BRITISH FOSSIL REPTILE SITES

by MICHAEL J. BENTON

ABSTRACT. Britain has a rich heritage of over 500 recorded fossil reptile sites. Of these, fifty have been designated as SSSIs because of their potential for research. The only valid justification for conservation of these sites is scientific, and their role is crucial for the proper furtherance of vertebrate palaeontology. Changes in quarrying techniques and reductions in the number of informed fossil collectors mean that these older sites must be conserved and exploited scientifically, since new sites will become available only rarely. Palaeontologists rely on the NCC to identify and conserve SSSIs effectively, and to facilitate collecting and excavation for scientific purposes.

THERE is currently some discussion over the meaning of conservation with respect to palaeontological sites. Is conservation to be an end in itself, or is it to be justified solely on scientific grounds (Benton and Wimbledon 1985; Allen *et al.*, in press)? In this paper, I shall argue that the scientific justification for palaeontological site conservation is the only valid one, and that all other proposed justifications--educational, recreational, cultural, aesthetic, and inspirational, either follow inevitably, or are not relevant. I shall then try to analyse the kinds of uses to which fossil reptile sites are put, and therefore the importance of different conservation approaches. This clearly has a bearing on the role of statutory conservation bodies such as the Nature Conservancy Council (NCC). I write from both sides of the fence, having worked for the NCC in 1981 and 1982 to identify Britain's key fossil reptile sites, and now as a university-based research palaeontologist, a user of sites.

HISTORICAL SUMMARY

Britain has a rich heritage of fossil reptile sites and, as with most other geological topics, the diversity of such sites is greater than the size of the country might suggest. The first known illustration of a British fossil reptile was given by Plot (1677), who showed the distal end of a *Megalosaurus* femur from Cornwell parish, Oxfordshire. The specimen is now apparently lost, as is the site. However, maps of Cornwell parish show traces of a number of old quarries, and careful searches might identify the original site. Further remains of dinosaurs from the Middle Jurassic of Oxfordshire were noted by authors such as Lhwyd (1699), Woodward (1728), and Platt (1758) (see review by Delair and Sarjeant 1975). Marine crocodiles from the Lower Jurassic of the Yorkshire coast were first noted by Chapman (1758) and Wooller (1758). Major systematic collections of fossil reptiles were begun in the nineteenth century, when large numbers of ichthyosaurs and plesiosaurs were collected from the Lower Jurassic of the Dorset coast (Conybeare 1821) and the Yorkshire coast (Young and Bird 1822). Further dinosaurs were collected at the same time from the Middle Jurassic of Oxfordshire (Buckland 1824) and the Lower Cretaceous of south-east England (Mantell 1822, 1825). Footprints of unknown animals were reported from the Permo-Triassic of England and Scotland (Buckland 1828; Grierson 1828). After 1830, major collections began to be made throughout the country, and the diversity of British reptile sites, ranging in age from the Permian to the Pleistocene, soon became apparent.

The total number of individual sites in Britain that have been recorded as a source of reptile remains (bones or trackways) was estimated conservatively by Benton and Wimbledon (1985) as 490 (10 Permian, 60 Triassic, 230 Jurassic, 150 Cretaceous, 40 Tertiary and Pleistocene). These sites consist largely of quarries, civil engineering excavations (railway and road cuttings), and

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coastal exposures (text-fig. 1); the great majority had been discovered by about 1890. There could be a number of reasons why so few new fossil reptile sites have been found this century, and I list them in what I believe is their approximate order of decreasing importance:

1. *Changes in the extractive industries.* The demand for building stone is less now than it was in the nineteenth century. At one time, nearly every rock type was exploited for building purposes, and each village or town was supplied by one or more quarries. Now, whole geological formations that once yielded abundant fossil remains are not worked at all, e.g. the Permo-Triassic of Elgin in Scotland, the Stonesfield Slate of Oxfordshire, and much of the Wealden and the Chalk. A second aspect of this is that quarrymen today use largely mechanical extraction techniques (blasting, draglines, large diggers) and any fossils in the rock are not seen. The Oxford Clay around Peterborough used to yield dozens of exquisitely preserved marine reptiles, but the large-scale digging equipment used now probably destroys most of the bones.

2. *Lack of interest in field collecting.* The collections of many museums are so good that many vertebrate palaeontologists do not feel the need to collect new specimens in the field. It is often said that the best fossil hunting is done in museum basements, and in terms of the scientific return per unit time, it can be a profitable technique. New methods of preparation and study can yield a great deal of important new information from old specimens. There is currently little systematic study of fossil reptile localities in Britain by professional vertebrate palaeontologists.

3. *Loss of the 'amateur network'.* In Victorian times, it seems that every area had an effective natural history society whose members would actively investigate their local geology, cultivate quarrymen, and transmit any seemingly new specimens to local or national museums. A large part of the publications of such distinguished vertebrate palaeontologists as Owen, Huxley, and Seeley were based on specimens that had been sent to them by keen amateur naturalists. This still happens occasionally today—for example, *Baryonyx*, the 'Claws' dinosaur, was found by an amateur collector, Mr William Walker, and subsequently excavated by a team from the British Museum (Natural History)—but this kind of discovery is all too rare. There seems to have been a loss of confidence on both sides: the 'amateurs' feel less and less able to contribute to the furtherance of palaeontology because of the 'professional' aloofness of many university and museum palaeontologists (Robinson 1988).

4. *Loss of professional collectors.* Many of the finest specimens in the British Museum (Natural History) and the older collections in Bristol, Cambridge, Edinburgh, Oxford, York, and elsewhere, were bought from professional collectors. It seems to be very hard to make a living now from selling fossils since a rare mixture of skill in discovery and preparation, as well as financial acumen, is required.

