Sustainable site-based management of collecting pressure on palaeontological sites

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ABSTRACT

Sustainable management of fossil collecting is based on the sensitivity of the site, the available palaeontological resource and its tolerance to collecting pressure. This paper aims to assist site managers to identify a broad management approach to the sites under their control and find consensus amongst the different parties with an interest in these sites on the basic principles of palaeontological site management.

Since 1990 (revised 2005) UK sites have been classified under the Earth Science Conservation Classification (ESCC). This identifies three categories according to their character: Exposure sites, such as an eroding coastline, are sites that have a geological resource that is extensive and frequently renewed. Integrity sites tend to be geomorphological in nature. Finite sites are those where the geological resource is irreplaceable such as a cave sediment or a derelict mine dump.

The management issues within this wide range of sites are varied. Exposure sites can sustain higher collecting pressures, especially where specimen rescue through collecting may be an important part of site management and conservation. Finite sites are more sensitive and require a different approach and more restrictive management.

Collecting pressures are created by user groups including casual collectors, the serious amateurs, the professional/commercial collectors, educational groups and researchers. Each can produce different pressures on a site but these pressures must be considered in the context of the sensitivity of the site in order to achieve sustainable management. Furthermore, the relationship between scientists and collectors is important in terms of promoting an understanding of the scientific interest and conservation value. Finally, there are the interests and responsibilities of landowners, complicated by the many and varied ownership laws between countries.

A model has been developed for palaeontological site management, which challenges scientists and site managers to consider the level of collecting that is sustainable or necessary at different sites. Management must be both practical and achievable in order to be effective and this depends on a consideration of the requirements of science, conservation and the sensitivities of the site. A number of key management questions are identified and the answers point towards appropriate management. Indicators are also considered as a measure of management success. These indicators must address both the conservation of the site and the availability and destination of material of key scientific importance coming from it.

This model is illustrated using British examples and is also applied globally to palaeontological World Heritage Sites. As a follow-up from the *Earth Heritage World*

Heritage conference (Dorset, September 2004) a discussion paper on this model will be developed at www.geoconservation.com/conference.

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NOTE

This is a consultation paper. It draws on experience within the UK and particularly England, through the work of English Nature, The Joint Nature Conservation Committee and practical experience in Dorset including the Dorset and East Devon Coast World Heritage Site. Across the world there is a huge variety of fossil bearing sites and divergent views as too how they should be managed. The collection of fossils is an emotive subject. This paper aims to develop sound advice and practical guidance on the management of palaeontological sites.

We welcome all comments. There is a feedback form attached to the document. Responses will be tabulated and used to inform the ongoing discussion about the management of fossil sites.

Everyone with a view is invited to look at the proposed model and contribute examples to this paper. Please circulate to your colleagues.

The authors, September 2005

1. THE NATURE OF THE PALAEONTOLOGICAL RESOURCE

1.1 Introduction

Fossils are the remains or traces of once living animals and plants, and range from microscopic plant and animal skeletons through to large vertebrate remains. Fossils are an integral part of our natural heritage. Their study allows us to understand past environments and the evolution of life and they are used by Earth scientists to correlate (establish the age equivalence of) rock units in different parts of the world.

Scientific and popular interest in fossils was at its greatest in Europe in the early 19th century with palaeontological studies contributing significantly to an understanding of how life evolved on the planet and how environments changed through time. The evidence of early life provided by fossils was at the time at the forefront of scientific debate. Prior to the 19th century fossils were not generally accepted as evidence of early life on the planet, nor were the timescales implied by the fossil record and its evidence for evolution compatible with contemporary beliefs about the origin of the planet or the human species.

The study of present day processes, including contemporary ecosystems, helps us to understand how our planet evolved physically and how life developed and the saying *'the present is the key to the past'* is frequently quoted in geological texts. We now appreciate that an understanding of past processes is essential to understand how our planet's surface is likely to change in the future. In the face of global warming, changes to weather patterns, mass extinction of contemporary species and the rise of sea level it is important for human society to look into the future using our knowledge of the past. In this case the geological past is the key to understanding our future environment – 'the past is the key to the future'.

The recognition of the scientific significance of fossil evidence, and the educational and environmental importance of this aspect of our natural heritage, has encouraged the recognition at national and international levels of sites important for their palaeontological record. The recognition and conservation of such sites is now a well established practice in many countries.

This conservation effort is all the more important because the preserved rock record is fragmentary rather than continuous, reflecting the unstable nature of the planet's surface and the erosional processes that are constantly reworking surface materials. Unravelling the remnants of this record, and developing a detailed history of the planet, is the major achievement of the geological sciences, and the study of fossils has made a major contribution to this work.

1.2 The nature of the fossil record

Although the fossil record is fragmentary, fossil bearing rocks are common but the nature of the material they contain and its scientific importance varies. Fossils at a particular site may be rare or common, well or poorly preserved and macro or microscopic in size. A site may yield only a restricted number of species or may be of very high diversity. All fossil assemblages are scientifically useful and informative but those sites that attract particular scientific interest, and may merit conservation through protected area status, usually fall into the following categories:

- Sites yielding exceptionally well preserved specimens that may reveal details of soft body parts, unusual external anatomical detail or details of ecology, i.e. feeding habits, relationships between species. The species found at such sites may not in themselves be rare fossil groups, but the quality of preservation is high;
- Sites that yield rare fossil species - some species are known only from single sites;

- Sites that contain particularly diverse assemblages of fossils, represented by the presence of a variety of species;
- Sites giving rare/unique insight into evolutionary stages/processes - some sites capture otherwise elusive moments in the evolutionary record;
- Animals evolved through time, and certain fossils can be used to identify very specific periods of geological time. Many sites contain a sequence of fossils that enables the rocks to be dated relative to other sites locally, regionally or globally, but some sites provide a particularly good record;
- Sites that combine two or more of the above, for example the fossil 'Lagerstatten' that have high species diversity and high quality preservation recording with unusual clarity the details of fossil communities.

1.3 The value of fossils and important fossil sites

Sites that yield fossils, and the fossil specimens themselves, have a variety of values:

- Intrinsic value as natural phenomena;
- Scientific value as a record of the life on earth and its evolution;
- Scientific value as a record of past environments, environmental change in the past and possible indicators of future environmental change;
- Scientific value as tools to correlate (establish the age equivalence of) rock units in different parts of the world;
- As educational tools for specific scientific teaching and for general environmental education programmes;
- Cultural value as a key element in the growth of geological sciences and the role that geological science has had in shaping human understanding of the natural world and the origin of life, including our own species.
- Recreational value as a stimulating and rewarding activity that may lead to a deeper interest;
- Aesthetic value
- Commercial value as fossils collected for sale. The vast majority of commercially valuable specimens are common and aesthetically interesting specimens with relatively low scientific value. A small proportion may be highly valuable for their rarity and therefore scientific importance and/or aesthetic appeal.

These are the values that motivate people and lead to collecting pressure on sites.

