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Discussions and interventions

What on Earth is geodiversity?

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Abstract

The concept of geodiversity is gaining recognition in many scientific fields, as well as in practical applications such as conservation and tourism. Although the importance of geodiversity is now widely accepted, its precise definition, scope and broader applicability continue to be debated and discussed. In this paper, we explore the variety of viewpoints that relate to geodiversity and scrutinize the importance of geodiversity for different audiences. These viewpoints include definitions, assessment, research fields, terminology and its applications. To help explore and convey the different viewpoints and values commonly attributed to geodiversity, we invoke the Rokua UNESCO Global Geopark in Finland as a specific case study. Finally, we present potential future directions for geodiversity research, including key knowledge gaps, and highlight the vulnerability of geodiversity to increasing human pressures that threaten its integrity and long-term sustainability.

Keywords: *biodiversity, geodiversity, geology, geopark, nature*

Introduction

Have you encountered the term "geodiversity"? Although it may sound unfamiliar, it is gaining recognition in both scientific research and practical applications, with northern environments being among the actively studied regions. Much like biodiversity, geodiversity is a multifaceted concept that can be explored from various viewpoints, and which are linked to global change from many perspectives. While certain practices and interpretations of geodiversity have become widely accepted, the core concept and many areas of geodiversity research are still developing and evolving. Thus, for

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someone encountering the term "geodiversity" for the first time, it might be challenging to grasp its full scope.

In this article, we explore current discussions and interpretations of geodiversity, offering a contextual introduction to this important yet often overlooked concept. We scrutinize the definitions of geodiversity and the related debates and explore the different viewpoints from which geodiversity has been approached, as well as scrutinize the values that can be related to geodiversity by using Rokua UNESCO Global Geopark as an example. In addition, we write about the essence of geodiversity for science, practical applications, and for any one of us. Finally, we introduce important new discussions and directions related to how the concept of geodiversity might evolve in the future.

Defining geodiversity

The journey to a unified definition of geodiversity has not been straightforward and is still ongoing. According to Gray (2021), the concept began to take shape in the early 1990s, particularly in Tasmania, where scientists began drawing parallels between biological diversity and geomorphological diversity, and their interdependence. By 1992 and the Rio Convention on Biological Diversity, geoscientists introduced geodiversity as a concept deserving protection alongside biodiversity. Geoscientists advocated for its recognition as an equally significant phenomenon as biodiversity, with major implications for nature conservation (e.g., Dixon 1996; Sharples 1993: 7–8).

Today, it is commonly accepted that geodiversity is defined as the diversity of geological (rocks, mineral, fossils), pedological (soil), geomorphological (landforms, topography, physical processes) and hydrological features, including their assemblages, structures, systems and contributions to landscapes (Gray 2013; also Fig. 1). This definition highlights the complexity of Earth's non-living components, emphasizing both their intrinsic values and their contribution to broader natural systems.

Figure 1. Natural diversity consists of biological, geological, and climatic components. Geodiversity encompasses the abiotic features of the Earth's surface and subsurface, such as rocks, soils, hydrology, geomorphology, and topography. It can be studied on its own or in connection with biodiversity and/or climate. The distinct features of geodiversity are easily recognizable in northern, barren landscapes. Photo: Helena Tukiainen, in Kilpisjärvi, Finland.

Defining geodiversity has often taken a natural scientific perspective, focusing on physical features or taxonomic classifications (e.g., Hjort *et al.* 2024). However, as our understanding of nature continues to evolve, discussions increasingly emphasize the need for a more inclusive perspective. Traditionally, "nature" has been primarily associated with biodiversity and living components (e.g., see glossary in IPBES N.D.), but recent discourse highlights the need to expand this view. An IUCN issue paper by Sophie Justice and others (2025) recommends redefining nature as "*encompassing both the non-living components (i.e., geodiversity) and the living components (i.e., biodiversity) of the natural world*" (Justice *et al.* 2025). This shift reinforces the importance of geodiversity in conservation and management, further highlighting its intrinsic connection to broader natural systems.

While geodiversity is generally described as the diversity of non-living nature, its interpretation can vary across different cultural and philosophical contexts. In many Indigenous cultures and religions—broadly labeled "Animistic"—geological features are perceived as active, living entities with spiritual significance and deep cultural meaning (Gray 2019; Verschuuren *et al.* 2021). This highlights the cultural and spiritual values associated with geodiversity, challenging the notion of "non-living" nature in certain contexts.

