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Evaluation of Paleontological Heritage Sites in Türkiye: Scale Design

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Abstract

Natural and cultural heritage sites are protected according to international and national laws. As of 2024, according to the lists of the Ministry of Culture, there are 624 sites where archaeological and paleontological excavations and similar studies are being conducted in Türkiye. These all form parts of the nation's heritage, including paleontological, geological, and archaeological heritage elements. Here, we emphasize the importance of revealing the heritage values of these areas within the context of their historical development, distribution, and relationship with the environment. We present an applied model using a scale to determine heritage value, focusing on three main dimensions—scientific, educational, and tourism—based on literature, expert opinions, and preliminary applications. For each main dimension, 48 items with four different ratings were prepared. The validity and reliability studies of the scale have been completed and are presented in the appendix of this publication.

Keywords: Geoheritage; Geotourism; Natural heritage; Paleontological heritage; Scale development; UNESCO World Heritage; Türkiye

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Introduction

The activities of humanity in the last 10,000 years are remarkable in terms of speed and variety. Last century, initiatives began to protect the environment, nature, and natural elements, and to shape human activities accordingly. The devastation, irreversible losses, and environmental degradation caused by the Industrial Revolution and the subsequent two World Wars have made it imperative to take more concrete steps. The International Union for Conservation of the Nature (IUCN) was established in 1948, and studies on endangered species began in 1964, followed by the "UNESCO International Convention for the Protection of the Cultural and Natural Heritage" in 1972. In 1991, the "Digne Declaration" was signed by representatives from 30 countries; this 13-point declaration not only addresses the protection of living species but also the conservation of geological areas in their natural habitats. Key developments on this topic can be found in Table 1.

In Türkiye, the Geological Heritage Protection Association (JEMİRKO) was established in 2000, and thanks to its efforts, 28 geological heritage sites have been identified. The Turkish Geosite Framework List (GFLT; JEMIRKO 2025) comprises 85 entries in ten categories (A–J). In addition, Türkiye became a party to the World Heritage Convention in 1983, and nine sites, including a geoheritage area, have been included in the World Cultural Heritage List (Somuncu & Yiğit 2010, p. 6). Furthermore, Kula (Afyon) is the first and only UNESCO Global Geopark in Türkiye, recognized by UNESCO in 2013, and other places have applied for this status (Cengiz et al. 2021, p. 3).

The goal is not only to protect the Earth's biodiversity, but also to generate scientific knowledge from these resources, share the beauty of these landscapes, and pass them on to future generations. The first step in ensuring protection and sustainability is identification, to determine the characteristics of the places to be protected. Some fundamental concepts can be listed as natural heritage, natural diversity, geological diversity, geosite, geoheritage, and geoconservation (Kazancı, Şaroğlu and Suludere 2015; Brilha 2016; Turoğlu 2025, p. 6; UNESCO World Heritage Convention, n.d.). Since the definition of these fundamental concepts has been carried out by organizations outside the scientific field, such as UNESCO, and has become the subject of agreements between countries and gained a legal basis, the concepts and their hierarchical order must be considered to create a theoretical framework.

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Concepts and Hierarchical Order

In numerous languages, the term "inheritance" means[1] “that which is transmitted to subsequent generations” or "things passed down to the next generation." This idea may be applied to cultural and natural heritage, referring to both human-made elements and components of the natural environment.

The identification and protection of World Heritage sites are carried out under the umbrella of the United Nations Educational, Scientific and Cultural Organization (UNESCO), which was established within the United Nations in 1945. The history of these activities began in 1959 with requests for protection of certain archaeological sites in Egypt and Sudan[2]. UNESCO carries out registration, protection and restoration activities according to its published definition of cultural and natural heritage. UNESCO's definition of natural heritage is considered important because it is developed through global collaborations and partnerships and used in decision-making mechanisms. Accordingly:

> *“Natural heritage is defined as: natural features consisting of physical and biological formations or groups of such formations, which are of Outstanding Universal Value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of Outstanding Universal Value from the point of view of science or conservation; natural sites or precisely delineated natural areas of Outstanding Universal Value from the point of view of science, conservation or natural beauty (UNESCO, n.d.).”*

The definition states that for an area to qualify as a natural heritage site, it must possess "outstanding universal value." Since it is necessary to explain what this value is and to establish criteria that will make it measurable, ten criteria have been listed. The first six of these relate to cultural heritage, while the seventh and subsequent criteria cover natural heritage. These are as follows:

[1] Dictionary.com. Heritage. https://www.dictionary.com/browse/heritage; ΛΟΓΕΙΟΝ. Heritagium. https://logeion.uchicago.edu/%CE%BB%CF%8C%CE%B3%CE%BF%CF%82; Nişanyan.Miras. https://www.nisanyansozluk.com/kelime/miras; Kubbealtı. Miras. https://lugatim.com/s/miras

[2] The Convention Concerning the Protection of the World Cultural and Natural Heritage; Turkey's accession to this Convention was deemed appropriate by Law No. 2658 dated 14.04.1982, ratified by the Council of Ministers Decision No. 8/4788 dated 23.05.1982, and published in the Official Gazette No. 17959 dated 14.02.1983.

