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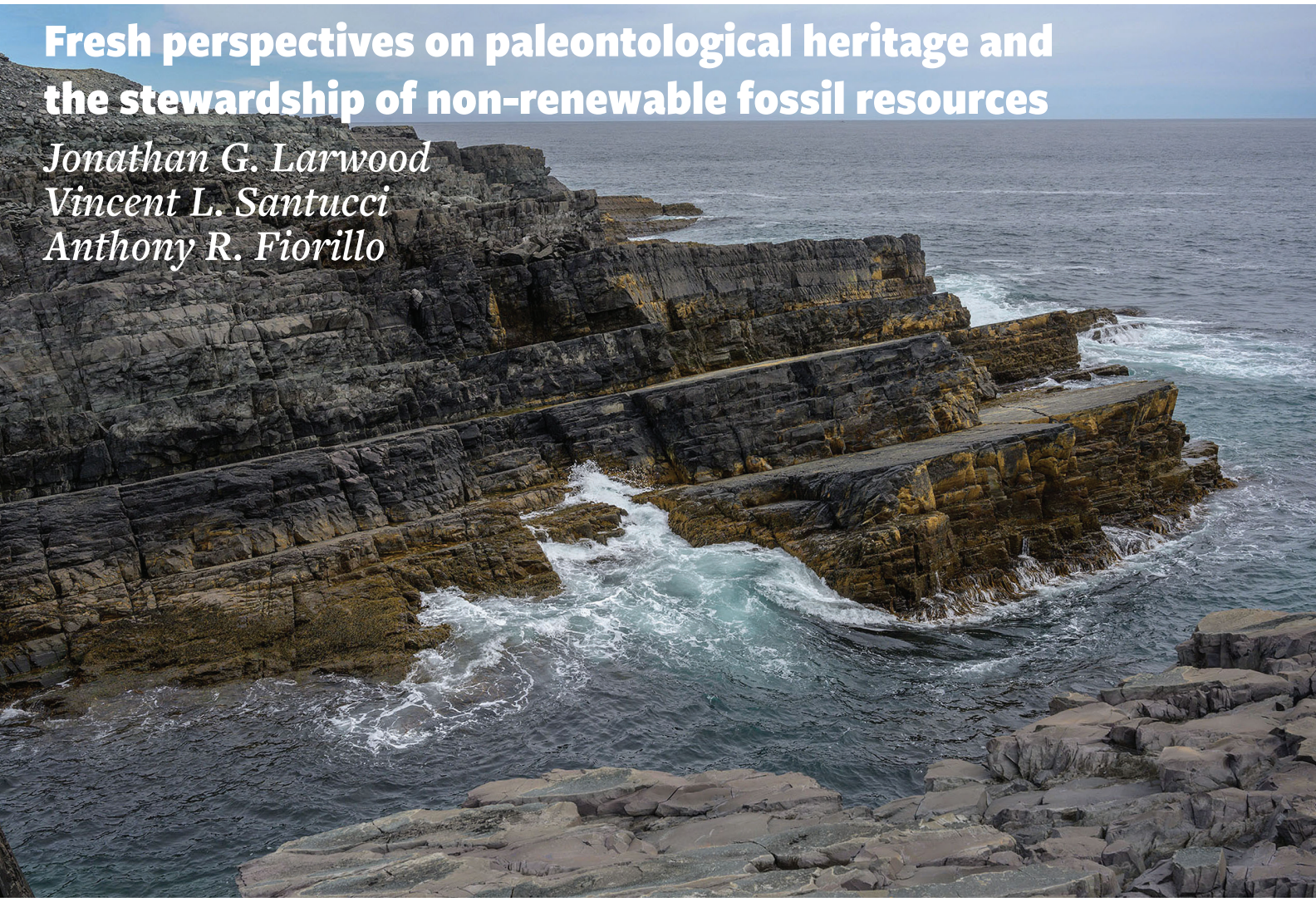
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Fresh perspectives on paleontological heritage and the stewardship of non-renewable fossil resources

Jonathan G. Larwood
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ABSTRACT

A "fresh perspective" provides an insight into the values attributed to paleontological heritage and the consequent behaviors, motivations, and management challenges for the stewardship of this non-renewable resource. To provide a global perspective, a survey was undertaken with over three dozen experienced paleontological resource managers examining values and management experiences. Notably, values attributed to paleontological resources were consistently wide-ranging, encompassing scientific, educational, cultural, aesthetic, economic, and other values, and there was a consequent diversity of management approaches and actions. Responses are discussed and lessons learned are outlined to provide a fresh perspective and key points for the successful stewardship of paleontological heritage.