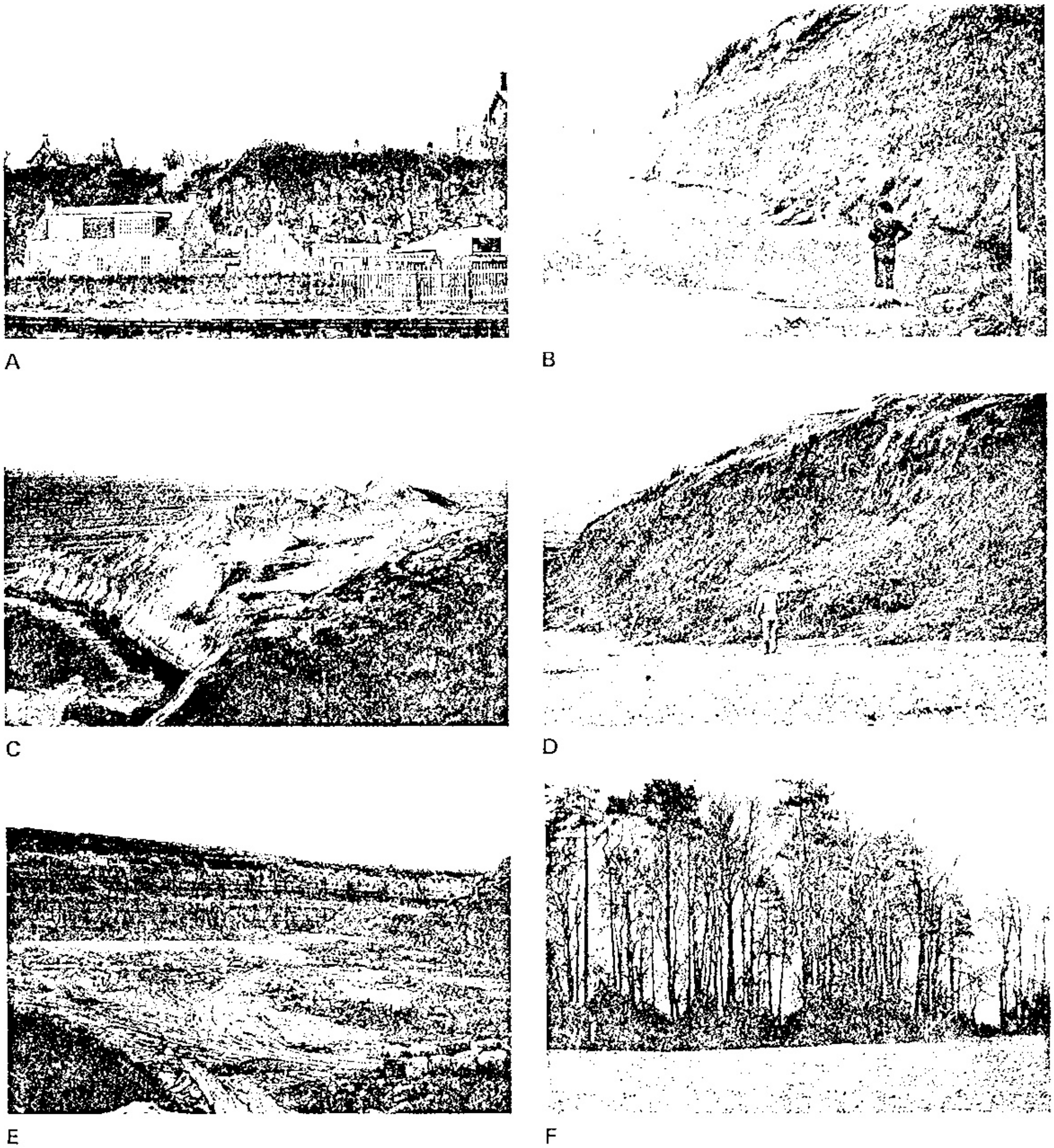
As a palaeontologist, I can only hope that new fossil reptile sites will continue to be discovered, but the fact is that we must particularly focus our interest on those already known.

THE JUSTIFICATION FOR GEOLOGICAL SITE CONSERVATION

The purpose, or rationale, behind earth-science conservation has rarely been fully articulated. In this brief section, I shall follow the argument given by Allen *et al.* (in press), with particular emphasis on British fossil reptile sites.

Geological site conservation lacks the immediate appeal of wildlife conservation. For most civilized people, it is unnecessary to justify the conservation of ospreys, orchids, or meadowlands, since these are considered to be 'good', to enhance our lives by their continued existence. This idea was extended to earth-science conservation by Stamp (1969, p. 42), who noted its importance in maintaining the habitats of plants and animals. This would probably be a popular conception too, and it has been reflected in certain recent NCC publications. However, Stamp (1969) also noted that wildlife and earth-science conservation are essentially different in their aims.

In a recent major statement of the NCC's view of conservation, Ratcliffe (1984, p. 75) argued that it should



TEXT-FIG. 1. Field photographs of some British fossil reptile localities, illustrating typical appearances and conservation problems. A, Lossiemouth East Quarry, Moray (Upper Triassic), was the source of a large reptile fauna (see Appendix, site 9), but its location within Lossiemouth, with houses above and below, makes it unavailable for excavation. B, Aust Cliff, Avon (Triassic–Jurassic), is an eroding cliff on the banks of the Severn estuary (see Appendix, site 15), but it is subject to development (note part of the Severn Bridge) and hence at risk of obscurement by engineering works. C, Kettleness Quarries, Yorkshire (Lower Jurassic), are old alum quarries which yielded sparse reptilian remains; unless worked commercially again, they are unlikely to yield more specimens – hence this site has not been designated an SSSI. D, Furzy Cliff, Dorset (Upper Jurassic), a typical rapidly eroding cliff line, has modest prospects for future finds (see Appendix, site 27). E, Broadcroft Quarry, Dorset (Upper Jurassic), is a largely disused quarry that may continue to yield fossil reptiles with episodic quarrying for facing stone. F, Cuckfield, West Sussex (Lower Cretaceous), the site of famous early discoveries of *Iguanodon*; this quarry has long been abandoned, and is now largely filled in it does not merit SSSI status because any potential for further finds has been lost through 'landscaping'.

be practised in a 'cultural way', so that 'the conservation of wild flora and fauna, geological and physiographic features' should be 'for their scientific, educational, recreational, aesthetic and inspirational value'. He noted also that 'geological and physiographical conservation are mainly orientated towards scientific purposes including the training of earth scientists'. NCC policy then focuses on the scientific justification for geological conservation, but a number of other educational and cultural reasons are noted. The scientific reasons for conserving fossil reptile sites (and earth-science sites in general) can be summarized under two headings:

1. *The essential role of field study in geological research.* In the case of fossil reptile sites, information on palaeoecology and taphonomy can only be established and checked at the site: what is the fauna, what are the associated plants and animals, how are they preserved, what is the sedimentary environment? The sites yield the only geological data that are unadulterated by human activity and they can be crucial in testing hypotheses.

