A PRELIMINARY INVENTORY OF PALEONTOLOGICAL RESOURCES WITHIN THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

by
David D. Gillette, State Paleontologist, and Martha C. Hayden

U. S. Geological Survey Professional Paper 164 Plate 3

GENERALIZED VIEW OF THE KAIPAROWITS REGION LOOKING NORTH FROM THE UTAH-ARIZONA BOUNDARY LINE

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UTAH GEOLOGICAL SURVEY
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Hayden A PRELIMINARY INVENTORY OF PALEONTOLOGICAL RESOURCES WITHIN THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT UGS Circular 96

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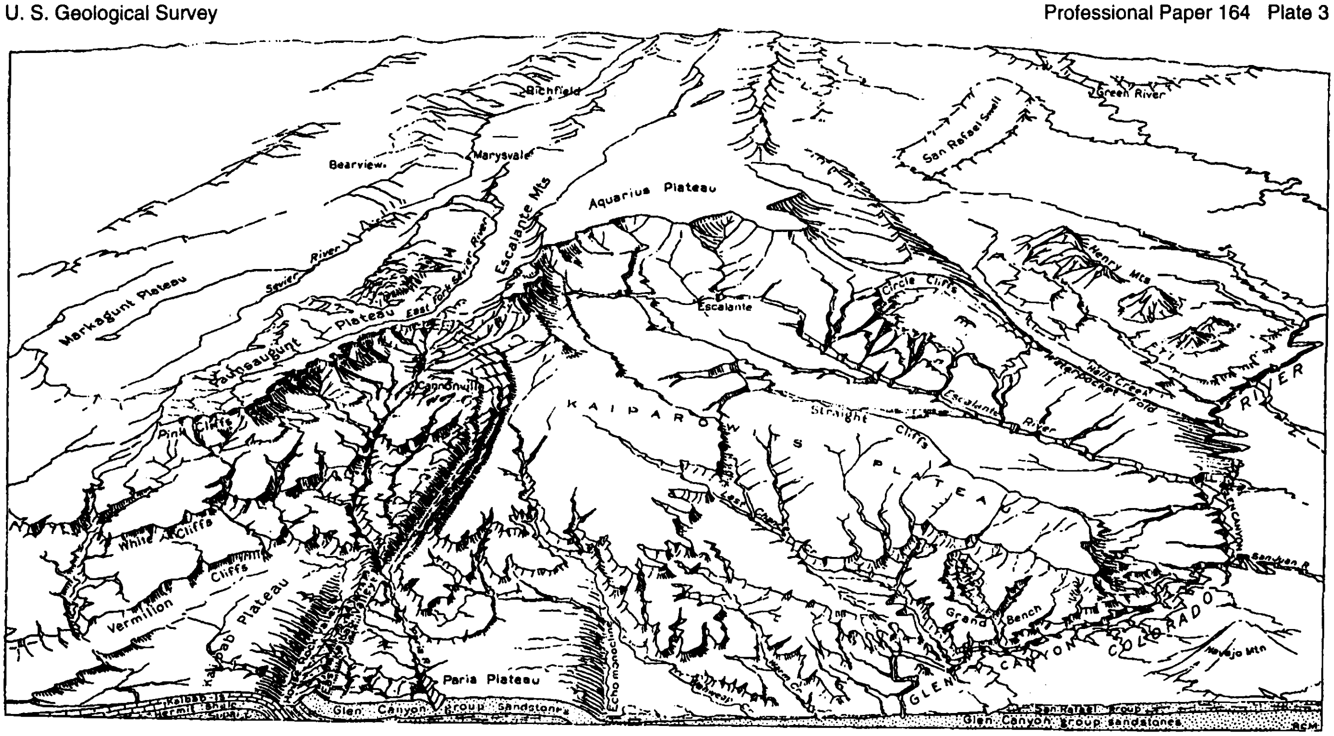

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PREFACE

The purpose of this report is to provide a preliminary inventory of the paleontological resources within the newly created Grand Staircase-Escalante National Monument for two principal reasons. First, in establishing the monument, President Clinton proclaimed the opportunities for scientific study, expounding at length on the paleontological resources and sites. He directed the U.S. Bureau of Land Management to develop a management plan for the monument within three years. Information on the location, extent, and importance of paleontological resources needs to be available to the monument planners, to paleontologists and other scientists, and to the interested public to help determine how these resources will be incorporated into the management plan. Will scientists be allowed to excavate specimens or sites? Can a sample be removed for additional study or curation? Are there sites that should be exposed in place and protected for public appreciation? These and many other questions will have to be answered in the management plan. The more information that can be provided to the BLM, the better they should be able to anticipate the location and size of potential impacts from scientific research.

Second, about 176,000 acres of surface lands managed by the Utah School and Institutional Trust Lands Administration for the benefit of Utah's school children are within the monument's boundaries. The President promised to trade out School Trust lands ("inholdings") for comparable federal lands elsewhere, presumably in Utah. The Trust Lands contain significant known and potential deposits of minerals and energy resources. In addition, these surface lands contain significant and potentially significant paleontological specimens and sites.

There are different opinions about the impact of fossils on land values. The scientific values are difficult to assess financially and it is generally not even attempted. To place a dollar value on a scientific specimen may tend to establish a price for illegally obtained or stolen pieces. However, there is a flourishing global market in fossils taken from commercial and private sites. Such lands can become quite valuable. Alternatively, the presence of scientifically valuable fossils may limit or, in rare cases, even prohibit other land development. In these instances, it is argued that the paleontological resources have reduced the land value.

It is the goal of the Utah Geological Survey to provide an inventory of paleontology resources on School Trust lands to identify their scientific importance and their impact on potential energy and mineral resource development. We will not place a dollar value on the fossils themselves.

The summary information in this report indicates that fossil resources in the monument are extensive, but that their distribution and locations are not well known. An active program of resource assessment on School Trust lands needs to be completed as part of the inholdings exchange. In the longer term, a continuing program of assessment on federal lands, along with recovery and mitigation, needs to become part of one of the monument's principal missions: paleontological study.

M. Lee Allison
February, 1997

Other publications on the Grand Staircase-Escalante National Monument from the Utah Geological Survey:

A preliminary assessment of archeological resources within the Grand Staircase-Escalante National Monument, Utah by David B. Madsen, Circular 95

Topographic map of the Grand Staircase-Escalante National Monument, Utah, PI-49

A preliminary assessment of energy and mineral resources within the Grand Staircase - Escalante National Monument, compiled by M.L. Allison, Circular 93

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INTRODUCTION

Background

On September 18, 1996, by the authority vested through section 2 of the Antiquities Act of June 8, 1906 (34 Stat. 225, 16 U.S.C. 431), President Clinton established by proclamation the Grand Staircase-Escalante National Monument (appendix A). The monument sets aside some 1.7 million acres, or about 2,700 square miles, in southern Utah to be protected for their scientific, historic, biologic, cultural, and scenic attributes. The proclamation cites examples of the attributes of the monument including: (1) exposed sedimentary rock layers that offer unobscured views of stratigraphy and geologic processes; (2) natural features like The Grand Staircase, White and Vermilion Cliffs, Paria Canyon, East Kaibab Monocline (The Cockscomb), Circle Cliffs, Waterpocket Fold, Escalante Natural Bridge, and Grosvenor Arch; (3) numerous archeological sites of the Anasazi and Fremont cultures; and (4) the variety of life zones from low-lying desert to coniferous forest.