INTRODUCTION

To provide a "fresh perspective" on paleontological heritage stewardship, a survey comprising four questions was distributed to a range of institutions, agencies, and individuals with global experience and expertise in paleontological resource management.

- **Question #1: How do different (human) values influence the ability to protect paleontological resources?**
- **Question #2: What's the most challenging management issue involving paleontological resources?**
- **Question #3: What best practices in paleontological resource management have been adopted?**

Mistaken Point World Heritage Site, Canada, is a globally significant Ediacaran fossil site. RICHARD DROKER

- **Question #4: What lessons have been learned from one successful or unsuccessful story in paleontological resource conservation?**

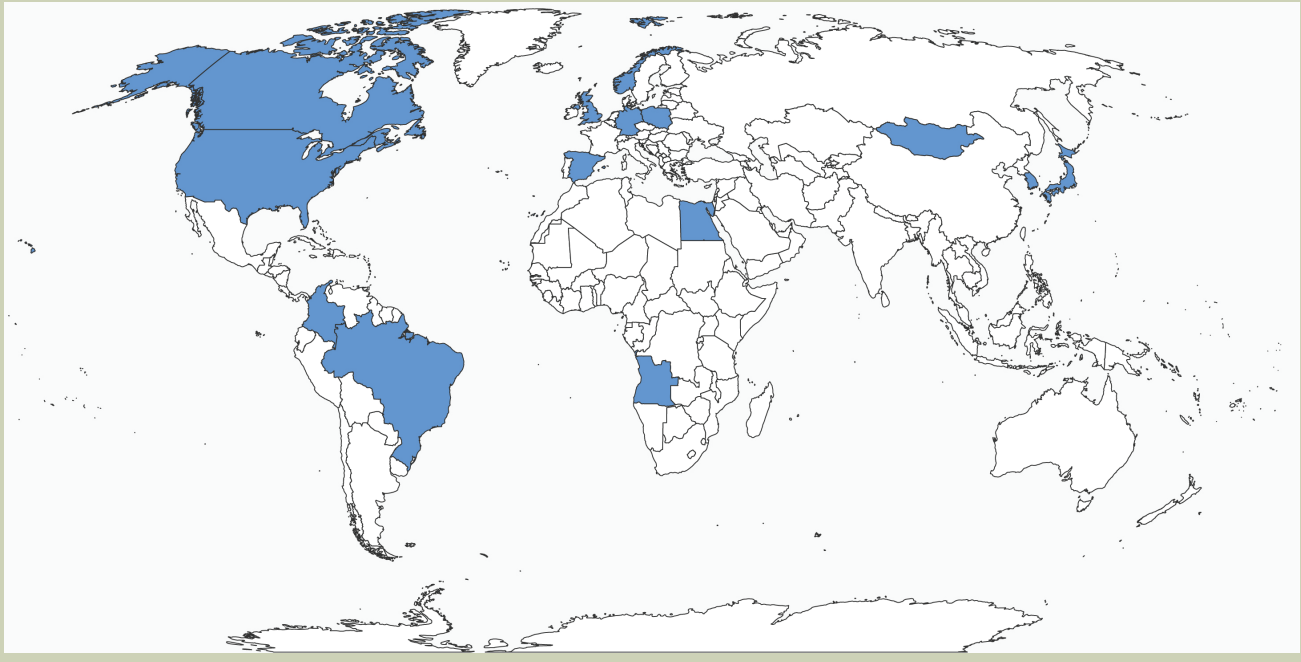
While not exhaustive, the answers do offer insights and reflections into the values attributed to paleontological heritage, the range of management challenges, and practical actions taken (both successful and unsuccessful).

The survey garnered 38 responses which fall into two broad groups: 17 responses from the United States (largely from employees of the US National Park Service), and 21 from Angola, Brazil, Canada, Columbia, Egypt, Germany, Japan, Mongolia, Norway, Poland, South Korea, Spain, and the United Kingdom (UK respondents were from England, Scotland, and Northern Ireland; Figure 1). The respondents represent a range of academic, museum, and land-resource management agencies and organizations with interests or responsibilities in paleontological resource management, including 13 US National Park Service areas, two United Nations Educational, Scientific, and Cultural Organization (UNESCO) Global Geoparks (Black Country, UK, and Holy Cross Mountains, Poland), and three UNESCO World Heritage Sites (Jurassic Coast, UK; Mistaken Point, Canada; and Messel Pit, Germany).