1.4 The nature of collections

Scientific fossil collections can be categorised within four broad groups:

Key Scientifically Important Specimens (KSIS): specimens that define a species or contain new information about a species.
Stratigraphical assemblage: specimens that enable the rocks to be dated and correlated to similar aged rocks elsewhere. Within this interest it is essential the necessary fossils are collected *in situ* at the site.
Representative collections: collections that represent the full known fossil fauna from a site.
Educational collections: Teaching resources held at universities, colleges and schools.

These collections should be housed in museums or learning institutes such as universities. Some scientifically important collections are made by individuals where arrangements are in place for the collection to be transferred to a museum at some time in the future.

There are many other collections made for personal interest. Some may have a scientific basis, others may be a lifelong personal collection and yet others may be held entirely for the aesthetic value of the specimens. Such collections may have no scientific value or they may contain any number of significant specimens.

Other definitions of palaeontological heritage can be found in *Special papers in Palaeontology*, Crowther, Wimbledon. Palaeontological Association and Page K.N (2002) Geoconservation Working Group, International Subcommission on Jurassic Stratigraphy, Newsletter No 29.

2. A CLASSIFICATION OF GEOLOGICAL SITES

Geological sites vary considerably in their physical attributes and their susceptibility to damage or change. Their physical characteristics will reflect the geological features that are present and also the natural or man-made processes that have operated to create rock exposure. As a consequence, the sensitivity or robustness of these sites will vary greatly, as will the management needs and requirements.

The UK has developed a site classification scheme that reflects the complex nature of geological and geomorphological sites and provides the basis for a range of site management strategies. The site classification scheme adopted in the United Kingdom is based upon recognition of three categories of site (NCC 1990, *Earth Science Conservation in Great Britain – A strategy*, and revised by Murphy, M, 2005. *New Earth Science Conservation Classification*. Earth heritage, 24, 13-14.

Figure 1. The Earth Science Conservation Classification (ESCC) within the UK as developed by English Nature (Larwood and King)

CATEGORY	SITE TYPE
EXPOSURE SITES	Disused quarries, pits, cuttings
	Active quarries & pits
	Coastal & river cliffs
	Foreshore exposures
	Inland outcrops & stream sections
	Mines & tunnels
INTEGRITY SITES	Static geomorphological sites
	Active process geomorphological sites
FINITE SITES	Caves and karst
	Unique mineral, fossil or other sites
	Mine dumps

Exposure Sites: These provide exposures of fossil bearing rocks that may be extensive at the surface and widespread underground. In temperate terrains, with extensive vegetation cover, the sites where these rocks can be seen are typically restricted to quarries, rivers, foreshores and coastal cliffs. So long as quarrying or natural erosion continues, the resource is effectively unlimited. It is possible to have an 'integrity element' within an exposure site, a fossil rich layer, for instance, but the important consideration here is how quickly that layer is being uncovered by the human or natural erosion processes acting on the site. In countries with arid or cold climates, vegetation is sparse or absent (deserts or tundra) resulting in wide expanses of exposed rocks and, often, fossils.

Most sites are included within the exposure category and these are managed to maintain and enhance the key fossil exposures for which they have been identified. In the case of quarrying and coastal erosion, fresh exposures are created continually but at the same time there is a potential on-going loss of fossils. Responsible collecting can form an important element of conservation at such sites.

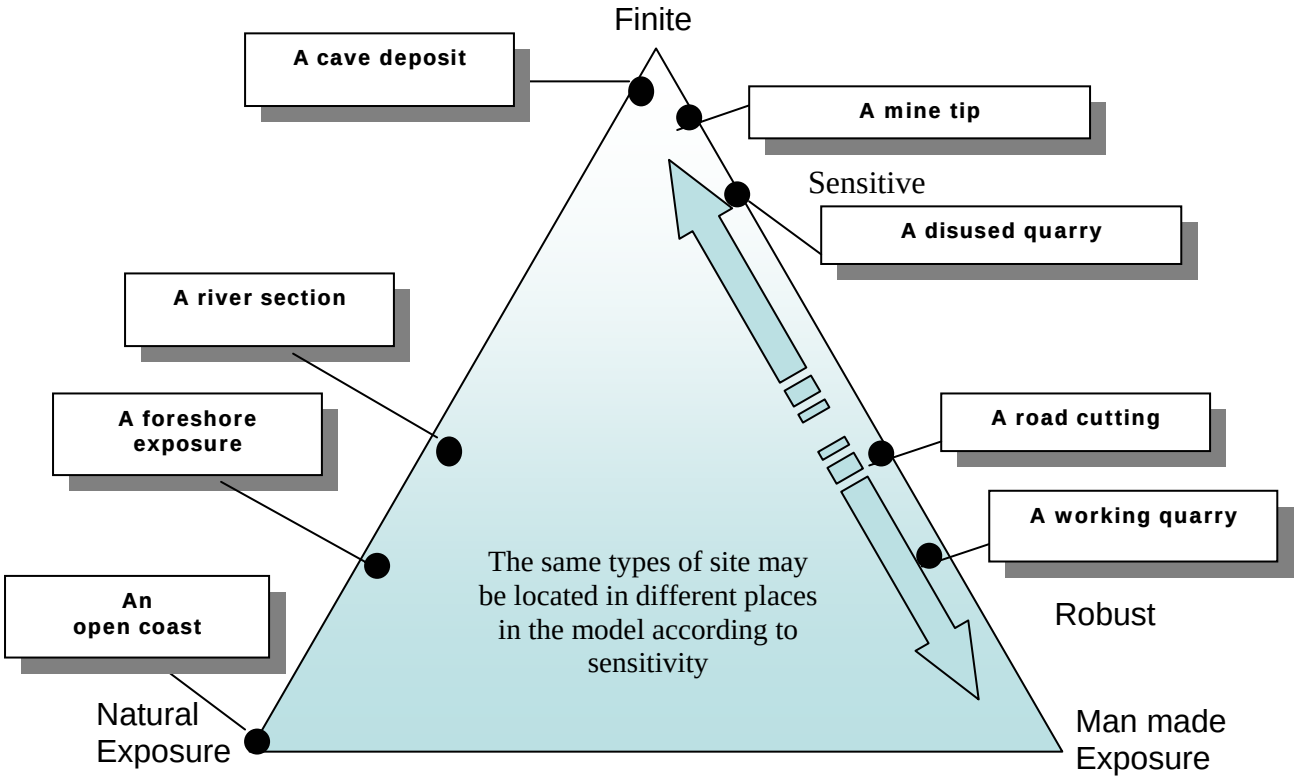
Integrity sites: These sites are principally geomorphological areas such as raised beaches, glacial features etc. These are not typically fossil bearing sites and therefore have little application in this paper.

Finite sites: this category contains sites that have a very limited or finite fossil resource which is irreplaceable if destroyed. This fragile category of sites includes fossil cave deposits or historical mine dumps where working has come to an end.

Finite sites are relatively uncommon but they require careful management and control. With such sites fossil collecting must be closely managed and is often limited to scientific research. These sites are typically quite small and can usually be afforded effective protection through fencing or policing.