Purpose and Goals

Since the establishment of the monument, issues regarding the mineral value of state and federal lands within the monument have come to the forefront of debates. The monument extends across large parts of Kane and Garfield Counties, and includes important paleontological resources.

The U. S. Bureau of Land Management (BLM), the agency assigned to administer the monument, has begun a three-year program to formulate a management plan. Part of the management plan will likely focus on the disposition of nearly 176,000 acres of School and Institutional Trust lands that are now within the monument. Recognizing their importance, President Clinton directed the Interior Secretary to act quickly to formulate plans to trade the School Trust lands within the monument for other federal lands or resources in Utah that are of comparable value. Fossils from the monument, including those on property managed by the Utah School and Institutional Trust Land Administration (SITLA), have high potential for educational values and museum displays.

The goals of this report are to (1) summarize existing knowledge of the paleontology of the Grand Staircase-Escalante National Monument, (2) assess the potential for discovery of new and important paleontological resources, and (3) recommend a plan that will address the need to more fully evaluate paleontological resources on School and Trust lands and utilize their potential to the benefit of Utah's school children.

Location and Physiography

The monument is located within the Colorado Plateau Physiographic Province, near its western margin (figure 1). The Kaiparowits Plateau is centrally situated in the monument surrounded by the towns of Escalante, Henrieville, and Glen Canyon City. Doelling and Davis (1989) described the region as characterized by a series of plateaus, buttes, and mesas that reflect the type and structure of the underlying geologic strata. The Grand Staircase is a broad feature which extends into the western half of the monument, and consists of a series of topographic benches and cliffs which, as its name implies, step progressively down in elevation from north to south. These step-like features include the Paria Terrace and the White and Vermilion Cliffs, which extend southward decreasing in elevation from the Paunsaugunt Plateau near Bryce Canyon (greater than 9,000 feet) to the Shinarump Flats (less than 5,000 feet).

The Kaiparowits Plateau covers approximately 1,650 square miles in the central part of the monument (figure 2). The feature is a broad structural basin; however, the topographic expression is that of a northward-tilted plateau (Doelling and Davis, 1989). The Kaiparowits Plateau merges to the north with the Aquarius Plateau, and to the northwest with the Paunsaugunt Plateau. Elsewhere, the edge of the Kaiparowits Plateau is defined by the outcrop of Cretaceous strata (Hettinger and others, 1996). The plateau is a dissected mesa that rises as much as 6,500 feet above the surrounding terrain. The landscape is defined by four sets of cliffs and benches that form a step-like topography between the Aquarius Plateau and Lake Powell (Sargent and Hansen, 1980). The Straight Cliffs form a prominent escarpment that extends northwest to southeast along the plateau's eastern flank; the escarpment is as high as 1,100 feet along Fiftymile Mountain (figure 2).

The monument, comprised mostly of BLM- and SITLA-administered lands, is bordered by several other federally administered land units. The Dixie National Forest lies to the north of the monument. The southern boundary abuts the Glen Canyon National Recreation area. Bryce Canyon National Park is adjacent to and west of the monument and Capitol Reef National Park is adjacent to and east of the monument. About 275 square miles of School Trust lands are scattered throughout the monument as in-holdings (figure 3).

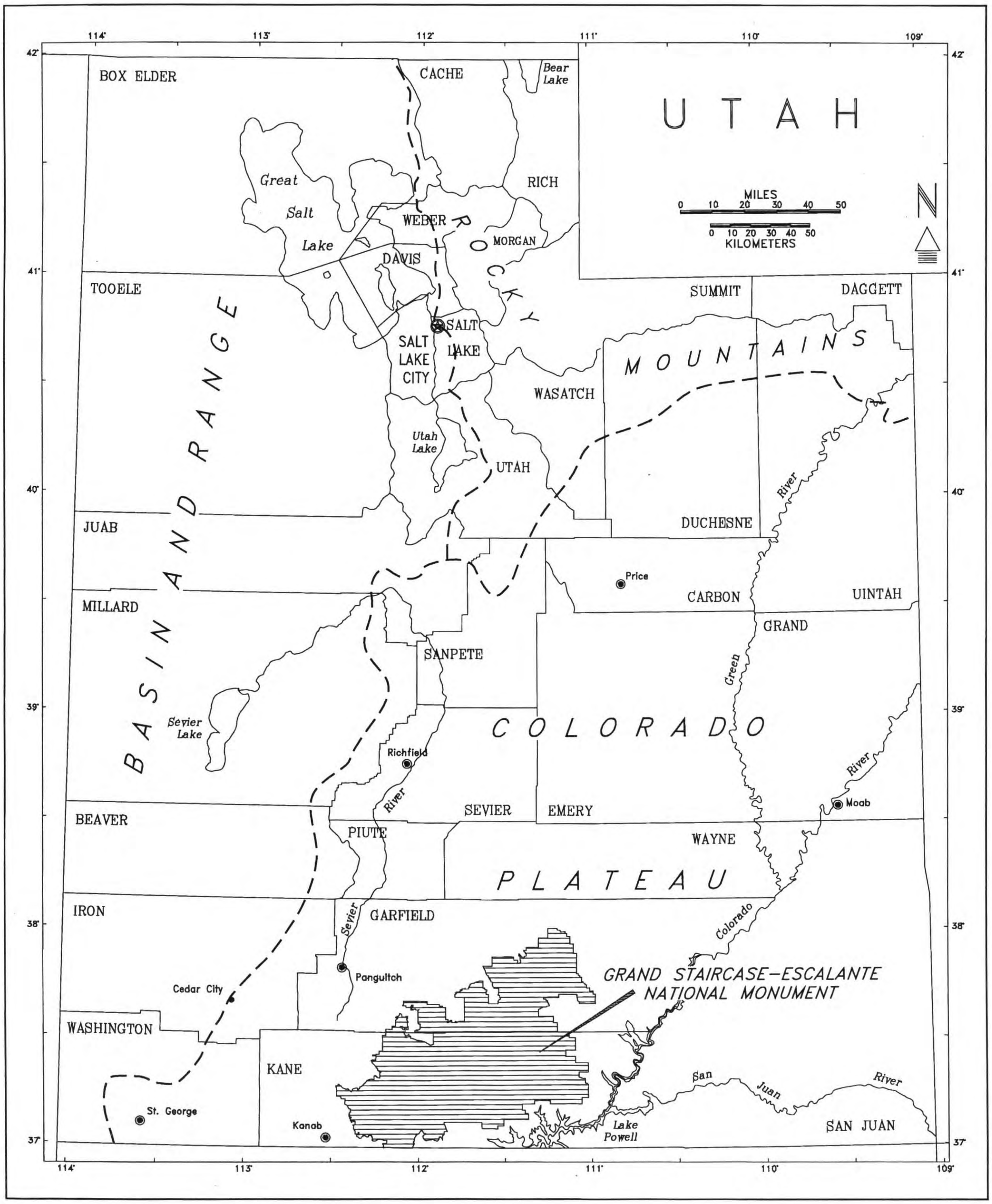

Figure 1. *Location of the Grand Staircase-Escalante National Monument and physiographic provinces of Utah.*