METHODS

A simple analysis of the four sets of responses was undertaken. Recognizing that the questions were not designed for a detailed statistical analysis, this review considered the language and key words used to ascribe value, attitudes, and management activities to paleontological heritage. The broad range of responses is quoted as a simple percentage. For Question #1, which focuses on values, a tabulation summary is provided (Table 1). A qualitative review of responses provided a more nuanced reflection on the motivation behind the values and explored in detail the responses to these values and the consequent management approaches and challenges. The narrative across respondents was similar, reflecting a common range of values, challenges, and solutions to paleontological resource management. Where there was a distinction (US versus non-US), this is briefly explored. The results and discussion presented here should be considered as indicative of only a subset of issues and experiences reported from a far more complex situation. A number of "lessons learned" were drawn from these experiences and are summarized.

Figure 1. Map showing countries represented by the paleontological resource practices and perspectives used in this study. © FREEVECTORMAPS.COM



QUESTION #1: How do different [human] values influence the ability to protect paleontological resources?	US	INTERNATIONAL	TOTAL
Values	12 / 17 70.6%	17 / 21 81.0%	29 / 38 76.3%
Knowledge / Understanding / Education	13 / 17 76.5%	15 / 21 71.0%	28 / 38 73.7%
Motivations	15 / 17 88.2%	14 / 20 70.0%	29 / 37 78.4%
Behaviors	13 / 17 76.5%	9 / 20 45.0%	22 / 37 59.5%
Consequences / Outcomes	10 / 17 58.8%	12 / 20 60%	22 / 37 59.0%
TOTAL (n=38)	**17**	**21**	**38**

Table 1. Tabulation of responses to Question #1: How do different (human) values influence the ability to protect paleontological resources? Responses fall into five categories: values (e.g., scientific, educational, recreational, commercial, etc.), knowledge/understanding/education, motivations, behaviors, and consequences/outcomes.

RESPONSES TO QUESTIONS

Question #1: How do different (human) values influence the ability to protect paleontological resources?

Collectively the responses to this question identified five factors in which human values influence the ability to protect paleontological resources, with participants frequently identifying one or more responses as important. These factors encompass individual values (76%) that have a strong influence on motivation (78%), behavior (59%), level of knowledge (74%), and the desired outcome (59%) for paleontological resource management.

The responses to this question consistently indicated a range of values assigned to paleontological resources, including scientific, educational, cultural, aesthetic, and economic. It is critical to understand these values, their motivation, and consequent behavior to arrive at a balanced and informed approach to conservation. One respondent said that "fossils are just stones unless experts find their value." Here, "experts" refers to the paleontologists; however, this assertion is important as the "value" placed on a fossil is entirely people-centric and diverse. Science and educational values were considered the most important (to some extent reflecting the research/paleontological background of respondents). These values are motivated by paleontological research, but also the recognition of the importance of learning/education that comes from paleontological heritage. Cultural and aesthetic value reflects a sense of place and connection to a community with a historical, emotional, or even spiritual link; these values were seen as potentially the most influential in achieving successful conservation. In relation to economic value, fossils can be considered a commodity with a monetary value for individual specimens; can have a broader economic value, for example as part of an extractive mineral resource; and are increasingly seen as a wider economic asset that, for example, can attract income through geotourism.

The influence of different values is further compounded as many of the organizations responsible for protecting paleontological resources have a wide natural environment remit requiring a balance of priority and resource. For example, balancing the competing resource needs—in terms of staff and funding—of biodiversity, paleontology, and archeology (which is often unhelpfully confused with paleontology) can leave less-understood disciplines (such as paleontology) under-resourced.

Interestingly, reflecting these wider values, globally paleontological heritage is protected either by

natural or cultural heritage legislation (examples of the former include the United Kingdom and Poland; of the latter, Mongolia and South Korea) and occasionally by a legal framework that combines both. For example, Colombia's Decree 1353/2018 combines scientific, educational, and cultural values for geological and paleontological heritage. Where it has not been possible to determine scientific value, educational and cultural values have been useful and have helped establish strong links with local communities.