This distinction between finite and exposure sites is central to the sustainable management of the resource. As a result, English Nature has developed a policy that requires *'the highest level of protection for our most finite and irreplaceable wildlife and natural features and the careful management of other natural assets'*.

Figure 2. A model for site classification



Fossil sites can be classified according to their sensitivity and this is a reflection on the size of the site or resource and the erosional processes acting on it. The same type of site may lie in a broad range within the model, depending on its sensitivity. For instance, a river cliff in a small stream section will lie toward the finite end of the scale compared with the bank of a very large river or estuary where the erosion rates will be higher.

3. PRINCIPLES AND PRACTICE OF SITE MANAGEMENT

Many people or ‘user groups’ have an interest in, or responsibility for, palaeontological sites. The conservation of the scientific value must be paramount but other factors may complicate this ideal. For many sites it is also possible to identify a sustainable level of use depending on the nature of the site. Indeed, collecting may well form part of the conservation. The concept of responsible collecting (English Nature *Position statement of fossil collecting* 1996 revised 2000, plus Larwood and King 2001) is an important management tool while the need to be inclusive in the management of sites is increasingly being recognised. The World Commission on Protected Areas has identified a new paradigm for protected areas (Thomas, Middleton and Phillips 2003) under the Best Practice Guidelines from the IUCN – The World Conservation Union and recognises that people, both expert and non expert, have a role to play in the management and use of sites. This paper embraces that concept. The IUCN work is focused on biodiversity and landscapes. There is potential to integrate geological heritage into this framework but that lies outside the scope of this paper.

3.1 The threats to palaeontological heritage

As with all other natural heritage features, fossils or the sites that contain them are under man-induced threat from a variety of sources. There are also natural threats to specimens, and, rarely, site integrity. Depending upon the type of site involved these threats include:

1. Landfill of quarry excavations;
2. Forestry developments;
3. Coastal defence works;
4. Housing or other building works;
5. Quarrying activity;
6. Degradation through neglect (encroachment of vegetation, rubbish etc);
7. Excessive or inappropriate collecting of specimens;
8. Loss or damage to fossils due to the process of exposure, natural erosion or human activity such as quarrying;
9. Lack of awareness of the scientific interest amongst collectors, landowners, site managers or planners;
10. Ineffective management.
11. Missed opportunity within temporary exposures such as road cuttings or pipeline laying or anywhere where fossils are being avoidably lost or destroyed.

The majority of these threats are 'incidental' to this paper in that they reflect land use changes of various kinds that can affect the integrity of a site and its continued use as a source of information and new fossil material. In some cases, fossil collecting may damage other interests such as archaeological or biological interest. Excessive or inappropriate collecting, loss or damage due to the process of exposure and ineffective management are the key issues for palaeontological management and are the focus for this paper. The identification of temporary exposures is a further key issue. This paper examines best practice in the management of such sites for palaeontological interest but the greatest challenge is in identifying the potential interest during the planning stage, long before excavation has begun.

3.2. The users of geological sites

The threats to fossil sites reflect the fact that a variety of collectors have an interest in fossils. These include:

- Collectors engaged in scientific research;
- Amateur collectors pursuing a personal interest;

- Recreational collectors;
- Professional collectors involved in commercial activity;
- Educational groups, both formal and informal.

The site will also be of interest to other groups, who may well have a responsibility for, but little awareness of, or interest in, the fossils;

- Landowners and land managers;
- Industry site managers (quarry managers, estate managers etc);
- Planners
- Local people

All of these different interest groups can have a positive part to play in the successful management of a site. All have the potential to damage the site in some way or other. The actions of individuals within any one group can have implications on how that group is perceived by others. Irresponsible collectors can give all collectors a bad name. Active and positive scientists develop constructive and fruitful relationships with collectors. Calls for excessive control on collecting can damage good will amongst the collecting community. Scientists who distance themselves from collectors promote disillusionment within the collecting community. Disinterested or over protective landowners or site managers make access difficult for all groups. Excessive regulation, especially where it is not enforced, can also be damaging to interest groups and the interest itself. Lewis M Simons captures the issue well in *'Fossil Wars'* published in the National Geographic Magazine, May 2005. Management should aim to maximise the relationships between the interest groups through creating a climate of cooperation, respect and trust. Effective management is as much about promoting these relationships as managing the site itself. *Partnerships in Palaeontology*, Manning. P. A Future for Fossils 2001. Furthermore, management may break down if one of these groups fails to play its part.

3.3 The ethics of collecting

People across the globe value fossils in different ways; scientifically, aesthetically, spiritually and commercially. The law in relationship to the ownership of fossils varies between countries and landowners have different expectations from their ownership. Collecting is a very human characteristic and in many cases opens the door to a deep and life long interest. For many palaeontologists, the spark of interest was originally fired by collecting fossil specimens. People can, and will collect, sell, exchange, donate, keep, study and be inspired by fossils.

The sale of fossils excites considerable debate. Many important fossils have come to the attention of science due to the efforts of commercial collectors. This group can invest large amounts of time and effort collecting because they sell the specimens. Academics in museums and universities do not have the time to search for specimens. In many sites, especially where specimen rescue is required, constant collecting is necessary and that collecting inevitably has a cost. The economic value of fossils largely reflects the time, skill and effort - 'the collecting investment'- in finding and preparing the specimens.

What is of fundamental concern for any site is that the interest is conserved so that scientific investigation can continue, key scientifically important specimens enter the collection of registered museums, fossils are recovered rather than destroyed and that, wherever possible, people are able to learn about, experience and enjoy the interest. People will always hold different values on fossil specimens. The real issue is to ensure that fossils are collected responsibly and at a level that is sustainable. The nature of the site where the specimens come from is the key to identifying a sustainable level of use.

3.4 Principles of site management

- Sites and the fossil material should be conserved in the best possible condition;
- Key scientifically important specimens and representative collections should be placed in museums;
- Collecting and/or the palaeontological interest should be accessible to as wide a public as possible;
- Management should be effective;
- Management should be inclusive and agreement on the management approach should be sought between landowners and other interest groups;
- The collection of fossils should be undertaken within the law;
- Collecting should be undertaken in a responsible and sustainable manner;
- Collecting should take into account health and safety considerations

3.5 Conservation objectives

- Material available for scientific study (*in situ* if required);
- Key scientifically important specimens are placed in registered museum collections;
- Fossil material is recovered from sites where it would be lost if not collected;
- Fossils collected in a sustainable fashion through responsible collecting
- The site remains in a favourable condition for scientific study and use.

3.6 What scale of collecting is sustainable?

Fossil collecting represents a specific management issue for sites that yield important specimens. Sustainable management of fossil sites is the policy objective of the nature conservation agencies in the United Kingdom, and the issue of collecting is directly addressed. 'Responsible collecting' of fossils from important sites - from all sites - is central to the sustainable management of the fossil resource (Larwood and King, 2001). This approach establishes the guiding principles relevant to all sites and all collectors. It also establishes the need to adapt this approach to the scale of the resource, to the exposure or integrity characteristics. Within this context, the scale of collecting that can be accepted as sustainable must be determined.