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"7. To include areas with outstanding natural phenomena or areas of outstanding natural beauty and aesthetic importance;

8. To have outstanding examples that represent key stages in world history, including life record, significant ongoing geological processes in the development of landforms or significant geomorphic or physiographic features.

9. To possess outstanding examples of ongoing ecological and biological processes and development in plant and animal communities across terrestrial, freshwater, coastal, and marine ecosystems.

10. To include the most important and noteworthy natural habitats for the in-situ conservation of biodiversity, containing species of outstanding universal scientific value and those at risk of extinction (UNESCO, n.d.).

Meeting at least one of these criteria has been deemed necessary to qualify for outstanding universal value. All these explanations and criteria allow for a registration procedure to be carried out to ensure the protection and sustainability of areas defined as natural heritage.

Another dimension of the issue is the international agreements that are binding on countries. The Convention Concerning the Protection of the World Cultural and Natural Heritage[3], adopted by 195 countries by 2025, has been a guiding document as it addresses the issues of definition and establishing criteria. According to the convention to which Türkiye is also a party, natural heritage is defined as follows:

"Natural monuments consisting of physical and biological formations or groups of such formations that have exceptional universal value from an aesthetic or scientific point of view; geological and physiographic formations of exceptional universal value from a scientific or conservation point of view, and precisely designated areas where endangered animal and plant species live; natural sites or precisely designated natural areas of exceptional universal value from a scientific, conservation or natural beauty point of view (Ministry of Culture, n.d.)."

The aforementioned agreement imposes primary responsibilities on signatory countries regarding heritage sites within the scope of its definitions.

[3] The Convention Concerning the Protection of the World Cultural and Natural Heritage was approved for accession by Türkiye through Law No. 2658 dated 14 April 1982. It was subsequently ratified by the Council of Ministers' Decision No. 8/4788 dated 23 May 1982 and published in the Official Gazette No. 17959 on 14 February 1983. The above legislative and ratification details were obtained from the UNESCO website (UNESCO World Heritage Convention, last updated 2025).

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> "*Article 4. Each State party to this Convention recognizes that it has as its primary responsibility the identification, protection, preservation, exhibition and transmission to future generations of the cultural and natural heritage referred to in Articles 1 and 2, which lies within its territory. To this end, it will do everything in its power to utilize its resources to the fullest extent and, where appropriate, to provide all kinds of international assistance and cooperation, especially in financial, artistic, scientific and technical fields (Ministry of Culture, n.d.).*"

The definitions of "heritage" and "natural heritage" have highlighted the qualities of diversity, rarity, and exceptionality in the determination of natural heritage. These may be determined through reference to science. Different scientific disciplines approach the topic of natural heritage from different perspectives, including geomorphology (landforms), petrography (rocks), mineralogy (minerals), paleontology(fossils), stratigraphy (sedimentary sequences), tectonics/structural geology (folds, faults, etc.), hydrology and hydrogeology (water), biology (plants and animals), climatology and meteorology (weather phenomena and climate), and pedology (soils). Scientific research can document these phenomena, and any geosite is generally defined as a rock, mineral, fossil assemblage, structure, stratum, landform, or land mass representing any current or past geological process, event, or feature (Kazancı 2012, p. 1; Brilha 2016, p. 120; JEMİRKO 2025). Areas scientifically identified as geosites are then subject to a series of institutionally defined assessment procedures to determine their status as natural heritage. In this case, scientific findings play a guiding role in determining natural heritage, and we include these in the current research.

Since biodiversity and heritage issues are constantly evolving and dynamic, new concepts are frequently introduced into the field. For example, fields such as "cultural geology", "cultural biology" and "cultural taxonomy" have recently been defined, and it has been shown how these fields can contribute to nature conservation by examining the cultural impacts of geological and biological elements (Caetano & Ponciano 2021). In addition, the concept of intangible geological heritage has been considered important for developing a more holistic approach to the conservation of culturally significant geodiversity elements. Cultural representations of geological features can be used as tools to increase public interest in geodiversity and to provide scientific information. Further, efforts to protect geological heritage may develop innovative strategies and ensure more active public participation in

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nature conservation processes. The use of Ordovician ichnofossils (such as *Cruziana* and *Skolithos*) from the Monsagro region (Salamanca, Spain) as decorative elements in local architecture, in addition to their scientific, educational, and touristic value, has given rise to a new field of research. The concept of ethnopaleontology, which arises from the fusion of paleontological elements with culture, reflects the interaction between the natural environment and humans (Simón-Porcar et al. 2020). A study of Upper Cretaceous fossils from southeastern Anatolia emphasized their identification and evaluation in terms of geoheritage, geoconservation, and geotourism (Özer & Mülayim 2022). For fossil sites, geoheritage is associated with the topics of geoconservation, geotourism, and geoeducation, which also encompass sustainability, development, and local values in a broader context (Cengiz et al. 2021; Özer & Mülayim 2022; Turoğlu, 2025).