From a broad, multidisciplinary perspective, Karjalainen (1986) defined geodiversity as the spatial diversity of the Earth, including both physical (or factual) diversity and the diversity of one's lived experience. This definition suggests almost a conceptual parallel between geography and geodiversity. As Karjalainen (1986, p. 22) states, *"geography is the orderly knowledge of the Earth's diversity as the world of humans"*, which renders geodiversity an intriguing paradigm within geographical studies (see also Claudino-Sales 2021). The field of geography, with its inherently interdisciplinary approach, provides a natural platform for exploring geodiversity from diverse perspectives beyond its current popularity in natural sciences.

A new paradigm in development?

Despite the progress in defining the term geodiversity, some key debates remain. One ongoing discussion centers on whether geodiversity should be regarded as a broad, multi-scale concept analogous to biodiversity (e.g., Gray & Gordon 2020), or if it should be applied more strictly in regional or local contexts (e.g., Brocx & Semeniuk 2019, 2020). The former emphasizes the intrinsic value of geodiversity, including its various contributions to nature and humans, of which underpinning biodiversity is just one example. In the latter context, the value of geodiversity is primarily recognized through its key role in supporting, and interdependence upon, biodiversity.

Another ongoing debate centers on whether, and to what extent, climate should be included in the definition of geodiversity (e.g., Bailey *et al.* 2024; Parks & Mulligan 2010; Zarnetske *et al.* 2019). Even professor Murray Gray, whose definition of geodiversity in his book "Geodiversity" (Gray 2013) is widely acknowledged, has recently proposed expanding the concept to include atmospheric components (Gray 2025). This discussion often arises from the common description of geodiversity as the "non-living" or "abiotic" diversity of nature, which can include both climate and geological, geomorphological or hydrological features. Furthermore, climate, as well as geology, are crucial aspects of environmental heterogeneity, which is a roof concept for

variables that can be used in explaining species diversity patterns in ecological research (Stein, Gerstner & Kreft 2014).

While climate is undoubtedly part of abiotic nature and closely linked to geodiversity, just as it is to biodiversity, treating climate as part of geodiversity could potentially undermine the distinct value and application of both entities. Climate science is a well-established field with its own goals, methods, and applications. Keeping climate and geodiversity separate may, therefore, be more beneficial for advancing the agendas of both fields and for ensuring clarity in research and practical applications (see also Maliniemi *et al.* 2024). However, this separation does not preclude the study of how climate and geodiversity intersect and interact (Fig. 1).

In general, the development of geodiversity concept and geodiversity research illustrates the essence of scientific progress, where ideas emerge and evolve simultaneously across different regions, disciplines, and purposes. In this way, geodiversity research reflects the "paradigm" approach in modern science, where multiple discussions and competing perspectives eventually converge into a dominant paradigm, a common and coherent set of ideas about the world (Gray 2021, 2024; Inkpen 2005). As such, geodiversity is not exclusively a scientific concept but also represents the dynamic and iterative nature of scientific progress and the myriad ways science aims to understand physical reality.

Multidisciplinary concept

Although the concept of geodiversity has evolved during the last three decades, the idea of including a holistic perspective on abiotic nature in environmental research is not new. Over 200 years ago, Alexander von Humboldt (1769–1859) explored the connections between non-living and living nature from an interdisciplinary, interconnected perspective. Von Humboldt's research was grounded in a holistic approach, relying on systematic empirical observation, and as such, he is often regarded as the father of multiple "geo-" disciplines, such as environmental science, earth system science, modern geography and geosciences (Schrodt *et al.* 2019).

Humboldt's holistic view of nature has faded over time as science has become fragmented into specialized disciplines. However, his approach has resurfaced in fields like biogeography. For instance, Schrodt *et al.* (2019; in a theme issue in Journal of Biogeography dedicated to von Humboldt) highlight the importance of "Humboldtian" thinking in addressing current global challenges, and how studying the links between geodiversity and biodiversity can specifically contribute to this need. Here, knowledge across various disciplines and research fields is essential for exploring geodiversity from diverse viewpoints, including those from both the humanities and natural sciences (Fig. 2).