The concept of sustainable management as applied to fossil sites also addresses the wide range of values placed on, and potential uses of, the fossil resource. Different user groups have different expectations. *Sustainable management integrates scientific, environmental, educational and social considerations.*

3.7 Indicators of sustainable management

Indicators are needed to establish whether sustainable management is being achieved. Indicators of a sustainably managed fossil resource include:

- Scientific interest - the palaeontological interest for which a site is important is maintained (or enhanced). Fossil collecting is not threatening the site's scientific interest. Systematic monitoring is needed to gauge site condition.
- New fossils - important finds are still being made and recorded from the site;
- Behaviour - a responsible collecting ethic is adopted by site users and damage by inappropriate collecting is minimal or non-existent.
- Collaboration - those with a key interest in the fossil resource (scientists, museums, collectors, land owners, land managers) - work in collaboration to ensure long term viability.

Within the context of sustainable management, finite sites represent the most sensitive elements of the fossil resource requiring the most careful management. These form the 'tip of the iceberg' and the smallest group of sites within any national inventory. Exposure sites are broadly categorised according to their likely sensitivity with the least sensitive element of the fossil resource being found in eroding coastlines.

4. FROM THEORY TO PRACTICE

Selecting the best management option is about understanding the nature of the site, the palaeontological interest and the user groups and balancing all the factors within the management option. Ultimately, it must be possible to implement the management option and everyone must be given the opportunity to play their part: scientists, collectors, educational groups, site managers and wardens, museum curators and landowners. This is the real challenge for management.

There are at least 10 key questions that should be considered. All sites are different and the following is simply intended as a guide. Each question should help to identify the best approach to management of a site.

i. The nature of collecting

Is there collecting pressure on the site?

ii. The nature of the site

Is the site an exposure or integrity site? If it is an exposure site then fossil material or geological specimens will be at risk of being lost to erosion or machinery. If the site is a finite site then it is likely to be vulnerable and easily damaged. Are there finite elements within an exposure site?

iii. The nature of the interest

Are the fossils common or rare?
What proportion of fossils are of key scientific importance?

iv. The process of exposure

Are the processes that uncover the fossils predictable or unpredictable? If they are predictable, then the recovery can probably be controlled but if they are unpredictable then it may be difficult to ensure that the material is recovered.

v. The window of opportunity

Is the time when the specimens are being exposed short or long? If short (a few days or weeks), and predictable, then it is easier to engage specialists in their recovery. However, if the time is longer (months or years), then this becomes increasingly difficult, especially if the process of exposure in unpredictable.

vi. The nature of the access

Is the access controllable (e.g. can it be fenced) or can it be policed (patrolled)? Will control be effective? Is this approach desirable/appropriate? What will the implications be to user groups if access is restricted?

vii. Ownership

Is the ownership straightforward or complex…i.e. does the interest lie within one ownership or span multiple owners? Is the landowner interested in specimen conservation? Is the site protected/designated and how does that affect ownership? Do the fossils have a commercial value? If so, how much of that value is 'intrinsic' and how much is 'added' by collection (i.e. the collector investment).

viii. The needs of the science

What are the scientific needs? What requirements are there for the material to be studied in situ? Should the material be prepared (cleaned)? or unprepared How much material? (Key scientifically Important Specimens (KSIS) and/or representative collections.) Are scientists engaged in the site? Are scientists available to do the work?

ix. Museum collections

Do museums have the space, skills and funds to acquire, prepare (clean) and curate new specimens?

x. The skills of collecting

What skills are required to recover fossils? (high, medium or low). If high, are those skills available when required? What is the best way to ensure that those skills are to hand? What are the cost implications?

4.1 Management options

In selecting the most effective management option, consideration of the following should also be made;

- The **implications** for the relationship between the different user groups.
- The **effectiveness** of the chosen approach.
- The **interests and responsibilities** of the landowner/site operator
- The **costs** of the selected/preferred management approach.

Three broad options are proposed:

a. Open collecting:

If management is not necessary, undesirable, impractical, unachievable or likely to be counter productive, then this is the best option. This option gives people access to the interest under the principles of 'responsible collecting' as developed by English Nature.

b. Open managed collecting:

If there are aspects of the site or fossil resource that require a degree of protection and that protection can be provided effectively. This may involve codes of conduct, working conditions (for health and safety for instance) or collectors working under the supervision of scientists with the understanding that key scientifically important specimens are retained and placed in registered museums.

c. Controlled Collecting:

If it is necessary and possible to establish complete control.

4.2 Trying it out in practice

Below is a guide to how the 10 questions of management may be used and how the answers point towards the best management option. No one factor can dominate the preferred choice of management option. For example, the recovery of scientifically important specimens is paramount but that does not mean that control should always be the preferred option since the management has to be effective. The fact that a site may be protected by law or that the specimens may belong to the state is almost immaterial in the selection of the management option for exactly the same reason. If these sites cannot be controlled, then people will continue to collect. Ineffective management will drive collecting underground or stop collecting altogether, in which case specimens will not come to the attention of science or will be destroyed by the processes that expose them. Furthermore, just because a site is an exposure site does not automatically suggest open collecting. It favours it but it may not be the right approach. Similarly, if a site can be policed, that does not mean that it should be, especially if there is no collecting pressure.

Figure 3. A template for the 10 questions of management

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	*Is there collecting pressure?*	'Yes' 'No'	Suggests managed or controlled collecting Suggests open collecting		
The nature of the site:	*Finite*	'Yes'	Strongly points to controlled collecting		
	Exposure	'Yes'	Favours open collecting		
The nature of the interest	*Are fossils common?*	'Yes'	Favours open collecting		
	Or rare?	'Yes'	Favours managed or controlled collecting		
The process of exposure	*Predictable*	'Yes'	Favours managed or controlled collecting		
	Unpredictable	'Yes'	Favours open collecting		
The window of opportunity	*Short term*	'Yes'	Favours managed or controlled collecting		
	Long term	'Yes'	Favours open collecting		
The nature of access	*Controllable*	'Yes'	Favours managed or controlled collecting		
	Policed?	'Yes'	Favours managed or controlled collecting		
	Uncontrollable	'Yes'	Favours open collecting		
Ownership	*Clear*	'Yes'	Favours managed or controlled collecting		
	Complex	'Yes'	Favours open collecting		
The needs of science	*How much material?*		KSIS and or representative collections		
	Material studied in situ?	'Yes'	Favours managed or controlled collecting		
Museums & research	*Are there resources for acquisition?*	'Yes' 'No'	Favours open collecting Favours managed or controlled collecting		
	Are scientists engaged?	'Yes' 'No'	Must be considered in management		
The skills of collecting	*High skills required?*	'Yes'	Must be considered in management		
	High skills available?	Yes/no	Must be considered in management		

Selecting the best management option is about balancing the nature of the site with the collecting pressure to achieve a practical and effective solution for conservation. Ultimately it is about the relationship between the user groups. This is the challenge of management; creating the right environment where relations between the user groups can grow and where these people accept the management. Jean-Pierre BERGER makes reference

to the importance of the relationships in *'Geotypes et collectionneurs de fossils: dangers et Avantages'* Geologia Insubrica, Vol 4 1999.