The conceptual framework employed in this study is grounded in the established scientific literature. However, it is widely acknowledged that Western science and Indigenous knowledge systems represent distinct epistemological traditions. In particular, knowledge systems rooted in local histories, oral narratives, and place-based experiences constitute alternative modes of knowledge production that should not be disregarded. Recognizing these epistemological differences adds necessary analytical depth, especially when addressing the concept of heritage.

The relationship individuals and communities establish with the places they inhabit fundamentally shapes how knowledge about those places is produced, transmitted, and interpreted. The locally generated knowledge emerging from such relationships cannot be directly equated with modern scientific disciplines such as botany, physics, or soil science, as they are grounded in different ontological and methodological premises. Some scholars conceptualize this distinction explicitly as that between “Western science” and “Indigenous science” (Black Elk 2016, p. 4). While this epistemological debate does not constitute the primary focus of the present study, it must be acknowledged.

Knowledge that becomes embedded within cultural practice and is transformed into artistic expression or material production acquires its own internal structure and symbolic logic. Understanding such productions requires interpretive engagement with the human–environment relationship and the socio-cultural meanings attributed to place.

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Accordingly, in discussing the scale development process, the human–fossil relationship is addressed as a meaningful component of paleontological heritage.

The Human–Fossil Relationship in the Context of Culture and History

In constructing the conceptual foundation of this study, international conventions, legal regulations, and institutional definitions were adopted initially to provide a structured and standardized framework. Nevertheless, it should be acknowledged that the presentation of heritage through institutional categorizations and classifications—such as those developed by IUCN or UNESCO—largely reflects a Eurocentric perspective. Heritage should also be evaluated within broader and more multidimensional approaches. Even elements classified under traditional UNESCO terminology as "natural heritage" acquire the status of heritage only through processes of human interpretation and value attribution; therefore, they cannot be considered entirely independent of cultural processes.

Historically, the concept of heritage has its roots in a legal framework referring to "the transfer of rights from one generation to another." In this sense, heritage inherently involves processes of belonging and meaning making. Accordingly, the heritage value of a place encompasses both tangible and intangible dimensions, including cultural, sociological, and psychological aspects. Whether a parcel of land or a folk song, what fundamentally characterizes an element as heritage is its transmissibility and its socially constructed meaning. Within this conceptualization, the question arises: where do fossils stand?

Communities living in fossil-bearing landscapes have engaged—albeit in culturally specific ways—with fossils since ancient times. For example, fossil discoveries in North America beginning in 1739 were facilitated by Indigenous communities who guided French soldiers in the region. The meanings attributed to fossils by French settlers and Native American communities were undoubtedly different. Although the available data transmitted through Indigenous narratives are limited, Mayor (2013, p. 26) emphasizes the existence of cultural connections between Indigenous communities and fossils. Earlier, Kindle (1935, p. 449) noted that fossils were regarded by Native American groups as protective against malevolent spirits and as sources of healing. Other studies suggest that human engagement with fossils predates the establishment of modern scientific frameworks. For example, in northeastern Brazil, local

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Indigenous groups recognized fossils through rock art representations, integrating this familiarity into cultural expression through various depictions (Troiano 2024, p. 5).

Beyond their geological character, fossils may become heritage elements imbued with meaning through their association with the beliefs, oral traditions, and everyday practices of communities inhabiting fossil-bearing landscapes. These relationships may manifest across a wide spectrum—from religious interpretations and oral narratives to healing practices, celebratory traditions, or mourning rituals. Fossils have, for instance, been interpreted in some contexts as "the footprint of the devil" and in others as the trace of a benevolent healing being, reflecting processes of cultural transmission and reinterpretation. Certain ancient myths in North America and Europe may have been inspired by fossil discoveries (Mayor 2000; Mayor & Sarjeant 2001). Similar conclusions have been drawn from analyses of Aboriginal rock art in Australia, which demonstrate that some depictions cannot be explained solely by reference to contemporary environmental features (Basedow 1914, p. 210).