Today, geodiversity is studied across a broad range of disciplines, each bringing their unique perspectives and terminologies. Major research fields include, for instance, geology, environmental science ecology, geography, science and technology[1], physical geography, paleontology, biodiversity conservation, and water resources (based on Web of Science 7.10.2024, search word "geodiversity"; Fig. 2). Although much of this research

[1] In the field of telecommunications and computer sciences, "geodiversity" is used to describe geographical diversity of networks (i.e., it does not relate to diversity in nature).

is grounded in the natural sciences, a large portion is published in multidisciplinary geoscience journals, such as *Geoheritage*, highlighting the cross-disciplinary appeal of geodiversity.

Each research field (Fig. 2) emphasizes different aspects of geodiversity. In multidisciplinary geosciences, research often focuses on geoconservation (e.g., Brilha 2016), geoheritage (e.g., Németh *et al.* 2021) and geotourism (e.g., Dowling 2011), highlighting the value of geodiversity, geological features, geosites, and landscapes for their historical, conservation, and educational significance. In ecology, studies usually examine how geodiversity shapes ecosystems and is related to its biotic counterpart, biodiversity (e.g., Salminen *et al.* 2023 in northern tundra environments). Geographic research often centers on spatial and temporal assessments of geodiversity, including producing maps of geodiversity at various scales (e.g., Toivanen *et al.* 2024). It also contributes to system-level research, including aspects from geodiversity, biodiversity and climate change (e.g., Brazier *et al.* 2012).

In the diverse collection of research fields, geodiversity is further conceptualized with a multiplicity of terminology. Going through geodiversity literature, you will encounter a set of terms beginning with "geo" (Fig. 2). Some terms, such as "geoheritage" and "geoconservation," have become well-established. These terms emphasize the protection and preservation of significant geological features, sites and landscapes, an effort supported by organizations like International Association for the Conservation of Geological Heritage (ProGEO), which has promoted geoheritage

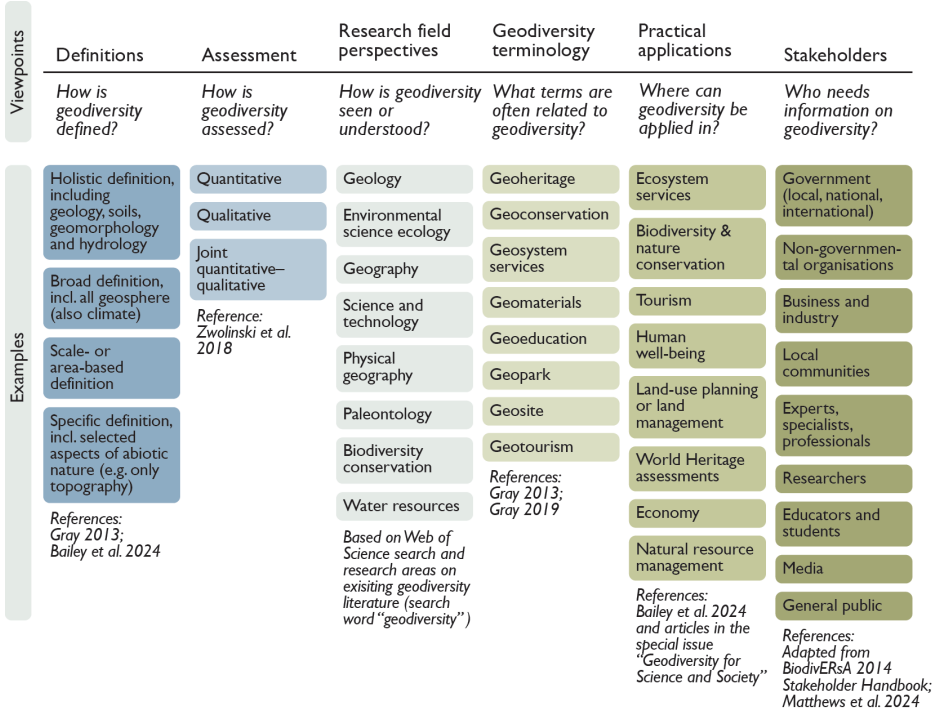

Figure 2. A collection of viewpoints in geodiversity research and applications which contribute to the diverse interpretations of geodiversity.

and geoconservation since 1993. For instance, the international *Geoheritage* journal was founded in 2009 by ProGEO (currently published by Springer), and the IUCN Guidelines for Geoconservation were published in 2020 (Crofts *et al.* 2020). Emerging terms like "geosystem services" represent newer interdisciplinary approaches still under active discussion (e.g., debate between Chen *et al.* 2023 and Gray *et al.* 2024). These and many other terms, such as "geoeducation" or "geomaterials", essentially emphasize the geodiversity related contributions, which are often overlooked in the context of nature's contributions to people.