This paper cannot and does not seek to prescribe the final management option for any type of site for the simple reason that such options need to be developed in consultation with the user groups. There are many models for management but none should be parachuted into a site without discussion, understanding and agreement on the best approach. In some instances it may not be possible to achieve complete agreement between all user groups or individuals within these groups. In such circumstances, it is important to demonstrate the process by which the management option was chosen and to demonstrate that the management is working.

4.3 The **Portable Antiquities Scheme** provides a very good example of adaptive management. Within the UK, outside of historically protected sites, metal detectorists can search for archaeological objects so long as they have permission from the landowner. There is no way to control this activity. The Portable Antiquities Scheme recognises this and works by encouraging collectors to record their finds. They also provide workshops and public events to promote awareness. The Annual Report for 2003/4 records that some 47,099 objects were recorded by 2,376 individual people. 403 of these objects were treasure trove. This approach is the most effective way to make the most from this activity. It remains a voluntary initiative and yet huge numbers of people contribute to it. The reason? The management is right, it is inclusive and it allows people to contribute and harnesses all their energy and enthusiasm. If archaeologists turned their backs on these collectors because they did not approve of their activities, the collectors would nevertheless continue and the information would be lost.

5. CONCLUSIONS

Sites that contain important fossil specimens or assemblages vary considerably in size and other physical characteristics. The nature and scale of human related pressures on sites also varies. To develop successful management plans, and to monitor their effectiveness, requires such plans to be site specific. Management plans must address the physical nature of each site, the nature and volume of the geological formations present and their susceptibility to damage and change.

Actual and potential human impacts on fossil sites also need to be assessed and taken into account in developing management plans. The needs of various users, specialist and non-specialist, must be considered and met provided this can be achieved in a sustainable fashion.

Where a site can be controlled and is so sensitive that it needs to be controlled, then management should be controlled access. However, where access cannot be controlled attempts to do so will simply lead to continued collecting and the specimens will not come to the attention of scientists. This also applies to sites where the process of exposure is unpredictable and where the window of opportunity is long. If scientists are unable to undertake the collecting (and there are numerous examples where this is the case) then collectors acting responsibly, offer the best opportunity to save specimens from destruction by the processes that expose them. Positive relationships will always be more effective. Cooperation is thus the key to successful management.

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Portable Antiquities Scheme *Annual Report 2003/4* Museums, Libraries and Archives Council, 16 Queen Anne's Gate, London SW1H 9AA

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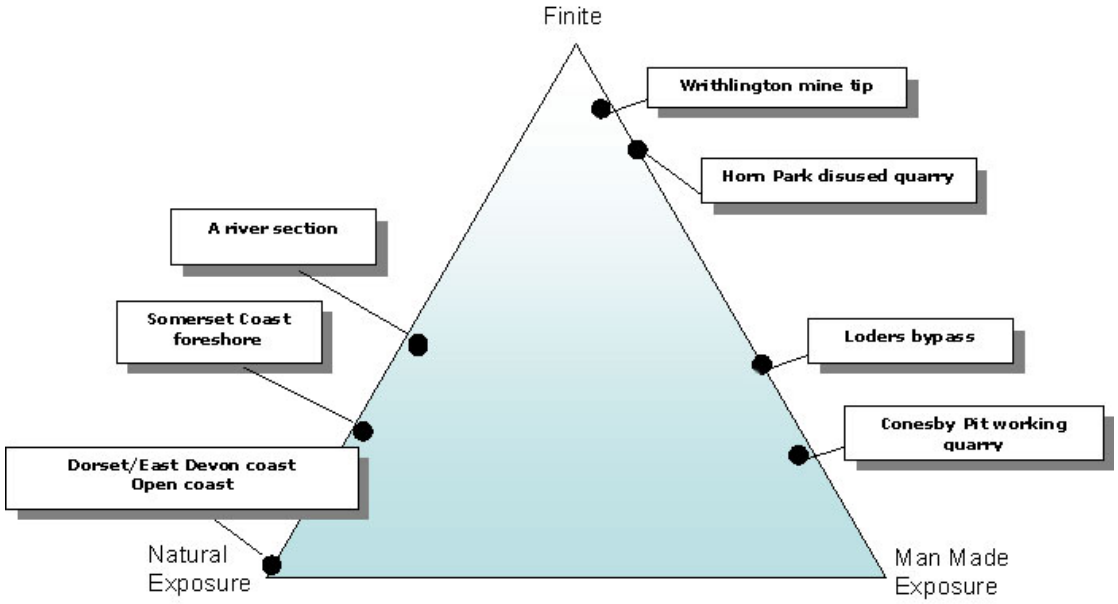
APPENDIX 1. A site based approach; examples from the UK



The Dorset and East Devon Coast, World Heritage Site

The coast between Lyme Regis and Burton Bradstock lies within the wider World Heritage Site and contains one of the finest sequences of Lower Jurassic rock successions in the World. It is also the richest source of Lower Jurassic reptiles, fish and insects of that age anywhere. This is a classic exposure site of the highest degree with massive landslides and winter storms providing an inexhaustible supply of fossils, both common and rare to the beaches. There are at least 12 access points (10 accessing both east and west into the site) between Pinhay Bay (west of Lyme Regis), and Burton Bradstock beach, a distance of some 15km and the interest is contained within remote sections of foreshore, cliff and landslide complexes.

Collecting has been a part of this coastline for more than two hundred years. The Anning family, most notably Mary Anning (1799-1847), discovered the first ichthyosaur, plesiosaur and flying reptile to come to the attention of science and this is the only locality where the early ornichischian dinosaur, *Scelidosaurus harrisoni* is known to occur. Discoveries new to science continue to be made by local collectors both amateur and professional/commercial, for example *Lectonectes moorei*, discovered in 1994 and now part of the Natural History Museum collection, London. A core group of local professional collectors is active and supports workshops and fossil shops in Lyme and Charmouth.

The coast is also popular with tourists and educational groups. The Charmouth Heritage Coast Centre was established in 1985 to focus the interest and provide information and advice on best collecting practice. In both Lyme Regis and Charmouth, fossil shops and museums provide a popular guided walks service.