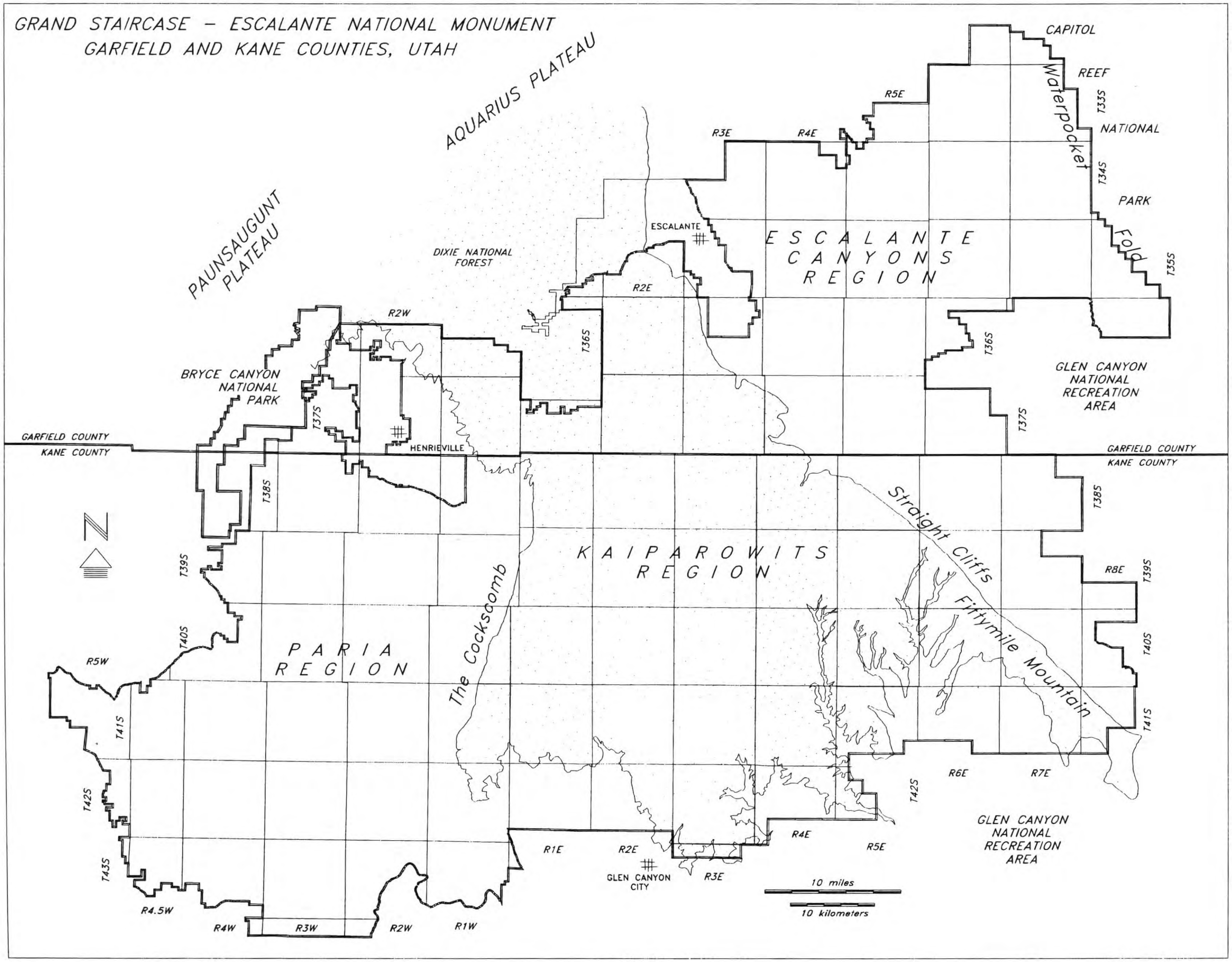

Figure 2. Physiographic features within the Grand Staircase-Escalante National Monument.

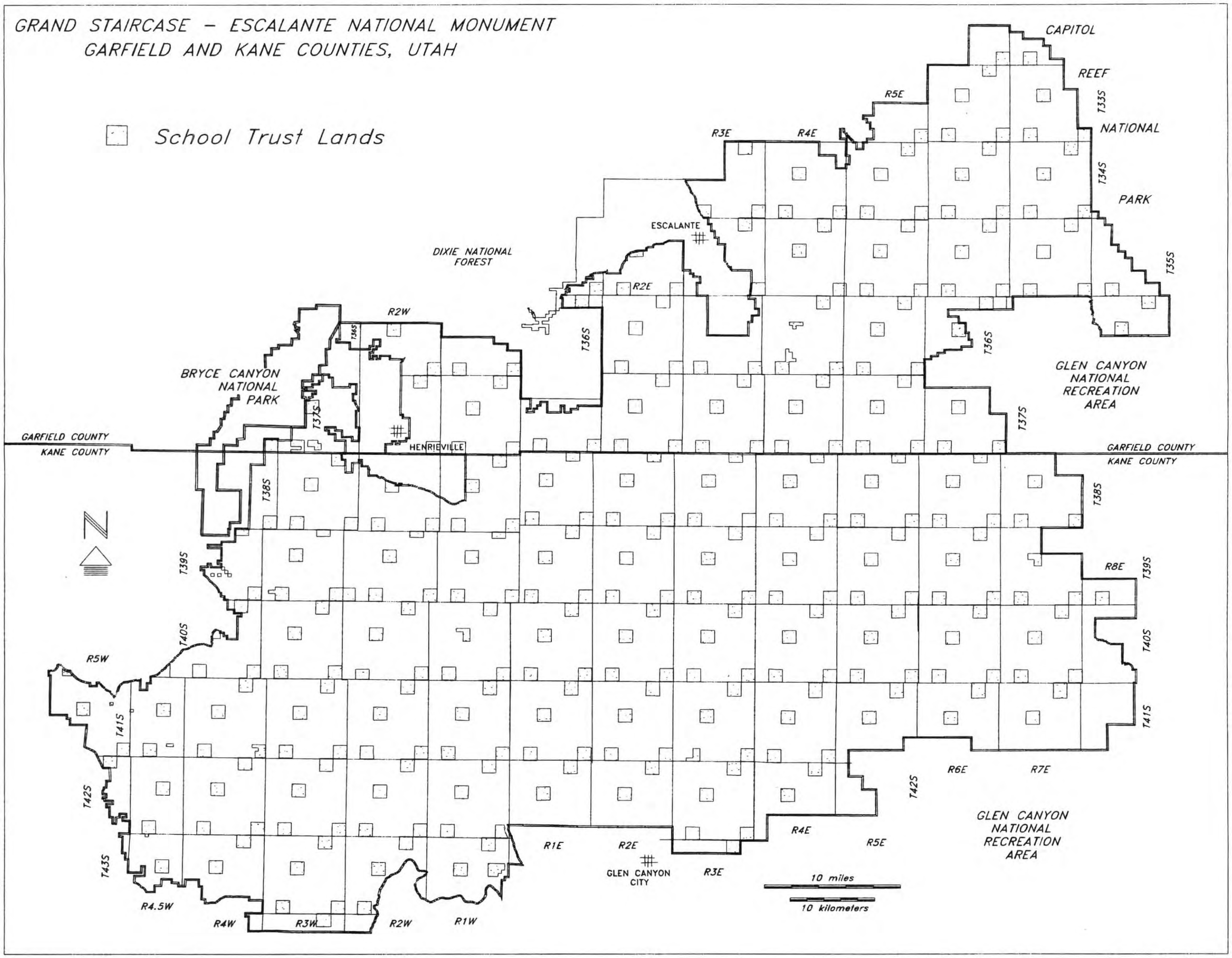

Figure 3. *Location of School and Institutional Trust Lands within the Grand Staircase-Escalante National Monument.*

GEOLOGY

The regional structure and overall geologic setting were presented by Allison (1997). The following summary of the stratigraphy of the Grand Staircase-Escalante National Monument is modified from Allison (1997).