Question #2: What's the most challenging management issue involving paleontological resources?

Management challenges reflected organizational (and wider) understanding of paleontological resources and associated management needs (26%), related competing priorities (26%), and associated lack of targeted funding (13%). Unauthorized fossil collecting (42%) was cited as the most immediate and direct impact on paleontological resources, though site degradation was also considered problematic, to some extent stemming from a lack of management, resources, and undervaluing.

Interestingly, the US responses were generally distributed equally among the four factors, whereas the non-US responses were dominated by unauthorized fossil collecting (67%), which may relate to the more varied approach to direct management of fossil collecting in areas outside of the management of the US National Park Service (Figure 2).

It is not surprising, given the range of values ascribed to paleontological heritage, that understanding and reconciling its value (and vulnerability) is widely seen as the most challenging management issue. Recognizing value and vulnerability (fossils are a finite and non-renewable resource), then seeking balance, compromise, and collaboration, is critical, though finding common ground is not always possible.

Figure 2. Park managers and researchers at Fossil Butte National Monument in Wyoming, USA, contemplate the commercial fossil collecting operations using quarries in the Eocene Green River Formation surrounding the boundaries of the monument. US NATIONAL PARK SERVICE



For many heritage organizations, undervaluing and misunderstanding the value of paleontological heritage leads to under-resourcing of both staff (with specialist paleontological knowledge) and funding. This was particularly noted by the US National Park Service, which encompasses a broad discipline portfolio. It was also recognized that paleontological heritage conservation is largely expert led—paleontologists identify what is important to conserve, based on scientific criteria. Given the broader range of values assigned to paleontological heritage, this can be considered narrow in scope, particularly obscuring aesthetic and cultural values and missing the wider story that connects paleontological heritage to a place or community. For example, "Pride of place, political pride, personal association … local communities with pride in something special about their home area" was seen as central to the care local communities place on paleontological heritage in the urban Black Country UNESCO Global Geopark.

Different values and ambitions tend to align with different communities and interest groups: the responsible local/legal authority, land manager, and owner; the collector (whether for research, hobby, or commercial reasons); the research institution and museum; the local community; and the tourist potentially all have an interest in or influence on the fossil resource and its stewardship. Recognizing that different values are held, then seeking balance, compromise, and common ground, is an important journey to follow. For example, where fossil acquisition is an important conservation and research outcome, museum funding, storage, and acquisition policy (e.g., accessioning specimens for educational versus research purposes) should align with it, otherwise collecting and conservation priorities can be undermined. In another example, balancing mineral extraction against the loss of fossil material was also seen by the respondent as problematic; again, the best outcomes are usually achieved through good communication and collaboration—here, between the mineral operator and the paleontological resource manager. In Aragon Region, Spain, such collaboration has enabled systematic collecting and recording of Lower Cretaceous dinosaur assemblages. In Holy Cross Mountains UNESCO Global Geopark, collaboration between the active Kowala Quarry and researchers has facilitated research and collecting of Upper Devonian trilobites, which are now on display in Kielce.

At a more practical level, paleontological site degradation is a widely shared concern, particularly as these resources are finite and non-renewable. Vegetation encroachment (especially in warmer, wetter climates) requires ongoing management to maintain accessible sections of fossiliferous strata. Physical processes (particularly erosion and weathering) can be either beneficial and problematic. Actively and rapidly eroding coasts (for example, at Jurassic Coast World Heritage Site) provide a renewed exposure of fossiliferous strata. However, where the paleontological resource is fragile and restricted, erosion and weathering can cause significant degradation (for example, the bedding plane Precambrian fossils of Mistaken Point World Heritage Site).

There is a desire to promote paleontological heritage to encourage visitation and the associated economic benefits this generates. However, too many people can lead to footfall erosion, over-collecting, and unrealistic demands on and expectations of managers (often influenced by broadcast and social media). Similarly, different or competing collecting values (science, education, recreation, or monetary) can place pressures on finite paleontological resources, understanding of their vulnerability, and the need for careful stewardship. The "cool versus not cool" fossil was cited in different ways by respondents. Simply put, a *Tyrannosaurus rex* fossil is seen as cool and the case to conserve it easy to make, whereas for more common fossils (which potentially may be no less important scientifically) the case for conservation and leaving these resources *in situ* is sometimes more difficult. Conversely, the dinosaur fossil has a range of different values, including high monetary value, which presents a different challenge: illegal and irresponsible collecting (often commercially driven). This is a particular concern in more remote areas where paleontological resources are often difficult to manage and monitor.

