lignite mining reveals enduring scars of industrial activities yet fosters unique ecosystems and habitats, attracting diverse species such as the bee-eater. This juxtaposition highlights the interconnectedness of ecosystems and the adaptive responses of life forms to anthropogenic changes. The bee-eater's flourishing in the post-mining landscape illustrates feral proliferation, where human-induced alterations create new opportunities for species to thrive in unconventional ways. The bee-eater is in the post-mining landscape *because* of, rather than *despite* it, being a presumably 'disturbed' landscape. The efforts of ornithologists to preserve critical breeding sites for the bee-eater reflect a commitment to fostering coexistence with more-than-human ecological processes, echoing Ahmann and Kenner's call to retrofit broken systems, though add a more-than-human perspective. By recognising and adapting to these unintended ecological outcomes, we gain insight into the intricate interplay between human activities and non-human life, gaining a deeper understanding of the dynamic character of ecological adaptation in post-mining landscapes. Taking care of the bee-eater in this particular environment means the constant involvement of humans to further 'disturb' the plants in order to keep the landscape open. If this part of the landscape would be left to 'natural succession', there would be too much vegetation at one point for the bee-eater to still live here.

Central to these narratives is the notion of a 'mode of attunement' (Ogden et al. 2013), which encompasses the ways in which humans and non-humans interact and adapt within shared environments. Rooted in multispecies ethnography, this concept emphasises the mutual awareness and responsiveness between humans and non-human species. It underscores the ethical dimensions of ecological restoration, advocating approaches that integrate ecological knowledge with empathetic engagement with non-human life. By developing a sensitivity to non-human agency and subjectivity, humans can foster coexistence with other species, thereby enriching the resilience and vitality of post-mining and other late industrial landscapes.

Ultimately, this ethnography epitomises how post-mining landscapes can be revitalised through collaborative efforts between human and non-human entities, offering a hopeful vision for reconciling ecological restoration with late industrial legacies. It stresses the need for nuanced approaches that recognise the dynamic interplay of human intentions and non-human agency in shaping landscapes amid environmental challenges. Simultaneously, post-mining landscapes highlight the necessity of materially renegotiating how we co-inhabit these spaces. The concept of an instrumentalised landscape, one that can be continually transformed, is a central aspect in which late industrialism sustains itself—through adaptation, revision, and renewal—while preserving its underlying structures (Ojani 2023: 228). However, this worldview of an instrumentalised landscape, made reusable, begins to show cracks and becomes an experimental field precisely because of the dependence on and the unruliness of non-human actors.

Although it might seem obvious that restoring landscape is a co-constitutive effort of non-humans and humans, this point is often overlooked in both the ecological restoration and post-mining landscape literature. In ecological restoration, projects are typically viewed as human-initiated and self-contained efforts. Conversely, in post-industrial landscape studies, biotic life is often perceived as 'wild' nature reclaiming or recolonising human debris

and ruins. My analysis demonstrates that while landscape restoration relies on non-human actions, humans frequently play a role in encouraging these actions, often even employing non-human actors for their interest. However, the non-human elements are dynamic, and do not always conform to the best-laid plans of the restorers, and prove themselves 'unruly' or 'lively', or simply thrive outside human intention (Van Dooren and Rose 2016). The exploration of human intentions to restore landscapes and their interaction with non-human activities prompts a reconsideration of agency and intentionality. Late industrialism possesses unfinished and consequential histories. As William Faulkner once wrote, "The past is never dead. It's not even past."

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