Permian through Jurassic Stratigraphy

The oldest exposed rocks in the region are Permian and crop out only along Kaibab Gulch southwest of The Cockscomb (figure 2). Exposed Permian units, from oldest to youngest, include the Hermit Shale, Coconino Sandstone, Toroweap Formation, White Rim Sandstone, and Kaibab Limestone (figure 4).

Triassic rocks are exposed in southern Kane County and include six members of the Moenkopi Formation and two members of the Chinle Formation. The Moenkopi comprises the Timpoweap, Lower Red, Virgin Limestone, middle red, Shnabkaib, and upper red Members, all deposited in intertidal or shallow marine environments. The Shinarump Member of the Chinle Formation is a fluvial conglomeratic sandstone unit resting unconformably upon the Moenkopi Formation. The upper units of the Chinle are dominated by colorful mudstones and sandstones related to fluvial channel and overbank deposition.

Peterson (1988) placed Jurassic sedimentary units into divisions bounded by unconformities or depositional surfaces where little intertonguing occurs. The Glen Canyon Group, consisting of the Wingate Sandstone, Moenave and Kayenta Formations, and the Navajo Sandstone, is the oldest of the Jurassic divisions. The Wingate and Navajo Sandstones are massive, wind-deposited (eolian) units separated by the Moenave and Kayenta Formations, which are water-lain (fluvial and lacustrine) in origin. The Glen Canyon Group sediments were apparently shed from a source region to the south and east and, therefore, become thicker to the west and northwest.

The Middle Jurassic San Rafael Group consists of the Page Sandstone, the Carmel Formation, the Entrada Sandstone, and the Romana Sandstone. The lower division (Page Sandstone and Carmel Formation) is primarily marine limestone and mudstone deposits, in the western part of the region. These deposits change laterally to the east and southeast to coastal sabkha deposits of mudstone and lenticular beds of gypsum. The Entrada Sandstone comprises the middle division and is separated into three members deposited in sabkha and eolian environments. The upper division consists of the Romana Sandstone which was deposited in marginal marine and eolian environments.

The Salt Wash and Tidwell Members of the Morrison Formation together form the lower division of the Upper Jurassic series. The Salt Wash Member consists of fluvial sandstone and conglomerate and very minor mudstone of lacustrine and flood plain origin. The Tidwell Member represents dominantly lacustrine deposition with associated deposition on mudflats, in evaporative environments, and in small eolian dune fields.

The upper division of the Morrison Formation consists of the Brushy Basin Member in the northern Kaiparowits region, and the Fiftymile Member (a facies of the Brushy Basin) in the southern Kaiparowits. These units were deposited in a broad lowland containing mudflats, lakes, dune fields, and few streams. The Fiftymile Member represents an alluvial complex that gradually moved from southwest to northeast across the Kaiparowits region toward mudflat and lacustrine environments represented by the Brushy Basin Member.

Cretaceous and Tertiary Stratigraphy

As much as 7,500 feet of Upper Cretaceous strata and 3,000 feet of Tertiary strata underlie the Kaiparowits Plateau (Lidke and Sargent, 1983). Upper Cretaceous strata include, in ascending order, the Dakota, Tropic Shale, Straight Cliffs, Wahweap, and Kaiparowits Formations, and the lower part of the Canaan Peak Formation. The Dakota Formation, Tropic Shale, and Straight Cliffs Formation are exposed along the margins of the Kaiparowits Plateau but are buried by younger strata in the central region. These sedimentary units were deposited under conditions ranging from shallow marine to terrestrial. The fossils found in the Cretaceous formations in the monument reflect fluctuations in sea level during the waning stages of marine transgression in this part of the North American continent.

By early Tertiary, regional tectonic activity and sea level changes had caused the final withdrawal of the shallow marine seaways. Volcanic activity in the region produced volcanic deposits that blanketed the area periodically, while rivers and streams eroded upland areas and deposited sediments in lowlands. Tertiary strata in the monument include the upper part of the Canaan Peak Formation, the Pine Hollow and Wasatch (Claron) Formations, and the overlying volcanic rocks of the Mount Dutton Formation and Osiris Tuff. Tertiary fossils have been found in the Claron Formation, but otherwise are not well known in the monument.

Tertiary and Quaternary Stratigraphy

By the Quaternary Period, dating from approximately

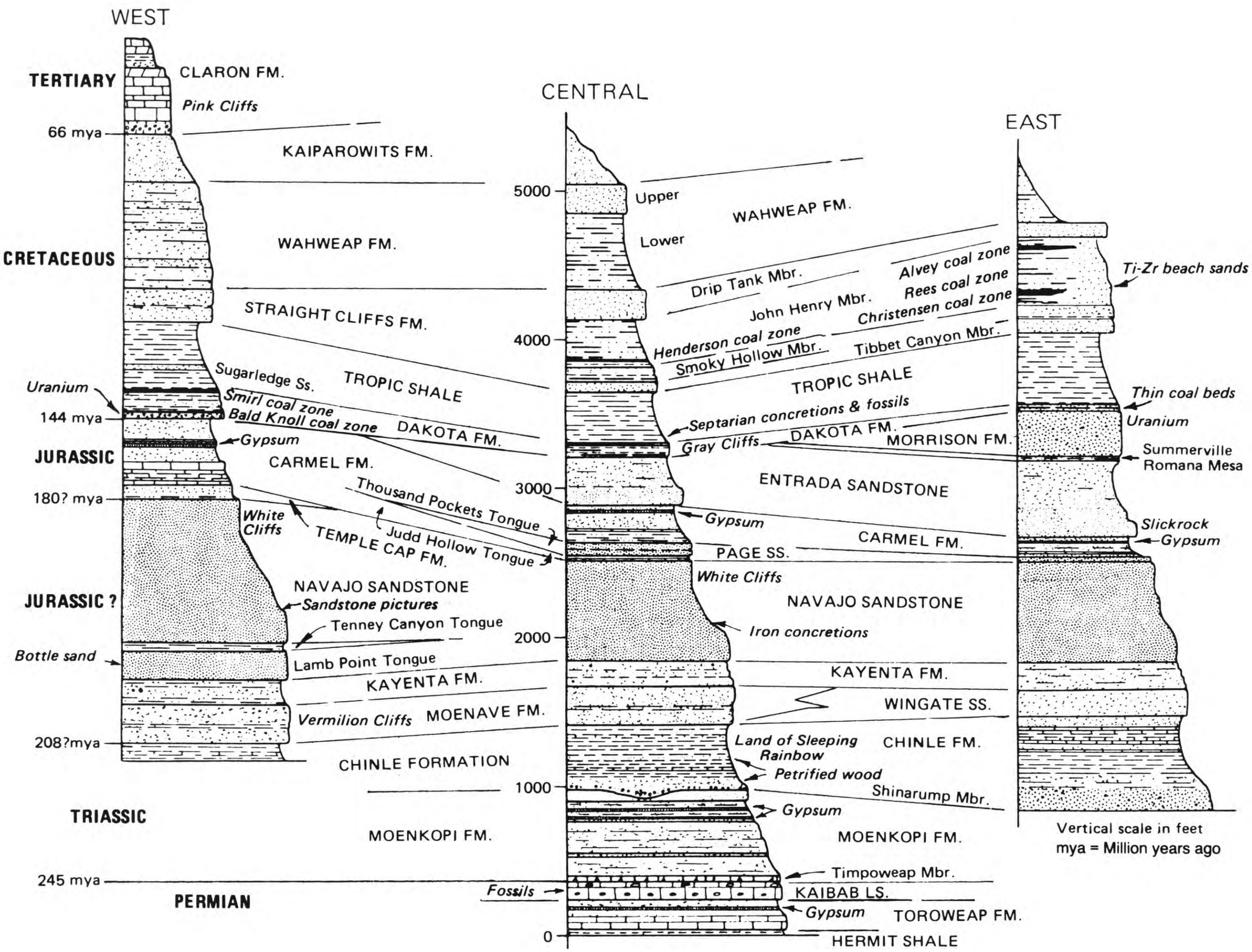

Figure 4. *Stratigraphic relationships (west to east) of exposed rock units in the Grand Staircase-Escalante National Monument (from Doelling and Davis, 1989).*