Based on the information provided so far, the conceptual framework and hierarchical structure are as shown in Figure 1. In the figure, other subgroups of the concepts of Cultural Heritage and Natural Heritage are not shown to avoid confusion.

Key Axes of Paleontological Heritage

Paleontological heritage is the entirety of natural resources that provide information about the evolution of life, biodiversity, ecosystems, and climatic conditions from the past to the present, and that possess scientific, educational, and aesthetic value. This inheritance may be in situ or transferred (ex situ). Its most notable aspects are that it is a non-renewable, or non-recycled resource, providing solid scientific evidence for explaining the properties of the entity and representing an important field of knowledge for educating future generations (Henriques and Pena dos Reis 2015; Lopes et al. 2019; Guo et al. 2024). Heritage sites in different parts of the world are being uncovered, studied, and efforts are being made to protect them for these reasons. The first stage of these studies is identification; the heritage site must be adequately defined in terms of its location, stratigraphic context, geological age, and the fossil groups it contains.

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The second fundamental axis is the scientific representation power of a locality, which can be assessed in terms of its type locality, whether it is the first finding, its rarity, and its place in the literature. For many fossil localities, including those in geoparks, scientific research is advancing, thereby increasing the fame and importance of those sites. For example, in a study of the paleontological heritage value of Lower Cretaceous amber deposits in the Iberian Peninsula, the scientific and cultural value of amber deposits was emphasized, and it was suggested that a more comprehensive conservation policy should be developed at the national and regional levels (Rodrigo et al. 2018). In another study, 16 trilobite genera and 18 species from the early Cambrian period within the Sierra Norte de Sevilla UNESCO Global Geopark were identified as one of the highest levels worldwide for this geological time interval (Alfaro et al. 2021). Las Hoyas in Cuenca (Spain) is an Early Cretaceous fossil site, one of the world's most unique and significant fossil areas and, with its rich flora and fauna, Las Hoyas is an exceptional conservation area (Konservat Lagerstätte) and has become an integral part of the identity of the region both scientifically and socially (Abad et al. 2017). The paleontological heritage has been a factor influencing the daily lives of the local people. Informed scientific literature can provide an idea of the scientific representation power of a paleontological heritage site.

In order to determine the paleontological heritage and demonstrate its significance, it is necessary to compare fossil localities with one another, at national, regional, and global levels. These comparisons require a variety of descriptive data produced through multidisciplinary studies. The main themes around paleontological heritage are sustainability, transfer, promotion, conservation, and education (Brilha 2016; Lopes et al. 2019; Caetano & Ponciano, 2021; Marok 2023; Guo et al. 2024; Cavalcante & Santucci 2025). After comparing the localities and identifying their similarities and differences, the next step is to determine the conservation and integrity status of the area. This last characteristic, which holds an important place within UNESCO's criteria, includes both legal recognition that will ensure protection and certain information that will determine its integrity. The concept of wholeness is defined by the consistency of the fossil findings with the locality, the continuity of the stratigraphic sequence, the represented paleoenvironment, and the impact of modern interventions. Thus, after reviewing the literature and UNESCO's evaluation criteria on this subject, the axes of definition, scientific representation, comparison, conservation, and integrity to be used in creating the scale were determined.

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Method

The aim of this research is to design a scale consisting of a set of criteria for measuring the heritage value of paleontological heritage sites. Scale designs involve several stages. Accordingly, the objective must first be determined, the target audience must be identified, the implementation must be planned, and how the results will be used must be determined. All these stages should be outlined as a theoretical framework before the scale is prepared. The draft work plan, usually based on the literature, also leads to the development of a draft conceptual framework, key axes, and scale items. In terms of methodological discussion, various studies conducted with the same objective have been examined. For example, the analysis application available on the GEOSSSIT website was used to prepare a geoconservation plan for the preservation of sauropod dinosaur footprints in the São Domingos geosite in the state of Tocantins, Brazil (Lopes et al. 2019). Another study aimed to create criteria for the inventory, strategy development, and management of paleontological heritage sites, and the criteria included scientific value, educational value, aesthetic value, cultural value, tourism potential, and risk of deterioration (Brilha 2016). Another study in the Tlemcen region of northwestern Algeria first identified geosite areas, and then their scientific, educational, and tourism-related values (Marok 2023). In research on the importance of the Aktepe Travertines in Giresun province as a geomorphosite, a 27-item scale, characterized by three main values and two additional values, was used. The scale was administered by four different experts, who scored it in relation to the same geosite. In conclusion, articles were prepared that included scientific, conservation, education and tourism values (Aylar et al. 2023).