The 10 questions of management in relation to an open and actively eroding coastline: the West Dorset coast, part of the Dorset and East Devon Coast World Heritage Site

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?	Yes	✓	✓	✓
The nature of the site:	Finite	No			
	Exposure	Yes	✓(11)	✓	✓
The nature of the interest	Are fossils common?	Yes	✓(12)		
	Or rare?	Yes		✓	✓ (1)
The process of exposure	Predictable	No			
	Unpredictable	Yes	✓ (2)		
The window of opportunity	Short term	No			
	Long term	Yes	✓ (3)		
The nature of access	Controllable	No	✓ (4)		
	Policed?	No	✓ (5)		
	Uncontrollable	Yes	✓		
Ownership	Clear	No			
	Complex	Yes	✓ (6)	✓	✓
The needs of science	How much material?	KSIS		✓	✓(10)
	Material studied in situ?	Yes		✓	✓(9)
Museums & research	Are there resources for acquisition?	Limited		✓	✓
	Are scientists engaged?	Some			
The skills of collecting	High skills required?	Yes	(7)		
	High skills available?	Yes	(8)		

Selecting the management option

Although a hugely important site for rare fossil material (1), the process of exposure is unpredictable (2), the window of opportunity is continuous (3), the site cannot be effectively controlled or policed (4 and 5) and the ownership is complex (6). Furthermore, this site requires great collecting effort to ensure the best chance of key scientifically important specimens being recovered, and the local professional collectors are available (7) and best placed to do that (8). The time that these collectors invest in searching for fossils and cleaning them generally reflects the value of the specimens they find.

Management option: **Open collecting** and **Open managed collecting**

The spread of indicators points to 'open collecting' but the nature of the rare material requires that a control should be in place, but that has to be achievable. This is an example of 'open managed collecting' for the experienced collectors, which has the effect of controlling digging *in situ* along fossil rich layers (9) and recording the Key Scientifically Important Specimens (10) by working with collectors, coupled with 'open access' for the public. This is an exposure site (11) of the highest degree and therefore very robust and able to withstand high collecting pressure. Fossils are common (12) and therefore collecting is sustainable.

Open managed collecting is achieved through a fossil collecting code of conduct which was established in 1998 agreed between all interest groups. The code aims to control digging

along certain fossil rich strata and provide for the recording of key scientifically important specimens recovered from the site. The core of the code is straightforward and requires collectors not to dig *in situ* without permission and to record their important discoveries. The code has greatly reduced digging in the cliffs and has established a record of important finds. Details of the code and records of specimens found are available at www.charmouth.org under the 'fossils' section. The site remains in a favourable condition and all fossil bearing strata are accessible for scientific study.

Indicators of sustainable management:

Scientific interest *- the palaeontological interest for which a site is important is maintained (or enhanced). Fossil collecting is not threatening the site's scientific interest.*
YES: All fossil bearing strata are accessible
New fossils *- important finds are still being made and recorded from the site;*
YES: 75 specimens of Key Scientific Importance recorded
Behaviour *- a responsible collecting ethic is adopted by site users and damage by inappropriate collecting is minimal or non-existent.*
YES: The great majority of local, expert collectors follow the fossil code
Collaboration *- those with a key interest in the fossil resource (scientists, museums, collectors, land owners, land managers) work in collaboration*
YES: Fossil code working group meets regularly to discuss the code BUT individual collaboration between collectors and scientists could be better.

The elements of this approach that still require addressing are that funding for acquisition is limited, engagement between scientists representing some of the interests is poor and enforcement against a very small minority of irresponsible collectors who continue to dig *in situ* continues to be a challenge. Is there an alternative approach? Could collecting be absolutely controlled? How many staff would be required to both recover the fossils and police the beaches? What powers would they have to stop and search people on the beaches?

Conesby Quarry, Scunthorpe, North Lincolnshire

An extensive quarry site once worked for the Lower Jurassic Frodingham Ironstone and then, in the late 1980's worked for aggregate with the site being progressively filled with landfill - a classic man made exposure site of low sensitivity. At the time of working, there was no formal management of collecting in place but it illustrates the principles applicable to this type of site.

The ammonite fauna from the ironstone is well known and well represented in the Scunthorpe Museum. The quality of preservation can be exceptional, with some ammonites having striking green chamosite shells and in filled with calcite of various colours. Prior to professional collecting interest, many thousands of such specimens and an unknown volume of other material were simply crushed for aggregate. Collectors approached the quarry managers and the landowner for permission to collect. During the time when these collectors were active, they found a significant number of unusual specimens and in total nearly one hundred fossils were voluntarily donated to Scunthorpe Museum, through an agreement arrived at between the collectors, owners of the mineral rights and the local museum (Thompson.S *Future for Fossils* 2001 page 65). Quarrying has now ceased but a stockpile of ironstone has been transferred to a nearby locality and a representative section of the sequence conserved at an adjacent site. Sole.D.T.C *The role of the private collector: two case histories* page 78-84 A Future for Fossils 2001.

The 10 questions of management in relation to a working quarry: Conesby Quarry

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?	Yes	✓	✓	✓
The nature of the site:	Finite	No			
	Exposure	Yes	✓	✓	✓
The nature of the interest	Are fossils common?	Yes	✓		
	Or rare?	Yes		✓	✓ (1)
The process of exposure	Predictable	Yes		✓	✓(3)
	Unpredictable	No			
The window of opportunity	Short term	No			
	Long term	Yes	✓ (2)		
The nature of access	Controllable	Yes		✓	✓(4)
	Policed?	Yes		✓	✓
	Uncontrollable	No			
Ownership	Clear	Yes		✓	✓ (5)
	Complex	No			
The needs of science	How much material?	KSIS		✓	✓(1)
	Material studied in situ?	Yes		✓	✓
Museums & research	Are there resources for acquisition?	Limited		✓	✓
	Are scientists engaged?	Some			
The skills of collecting	High skills required?	Yes			
	High skills available?	Yes			

Selecting the management option

This was a working quarry where material was being destroyed. The site had the potential to yield rare specimens (1) and the window of opportunity was long term (2). However, the process of exposure was predictable (3), allowing scientists to be present at the crucial times should they be available and wish to do so, and access could be controlled (4). In this situation 'Open managed collecting' would be the best option. Collectors should be allowed on site (subject to health and safety considerations) because of the long window of opportunity (2) and they should work to an agreement whereby all material is assessed for scientific importance and material key importance is retained. (This would require a clear and agreed definition). Scientists would be able to identify the best time to undertake field work. The landowner (5) may wish to profit from such a site and consideration should be made for that. The best way to provide maximum collecting effort is through collectors being on site and with significant benefits to encourage them to play their part.

Suggested management option: **Open managed collecting**

The priority for management at such sites should be access for scientific study and the rescue of a representative collection which should then be placed in museum collections. It should also consider the rescue of non-scientific specimens that would otherwise be destroyed without collecting. Collectors should be allowed on site but all material found should be assessed for scientific importance, under agreed criteria, and key important specimens should be retained for museum collections. There is also the very real issue of health and safety. This

is a good example where the contractor's interest in completing the excavation to time and under agreed health and safety guidelines may conflict with the needs of management for the fossil interest.