2. *The need for specimens.* Fossil reptiles are generally rare, and new specimens frequently reveal new data. They may be hitherto unknown species (the one specimen of *Baryonyx*, found in 1983, represents a new family; Charig and Milner 1986), they may offer further information about the anatomy and biology of a species that is already known, or they may represent a new record of occurrence that could have palaeobiogeographical, stratigraphical, and palaeoecological importance. Sites that have yielded specimens in the past, even if only scrappy pieces of bone, tend to have strong potential for future finds, all other things being equal.

The other justifications of earth science conservation offered by Ratcliffe (1984, p. 75) are so subsidiary to the scientific justification that they are unnecessary. The strongest of these is the educational argument. As a field-based research science, much of geology teaching uses localities to demonstrate techniques and principles. However, it is hard to think of an example of a teaching site that ought to be uniquely conserved, but which is deemed to be of low research value. In other words, many geological sites which are used in teaching are conserved because of their scientific interest. Others, whether they illustrate cross-beds or faults, or yield easily collectable fossils, are commonly used in geology teaching, but could not be strongly justified for conservation: any other site with those features would suffice. The educational aspect of conserved sites is important, and there is a need to create teaching sites to reduce the pressure on scientifically important sites. However, educational value *alone* is not an adequate justification for geological site conservation.

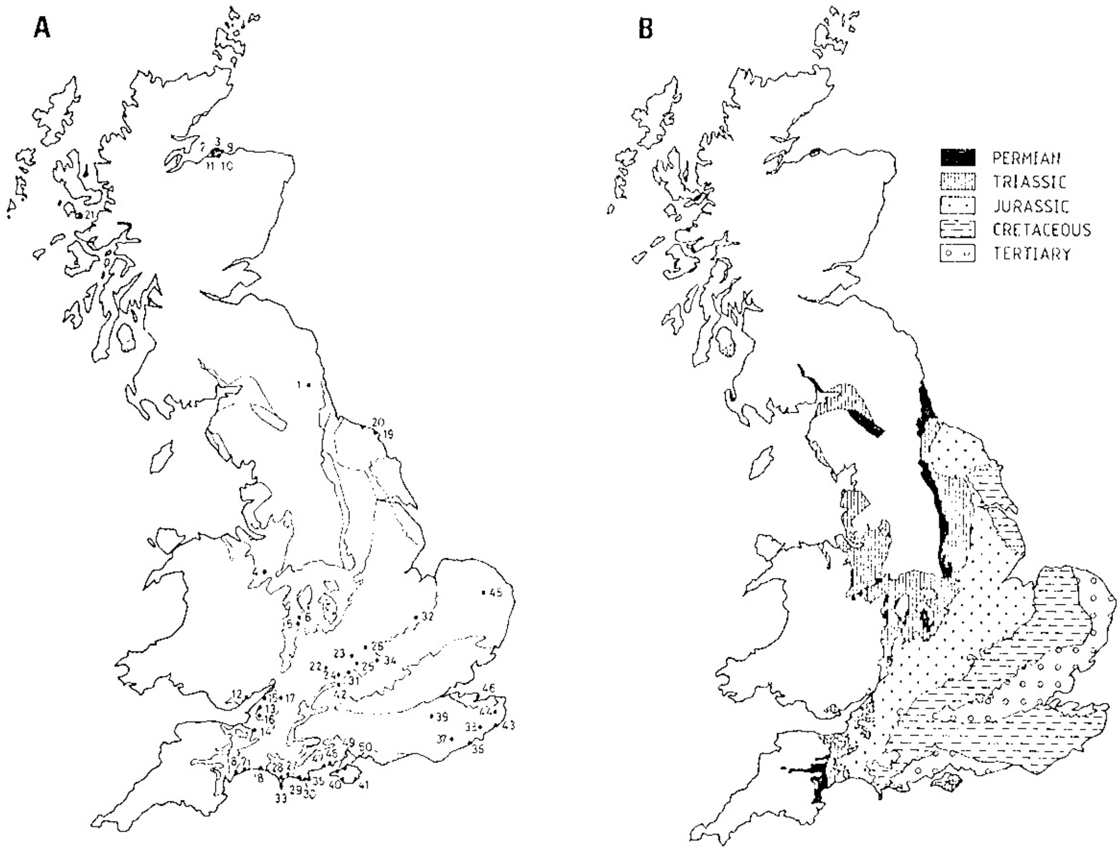
The other subsidiary justifications are less clearly defined—the 'recreational, aesthetic and inspirational value'. Anyone would enjoy picking up fossils on the beach during a family outing; rock climbers find their recreation on geological outcrops; and children no doubt like to run around in caves or on sand dunes. These are examples of 'geological' recreation that would be key factors in laying out public areas in a nature reserve, or in developing the attractions of a holiday resort, but they hardly seem to relate to conservation. Similarly, most people would admit the aesthetic and inspirational qualities of Fingal's cave on Staffa, or the white cliffs of Dover, or of the Cairngorms. However, these qualities are not clearly justifications for earth-science conservation, but relate to the preservation of the countryside and tourist development. These sites may also happen to be geological Sites of Special Scientific Interest (SSSIs), but that is because of their scientific importance. It is possible to argue that Hutton's unconformity has inspirational value for the geologist—it is conserved because it was the first site where the idea of unconformities was worked out, the 'birthplace of modern geology'. However, this is a justification in terms of the history of science (i.e. scientific) and it would be unlikely to inspire the non-geologist.