The absence of legislative control was seen by respondents as problematic, as it can leave fossil resources vulnerable to collecting with no effective means of monitoring them. Where legislation exists, even at its most stringent (i.e., where collecting

is only allowed for scientific purposes), resource monitoring and management are still needed, and understanding and education are seen as critical.

Question #3: What best practices in paleontological resource management have been adopted?

"Best practices in the field are highly variable" was one respondent's astute summary of the range of perspectives on best management practice. Establishing protection (34%) and associated strategies for resource management (19%), alongside the importance of understanding the resource through research and education (28%), resource inventories (12%) and monitoring (6%), are all emphasized in response to this question.

It was clear from the shared perspectives among the individuals engaged in fossil protection that the key elements to best practices include commitments to conservation, monitoring, and public education programs (Figure 3). On a second tier, calls for standardization of data, research, directed collecting

Figure 3. The Jurassic Coast World Heritage Site, UK. *Ichthyosaurus communis* (Lower Jurassic, Blue Lias Formation) recovered and prepared by local collector Fiann Smithwick. A: Extracted block on foreshore prior to removal with arrow indicating visible ribs. B: Prepared specimen. A juvenile *Ichthyosaurus communis*. The jaw and half a paddle is missing (lost to erosion) indicating the value of early discovery and prompt recovery through collaboration with local collectors. FIANN SMITHWICK



for scientific goals, consultations with trained professionals, and collaboration efforts with broader communities were also key components.

There is some unity in the key elements of best practices across all of the individuals who responded to our survey. Breaking out our responses into two subgroups, US versus non-US, a broad pattern of how to achieve best practices begins to emerge.

For the US-based paleontological resource managers, key components include directed collecting for scientific goals, standardization of data, monitoring, public education programs, and consultations with trained professionals. For non-US-based managers, standardization of data, monitoring, and public education are also emphasized alongside broader research goals, which can include directed collecting for scientific goals, as well as site conservation and the role museums play in conserving specimens. What is of particular interest within this non-US group is the emphasis on collaboration with communities to achieve a best practice goal. One person wrote that "they take into account people who are linked to the site or to the fossils...." The result of such a broad approach is the creation of viable network of partners outside of official management personnel. Implied in some responses is that this provides greater capability for resource protection, given limited staffing, budget, or other capacities within the site-managing organization.

Question #4: What lessons have been learned from one successful or unsuccessful story in paleontological resource conservation?

Like those to question #3, the responses to this survey question also covered a range of perspectives. Responses were broadly divided between successful and unsuccessful stories in paleontological management. Interestingly, successful and unsuccessful experiences sometimes follow one another. The over-arching theme for success can be summed up by one respondent who said, "Without a dedicated staff position for resources and science, none of this [success] would have occurred," This highlights what may seem to be intuitively obvious: that the commitment of resources, whether equipment, staffing, or both, is critical to a sustained success story. Sustained investment of resources is essential, whereas one-off interventions may not be sufficient. It is encouraging that respondents, whether US- or non-US-based, shared more success stories than not.

For the US-based paleontological resource managers, success is attributed to proper funding to protect the resource through conservation and mitigation measures, overall education, as well as appropriate communication both internally to the staff and externally to the public and additional stakeholders. In some examples, educating the public provided the benefit of additional "eyes" for monitoring and protecting the fossil resources. For example, in 2019 in Grand Canyon National Park (USA), two individuals were caught using hammers and chisels to remove fossils. Fortunately, "visitors who knew that fossil resources were protected … reported this occurrence to Park Rangers…." Elsewhere, formal protection of fossil sites around Oslo, Norway, still remains viable after 30 years largely as a consequence of the local pride that landowners place in this resource and the story it tells of Oslo's past. Messel Pit World Heritage Site has benefited tourists for over 17 years by providing access to researchers and skilled communicators. Additionally, in Black Country UNESCO Global Geopark an arts-based initiative, the Wrosne Project, connected young people to their paleontological heritage through dance, using their own choreography in a live performance telling geological and more recent historical stories connected to fossils, which had a lasting positive effect on community attitudes to these resources.