The research question here is: “What is an appropriate scale for determining paleontological heritage value?" A multi-stage design process ensured that the scale reveals the heritage value potential of paleontological excavation sites using objective criteria. Similar studies in the literature were reviewed (e.g., Lisec & Drobne 2009; Kazancı et al. 2015; Brilha, 2016; Lopes et al. 2019; Simón-Porcar et al. 2020; Açedo et al. 2025; JEMİRKO 2025b). A preliminary study was conducted to prepare the research questions, and expert opinions were sought. The draft expert evaluation form (Appendix 1) was presented to paleontology and related scientific field experts at two scientific meetings, the 3rd International Congress of Anthropological Sciences on October 24-26, 2025, and the "Geological Collections of

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Türkiye Workshop" held at the MTA Martyr Cuma Dağ Natural History Museum in Ankara on December 4–5, 2025. The experts consulted included geographers, geography teachers, and paleontologists with expertise in scale design (Table 2).

Results and Discussion

Based on the literature review and expert opinions, it is concluded that geoconservation is related to education and promotion. Key components of the scale criteria include the continuity of heritage, the addition of new findings/elements, its promotion, its opening to tourism and its contribution to development and the local economy, the determination of its place within the culture, its use in constructing meaning for society, and its transmission to future generations.

Heritage protection requires a well-functioning system that includes risk analysis, planning, implementation, monitoring, and controls. In the operation of this system, environmental factors are taken into account in addition to the scientific potential of a locality. For example, the region's development status and economic potential, population, and educational opportunities are key factors. From this perspective, determining the paleontological heritage value of an area has become linked not only to its possession of rare fossil collections but also to the social and economic conditions of the people living in that vicinity.

Natural diversity encompasses a broad range of aspects, including both living and non-living environments. In planning conservation measures, geological issues such as formations and their characteristics are generally taken into consideration, as well as living organisms and people. What is the current flora and fauna found here, and how is it related to this fossil site? What are the soil and water characteristics like here? What kind of living space is this? Has it become a settlement area for people? If that wasn't possible, why didn't people choose to settle here? If this is a residential area, why did it become a residential area? What are the economic activities of the settlements located in this area? What are everyday life practices, what are the abstract and concrete elements of culture? Which administrative unit does this field fall under? What is this administrative unit's relationship with the central government? What is the significance of this area for the central government? It could be part of a development plan, a critical military border region, a tourism area, or a place where agricultural activities are carried out. There can be mines. What are the laws and regulations

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that govern these activities? All these details are factors that affect the preservation of paleontological heritage. Conservation efforts have three aspects: the scientific community's perspective; the state of the government of the country; and the perception of the local population.

A study on local communities' perceptions of paleontological heritage in the UNESCO Global Geoparks of Araripe (Brazil) and Arouca (Portugal) determined that fossils hold scientific, economic, and cultural (particularly belief-related) significance for different social groups (Henriques & Carvalho 2022). Therefore, fossils are not only scientific objects but also a part of local life, and are thus interpreted by the people living in the region, who assign meaning to fossils in everyday life, such as in matters of belief. Therefore, it is necessary to raise the local population's awareness of the land they own and to ensure sustainable protection.

Another dimension of conservation is the conservation and rescue programs organized by governments, where key issues are legal regulations, inclusion in environmental impact assessment reports, and inclusion in development programs or plans (Cavalcante & Santucci 2025). Such work at paleontological sites requires an environmental impact assessment, and this could encompass risk assessments for mining, geothermal energy, or other activities around the paleontological heritage site. As an example, GEORISK is an open-source website developed by 15 participants from 9 countries, with the support of the European Commission. Its purpose is to conduct environmental risk assessments during the construction process of geothermal power plants, in a module offered by GEOS-IL.LTD. Both modules, like their counterparts, conduct an impact analysis of multiple factors in the environment in terms of planned economic activities. There are other open sources on this topic as well.

Although fossil sites have a high protection status, they are at risk of uncontrolled exploitation by collectors. Declaring the area a geopark and including it in the inventory will enhance conservation measures, although over-collection risks might increase. Geoparks have the potential to create routes and exhibits to promote paleontological heritage, and such initiatives can increase the international projection of the field and contribute to the local economy (Haag 2016; Rodrigo et al. 2018: Caetano & Ponciano 2021; Özcan & Tarakçı 2021).