The above arguments of course refer only to the justification for geological site conservation. The need to promote geology and geological conservation is a separate issue that requires a large effort in terms of education and publicity. This must go ahead side-by-side with the scientific aspects of site selection and conservation.

FOSSIL REPTILE SITES AND THEIR USERS

In a perfect world, palaeontologists would have access to total exposure of the rock formations of interest to them. They must, however, accept the obscuring presence of soil, roads, towns, and the like. They must also accept that a balance has to be achieved between economic pressures on exposures (e.g. landfill, large-scale extraction, building) and the need to keep as many key exposures available for research as possible.

Clearly, all 500 recorded fossil reptile sites in Britain are not worth conserving. Some might



TEXT-FIG. 2. A, distribution of major fossil reptile sites in Great Britain; the numbers 1–50 refer to the sites selected by NCC's Geological Conservation Review for notification as Sites of Special Scientific Interest, as listed in the Appendix. B, the outcrop pattern of the Permian, Triassic, Jurassic, Cretaceous, and Tertiary.

have yielded only one tooth or bone fragment last century, and may never be productive again, even with extensive excavation. Others, however, have demonstrated a potential for new finds either in profusion (e.g. the Lias of Whitby, the Purbeck beds of Dorset, or the Wealden of the Isle of Wight) or sporadically (e.g. the Triassic of Warwick, or the Bathonian 'Cotswold Slates' of Gloucestershire). The balance between the cost of conservation (research, site identification, notification, legal protection) and the probability of new research results has resulted in a provisional list of fifty designated SSSIs for fossil reptiles (text-fig. 2; Appendix).

The rationale and methods of fossil reptile site selection have already been outlined (Benton and Wimbledon 1985). It is interesting to note the approximate statistics behind the reduction from 500 to fifty sites. The factors paramount in causing this 90% cut were: 1, moderate or low research potential (assessed from the literature), minus 50%; 2, sites filled in, covered with concrete, or otherwise inaccesible, minus 30%; and 3, duplication of research interest, minus 10%. These figures are highly variable, depending on the rock type, the distribution of fossil finds at sites, and geographical location. For example, no SSSI could be established for any Oxford Clay reptile site because the brick pits are partly filled in and built over, there is no clear evidence for the precise horizons of finds (i.e. potential for new finds is unpredictable), and the sediments collapse readily; to be of value, the site needs constant small-scale working to keep the faces clean and to turn up bones, but the massive diggers currently in use do not generally allow this. The sites filled in (factor 2) probably account for a greater percentage of extant sites 'dropped' from the list, since many of the 'low interest' category (factor 1) are probably also lost: as many as half of the 500 recorded fossil reptile sites in Britain may now no longer be available. The duplicate sites (factor 3) might in some cases be useful if the SSSI were itself lost.

Clearly, new fossil reptile sites will be generated as a result of unpredictable events (e.g. chance finds during building works or other excavations, serendipitous discoveries by amateurs) and as a result of systematic searches by palaeontologists and collectors. For example, Patrick Spencer, then a schoolboy, discovered a remarkable collection of new fossil reptiles in Middle Triassic sediments near Sidmouth (Spencer and Isaac 1983). His discoveries were partly within the area of an SSSI, as it happens, but they extended its boundaries and expanded our view of its potential for research. The remains of *Baryonyx* were found in a brick pit that had produced occasional reptile remains in the past. However, the pit would probably not have been designated a palaeontological SSSI if *Baryonyx* had not been found, since it illustrates the potential for more discoveries of that unique taxon.

New discoveries may open up completely new research fields, and thus necessitate the reappraisal of a site as a potential SSSI. For example, Stan Wood's excavations in the Scottish Carboniferous have strengthened the case for SSSI status of some doubtful sites, and have also generated new SSSIs in places hitherto unreached by that form of conservation protection. Research in stratigraphy, structural geology, sedimentology, and other fields will also lead to the need for constant reassessment of the list of geological SSSIs. The temporary nature of many Quaternary deposits will give rise to a very fluid set of SSSIs. At least 10% of all geological SSSIs will probably have to be reassessed each year in the light of new research findings, and this is likely to add to the list more often than it will subtract from it. This probable future expansion of the list of geological SSSIs arises from the fact that there are now more geologists actively working on British geology than there were a century ago, or even 10 years ago. It also depends on the fact that many of the 'SSSIs' that would have been selected in 1890 have been lost to development, and one can only hope that the SSSIs of 1990 will escape that form of destruction.

THE ROLE OF THE NATURE CONSERVANCY COUNCIL

Palaeontologists need an effective organization to carry out the conservation of SSSIs; this is the role of the NCC. The requirements are: rapid notification of sites to their owners (at least within a year of identification to allow time for the resolution of occasional confusions over ownership and opposition to designation) so that selected SSSIs are not lost. After notification, palaeontologists want to be able to feel that a site is protected from infilling or other development—and that the NCC will use its legal powers to carry this out. Clearly, of course, if an owner wilfully destroys a site, little can be done to rectify the damage, but palaeontologists would want the NCC to take every step to secure a conviction against the malefactor, and to locate or attempt to create a viable alternative site as soon as possible.

Users of fossil reptile sites generally would not expect any particular 'site care' to take place. Inland sites in old quarries will usually be overgrown and collapsed to some extent, and site cleaning exercises would generally not be particularly helpful. Indeed, in some cases they might be detrimental in damaging bone-bearing horizons, or removing protective scree from soft bone-beds.