1.8 million years ago to the present, the Colorado Plateau had been elevated well above sea level, and tectonic activity in the Rocky Mountain region had produced massive mountain ranges in Utah and surrounding states. Fluctuating glacial conditions on the global scale included alpine glaciers as far south as central Utah, with attendant fluctuations in climate that affected the entire continent. In the monument, sediments that accumulated during this time (Doelling and Davis, 1989) include wind-blown sand; a variety of river and stream deposits including silt, sand and gravel; and mass-wasting deposits such as landslides and talus debris. Basalts from nearby volcanic vents also accumulated in the monument during the Quaternary, affecting drainage patterns and erosional conditions.

PALEONTOLOGY

Sedimentary rocks, deposited over the past 256 million years, dominate the surficial geology of the Grand Staircase-Escalante National Monument (Doelling and Davis, 1989). Most of the geological formations in the monument contain fossils. Certain rock types, especially limestones and coal, are almost always richly fossiliferous. Because some formations crop out more extensively, or are more accessible, scientific coverage of the various formations in the monument is uneven. Exposures are widespread, allowing access to most formations within the monument. These exposures facilitate paleontological fieldwork. Paleontological studies have been conducted within the boundaries of the monument and vicinity since the middle of the nineteenth century. The fossil record includes marine and terrestrial fossils that are critical for stratigraphic correlation, paleoenvironmental reconstruction, and study of the evolving faunas and floras.

Reports of fossils used for stratigraphy date back to the early part of the twentieth century. Most of those published records are imprecise at best, precluding determination of exact locations where the fossils were found. In the past decade, paleontological research in the area now included in the Grand Staircase-Escalante National Monument has expanded dramatically. To the extent that the locality information is accurate and available, it is possible to summarize the knowledge of the paleontology of the monument with a measure of confidence. Nevertheless, knowledge of the paleontology for all geologic formations in the monument remains meager at best. Despite long lists of taxa that constitute the known biotas for each formation (appendix B), most fossils have not been thoroughly studied, although paleontologists have recently contributed a considerable effort to improve that knowledge, especially in the Cretaceous formations.

Most of the formations that are exposed in the monument are found elsewhere in Utah. Some extend throughout the Colorado Plateau and beyond. However, because of changing geographic conditions related to plate tectonics and continental drift, the fossils in each formation in the monument represent specific paleogeographic conditions. For example, the Morrison Formation, famous for its Jurassic dinosaurs, extends from central New Mexico to northern Montana, and from western Oklahoma to central Utah. Exposures of the Morrison Formation in the monument are the westernmost occurrence of that formation; Morrison dinosaurs and other organisms found in the monument are therefore the westernmost biota known for that formation. The Morrison biota in the monument should reflect the influence of geography on the habitats, a subject that has not yet reached maturity in paleontological research. Paleontologists suspect that biotas were not uniform throughout the Morrison, but instead varied north to south, east to west, lowland to upland, and wet land to dry land. Conditions during the depositional history of the Morrison within the monument were therefore different from conditions elsewhere in the Morrison outside the monument. Consequently the biota represented by the fossils found in the Morrison Formation in the monument is unique. Similar statements can be made for each formation in the monument.

In contrast, several Cretaceous formations are known only from southern Utah, in particular the Straight Cliffs, Wahweap, and Kaiparowits Formations, all of which are exposed extensively within the monument. Because of the extremely limited geographic extent of these formations, their biotas represent restricted and unique habitats and populations. Paleontologists have begun to study the fossils from these formations in earnest because of these unique conditions of limited geography and restricted populations.

Fossils from every formation in the monument are important for a variety of reasons: (1) they represent the populations that lived in this area when the sediments in those formations were deposited; (2) they represent various habitats and geographic effects in the monument that were influenced by tectonic activity and sea level changes; and (3) some represent highly restricted habitats and depositional conditions with unique biotas that are known only from southern Utah, especially from the monument. The biotas in those formations are therefore unique and cannot be duplicated anywhere else.

Paleontological Record

Several of the geologic formations in the monument are virtually barren of fossils, and in several others the fossil record is sparse. In some formations, however, the fossil record is expanding rapidly, owing to considerable research that has been conducted in the area since the middle 1980s. Several of the Cretaceous formations have been studied with great intensity in recent years for the record of vertebrate life in this area. Mammals and dinosaurs are particularly important targets for this ongoing research, which has produced thousands of specimens that are housed in several major institutions. Consequently, this report can provide only a reflection of the paleontology of the national monument. The lists and summaries provided below are sure to change drastically in the next decade as new studies are undertaken and current studies are completed and published.

Sources of Information

This report summarizes knowledge of the paleontology of the Grand Staircase-Escalante National Monument. Geological terminology follows that of Doelling (1975), Doelling and Davis (1989), and Allison (1997). Sources of paleontological information used to compile this report include published literature (see Selected Bibliography), records contained in the Utah Bibliography of Paleontology database at the Utah Geological Survey, and unpublished information kindly supplied by researchers and curators of several institutions, including: Harley Armstrong (U.S. Bureau of Land Management); Sidney Ash (Weber State University); Brooks Britt (Museum of Western Colorado); Richard L. Cifelli (Oklahoma Museum of Natural History, University of Oklahoma); Jeffrey G. Eaton (Weber State University); Janet Whitmore Gillette (Utah Museum of Natural History, University of Utah); James Jensen, Provo, Utah; and Kenneth Stadtman (Earth Science Museum, Brigham Young University).

Localities

Fossils occur broadly throughout the formations within the monument. Most technical publications do not provide exact locality information. Most records in the UGS database are specific only to the level of township and range (roughly 36 square miles). Table 1 lists fossil localities by township and range, arranged by geologic periods.

This list is certainly incomplete for two reasons: (1) paleontologists and their museums are generally reluctant to divulge exact locality information in print in order to protect the sites, and (2) fossils occur broadly throughout the formations, rather than only at isolated sites. Fossils found in one location may be expected elsewhere at the same stratigraphic horizon wherever that level is exposed. Therefore, a specific fossil locality is a general indication of the fossil content of a formation at a certain stratigraphic position.

PALEONTOLOGICAL RESOURCES BY GEOLOGIC FORMATION

The most effective way to summarize the paleontology of the Grand Staircase-Escalante National Monument is by geologic formation (figure 4 and table 1). Full lists of the biota for each formation are provided in appendix B.

Permian System

Hermit Shale

Most of the Hermit Shale is shale and sandstone, with likelihood of occasional discovery of new fossils, especially plants and fish. The plants seem to indicate continental sedimentation for some or all of the sandstones and shales, or at least proximity to land. Land-dwelling vertebrates (quadrupeds) are expected in this formation, but it has not been systematically surveyed for fossils in the monument. The paleontological record is sparse; land plants, insects, amphibian footprints, and worm trails are the only fossils recorded from this formation.