Indicators of sustainable management:

Scientific interest *- the palaeontological interest for which a site is important is maintained (or enhanced). Fossil collecting is not threatening the sites scientific interest.*
NO: Quarrying has now ended but a stockpile of material has been set aside
New fossils *- important finds are still being made and recorded from the site:*
YES: Nearly 100 specimens recovered and donated to the local museum
Behaviour *- a responsible collecting ethic is adopted by site users and damage by inappropriate collecting is minimal or non-existent.*
YES: Collectors acted responsibly
Collaboration *- those with a key interest in the fossil resource (scientists, museums, collectors, land owners, land managers) work in collaboration*
YES: Collectors worked with proactive museum curators

Loders Bypass, Dorset UK

An example of a temporary excavation within the low sensitivity side of the exposure site category. The excavation created a rare opportunity to study and collect fossils from the Middle Jurassic Inferior Oolite. Across its outcrop, the Inferior Oolite is highly variable. No two outcrops are identical as there are gaps in the rock record within each. These can be seen as erosion surfaces within the rock succession but are also detected by the presence or absence of certain fossil ammonites. The Inferior Oolite is complex and any opportunity to study and collect specimens is of great scientific value.

The road cutting was created in 1982. There was no agreed management for the fossil interest. Indeed, there was no awareness amongst planners and contractors of that interest. Local collectors approached the contractors in order to gain access and recover the material. One of the key issues within temporary exposures is to identify them and the likely interest long before the excavation begins and ensure that scientific study and specimen rescue is incorporated into the management of the site. This is established practice within the UK planning system for archaeology, nature conservation and landscape but geology has often been overlooked.

The 10 questions of management in relation to a temporary exposure: Loders Bypass

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?	Yes	✓	✓	✓
The nature of the site:	Finite	No			
	Exposure	Yes	✓(6)	✓	✓
The nature of the interest	Are fossils common?	Yes	✓(7)		
	Or rare?	Yes		✓	✓(1)
The process of exposure	Predictable	Yes		✓	✓(3)
	Unpredictable	No			
The window of opportunity	Short term	No			
	Long term	Yes	✓ (8)		
The nature of access	Controllable	Yes		✓	✓(4)

	Policed?	Yes		✓	✓
	Uncontrollable	No			
Ownership	Clear	Yes		✓	✓ (5)
	Complex	No			
The needs of science	How much material?	Rep & KSIS		✓	✓(2)
	Material studied in situ?	Yes		✓	✓
Museums & research	Are there resources for acquisition?	Limited		✓	✓
	Are scientists engaged?	Some	(9)		
The skills of collecting	High skills required?	Yes			
	High skills available?	Yes			

Rare fossils will be uncovered during the excavation (1) and there is a need to retain both a representative collection and key scientifically important specimens (2). The process of exposure is predictable (3), controllable (4) and the ownership is clear (5). However, this is an exposure site (6), there are going to be a great many fossils destroyed if not collected (7), the window of opportunity is long (over six months) (8) and the availability of scientists is limited (9). There will also be health and safety considerations with regard to access.

Suggested management option: **Open managed collecting**.

Scientists should have priority access but the rescue nature of the dig and the long window of opportunity will require collecting effort every day of the excavation. Because access can be controlled, it will be possible to allow collectors access to the site on condition that the material found is reviewed for scientific importance and, under agreed criteria, those specimens regarded as of sufficient importance should be retained and placed in museums. This approach was adopted for the nearby Charmouth Bypass of 1990. In that case, a team of local collectors was allowed on site under the conditions outlined above but a scientist was also employed to undertake recording. Even in this instance, numerous fossils were lost to the excavators but a great many were rescued due to the co-ordinated effort of these collectors. Sole.D.T.C *The role of the private collector: two case histories* page 78-84 A Future for Fossils 2001

Horn Park Quarry, Site of Special Scientific Interest, Dorset

Horn Park Quarry SSSI, Dorset, has long been recognised as internationally important as a section through the Middle Jurassic Inferior Oolite limestone. This was once a working quarry and therefore an ‘exposure’ site but now only a small un-worked area remains, placing it towards the most sensitive end of the exposure category. During its working life, countless fossils, most notably ammonites, were collected by scientists and private collectors from Dorset, England and the world. A series of light industrial units have now been built on part of the quarry floor and the unworked area remains in one corner of the former quarry.

The 10 questions of management in relation to a disused quarry: Horn Park

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?	Yes	✓	✓	✓

The nature of the site:	Finite	Yes			✓ (1)
	Exposure	No			
The nature of the interest	Are fossils common?	Yes	✓		
	Or rare?	Yes		✓	✓
The process of exposure	Predictable	Yes		✓	✓
	Unpredictable	No			
The window of opportunity	Short term	Yes		✓	✓
	Long term	No			
The nature of access	Controllable	Yes		✓	✓(2)
	Policed?	Yes		✓	✓
	Uncontrollable	No			
Ownership	Clear	Yes		✓	✓
	Complex	No			
The needs of science	How much material?	KSIS		✓	✓
	Material studied in situ?	Yes		✓	✓(3)
Museums & research	Are there resources for acquisition?	Limited		✓	✓
	Are scientists engaged?	Yes			
The skills of collecting	High skills required?	Yes			
	High skills available?	Yes			

Selecting the management option

Quarrying has ended and only a small area remains un-quarried. It is unlikely that an extension of the quarry will ever take place in the future, and coupled with the international importance of this site, it should be regarded as entering the finite category. Controlled collecting (1) is the correct option for this site. Access to the site is controllable (2) and has been policed to an extent. It is important that the material is available for study *in situ* (3).

Suggested management option: **Controlled collecting**

The first three factors alone support **controlled collecting** as the correct management option. This site needs to be fenced to protect the interest. Consideration should be made for further scientific excavation. This site has great potential for educational use but that needs to be strictly controlled. There is some work to do here!

Currently this paper is under development and other sites are invited to contribute by trying the model out. Suggestions include:

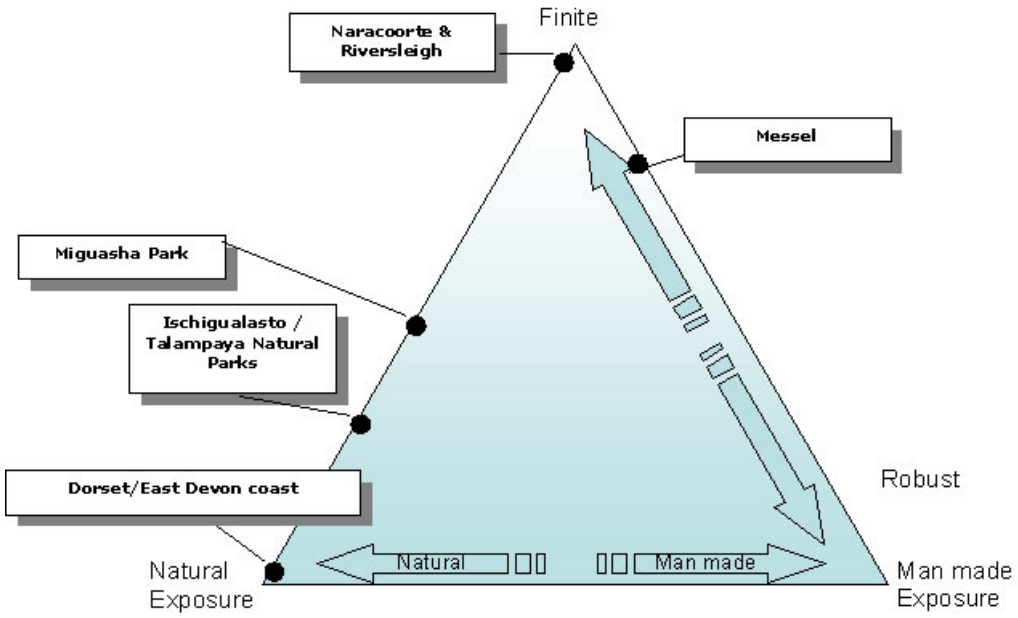
Writhlington mine dump

The Somerset coast – foreshore exposure

Birk Knowles, Southern Scotland - A river section

APPENDIX 2. A site based approach; examples from World Heritage Sites

Currently this paper is under development and other sites are invited to contribute by trying the model out.