The major factors for unsuccessful stories largely reflect lack of appropriate communication within the staff so that priorities are not set and periodically evaluated, as well as the inability to secure funding to address the protection of fossil resources. One particularly tragic example of this occurred during the mid-20th century at Fossil Cycad National Monument in South Dakota, USA (Figure 4). The lack of understanding of the need for fossil preservation by the public, as well as poor management policies, led to such extensive looting of the fossil resource that the US government de-authorized the monument. In a similar example from the present day, the Cariri Region in Brazil has some of the richest and most diverse paleontological resources in the world. Lack of relevant legislation has meant the area has been subjected to illegal collecting and associated smuggling (supplementing local income). The recent establishment of Araripe UNESCO Global Geopark has provided "scientific management" for the area, widening the values placed on fossils and establishing the possibility of maintaining local heritage.



Figure 4. Yale paleobotanist George Wieland and US National Park Service officials oversee a Civilian Conservation Corps field crew in a test excavation at Fossil Cycad National Monument, South Dakota, during the 1930s. US NATIONAL PARK SERVICE

WHAT HAVE WE LEARNED?

Inherent to any analysis of qualitative data such as these survey responses are challenges to quantifying the results. However, a detailed analysis of repeated phrases or terms in the responses does bring forward some key lessons learned. The results of our survey suggest the following key points of learning.

- Understanding different values and associated motivations is important both at an organizational level and a practical delivery level for paleontological resource stewardship.

  Scientific, educational, cultural, aesthetic, and economic values were consistently ascribed to paleontological heritage. Most approaches to paleontological resource valuing and management, however, start with science and are expert led, providing a systematic, repeatable, and rigorous approach. The importance of this approach should not be underestimated. However, other values should be better understood and given more weight. Many of the success stories and best practice approaches reported were founded on linking to local communities and, in particular, understanding their cultural connection to a place and its heritage.

- Clear communication highlighting the importance of paleontological resources, their relevance and vulnerability, how we manage them, and the benefits of doing this are important components of success.

  Paleontological resources are vulnerable and finite, and this is often misunderstood. For those organizations responsible for managing paleontological heritage, establishing an understanding of this fragility, alongside securing adequate expertise and funding, are critical to successful paleontological conservation. This will be about the different values placed on paleontological heritage, from scientific to cultural, and their importance, both in their own right and in how they overlap with other values. Explaining scientific value, but more particularly how it helps people to understand the natural

world around them (how it has evolved and changed) makes a connection between people and paleontological resources that instills pride of place.

- Find common ground and a collaborative approach.

  The collaborative approach was widely seen as the route to success. Finding common ground and building trust between different communities takes considerable time and effort. It is also important to understand that, while common ground is not always achievable, the dialogue to understand why not is critical.

  Successful conservation almost always requires several parties. On-site collaboration between land manager, landowner, researcher, and collector is critical. Potential links off-site are important; for example, connecting with museum collections in instances where it is anticipated fossil material will be conserved, curated, and available for scientific research or public education.

- Monitoring paleontological heritage.

  Paleontological resource inventory and monitoring supports an increased awareness of the scope, significance, distribution, and management issues associated with fossils. This includes identifying the vulnerability of fossils, which, alongside understanding threats and pressures, will define the resources needed and help to determine best management practice and outcomes. An inventory of paleontological resources provides a baseline for monitoring. Degradation from collecting, vegetation encroachment, weathering, and erosion, as well as the impact of development, are all potential risks. Monitoring (usually photographic) provides the best evidence of change and the need for management intervention.

- Securing and sustaining resource-specific management planning and activities.

  Successful paleontological resource management requires sustained resources, both in terms of expert staff and funding to support management interventions. In the US, for example, the Paleontological Resources Preservation Act (16 USC 470aaa–1), enacted in 2009, specifically mandates federal land managing agencies to "manage and protect paleontological resources on Federal land using scientific principles and expertise … [and] develop appropriate plans for inventory, monitoring, and the scientific and educational use of paleontological resources…."

- Legislative and policy frameworks.

  The absence of legislative control was seen as problematic, because without it there is potentially no effective means of managing the collection of fossils or impact from development. A legislative and policy framework can emphasize and underpin paleontological value and provides a mechanism for communication and intervention within an established management and planning system. As noted earlier, both natural and cultural legislative and policy systems exist for paleontological heritage, reflecting its wider values. Communication, collaboration, and establishing local heritage value remain the most important tools for successful paleontological stewardship whether in the presence or absence of legislation.