Beyond purely scientific perspective, which can be dense with terminology, geodiversity also intersects with literary traditions. For instance, "geopoetics" blends geography, poetry, and human experience, originally emerging as a response to more analytical geographic approaches (White N.D.). The complex connections between language, human experience, and nature also span popular literature, from Aleksis Kivi (1834–1872), Finland's first professional writer, whose works infused landscapes with symbolic and emotional meanings (Turunen 2018), to contemporary authors, such as Anni Kytömäki, who vividly portrays Finland's diverse terrain in her novels, such as in the year 2020 Finlandia prize winner *Margarita*. Whether through research or storytelling, the way we speak about nature shapes how we see and protect it. As British writer Robert Macfarlane argues in his book Landmarks (2015): our ability to perceive and value nature and landscapes is deeply connected to the words we use to describe it.

While the diversity of perspectives enriches the study of geodiversity, it also presents challenges. The multiplicity of approaches can make it difficult to establish a unified definition of geodiversity on which can be agreed upon. On the one hand, this diversity allows for a more nuanced understanding of geodiversity's roles and values. On the other hand, the variety of interpretations and applications can diminish the concept's impact, making it harder to communicate its significance to varying audiences. Achieving a balance between contrasting perspectives and a coherent, shared understanding of geodiversity will be crucial for advancing both research and practical efforts.

Assessing geodiversity

Measuring geodiversity is essential in understanding the spatial and temporal patterns of geodiversity, tracking environmental changes and in guiding nature conservation efforts. How to assess geodiversity is an active topic of debate among researchers and practitioners across various fields and there are two primary approaches: quantitative and qualitative (Zwoliński *et al.* 2018; Fig. 2).

Quantitative assessments involve numerical methods to evaluate geodiversity across different areas. These assessments often rely on digital spatial data and geographic information systems (GIS), such as geological maps. In some cases, particularly at the local scale, geodiversity data can be gathered directly through fieldwork (e.g., Hjort *et al.* 2022). The results of these efforts are typically expressed as geodiversity indices or maps, with some datasets being made openly accessible (see e.g., European geodiversity data by Toivanen *et al.* 2024). However, despite technological and methodological advances, quantitative geodiversity datasets are still largely lacking and scattered (see also discussion in Schrodt *et al.* 2024).

Qualitative geodiversity assessments draw on expert classifications, descriptive documentation, or methods that emphasize the values and benefits associated with

geodiversity. These assessments use various data sources, such as photographs, literature, or expert evaluations (Zwoliński *et al.* 2018). They can also explore more subjective elements, such as how people experience and perceive landscapes and their abiotic components. Such approach can also link geodiversity to broader contexts like human and planetary health (e.g., Alahuhta *et al.* 2022).

Quantitative geodiversity assessments are conducted and developed actively in northern environments. For instance, geodiversity of Finnish Lapland in northern Europe has been explored across many perspectives, from local (e.g., Salminen *et al.* 2023, based on field data from study circles of 5 m radius) to landscape scales (e.g., Hjort & Luoto 2010, based on field data and aerial photographs in a grid of 500 × 500 m cell size). Northern environments and specifically, their inherent wealth of geodiversity are also the focus and inspiration for our own geodiversity-themed PhD theses (Toivanen 2024; Tukiainen 2019).

Quantitative geodiversity measures have faced criticism for lacking a clear purpose or being too generalized, as they may overlook certain qualitative aspects of geodiversity, such as unique cultural, conservational, or aesthetic values (Gray 2021). Qualitative assessments, in turn, are considered to be more nuanced and context specific. On the downside, qualitative data collection is often more labor-intensive and time-consuming. Given the strengths and weaknesses of both quantitative and qualitative methods, the most comprehensive approach could be to integrate both perspectives (Zwoliński *et al.* 2018; Fig. 2). This would allow for a more complete and balanced understanding of geodiversity, capturing both its measurable properties and its broader, sometimes intangible, values. These values range from intrinsic to aesthetic, economic, functional and scientific values (Gray 2005; Hjort *et al.* 2015; see Box 1 where the values of Rokua UNESCO Global Geopark are explored in detail).