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In Türkiye, the first studies on this subject were conducted in 2015, and have continued since then, particularly through activities within JEMİRKO. With the proposal to prepare an umbrella list on this subject and subsequently with the intention of continuing this as an active and dynamic process, this work has been made available to researchers as a webpage (JEMİRKO 2025). The legal framework in Türkiye is defined by Law No. 2863 on the Protection of Cultural and Natural Assets, enacted in 1983, together with its implementing regulations. Under this law, fossils are explicitly included within the category of "movable cultural and natural assets requiring protection," defined as materials dating to geological periods that possess documentary value in terms of geology, anthropology, prehistory, archaeology, and related disciplines. Individuals who discover fossils are legally obliged to notify a museum or the relevant civil authority within three days. Such assets are considered state property. Unauthorized excavation, drilling, unreported buying and selling, and the export of fossils abroad are subject to severe legal sanctions. Following their transfer to a museum, procedures concerning classification and registration are regulated under the museum acquisition regulation. Additionally, private collecting activities are governed by a separate supervisory regulation (Official Gazette 1983). Under these provisions, all fossil localities in Türkiye are legally protected. Nevertheless, deficiencies in monitoring and occasional conflicts of interest may pose threats to fossil-bearing sites. The present scale development study grounds its evaluative framework and practical applicability within the protection and registration practices shaped by Türkiye's Law No. 2863 and its associated regulatory system.

Up to this point, through the evaluation of both UNESCO criteria and the scholarly literature examined on the subject, a set of qualifications that may be considered fundamental in determining heritage value has been identified. These are issues of definition, scientific representation, comparative advantage, preservation, and integrity. It is possible to support these points with lower-level criteria. These are briefly shown in Table 3, and these competencies were taken into consideration when creating the scale.

The scale items have been designed under three thematic titles, ensuring ease of use and comprehensibility. These themes were identified using the literature and institutional definitions previously mentioned in the theoretical section, and supported by expert opinions. The scale consists of 192 items categorized under scientific, educational, and tourism value,

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with each item assigned a score between 1 and 4. The themes are scientific, educational, and economic dimensions, and are presented in Table 3 along with their respective scales (Table 4).

Scientific Dimension

To define a fossil locality, it is necessary for relevant field experts to prepare reports describing the location, stratigraphic characteristics, geological age, and fossil groupings of the locality. This can also be thought of as a registration process. Publications regarding local findings provide detailed information about the findings, and this information is also internationally tested and validated by the scientific community. Therefore, scientific publications and the information presented in these publications are important. These areas are not only valuable for their scientific significance, as they possess information that sheds light on the history of world science, but they sometimes, but not always, possess scenic beauty. The determination of scientific value is a variable process, with new information being added periodically through ongoing excavation and research activities. New discoveries can reveal previously unknown information and lead to re-evaluations of the importance of a paleontological site, at national, regional, and international scales.

Scientific information is also required for determining conservation status. Protection, primarily supported internationally by organizations such as UNESCO, is achieved through the definition of the area. The first step in adding these areas to the international conservation inventory is scientific identification. The scientific section of the scale, based on the information provided above, was initially drafted and subsequently revised based on expert opinions, resulting in 17 items and 68 sub-items graded under those items.

Economic Dimension: Sustainability, Development, Local Economy

Excavation activities require financial support, and the return on investment for these economically supported sectors may be a subject of debate. From a mining perspective, underground excavations represent high income potential. However, protecting an area through archaeological and paleontological excavations, and separating it from other economic activities, brings with it numerous economic, social, and cultural contradictions. This raises the question of whether that area has a profit-generating value or, conversely, whether its economic value is being wasted.

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The integration of paleontological sites into the economic activities of modern life, and their contribution to local communities and development by generating economic value, has become a prominent topic. Discussions have focused particularly on geoparks, which may promote economic and social capital development for the local population; an example is the paleontological heritage of the Araripe Geopark (Brazil) and its contribution to the region's economic development through geotourism (Carvalho 2021). Besides spending time within the park areas, visitors find accommodation and food services in nearby settlements, as well as purchase local souvenirs and other products. Activities offered to geopark visitors are important. For example, in the Sierra Norte Geopark in Spain, paleontological routes and geological guides have been developed in the Cerro del Hierro region. There are special routes used by tourism companies for visitors (Alfaro et al. 2021).

Brodie (2010) discussed whether economic value and cultural value can be measured in the same way. Accordingly, the economic value of the excavation is linked to the willingness of states and the public to pay for it. The economics of paleontological and archaeological excavations emerge in relation to cultural heritage, values, and ethics. The economic value of findings—unless they are looted and sold off illegally—is generally immeasurable. States could solve the problem by establishing cultural property laws that allow for valuation and prioritize funding. For Türkiye, the fundamental framework is defined by the Law on the Protection of Cultural and Natural Assets. Therefore, in questions concerning legal protection, what is essentially being measured is not only the respondents' knowledge of the legislation, but also their assessment of the implementation (adequate/inadequate) and their perceptions (the law exists and is effectively enforced / the law exists but is not implemented). When the issue is considered from the perspective of social capital, raising public awareness through education, tourism, and media will support the implementation of relevant regulations (Brodie 2010, p. 263-267). From this perspective, factors such as population, transportation, services, and scenic views that attract tourists are significant in determining the economic value of the area.