These key points demonstrate that there are no clear and pre-set protocols for establishing future protected paleontological areas. Instead, these survey data illustrate the complexities of such undertakings and the importance of adapting to local circumstances. For those individuals directly involved in paleontological resource management, it is hoped that the results of this work will help guide future discussions of the ingredients of success.

ACKNOWLEDGMENTS

This paper has only been possible through the enthusiastic response to our survey. We extend our appreciation to the 38 individuals, representing an international community of specialists in paleontological heritage, for sharing their knowledge and experiences through participation in the survey. Additionally, we are grateful to the George Wright Society leadership and Roger Crofts for the invitation to contribute this article to include in this important publication.

USEFUL FURTHER READING

Values

Santucci, V.L., P. Newman, and B.D. Taff. 2016. Toward a conceptual framework for assessing the human dimensions of paleontological resources. In *Fossil Record 5*. R.M. Sullivan and S.G. Lucas, eds. Bulletin 74. Albuquerque: New Mexico Museum of Natural History and Science, 239–248.

This paper discusses in detail the range of human values ascribed to fossil resources, expanding on the discussion above.

Collecting

Natural England. 2012. Managing geological specimen collecting: Guidance. Technical Information Note TIN111. York: Natural England. http://publications.naturalengland.org.uk/publication/1648636

This advice is aimed at helping those with responsibility for managing fossil resources and collecting. It poses a series of questions and different scenarios for anyone responsible for managing collecting. It is England-based, but the principles are broad with wide application.

Monitoring

Santucci, V.L., and A.L. Koch. 2003. Paleontological resource monitoring strategies for the National Park Service. *Park Science* 22(1): 22–25.

This brief guidance discusses paleontological monitoring and provides a summary of the factors that can affect paleontological resources.

Santucci, V.L., J.P. Kenworthy and A.L. Mims, 2009. Monitoring *in situ* paleontological resources. In *Geological Monitoring*. Young, R. and L. Norby, eds. Boulder, CO: Geological Society of America, 189–204.

This is a comprehensive guide on resource monitoring for assessing the stability condition of in situ paleontological resources.

Earth science ideas

Earth Science Literacy Initiative. 2010, Earth Science literacy principles—the big ideas supporting concepts of Earth Science. http://www.earthscienceliteracy.org/

This is a good source of general principles setting out the "big ideas" in earth science and why they are relevant today.

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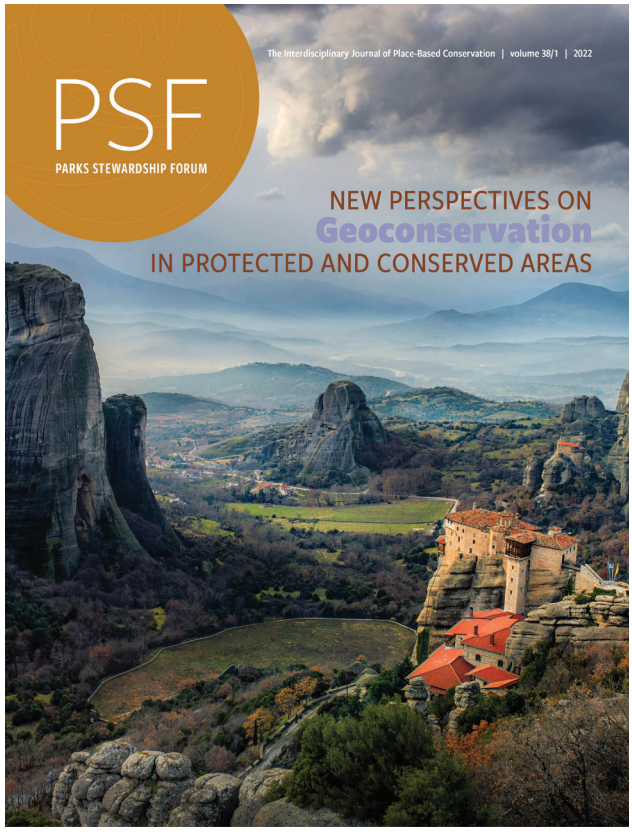
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On the cover of this issue
The precipitous rock spires of Meteora World Heritage Site in Greece have a complex geological history. Over the centuries a number of Eastern Orthodox monasteries were built atop them, and today's World Heritage Site recognizes this cultural history as part of the overall geoheritage. | STATHIS FLOROS