Importance: Fossil vertebrates from the Permian Period are generally rare in Utah. Discoveries of amphibian and reptile skeletons and track sites are possible.

Coconino Sandstone

Limestone beds immediately overlying the Hermit Shale are very fossiliferous (Doelling and Davis, 1989). The measured section of the Coconino Sandstone in Doelling and Davis (1989), taken from Noble (1928, p. 46), includes several references to fossils, but they were not identified. Marine invertebrates reported from this formation include bivalves, brachiopods, and crinoids. With additional field study, the faunal and floral list should be greatly expanded.

Importance: The Coconino Sandstone has been thoroughly studied elsewhere in Utah and Arizona. Additional paleontological fieldwork in this formation in the monument might produce important fossils that will provide critical information related to paleoenvironments and depositional conditions.

Table 1.
Exposed rock units (from Allison, 1997, after Doelling and Davis, 1989), summary of their fossil content, and list of recorded fossil localities by township and range. Figures in parentheses indicate number of fossil localities in the township and range. For a reference to the map location of the townships and ranges, see figures 2 and 3.

Formation	Age	Fossils	Localities
unnamed	Quaternary	mammoth, mammoth dung, bison, plants	
Claron	Tertiary	leaves, pollen, snails, clams, turtles	T36S R2W T37S R3W
Kaiparowits	Tertiary	plants, pollen, clams, snails, sharks, rays, fish, amphibians, turtles, lizards, crocodiles, birds, dinosaurs, mammals	T36S R1W (17) T37S R1W (5) T38S R1W T37S R1E T38 S R1E (14) T38S R2E (17) T39S R2E (15)
Wahweap	Cretaceous	plants, petrified wood, clams, snails, ostracodes, fish, amphibians, turtles, lizards, crocodiles, dinosaurs, mammals.	T36S R3E T37S R1W (3) T37S R2E (2) T39S R3E T39S R4E T40S R3E T40S R4E (2) T41S R2E (2) T41S R3E (4)
Straight Cliffs	Cretaceous	plants, petrified wood, leaves, carbonized wood, pollen, corals, bryozoans, snails, clams, ammonoids, sharks, fish, salamanders, frogs, turtles, lizards, crocodiles, pterosaurs, dinosaurs, mammals	T36S R2W (2) T37S R3W T37S R2W (2) T37S R1W (4) T37S R4E T38S R4E (2) T39S R4E (2) T39S R5E (2) T40S R4E T40S R5E (4) T40S R6E T41S R3E (2) T41S R4E (4) T41S R5E (2) T41S R7E (3) T41S R8E (2) T42S R1E T42S R3E (10) T42S R4E (2) T42S R5E
Tropic Shale	Cretaceous	plants, clams, snails, ammonoids, crabs, worms, sharks, fish, marine reptiles	T35S R3E (3) T36S R3E (5) T37S R3W (3) T37S R2W (7) T37S R4W (3) T38S R3W T38S R1W (2) T38S R4E T38S R1W (2)

Formation	Age	Fossils	Localities
Tropic Shale (continued)			T38S R4E T39S R1W T40S R1W T40S R6E (5) T40S R7E (2) T41S R5E T41S R6E T41S R8E T42S R1W (4) T42S R1E (2) T42S R4E (3) T42S R5E
Dakota	Cretaceous	plants, petrified wood, pollen, snails, clams, ammonoids, worm tracks, ostracodes, sharks, rays, fish, salamanders, turtles, lizards, crocodiles, dinosaurs, mammals	T35S R2E T36S R3E T37S R1W T37S R4E T38S R1W T40S R6E (2) T41S R5E (16) T41S R6E (12) T41S R7E (9) T41S R8E (8) T42S R1W (9) T42S R1E (4) T42S R2E (9) T42S R4E (11) T42S R5E (16)
Morrison	Jurassic	petrified wood, dinosaurs	T35S R3E T39S R1E T41S R6E T41S R8E T42S R4E
Summerville, Henrieville, Romana	Jurassic	none	
Entrada Sandstone	Jurassic	none	
Carmel	Jurassic	plants, algae, corals, brachiopods, bivalves, snails, ammonoids, crinoids, echinoids, ostracodes, and worm traces	T38S R2W
Temple Cap Sandstone	Jurassic		
Navajo Sandstone	Jurassic	dinosaurs tracks	T35S R4E T43S R4W T43S R2W
Kayenta	Jurassic	petrified wood, clams, reptile tracks, worm traces	T42S R4W T43S R4W T43S R2W
Moenave	Jurassic	pollen, fish, crocodiles, tracks of insects and worms	T42 S R4W

Formation	Age	Fossils	Localities
Wingate Sandstone	Jurassic	none	
Chinle	Triassic	petrified wood, plants, snails, clams, insects, insect traces, fish, lungfish burrows, phytosaurs, reptile tracks	T32S R6E (3) T33S R6E T34S R4E T34S R5E T34S R6E (2) T35S R5E T35S R7E T38S R1E T39S R1E T40S R3W T41S R2W (3) T42S R4W T43S R4W
Moenkopi	Triassic	plants, snails, clams, ammonoids, crinoids, echinoids, ostracodes, fish, tracks of reptiles and arthropods	T33S R6E (2) T34S R7E (4) T42S R3W (2) T42S R1W T43S R3W(2)
Kaibab	Permian	brachiopods, bryozoans, clams, snails, corals, sponges, algal stromatolites, cephalopods, trilobites, conodonts	T34S R7E T35S R7E (3) T35S R8E (4) T37S R1E T42S R3W
Toroweap-White Rim, Coconino	Permian	clams, brachiopods, crinoids	
Hermit Shale	Permian	land plants, insects, amphibian tracks, worm tracks	

Toroweap-White Rim Formations

The Toroweap Formation contains marine fossils of Permian age (Doelling and Davis, 1989). It includes fossiliferous limestones with abundant, large brachiopods. Doelling and Davis (1989) did not mention finding fossils in the White Rim Formation. Various authors have listed brachiopods, bivalves, and small crinoid stems in the Toroweap Formation.

Importance: Although the Toroweap Formation has not been recognized as fossiliferous in the monument and exposures there are limited, additional fieldwork should expand knowledge of the fossils of this formation.

Kaibab Formation

Blakey (1970) commented on the mode of preservation of fossils in this formation and listed the following fossils in the Fossil Mountain Member of the Kaibab Formation: brachiopods, bryozoans, bivalve fragments, and crinoid columnals. The faunal and floral lists are extensive (appendix B).

Importance: The fossil record of the Kaibab Formation is the most extensive among the several Permian formations in the monument. These fossils are important for correlations with other formations of similar age.

Triassic System

Moenkopi Formation

Doelling and Davis (1989) listed gastropods and bivalves in the Timpoweap Member (previously considered a member of the Kaibab Formation); they listed fossiliferous limestone, molluscs, crinoid stems, the index fossil *Tirolites*, and ostracodes in the Virgin Limestone member. Others have recorded additional taxa, but with few concentrated efforts to thoroughly study this formation. The biota includes a rich assemblage of marine and terrestrial organisms (appendix B).

Importance: These animals and plants existed during or just before the origin of dinosaurs. Fossils from the Moenkopi Formation have the potential to reveal important details of the conditions under which dinosaurs and many of their relatives originated. While the marine fossils allow for precise correlation and age determination, the terrestrial organisms stand in a critical stratigraphic position. This formation deserves systematic field work for its potential fossil content, especially dinosaurs and their relatives.