Essential geodiversity

Geodiversity is an essential yet often overlooked aspect of the natural world, playing a critical role in shaping landscapes, supporting ecosystems, and fostering human well-being. It forms the physical framework of natural environments and healthy ecosystems, but also influences human culture, identity, and our connections to nature. From mountains and rivers to caves and coastlines, geodiversity represents many things we depend on, from material resources to profound cultural and spiritual value (see also Box 1). Recognized in global initiatives, such as UNESCO Global Geoparks, Natural World Heritage Sites, and International Geodiversity Day by UNESCO, geodiversity emphasizes Earth's historical, aesthetic, and ecological complexity (IUCN 2024).

In everyday discussions, geodiversity is easily reduced to mere natural resources as we are accustomed to viewing minerals, sand, and other geological materials primarily in terms of their practical use, for example as building materials or parts of the electronic devices that we use daily. Sand, for example, is a key component of concrete, glass, and even modern technology, yet it is increasingly becoming a scarce resource due to overexploitation (Finite sand resource needs better governance 2024). Similarly, materials like lithium—critical for renewable energy technologies such as batteries for electric vehicles—highlight the tension between economic demands and sustainable management of geodiversity (Rentier *et al.* 2024).

Box 1. Case study: Unpacking geodiversity values at Rokua UNESCO Global Geopark

Geoparks are designated areas where geodiversity is actively studied, managed, and valued. This case study explores the diverse values of geodiversity through the example of Rokua UNESCO Global Geopark in Finland (Fig. B1.1), illustrating how geodiversity shapes landscapes, ecosystems, and human history. By examining the geological, biological, and cultural heritage of Rokua—all in the heart of the geopark concept—we can gain deeper understanding of the multifaceted significance and presence of geodiversity in practice. More specific examples of 30 different geodiversity-related values are given in Table B1.1. They are adapted and developed from the frameworks presented by Gray (2005) and Hjort *et al.* (2015).

Geological heritage. Rokua Geopark is home to some of the oldest bedrock in Europe, including gneisses that date back 2.9 billion years. The post-glacial landscape features regionally unique assemblage of geofeatures such as eskers, kettle holes, and sand dunes. In addition, the sedimentary rocks of the Muhos formation, which were once part of a shallow sea and river delta, contain fossils of primitive unicellular organisms, offering a glimpse into the history of life on Earth and the development of ecosystems (Huttunen *et al.* 2012). Different water elements are an important part of the landscapes of the geopark, including rapids, rivers and lakes of different sizes.

Figure B1.1. Rokua UNESCO Global Geopark, one of the northernmost geoparks in the world, is located in Finland, in northern Europe. Rokua National Park is located within the geopark area and is characterized by lichen-covered pine forests and lakes. Background maps are from the National Land Survey of Finland (topographic map) and Natural Earth (grey background map). Photo: Helena Tukiainen.

Table B1.1. Values of geodiversity with examples from Rokua UNESCO Global Geopark. Values are adapted from Gray (2005) and Hjort *et al.* (2015).