Two kinds of site-based activities are normally carried out by the research palaeontologist: excavation of specimens; and the study of their context. In the first case, minor hand excavation suffices in coastal exposures where marine erosion removes much of the overburden and reveals the presence of bones or skeletons. At inland sites, heavier excavation may be required (e.g. mechanical diggers, pneumatic drills, explosives) in order to locate specimens and/or remove overburden in prospecting for remains. In studying the context of fossil reptiles (palaeoecology, taphonomy), much of the work involves data recording, e.g. sedimentary logging from lightly cleaned faces or trenches dug with shovels, excavation (by hand or machine) and sieving of sediment for fossil remains, and so on. Thus, while some research projects involve major expensive equipment (which requires funding), others require little more than an enthusiastic labour force.

The role of the NCC in these activities should first of all be to help the investigator by supplying information. This will be done soon, as the scientific results of the Geological Conservation Review (GCR) are published in a rolling programme from 1988 onwards. In addition, investigators may have specific questions about the ownership of sites or legal aspects which could be answered by officers of the NCC. A second area in which the NCC can continue to serve the scientific community is to fund particular excavations at SSSIs, or to fund investigations of the scientific aspects of geological SSSIs. Such stimulus from the NCC will encourage vertebrate palaeontologists to undertake more site-based investigations in the future.

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APPENDIX

List of the fifty British fossil reptile sites that were selected by the Geological Conservation Review for scheduling by the NCC as SSSIs. The sites are identified by name and by National Grid Reference. They are arranged in stratigraphical order, and a brief summary of the scientific importance of each is given.

Upper Permian

1. Middridge Quarry, Middridge, Durham, England (NZ 249 252). Marl Slate. Source of supposed labyrinthodont amphibian *Lepidotosaurus* and specimens of diapsid reptile *Protorosaurus*. Bone fragments collected recently.
2. Cuttie's Hillock, Quarry Wood, Elgin, Morayshire, Scotland (NJ 185 638). Cuttie's Hillock Sandstone Formation (?uppermost Permian). Type locality of three genera, and up to six species: pareiasaur *Elginia*, dicynodonts *Geikia* and *Gordonia* (four species), and unnamed procolophonid. Fossil footprints apparently also found here.
3. Masonshaugh Quarry, Cummingstown, Morayshire, Scotland (NJ 123 692–133 692). Hopeman Sandstone Formation (?uppermost Permian). Excellent range of fossil footprints (small, medium, and large), probably made by mammal-like reptiles, with stratigraphical potential.

Triassic: Ladinian

4. Grinshill Quarries, Grinshill, Shropshire, England (SJ 525 238). Tarporley Siltstone Formation and base of Helsby Sandstone Formation, Mercia Mudstone Group. Type locality of rhynchosaur *Rhynchosaurus articeps* (first collected 1840, many skeletons found since). Also small rhynchosauroid footprints.
5. Coton End Quarry, Warwick, Warwickshire, England (SP 290 655). Bromsgrove Sandstone Formation, Mercia Mudstone Group. Disarticulated but excellently preserved diverse fauna of amphibians and reptiles (first reported 1830s by Murchison, Owen and others). Type locality of labyrinthodont amphibians *Cyclotosaurus leptognathus*, *C. pachygnathus*, and *Mastodonsaurus jaegeri*, and three other species since synonymized. Reptilian taxa include a new species of *Rhynchosaurus*, a macrocnemid, a large 'thecodontian', a poposaurid, and a supposed prosauropod dinosaur.
6. Guy's Cliffe, Warwick, Warwickshire, England (SP 293 668). Bromsgrove Sandstone Formation, Mercia Mudstone Group. Bones first found 1823; remains include fine lower jaw of labyrinthodont *M. jaegeri*.
7. High Peak, Sidmouth, Devon, England (SY 101 855–112 867, SY 121 869). Otter Sandstone Formation, Mercia Mudstone Group. Abundant disarticulated fish, amphibians, and reptiles (since 1860s, with major finds recently). Type locality for *M. lavisi* and undescribed rhynchosaur. Other taxa include labyrinthodonts, procolophonids, and 'thecodontians'.
8. Otterton Point, Budleigh Salterton, Devon, England (SY 077 819). Otter Sandstone Formation, Mercia Mudstone Group. Rhynchosaur maxilla found 1860s. Important comparative locality.

Triassic: Carnian

9. Lossiemouth East Quarry, Morayshire, Scotland (NJ 236 707). Lossiemouth Sandstone Formation. Britain's richest Late Triassic reptile locality; about eighty specimens of eight species (since 1840s). Type specimens of six species (five unique to locality): sphenodontid *Brachyrhinodon taylori*, rhynchosaur *Hyperodapedon gordoni*, 'thecodontians' *Stagonolepis robertsoni*, *Scleromochlus taylori*, and *Erpetosuchus granti*, and supposed dinosaur *Saltopus elginensis* (oldest dinosaur from Europe). Other taxa: procolophonid *Leptopleuron*, and 'thecodontian' *Ornithosuchus*.
10. Spynie Quarries, Spynie, Morayshire (NJ 223 658, and others). Lossiemouth Sandstone Formation. Type locality for procolophonid *L. lacertinum* and 'thecodontian' *O. longidens*. Other taxa include two fine skulls of rhynchosaur *Hyperodapedon*.
11. Findrassie, Elgin, Morayshire, Scotland (NJ 207 652, NJ 204 651). Lossiemouth Sandstone Formation. Historically important site (first bones from Elgin area, 1857). Excellent 'thecodontians' *Stagonolepis* and *Ornithosuchus*.

Triassic: Norian

12. Bendrick Rock, Barry, South Glamorgan, Wales (ST 131 668). Dolomitic Conglomerate, Mercia Mudstone Group. Numerous dinosaurian footprints called *Anchisauripus*, probably produced by medium-sized prosauropod.