Chinle Formation

Doelling and Davis (1989) reported abundant carbonaceous material and logs of petrified wood in the Shinarump Member, petrified wood in the Petrified Forest Member, and a palynological assemblage of 20 taxa in the Monitor Butte Member that indicated Carnian-Norian (Late Triassic) age for the upper part of the Chinle Formation. Others have recognized extensive occurrences of fossil bones and plants that have not been studied. The floral and faunal list (appendix B) spans a broad spectrum of fossils, including plants, petrified wood, snails, clams, fish, insects, horseshoe crabs, ostracodes, fish, reptiles, and tracks.

Importance: The plants and animals of the Chinle Formation represent terrestrial and fresh-water habitats. Elsewhere (for example, the Petrified Forest National Monument, Arizona and the Ghost Ranch area, New Mexico) the Chinle Formation has produced hundreds of taxa, including the oldest dinosaurs in North America, and perhaps the world. The paleontology of the Chinle Formation in the Grand Staircase-Escalante National Monument has not been methodically studied. Exposures of this formation hold great promise for discovery of important plants and animals that constituted the biota that existed with the earliest dinosaurs. This formation deserves systematic field work for its potential fossil content, especially dinosaurs and their relatives.

Jurassic System

Moenave Formation-Wingate Sandstone

The Moenave Formation is exposed in the western part of the Grand Staircase-Escalante National Monument (figure 4) and has yielded a small assemblage of fossils. Colbert and Mook (1951) defined the Dinosaur Canyon member of the Moenave Formation in their report on the occurrence of the ancestral crocodile, *Protosuchus*. Doelling and Davis (1989) summarized reports of fish in the Whitmore Point Member of the Moenave Formation that began with discoveries by C. D. Walcott in 1879, and continued with revisions and additions by Eastman (1905, 1917), Schaeffer and Dunkle (1950), Wilson (1959), and Stewart and others (1972). As of 1989, the revised fish fauna included two species based on type specimens that came from the Moenave Formation in the Kanab area.

The biota of the Moenave Formation (appendix B) is limited to stromatolites, petrified wood, pollen, spores, a few occurrences of fish, a crocodile, and trace fossils.

The correlative Wingate Formation is exposed in the eastern part of the monument. There are no confirmed

records of fossils in the Wingate Formation in the vicinity of the Grand Staircase-Escalante National Monument.
Importance: These two formations typically produce few fossils. The likelihood of discovery of new and important fossils in either of these formations is low. Because of the rarity of fossils in these two formations, however, any new discovery, such as additional skeletal material of the crocodile *Protosuchus*, will be important.

Kayenta Formation

Doelling and Davis (1989) reported dinosaur tracks from the Kayenta Formation, and noted that bones of certain Jurassic reptiles have been found in that formation near Kayenta, Arizona. Tracks of dinosaurs and other Jurassic reptiles are, in places, abundant in the Kayenta Formation. Isolated occurrences of vertebrate fossils, including dinosaurs, are also rather common in the Kayenta Formation in general, but have not been recognized within the monument.

The confirmed biota of the Kayenta Formation in the Grand Staircase-Escalante National Monument and vicinity is sparse (appendix B). It includes petrified wood, clams, worm traces, and tracks of dinosaurs or related animals.
Importance: All vertebrate fossils in the Kayenta Formation are important because of their critical stratigraphic position between the faunas containing the early and primitive reptiles of the Chinle Formation and faunas with the more advanced reptiles of the Morrison Formation. Paleontologists have recovered skeletons of dinosaurs and other reptiles from the Kayenta Formation outside of the monument. This formation deserves special attention in the monument for new discoveries of vertebrate fossils, including dinosaurs.

Navajo Sandstone

The Navajo Sandstone is nearly barren of fossils throughout its wide geographic extent. Doelling and Davis (1989) did not list any fossils in the Navajo Sandstone in Kane County. Elsewhere, dinosaur tracks and petrified wood have been recognized in "oasis" interdune deposits in the Navajo. Similar fossils should be expected in the Navajo Sandstone in the monument. Geologists conducting field research in the monument have noted incidental discoveries of plants, tracks, and a few invertebrates. The published floral and faunal list (appendix B) includes plants, invertebrates, and trackways of dinosaurs and their relatives.
Importance: In other places in Utah, petrified logs and vertebrate tracks are associated with geologic conditions that have led to the notion of the oasis habitats. The few fossils recorded for the Navajo Sandstone in the monument and vicinity probably occur in such deposits. If oasis deposits are discovered in the monument, they could be highly important, especially if they should contain fossil bones of dinosaurs or other reptiles.

Temple Cap Sandstone

Doelling and Davis (1989) did not record any fossils in this formation, nor are there any other records in the available literature and databases.

Carmel Formation and Page Sandstone

The Carmel Formation contains a diverse assemblage of fossils including marine plants, corals, gastropods, echinoids, oysters, crinoids, and worms. This formation is rather fossiliferous in the monument and vicinity (Gregory, 1950; Imlay, 1964; Doelling and Davis, 1989; appendix B). There are no records of fossils from the Page Sandstone.
Importance: Fossils in the Carmel Formation have been important for correlation studies. Published records of fossils in the vicinity of the monument are largely incidental. Additional fieldwork should produce a much longer list of fossils, including some that are diagnostic as index fossils for precise correlation with marine rocks of similar age elsewhere in North America.

Entrada Sandstone

Doelling and Davis (1989) did not report any fossils from this formation, although one member includes a coal bed which probably contains abundant microfossils and fossil plants. We found no additional records of fossils in the Entrada Sandstone in the Grand Staircase-Escalante National Monument and vicinity. In other places this formation is equally barren, and cannot be expected to produce any fossils in the monument.

Summerville Formation, Romana Sandstone, and Henrieville Sandstone

Doelling and Davis (1989) did not report fossils from either the Summerville Formation or the Henrieville Sandstone, but they recorded worm tubes from a sandstone bed in the Romana Sandstone. During the past year, new discoveries of skeletons and tracks of dinosaurs and relatives in the Summerville Formation elsewhere in Utah indicate that similar fossils should be found in the Grand Staircase-Escalante National Monument.

Importance: Despite the generally unproductive history of fossil discoveries in the Summerville Formation, in recent years it has yielded some critically important fossils, including unpublished reports of tracks of pterosaurs, dinosaurs, and some undescribed fossil bones. Any fossils found in the monument will be important for their stratigraphic position immediately preceding the dinosaurs and associated biota of the Morrison Formation.

Morrison Formation

Doelling and Davis (1989) recorded petrified logs and wood in the Morrison Formation. Dinosaur bones are common in the Morrison Formation elsewhere and are likely to be present in the monument. The list of confirmed fossils in the Morrison Formation in the Grand Staircase-Escalante National Monument and vicinity includes plants, dinosaurs, and other reptiles (appendix B).

Importance: The Morrison Formation has produced the classic dinosaurs of the Jurassic Period (for example, *Allosaurus*, *Apatosaurus*, *Barosaurus*, *Brachiosaurus*, *Camptosaurus*, *Ceratosaurus*, *Diplodocus*, *Seismosaurus*, *Stegosaurus*, *Supersaurus*, and many others). Dinosaurs and associated animals and plants from the Morrison Formation have become the world standard for Late Jurassic faunas and floras. Faunal and floral lists from important sites such as Dinosaur National Monument typically include several hundred taxa of fish, amphibians, reptiles (including dinosaurs), mammals, invertebrates, plants, pollen, and spores. Many of the most important sites in the Morrison Formation are in Utah and Colorado, but none are close to the Grand Staircase-Escalante National Monument. Unpublished records of dinosaur sites in this formation within the monument indicate that it holds considerable promise for productive and important sites. Discovery of dinosaurs and associated fossils in the monument will be critical to understanding the geographic and temporal variation of the Late Jurassic dinosaurs because of the geographic setting as the westernmost occurrence of the Morrison Formation in North America.