In some cases, the geological and paleontological riches of a region can generate economic value. Depending on local characteristics, people may utilize certain elements from the natural environment in various production areas such as house construction and tool making.

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While this use of geological structures with paleontological heritage value sometimes supports the local economy, it can also sometimes lead to the depletion or deterioration of these valuable structures. The development of locally specific architecture and the emergence of an economy based on it has simultaneously led to the birth of a new sustainable tourism sector (Simón-Porcar, et al. 2020). This results in a model where local characteristics and economic value are perfectly aligned.

Considering the characteristics mentioned here, a scale for the use of tourism as a second theme has been prepared to determine economic value. Within this scale, 64 sub-items have been prepared under 16 main items in the context of tourism as an economic activity. The final version of the scale, after expert opinions and validity and reliability tests, is given in Appendix 2.

Educational Dimension: Promotion, Teaching, Maintenance, Protection

Paleontological heritage can be addressed at different scales, from local, national, and global levels. Many fossil sites of high scientific value are not recognized by the local population or in national policies. Campos-Medina et al. (2018) investigated how the paleontological heritage in Río San Pedro, Spain is understood and used by the local people. Establishing a dialogue between local and scientific knowledge should strengthen the preservation and interpretation of heritage (Campos-Medina et al. 2018, p. 669). In another study on the paleontological heritage of the Solimões Formation in Acre State, Brazil (Haag, and Henriques, 2016), fossil diversity, heritage value for scientific/social use, and accessibility were evaluated, and education played an important role in paleontological assessment.

Local people may be connected to excavation sites in various ways, and some professional groups may even become involved in excavation work. Fossil exploration in significant paleontological sites in the Mexican states of Puebla and Hidalgo has shown positive results from engaging local construction and quarry workers (González-Rodríguez 2023). This positive example should be considered in paleontological conservation efforts.

In another study, Romero et al. (2004) found the current legal framework for the protection of paleontological sites in Murcia (Spain) to be inadequate. In exploring the potential public presentation of an Upper Jurassic dinosaur egg fossil from the Paimogo fossil site in Portugal,

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a multidisciplinary approach was used to analyze data collected from the site and to prepare an authentic exhibition area (Fernandes et al. 2021). This highlights the importance of educating local people on the recognition, protection, and sustainability of paleontological excavation sites. This can be achieved by preparing information about paleontological heritage in the form of educational materials for school curricula and other visitors, taking into account their demographic characteristics, socio-economic status, and the environmental conditions of the region. It can be considered a future investment or a way to build social capital, both for adults and school students. In this context, we have prepared a scale for the use of education as a tool, comprising 15 main items and 60 sub-items (Appendix 2).

Conclusion and Suggestions

In this study, we used the heritage value of paleontological sites to develop an assessment scale, presented as Appendices 1 and 2. The scale was completed after defining the basic concepts and establishing the criteria, obtaining expert opinions, conducting item validity and reliability analyses, and performing final linguistic checks.

Paleontological heritage is of interest not only to paleontologists or geologists, but also to fields such as geography, history, economics, tourism, sociology, pedagogy, law, and public administration. Multidisciplinary perspectives and expert support are important in studies like this, while enabling experts to view their own work through the lens of another science has suggested some overlooked issues.

The preservation of heritage sites faces various challenges in developed, developing, and underdeveloped countries. The illegal removal of valuable underground and above-ground resources from the country is a significant problem, made worse in some cases by poor administrative measures. Problems persist due to the multifaceted nature of the issue, the scarcity of personnel working in this field, and the inadequacy of resources. These are found not only in paleontological conservation areas but in all heritage sites. For example, Türkiye faces problems of inadequate management in nine sites registered on the UNESCO World Heritage List (Somuncu & Yiğit 2010, p. 6). These issues can be overcome through awareness activities and consideration of comprehensive criteria.

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Developing a scale to determine the characteristics of a paleontological heritage site is a first step, and the scale should be applied to real cases and the results presented comparatively. Initial implementation of the scale will enable an expert-based evaluation of its coherence and functionality. As previously noted, the forms of engagement and cultural production developed by communities living in fossil-bearing localities have been recognized as part of heritage, and this could require an additional scale component developed in collaboration with folklorists. However, we have excluded this aspect here.

Our assessment scale may be of wider use, but variations in legal frameworks and implementation practices across countries limit the construction of a standardized scale. The present study has been conducted on the assumption of the validity and applicability of UNESCO conventions. Nevertheless, it should be acknowledged that fossil protection practices differ worldwide, and the scale should be interpreted within this broader context. Direct application of the scale in different countries, without considering national legal components such as fossil ownership regimes, restrictions on trade, registration procedures, and responsible protection institutions, would be methodologically limited. Broader use of the scale will facilitate its refinement, allowing potential deficiencies to be identified and addressed.