13. Slickstones, Cromhall Quarry, Avon, England (ST 704 916). Fissure filling of possible Norian age. Four species of sphenodontid, a dinosaur, and five other reptiles. Type locality for sphenodontids *Clevosaurus hudsoni*, *Planocephalosaurus robinsonae*, *Pelecymala robustus*, and *Sigmala sigmala*.
14. Emborough Quarries, Emborough, Somerset, England (ST 623 505). Fissure filling of possible Norian age. Numerous reptiles. Type locality for trilophosaur *Variodens inopinatus*, gliding reptile *Kuehneosaurus latus*, and other undescribed forms.

Triassic: 'Rhaetian' (end-Norian)

15. Aust Cliff, Aust, Avon, England (ST 565 894–572 901). Rhaetic Bone Bed, Westbury Beds, Penarth Sandstone Group. Reworked fish, ichthyosaurs, plesiosaurs, and rare dinosaurs. Marine reptiles represented by teeth, vertebrae, ribs, and paddle bones. Type locality for three 'species': *Plesiosaurus rugosus*, *P. costatus*, and *P. rostratus*. Dinosaur remains include long bones, possibly of large prosauropod, and teeth and other fragments of carnivorous form. Remains of pterosaur *Dimorphodon* found, probably from overlying Lower Lias (Hettangian).
16. Durdham Down, Bristol, Avon, England (ST 572 747). Fissure filling of presumed Rhaetian age. Two species of sphenodontid. Type locality for phytosaur *Rileya platyodon* and two prosauropod dinosaurs, *Thecodontosaurus antiquus* and *Palaeosaurus cylindrodon*.
17. Tytherington, Avon, England (ST 662 888). Fissure filling of Rhaetian age. Sphenodontids, a crocodile, and a dinosaur. Type locality for sphenodentid *Diphydontosaurus avonis*. Associated with fish remains and datable palynomorphs.

Jurassic: Hettangian–Sinemurian

18. Lyme Regis, Dorset, England (SY 321 908–373 928). Blue Lias and Shales with Beef. Hundreds of extremely well-preserved ichthyosaurs, plesiosaurs, pterosaurs, and dinosaurs. Type locality for more than fourteen species: armoured dinosaur *Scelidosaurus harrisoni*, pterosaur *Dimorphodon macronyx*, plesiosaurs *Plesiosaurus conybeari*, *P. dolichodeirus*, *P. eleutheraxon*, *P. hawkinsi*, *P. macrocephalus*, and *P. rostratus*, and ichthyosaurs *Ichthyosaurus breviceps*, *I. communis*, *I. conybeari*, *Temnodontosaurus platyodon*, *T. eurycephalus*, and *T. risor*. Fossil reptiles collected here since eighteenth century; abundant new finds still made.

Jurassic: Toarcian

19. Whitby, North Yorkshire, England (NZ 901 115–916 109). Main Alum Shales, Alum Shale Formation: and ?Bituminous Shales, Jet Rock Formation. Many fine plesiosaurs, ichthyosaurs, and marine crocodilians. Type locality for seven species: crocodilians *Steneosaurus brevior* and *S. gracilirostris*, ichthyosaurs *Stenopterygius acutirostris* and *T. longirostris*, and plesiosaurs *Macroplata longirostris*, *Microcleidus homalospondylus*, and *Sthenarosaurus dawkinsi*. First fossil 'allegator' reported 1759; many fine specimens still found.
20. Loftus Quarries, Boulby, North Yorkshire (NZ 735 200–757 194). Main Alum Shales, Alum Shale Formation. Many marine reptiles. Type locality for plesiosaurs *Eretmosaurus macropterus* and *Thaumatosaurus zetlandicus*, ichthyosaur *I. crassimanus*, and unique pterosaur *Parapsicephalus purdoni*.

Jurassic: Bathonian

21. Kildonnan and Eilean Thuilm, Eigg, Hebrides, Scotland (NM 495 870, NM 483 913). Kildonnan Member, Lealt Shale Formation, Lower Bathonian. 'Hugh Miller's Bonebed' known for fossil reptile bones since 1845. Recent finds confirm fauna of fish scales, teeth, and spines; isolated bones and teeth of plesiosaur-like *Muraenosaurus*; and doubtful bones ascribed to crocodilian, pterosaur, and turtle.
22. New Park Quarry, Stow-on-the-Wold, Gloucestershire, England (SP 175 282). Chipping Norton Formation, Lower Bathonian. Abundant well-preserved crocodile *Steneosaurus*, and dinosaurs *Megalosaurus*, *Cetiosaurus*, and *Stegosaurus*. Best Lower Bathonian terrestrial locality in Britain.
23. Stonesfield, Oxfordshire, England (SP 392 172, SP 387 168, SP 387 171). Stonesfield Slate, Middle Bathonian. Abandoned mines, renowned for fossil vertebrates since seventeenth century, and particularly early nineteenth century when William Buckland found type specimens of first-described dinosaur, *Megalosaurus bucklandi*. Plesiosaurs, marine crocodilians, dinosaurs, pterosaurs, turtles, and mammal-like reptiles (ictidosaurs) occur as well-preserved teeth, scutes, limb elements, and vertebrae. Type locality for dinosaurs *M. bucklandi* and *Iliosuchus incognitus*, crocodilian *Teleosaurus geoffroyi*, pterosaurs *Rhamphocephalus bucklandi* and *R. depressirostris*, turtle *Protochelys stricklandi*, and ictidosaur *Stereognathus ooliticus*. Richest Middle Jurassic vertebrate locality in Britain.

24. Huntsman's Quarry, Naunton, Gloucestershire, England (SP 125 255). 'Cotswold Slates', Middle Bathonian. Abundant scattered bones of turtles, crocodilians, dinosaurs, and pterosaurs, many in excellent preservation.
25. Shipton-on-Cherwell Quarry, Oxfordshire, England (SP 475 178). White Limestone Formation and Lower Cornbrash, Upper Bathonian. Known for fossil reptiles since 1820. Fine cranial remains of five or more long-snouted crocodilians *Steneosaurus* and *Teleosaurus*, including type material of *S. meretrix*. Type specimen of early stegosaur dinosaur *Dacentrurus vetustus* from Lower Cornbrash.
26. Kirtlington Old Cement Works, Kirtlington, Oxfordshire, England (SP 494 199). White Limestone Formation and Forest Marble, Upper Bathonian. Abundant dinosaurs *Megalosaurus*, *Cetiosaurus*, and *Bothriospondylus*, crocodilian *Steneosaurus*, and plesiosaurs from White Limestone Formation. Similar dinosaur, pterosaur, and crocodilian remains collected recently in Kirtlington Mammal Bed at base of Forest Marble, with turtles, lizards, and mammals.