Value		**Examples**
Intrinsic value	Intrinsic value	biotic nature free of human valuations
Cultural value	Archaeological/Historical	Early settlement comb ceramics; Stone Age settlements; peasant culture in *Lamminaho House*; museums
	Folklore	Folktales in national epoch *Kalevala* from the village of Ahmas
	Spiritual	Old wooden churches from 16th and 17th centuries
	Sense of place	Local livelihoods and traditions (e.g., tar burning); *The Birch and the Star* tale by Zachris Topelius
Aesthetic value	Local landscapes	Post-glacial landscape features; dune landscapes; river valleys and channels; aapa mires; Lake Oulujärvi
	(Geo)tourism	Rokua National Park; nature attractions; cultural attractions
	Leisure activities	Trail network (e.g., *Tar route hiking trail*); foraging; fishing; canoeing; skiing; wellness
	Remote appreciation	Virtual reality experience initiative (*Aikamatka*); "story database" initiative (*Kiehtovat tarinat Rokua Geopark -alueen vetovoimatekijöiksi*)
	Voluntary activities	Dune habitat restoration in the national park
	Artistic inspiration	"An expedition into art" initiative (*Löytöretki taiteeseen*); *Kassu Halonen Art House*
Economic value[1]	Business support and collaboration	*Humanpolis Oy* (Geopark operations for residents, businesses and tourists); Geopark entrepreneurship; *Smart and Transformative Oulu Region* initiative
	(Geo)tourism, recreation and health	Geotourism as a tool for developing nature-based tourism (e.g., *Geoparks – attractive sustainable travel destinations* initiative); wellness (e.g., *Rokua Health & Spa*); outdoor activities (e.g., equipment rental)
	Cultural and heritage branding	*Rokua Skincare*; Local hand-made jewellery
	Energy	Hydropower (now also preserved as cultural history sites)
	Soil	Food production (e.g., GEOfood initiative)
Functional value	Platforms	Waterways as historical travel and trade routes
	Storage and recycling	Groundwater; peatlands as carbon sinks
	Health	Outdoors and variable landscape promotes physical and mental human health
	Burial	Graveyards
	Pollution control	Soil and rock as water filters
	Water chemistry	Drinking water
	Soil functions	Agriculture; forestry; water filtration
	Geosystem functions	Groundwater and surface water processes; flood regulation; carbon fixation
	Ecosystem functions	Habitat provision; supporting biodiversity

Value		Examples
Scientific value	Knowledge of Earth history, materials, and processes	*Kilonniemi* gneiss outcrop; *Luokkiniemi* diabase vein; *Pyhäkoski* granite cliffs; *Kieksi* conglomerate outcrop
	Fossils	Fossils in the *Muhos formation*
	Geoscience research	Post-glacial landscape and processes; groundwater processes; geodiversity
	Environmental monitoring	Microclimate; groundwater
	Education and training	Geopark as a "living textbook"; local Geopark schools; camp schools and excursions; research collaboration; GEOclimGOME-PRO initiative

[1]Traditionally, the economic values of geodiversity have been associated with its role as a resource (e.g., for energy or mineral extraction) (Gray 2005), but geodiversity also provides resources and assets for other aspects of economic development, such as tourism (Hjort *et al.* 2015).

Biological heritage. The diverse landscapes of Rokua support a range of distinct habitats, from lichen-covered pine forests to aapa mires and lush groves in the river valleys. For example, in Rokua National Park, which is located inside the geopark, sandy soils and hydrology influence vegetation patterns, creating specialized microenvironments (e.g., sunny and dry esker habitats) that sustain rare and endangered species (e.g., *Thymus serpyllum* subsp. *serpyllum* and insects feeding on them, such as *Pyrausta cingulata*) (Maliniemi *et al.* 2023).

Cultural heritage. Human interaction with Rokua Geopark's landscapes dates back to the Stone Age, as evidenced by early settlement sites and comb ceramics, among the oldest in Finland (Huttunen *et al.* 2012). The region's waterways historically served as trade and travel routes, shaping local livelihoods such as fishing, farming, tar production and forestry. Folklore inspired by the region's natural heritage in the village of Ahmas is reflected in folktales such as the Finnish national epoch *Kalevala*. Today, environmental art and different educational activities are one way of reaching people living, and visiting, in the geopark area (Fig. B1.2).

Figure B1.2. Geoparks highlight the many values of geodiversity, including artistic inspiration and educational activities. The image on the left features an environmental art project on a bridge crossing the Muhosjoki River, showcasing silver-barred sable (*Pyrausta cingulata*). The image on the right shows university students exploring the delicate nature of Rokua National Park during a physical geography field course. Photos: Helena Tukiainen (left) and Maija Toivanen (right).