Naracoorte Caves fossil mammal site - Australia

Naracoorte and Riversleigh are two sites are representative of the development of Australia's mammal fauna. Riversleigh's faunal assemblages have profoundly altered understanding about Australia's mid-Cainozoic vertebrate diversity. The Pleistocene fossil vertebrate deposits of Victoria Fossil Cave at Naracoorte are considered to be, in terms of volume and diversity, Australia's largest and best preserved. Cave and fissure deposits are significant at these sites.

The 10 questions of management in relation to a cave deposit: Naracoorte Caves

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?	No		✓	✓
The nature of the site:	Finite	Yes			✓(1)
	Exposure	No			
The nature of the interest	Are fossils common?	No			
	Or rare?	Yes			✓(2)
The process of exposure	Predictable	Yes			✓(3)
	Unpredictable	No			
The window of opportunity	Short term	Yes			✓(4)
	Long term	No			
The nature of access	Controllable	Yes			✓(5)
	Policed?	Yes			✓
	Uncontrollable	No			

Ownership	Clear	Yes			✓(6)
	Complex	No?			
The needs of science	How much material?	All			✓(7)
	Material studied in situ?	Yes			✓(8)
Museums & research	Are there resources for acquisition?	Not applicable			
	Are scientists engaged?	Yes			✓(9)
The skills of collecting	High skills required?	Yes			
	High skills available?	Yes			

The answers to the questions and the implications for the best management option are, not surprisingly, almost exactly opposite to those for the West Dorset coast, another palaeontological World Heritage Site. This is a finite site (1), all the fossils are rare(2), the process of exposure is entirely predictable (3), the window of opportunity is short (4) (scientists agree a time, date and duration for an excavation and then do it). Significantly, the site is totally controllable (5), the ownership is clear (6), all the material is important (7), all needs to be excavated from in situ (8), by scientists (9).

Management option: **Controlled collecting**

Research undertaken by palaeontologists involves the removal of fossil-bearing limestone from the nominated site under permit. The caves are gated and bolted because they need to be and they can be. Explosives may be used to extract limestone, although its impact is restricted to very small areas. The most significant impact on the natural condition of the site is the collection of fossil-bearing limestone by palaeontological researchers. However, the impact is minor and localised. Public access is allowed through guided walks and interaction with scientists and managers working on site.

One of the conflicts is that researchers from different disciplines impact on the site through poor methodologies where palaeontological and other values are unnecessarily impacted.

Other suggested examples. Site managers to be encouraged to contribute

Messel Pit

Miguasha Park, Canada

Ischigualasto / Talampaya National Parks
Argentina

APPENDIX 3

Site management proforma

Key questions		Answer	Management options		
			Open collecting	Open managed collecting	Controlled collecting
The nature of collecting	Is there collecting pressure?				
The nature of the site:	Finite				
	Exposure				
The nature of the interest	Are fossils common?				
	Or rare?				
The process of exposure	Predictable				
	Unpredictable				
The window of opportunity	Short term				
	Long term				
The nature of access	Controllable				
	Policed?				
	Uncontrollable				
Ownership	Clear				
	Complex				
The needs of science	How much material?				
	Material studied in situ?				
Museums & research	Are there resources for acquisition?				
	Are scientists engaged?				
The skills of collecting	High skills required?				
	High skills available?				

APPENDIX 4

Sustainable site-based management of collecting pressure on palaeontological sites

Consultation feedback

Feedback questionnaire

Your reactions to the ideas and views set out in this paper would be most helpful. We have therefore prepared the following questionnaire and would be grateful if you cold take the time to complete it.

To complete the questionnaire online, or to download an editable version in a Word format (to be returned to GeoConference@jncc.gov.uk), please click on the links below.

Online: http://www.geoconservation.com/EHWH/docs/fossilqus.htm
Word format: http://www.geoconservation.com/EHWH/docs/fossilqus.doc

We regret that anonymous responses will not be accepted.

Name:

Contact e-mail/tel number:

Interest: (scientist, museum curator, landowner, site manager, collector, student, other (specify) etc…..)

Are you prepared for your comments to be attributable and available on line? YES/NO

Do you agree or disagree that a site based approach to the management of palaeontological heritage is a useful approach? YES/NO

Why? (for or against)

Is it the best approach or is there a better way? YES/NO

Do you agree or disagree that management is as much about the relationship between user groups as it is about a site? YES/NO

Why? (for or against)

Do you agree or disagree with the principles of site management as defined in this paper: (tick or cross as appropriate)

- Sites and the fossil material should be conserved in the best possible condition;
- KSIS and representative collections should be placed in museums;
- Fossils should be saved from destruction where ever possible;
- Collecting and/or the palaeontological interest should be accessible to as wide a public as possible;
- Management should be effective;
- Management should be inclusive and agreement on the management approach should be sought between landowners and interest groups;

- The collection of fossils should be undertaken within the law:
- Collecting should be undertaken in a responsible and sustainable manner

Any comments on the above…….

Do you agree or disagree with the conservation objectives: (tick or cross as appropriate)

- Material available for scientific study (*in situ* if required);
- Key scientifically important specimens are placed in registered museum collections;
- Fossil material is recovered from sites where it would be lost if not collected;
- Fossils collected in a sustainable fashion through responsible collecting
- The site remains available for scientific study and use.

Any comments on the above…….

Do you accept or oppose the sale of fossil specimens? YES/NO

Why?

Are the proposed 10 questions of management useful? YES/NO

What questions are missing?

Are the three broad management options correct or are there others?

Do you agree or disagree with the considerations for management? (tick or cross as appropriate)

- The **implications** for the relationship between the different user group/s.
- The **effectiveness** of the chosen approach.
- The **interests and responsibilities** of the landowner/site operator
- The **costs** of the selected/preferred management approach.

Do you believe that it is possible to have regulation even when it is not possible to enforce that regulation? YES/NO

If yes, why?

Do you agree or disagree with the management options identified for:

The West Dorset Coast
Conesby Quarry
Loders Bypass
Horn Park Quarry

If you disagree, why?

And finally

Is there anything missing in this paper? Do you have any other comments?

Please return to:
GeoConference@jncc.gov.uk