Jurassic: Oxfordian

27. Furzy Cliff, Overcombe, Dorset, England (SY 697 817–703 819). Jordan Cliff Clays, Upper Oxford Clay, Lower Oxfordian. Type locality for carnivorous dinosaur *Metriacanthosaurus parkeri*. Other remains include *Ophthalmosaurus* sp., the only British Oxfordian ichthyosaur, and few plesiosaur vertebrae. Important because of rarity of Oxfordian reptiles worldwide.

Jurassic: Kimmeridgian

28. Smallmouth Sands, Weymouth, Dorset, England (SY 669 764–672 772). Lower Kimmeridge Clay. One of most varied Kimmeridgian faunas, including four species of turtles, three species of pterosaurs, sauropod dinosaurs, ichthyosaurs, and plesiosaurs. Type locality for turtle *Pelobatochelys blakei*, pterosaurs *Rhamphorhynchus manselii* and *R. pleydelli*, sauropod *Pelorosaurus humerocristatus*, ichthyosaur *Brachypterygius extremus*, and possibly the plesiosaur *Cimoliosaurus brevior*.
29. Gaulter Gap–Broad Bench, Kimmeridge, Dorset, England (SY 898 789–909 789). Kimmeridge Clay. Classic Kimmeridge Bay locality. Many turtles, crocodiles, pterosaurs, plesiosaurs, ichthyosaurs, and dinosaurs. Type locality for crocodilians *Dakosaurus maximus* and *Steneosaurus megarhinus*, plesiosaur *Plesiosaurus brachistospondylus*, ichthyosaurs *Macropterygius ovalis* and *Nannopterygius enthekiodon*, and dinosaur *Pelorosaurus manseli*.
30. Swyre Head–Chapman's Pool, Encombe Bay, Dorset, England (SY 937 773–955 771). Upper Kimmeridge Clay. Turtle (probably *Pelobatochelys*), crocodile, plesiosaurs, and ichthyosaurs. Type locality for plesiosaur *Kimmerosaurus langhami*.
31. Chawley Brickpits, Chawley, Oxfordshire, England (SP 475 042). Typical Kimmeridgian marine reptiles: two species of ichthyosaur, two of plesiosaur, two of pliosaur, and a fine *Camptosaurus prestwichii* (only unequivocal European species of *Camptosaurus*, a typically North American genus).
32. Roswell Pits, Ely, Cambridgeshire, England (TL 550 805–555 811). Diverse fauna of turtles, crocodilians, sauropod dinosaurs, plesiosaurs, pliosaurs, and ichthyosaurs. Type locality for three species: crocodilian *Dakosaurus lissocephalus*, dinosaur *Gigantosaurus megalonyx*, and pliosaur *Pliosaurus brachyspondylus*. Sauropods and pliosaurs particularly significant.

Jurassic: Portlandian

33. West Cliff, Kingbarrow Quarries, Yeolands Quarry and Grove Cliff, Portland, Dorset, England (SY 685 729–676 684, SY 691 729, SY 702 718). Portland Stone. Large fauna. Type locality for three important turtles *Plesiochelys planiceps*, *Pleurosternon portlandicus*, and *Portlandemys mcdowelli*, and plesiosaur *Colymbosaurus portlandicus*.
34. Bugle Pit, Hartwell, Buckinghamshire, England (SP 793 121). Teeth from sauropod dinosaur *Pelorosaurus* (only Portlandian sauropod in Europe) and carnosaur '*Megalosaurus*' (only Portlandian carnosaur in Britain), and bones of turtles and possible ornithischian dinosaurs.

Jurassic–Cretaceous: Portlandian–Berriasian–Valanginian

35. Durlston Bay, Swanage, Dorset, England (SZ 035 780). Middle–Upper Purbeck, Jurassic–Cretaceous boundary. Hundreds of specimens of turtles, sphenodontids, lizards, crocodilians, pterosaurs, and dinosaurs from at least four separate horizons. Type locality for at least thirty species of turtles *Dorsetochelys*, *Mesochelys*, *Platychelys*, *Plesiochelys* (3), *Pleurosternon*, and *Tretosternon*; lizards *Becklesisaurus*, *Dorsetisaurus* (2), *Durotrigia*, *Macellodus*, *Paramacellodus*, *Pseudosaurillus*, and *Saurillus* (2);

crocodilians *Goniopholis* (3), *Nannosuchus*, *Oweniasuchus* (2), *Petrosuchus*, *Pholidosaurus*, and *Theriosuchus*; pterosaur *Ornithocheirus*; and dinosaurs *Nuthetes*, *Echinodon*, and *Iguanodon*.

Cretaceous: Valanginian

36. Hastings, East Sussex, England (TQ 831 095–853 105). Wadhurst Clay Formation, Hastings Group. Many specimens of dinosaurs, pterosaurs, turtles, crocodilians, and plesiosaurs, including species of dinosaurs *Iguanodon*, *Megalosaurus*, and *Cetiosaurus*. Type locality for crocodilian *Heterosuchus valdensis*.
37. Blackhorse Quarry, Telham, East Sussex, England (TQ 769 142). Wadhurst Clay Formation, Hastings Group. Type locality for Telham Bone Bed (conglomerate of polished pebbles, fish scales, bones, teeth, and coprolites); turtles, crocodilian *Goniopholis*, pterosaur *Ornithocheirus*, and dinosaurs *Megalosaurus*, *Cetiosaurus*, *Iguanodon*, and *Hylaeosaurus*.
38. Hare Farm Lane, Brede, East Sussex, England (TQ 832 184). Wadhurst Clay Formation, Hastings Group. Type locality for Brede Bone Bed (coarse sand with comminuted scales, teeth, and bone); jaws and teeth of crocodilians, and isolated bones and a partial skeleton of *Iguanodon*.