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Availability of Data and Materials

Appendix 1. Draft Paleontological Heritage Value Scale Expert Opinion Form.

Appendix 2. Paleontological Heritage Value Scale.

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Table 1. Major international initiatives on geological heritage and geoconservation. Sources: UNESCO, 1971; UNESCO, 1972; UNESCO 2015; ProGEO, 1993; ProGEO 2008; ProGEO, 2018; UNED, 2021; IUCN, 2022; IUGS, 2024. Also, 2025 marks the 10th anniversary of the UNESCO Global Geoparks Programme, and October 3, 2025, is celebrated as International Geodiversity Day (Global Geoparks Network, 2025).

Year	Initiative / Declaration	Significant Contribution
1971	UNESCO Paris Declaration – "Geological and Physiographical Aspects of Natural Heritage"	It was proposed that geological heritage be addressed within the scope of nature conservation; the first international basis for the concept of geoconservation.
1972	UNESCO World Heritage Convention	Inclusion of geological and physiographic values in the "Natural Heritage" category.
1991	The Establishment of ProGEO	Organization for the systematic protection of geological heritage in Europe.
1993	Declaration of Digne (France)	Geoheritage has been declared to be of equal importance to biological heritage.
2000	European Geoparks Network (EGN)	Geopark model has been developed.
2004	UNESCO Global Geoparks Program	The concept of geopark has gained international recognition.
2008	Oslo Declaration	A call for a common geoconservation policy in Europe.
2010	Geoheritage Journal	The scientific platform for the field has been established.
2015	UNESCO Global Geoparks Status has been officially granted.	Geoparks have become an official UNESCO designation.
2018	Declaration of Chęciny (Poland)	Integration into the 2030 sustainable development tools
2021	UN Decade for Ecosystem Restoration (2021–2030)	Geological processes have been incorporated into restoration policies.
2022	IUCN Key Geoheritage Areas (KGA) Initiative	It was proposed that geoheritage be given global priority.

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2023/ 2025	Dublin Declaration & IUGS geoheritage Guide	Digital geoheritage, areas requiring protection, pilot regions, and an emphasis on young researchers.

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Table 2. Research model (Hinkin 1998; Worthington & Whittaker 2006; Boateng et al. 2018).

Stage	*Step*	*Aim*	*Method*
1. Development	Article Writing	Conceptual representation	Literature and Expertise
	Expert Evaluation	Article compliance	Content Validity
2. Discovery	Pilot Application	Pre-test problematic article	Small sample analysis
	AFA	Factor structure and article selection	Factor analysis load >0.40
	Reliability	Measuring consistency	Cronbach's Alpha
3. Verification	DFA	Structural validity verification	Compliance indices
	Reliability	Intergroup comparison	Multi-group DFA
	Validity	Comparison with external criteria	Correlation/Regression
4. Reporting	Final scale	Valid and reliable form	Directive

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Table 3. Basic competencies in scale development

A. Definition	**Location**
	Stratigraphic Context
	Geological Age
	Fossil Groups
B. Scientific Representation	Type Locality
	First Finding
	Rarity Level
	Its Place in International Literature
C. Superiority	Counterparts on a National Scale
	Regional Global Equivalent
	Aspects of Superiority
D. Protection and Integrity	Territorial Integrity
	Risk of Destruction
	Legal Status

Table 4. Basic dimensions used in scale preparation and related scales.

	DIMENSION	SCALE
1.	Scientific	1. Scientific Value Scale
2	Education: Promotion, Teaching, Maintenance, Protection	2. Educational Use Value Scale
3	Economic: Sustainability, Development, Local Economy	2. Tourism Use Value Scale

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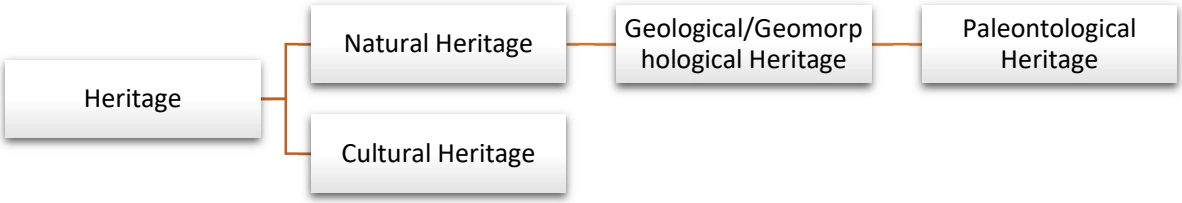

Figure 1. The place of the concept of paleontological heritage in the hierarchical order

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