Beyond natural resource management, geodiversity is integral in many other applications (Fig. 2). Ecosystems are shaped by their physical environment, and without protecting the geological and geomorphological features that sustain them, nature conservation efforts may be incomplete. Conservation has traditionally focused on biodiversity, but there is growing awareness of geodiversity's foundational role in these efforts (e.g., Gordon *et al.* 2022). Recent initiatives, such as the IUCN's guidelines for geoconservation (Crofts *et al.* 2020), the introduction of International Union of Geological Sciences (IUGS) Geological Heritage Sites since 2022, and the introduction of Essential Geodiversity Variables framework (Schrodt *et al.* 2019, 2024) are examples of integrating geodiversity into conservation applications. This evolving perspective has led to calls for a more inclusive definition of "nature" that fully acknowledges geodiversity's role in conservation applications, alongside biodiversity (Justice *et al.* 2025).

Beautiful landscapes and conservation areas, with unique geological features like mountain ranges, canyons, and coastlines, attract tourists. Destinations such as UNESCO Global Geoparks emphasize geodiversity by identifying sites of global geological significance, fostering conservation, and promoting sustainable tourism. These sites preserve unique geology and contribute to local economies and environmental education, showcasing the broad impact of geodiversity. However, the cultural and aesthetic value of geodiversity extends beyond tourism, inspiring art, literature, and a deeper human appreciation of the Earth's landscapes and physical properties. For instance, the concept of "national landscapes" (such as the landscape from Koli, Finland, in Fig. 3), demonstrates how geodiversity can also shape national identity and cultural heritage.

Figure 3. National landscape of Finland from the highest peaks of Koli to lake Pielinen. Painting by Eero Järnefelt (1923). Picture is retrieved from the Finnish National Gallery / Yehia Eweis under CC0 licence (https://www.kansallisgalleria.fi/fi/object/506760).

Future discussions

In this paper, we have explored a variety of current geodiversity discussions that essentially present it as a highly diverse concept with multiple interpretations, depending on the viewpoint of how it is approached or utilized (Fig. 2). There are ongoing discussions related to the terminology, assessment and application of geodiversity, but from whatever viewpoint, it represents an invaluable component of our planet's natural diversity, and an essential provision to its inhabitants. In the future, there are multiple aspects of geodiversity that can be acknowledged and developed by researchers, practitioners and by all in our everyday lives—from admiring and conserving beautiful scenery to using natural resources in a sustainable way. Researchers will be tasked with geodiversity knowledge production across many research fields and from different perspectives. For example, in the face of global land-use change from natural to human-impacted environments, it is increasingly important to study urban or man-made geodiversity (see e.g., Del Monte *et al.* 2016; Wolniewicz 2022). Many questions also remain under the topical theme of sustainability and its links to geodiversity (see e.g., Gray 2024; Matthews *et al.* 2024).

In turn, a wide range of stakeholders can benefit from improved access to, and knowledge of geodiversity (Fig. 2). For example, government bodies for policy-making, NGOs for conservation advocacy, and businesses for guiding sustainability strategies (e.g., Nokia 2023). Geodiversity information will be used by experts and professionals in regional planning, such as environmental impact assessment procedures (e.g., Sitowise 2024), while local communities could use knowledge on geodiversity to enhance their cultural identity and economic opportunities in such areas as tourism. Educators and students can play key roles in fostering environmental awareness across the greater public, with media serving as an essential link between different stakeholders.

In the face of global, human-induced environmental change, such as climate warming and growing natural resource extraction, information on geodiversity is essential. While biodiversity and climate are routinely included in international conventions, geodiversity is often overlooked, resulting in poor policy and management decisions regarding surface and subsurface features and resources (Bailey *et al.* 2024). The acknowledgement of geodiversity is especially timely in vulnerable northern areas, where for example, Arctic warming over the past decades has been almost four times larger than the global mean (van Oort, Lund & Brisebois 2022). As a consequence, it is predicted that unique landforms called palsas (peat hummocks with permafrost cores, found in regions of sporadic and discontinuous permafrost) will face dramatic or even complete loss during the next 60 years in the Northern Hemisphere (Leppiniemi *et al.* 2024).

Knowledge and appreciation towards geodiversity can broaden our perspectives towards reshaping our understanding of nature into a holistic, "Humboldtian" view by which to approach the Earth's natural heterogeneity (Schrodt *et al.* 2019). As Gray (2008, 2021) suggests, geodiversity is a multi-faceted and evolving paradigm that fundamentally shapes our understanding of Earth's diversity. By engaging with geodiversity—whether through scientific study, exploration of natural sites, or artistic expression—we can foster a greater appreciation for the diverse physical "stage" upon which life unfolds.

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