Cretaceous: Hauterivian–Barremian

39. Smokejack Brick Pit, Ockley, Surrey, England (TQ 112 374). Weald Clay. Recent finds include crocodilian teeth, coprolites, a partial skeleton of *Iguanodon*, and a skeleton of the spectacular meat-eating 'Claws' dinosaur *Baryonyx*.
40. Brook–Atherfield, Isle of Wight, England (SZ 375 842–452 788). Wealden. Numerous remains at several horizons along coastal strip. Dinosaurs include fine *Megalosaurus*, *Ornithopsis*, *Iguanodon*, *Hypsilophodon*, and *Polacanthus*. Type locality for turtles *Helochelydra* sp., *Plesiochelys brodiei*, *P. valdensis*, and *P. vectensis*; crocodilians *Hylaeochampsa vectiana* and *Vectisuchus leptognathus*; pterosaurs *Ornithodesmus cluniculus* and *O. latidens*; and dinosaurs *Aristosuchus pusillus*, *Calamospondylus foxi*, *Thecocoelurus daviesi*, *Astrodon valdensis*, *Titanosaurus valdensis*, *Hypsilophodon foxi*, *Iguanodon atherfieldensis*, *I. gracilis*, *Valdosaurus canaliculatus*, *Vectisaurus valdensis*, *Polacanthoides ponderosus*, and *Polacanthus foxi*. One of richest dinosaur areas in Europe.
41. Yaverland, Sandown, Isle of Wight, England (SZ 613 850–622 853). Wealden Marls. Well-known for large dinosaur bones since 1829. Eleven genera of turtles, crocodilians, dinosaurs, and plesiosaurs known. Type locality for oldest known pachycephalosaur *Yaverlandia bitholus*.

Cretaceous: Albian

42. Wicklesham Pit, Faringdon, Oxfordshire, England (SU 292 943). Faringdon Sponge Gravels, Lower Greensand. Isolated reworked bones of turtles, crocodilian *Dakosaurus*, plesiosaurs *Cimoliosaurus* and *Pliosaurus*, and ichthyosaurs. Best currently available Lower Greensand site.
43. East Wear Bay, Folkestone, Kent, England (TR 243 366). Gault. Mainly marine forms from several horizons: turtle *Rhinochelys*, ichthyosaur *Ophthalmosaurus*, plesiosaurs *Cimoliosaurus* and *Mauisaurus*, pliosaur *Polyptychodon*, and pterosaur *Ornithocheirus*. Type locality for plesiosaur *M. gardneri* and pterosaur *O. daviesi*.

Cretaceous: Cenomanian–Turonian

44. Culand Pits, Burham, Kent, England (TQ 738 616). Lower and Middle Chalk. Turtles, plesiosaurs, pterosaurs, and lizards. Type locality for turtle *Chelone benstedi*, pterosaurs *O. compressirostris*, *O. cuvieri*, and *O. giganteus*, and lizard *Dolichosaurus longicollis*.

Cretaceous: Coniacian–Campanian

45. St James Pit, Norwich, Norfolk, England (TG 242 094). Upper Chalk. Teeth, jaws, vertebrae, and other bones of *Mosasaurus* and *Leiodon*. One of few mosasaur localities in Britain.

Tertiary: Eocene: Ypresian

46. Warden Point, Isle of Sheppey, Kent, England (TQ 955 738–TR 024 717). London Clay. Well known since 1820s. Turtles *Argillochelys*, *Chrysemys*, *Eosphargis*, *Puppigerus*, and *Trionyx*, crocodile *Crocodylus*, and snake *Palaeophis*. Type locality for nine species: turtles *Palaeaspis bowerbanki*, *Argillochelys cuneiceps*, *A. antiqua*, *Eosphargis gigas*, *Chrysemys bicarinata*, *C. testudiniformis*, and *Dacochelys delabechei*; snake *Palaeophis toliapicus*; and crocodilian *Crocodylus spenceri*.

Eocene: Bartonian

47. Barton Cliff, Barton on Sea, Hampshire, England (SZ 224 930–251 925). Barton Beds. Fauna particularly rich in turtles *Argillochelys*, *Eochelone*, *Puppigerus*, and *Trionyx*, with snake *Palaeophis* and lizards.

Eocene: Priabonian

48. Hordle, Hampshire, England (SZ 254 925–270 921). Lower Headon Beds. Numerous well-preserved specimens of turtles *Allaeochelys*, *Ocadia*, and *Trionyx*, lizards *Iguana* and *Plesiolacerta*, snakes *Palaeophis* and *Paleryx*, and crocodile *Diplocynodon*. Type locality for over fifteen species. One of best Tertiary reptile sites in Britain.
49. Headon Hill, Totland, Isle of Wight, England (SZ 305 856–319 865). Lower Headon Beds. Several horizons have yielded turtle *Emys*, crocodile *Diplocynodon*, lizards *Ophisaurus* and *Necrosaurus*, and snakes *Paleryx*, *Dunnophis*, and *Vectophis*.

Oligocene: ?Chattian

50. Bouldnor Cliff, Hamstead, Isle of Wight, England (SZ 375 902–403 919). Hamstead Beds, Middle Oligocene. Turtles *Trionyx* and *Ocadia*, crocodiles *Diplocynodon* and *Crocodylus*, and snake *Paleryx*.

DISCUSSION

K. L. Duff. The 'cultural, recreational, or aesthetic' justifications for site conservation, referred to by Ratcliffe (1984), have never been used by the NCC as significant criteria within Earth-science conservation. The scientific significance has always been paramount in site designation.