Cretaceous System

Ongoing research on the paleontology of the Cretaceous formations of the Kaiparowits Plateau by Rich Cifelli, Jeffrey Eaton, and colleagues that began in 1982 has greatly expanded knowledge of the Cretaceous biota of southern Utah (Cifelli and Madsen, 1986; Cifelli and Eaton, 1987; Eaton, 1987a, 1987b, 1988, 1991, 1993a, 1993b, 1995; Eaton and others, 1987; Kirkland, 1987; Eaton and Cifelli, 1988; Cifelli, 1990a, 1990b, 1990c, 1990d; Eaton and Nations, 1991; Parrish and Eaton, 1991; Cobban, 1993; Cifelli and Johanson, 1994; Eaton and others, in press). With the recognition of the abundance and importance of this fauna, additional specialists have joined this team. Currently, researchers from Weber State University, Dinosaur National Monument, University of Oklahoma, University of California, University of Illinois, University of Colorado, and Dinamation International, Inc., are studying various aspects of the Cretaceous biota.

Dakota Formation

In the Dakota Formation, Doelling and Davis (1989) reported petrified wood, coal, coalified vegetal debris, palynological samples, coal beds with pollen and spores, oysters, ammonoids, and turtles. As of 1989, that was the extent of knowledge concerning fossils of the Dakota Formation in Kane County. Once considered almost barren of fossils, the concerted efforts of the team of paleontologists identified above have produced a fauna from the Dakota Formation with critical importance in understanding the transition from archaic faunas of the Late Jurassic and Early Cretaceous to the more advanced faunas (containing advanced dinosaurs and advanced mammals) of the Late Cretaceous. The total numbers of identified and catalogued specimens and localities of the Dakota Formation have not been tallied. Faunas have been recovered from a multitude of sites that have produced thousands of specimens.

Paleontologists now recognize that the fossil record of the Dakota Formation is rich and diverse on the Kaiparowits Plateau (appendix B). It contains at least two new species of sharks, a new genus and species of ray, a rich assemblage of fish from at least five orders and including at least one new species, at least two genera of amphibians, at least four families of turtles, at least seven families of lizards, at least three families of crocodiles, at least four families of saurischian dinosaurs, at least four families of ornithischian dinosaurs, and at least five families of mammals including multituberculates, symmetrodonts, and marsupials.

Importance: For decades the fauna and flora of the Dakota Formation were ignored, on the assumption that the fossils were neither useful nor important. Recent research, especially on the vertebrates, has reversed that practice. The fossil content of the Dakota Formation is currently under intense scrutiny, especially in the Grand Staircase-Escalante National Monument. Newly published technical reports, several reports in press, and ongoing research activity in the monument indicate long-term interest in these fossils. Their importance lies in the critical stratigraphic position of the Dakota Formation, between the older Morrison Formation and its relatively archaic biota of the Late Jurassic and the younger Cretaceous formations (see below) with their advanced dinosaurs, mammals, birds, and flowering plants.

Tropic Shale

This formation has yielded a modest fauna (Doelling and Davis, 1989) that includes a variety of fossils found in limestone concretions: molluscs, ammonoids, crabs, fish, and bones of marine reptiles.

Recent research on the paleontology of the Tropic Shale has greatly expanded the floral and faunal lists (see also comments under Cretaceous System, above). Fossils in the Tropic Shale are mainly of animals that lived in shallow marine habitats and plants from nearby terrestrial habitats (charophytes, dicots, plant leaves). The invertebrate fossils in this formation have been used extensively for correlation. The occurrence of marine reptiles immediately outside the monument boundary indicates the probable existence of additional specimens in the Grand Staircase-Escalante National Monument. The floral and faunal lists for the Tropic Shale are extensive (appendix B).

Importance: The marine invertebrates are important for correlations with other strata of similar age, and for understanding relationships with formations stratigraphically below (Dakota Formation) and above (Straight Cliffs Formation). The marine vertebrates, especially the reptiles, are rare in this formation and at this age; additional specimens will be critical to understanding the history of the giant mosasaurs (these might be the earliest records of mosasaurs in North America) and plesiosaurs.

Straight Cliffs Formation

Fossils in the Straight Cliffs Formation have been extensively studied for faunal succession and correlation with other Cretaceous formations (see also comments under Cretaceous System, above). Doelling and Davis (1989) recognized a distinctive suite of invertebrate fossils that characterize the Tibbet Canyon Member, including bivalves, gastropods, cephalopods, shark teeth, and trace fossils. The Smokey Hollow Member and John Henry Member contain carbonaceous mudstone and coal with fragments of woody plants, including twigs, leaves, pollen, and coalified branches. Marine facies of the Straight Cliffs Formation contain marine invertebrates including bivalves, sharks, gastropods, cephalopods, and trace fossils.

Recent research has greatly expanded the floral and faunal lists (appendix B), especially for the vertebrates.

Importance: Research on the fauna and flora of the Straight Cliffs Formation is currently intense, especially for mammals and dinosaurs. Because of its stratigraphic position and geographic setting, the biota of the Straight Cliffs Formation in the Grand Staircase-Escalante National Monument is critical to understanding the history of the shallow marine and terrestrial habitats of the Late Cretaceous.

Wahweap Formation

Doelling and Davis (1989) recognized sandstones in the Wahweap Formation with dinosaur bones, petrified wood, ostracodes, and molluscs. Current research has expanded the biota considerably, demonstrating that this formation is richly fossiliferous (see also comments under Cretaceous System, above). The biota includes a wide range of organisms, with an extensive list of vertebrate taxa (appendix B).

Importance: Nearly all the vertebrate fossils recorded for the Wahweap Formation have been discovered in the past decade. They are currently under study by a team of researchers whose interests are directed almost wholly within the Grand Staircase-Escalante National Monument. Sites have been sampled, but many have not been fully evaluated for their potential or need for additional field study. Research on this formation is intense, and will continue indefinitely owing to the rich content of fossil mammals.

Kaiparowits Formation

This formation is the youngest of the Cretaceous formations in the Grand Staircase-Escalante National Monument. Palynomorphs (pollen and spores) from the Kaiparowits Formation have been used for correlation and age determination. Turtle shell fragments, dinosaur bones, non-diagnostic molluscs, and plant fossils have been recognized in the Kaiparowits Formation (Doelling and Davis, 1989) but, until the past decade, little concentrated paleontological research in this formation was undertaken in the Grand Staircase-Escalante National Monument.

The Kaiparowits Formation in the monument has been the focus of considerable attention by paleontologists since the middle 1980s (see also comments under Cretaceous System, above). The vertebrate fauna of the Kaiparowits Formation is the most extensive Late Cretaceous biota in Utah, and one of the most important in North America. The floral and faunal list for the Kaiparowits Formation is extensive (appendix B).

Importance: The stratigraphic position of the Kaiparowits Formation, immediately preceding the major extinction episode at the end of the Cretaceous Period, is especially critical for the mammals in this formation. These mammals immediately preceded the great expansion of mammals following the extinction of the dinosaurs. Research on the habitats and paleobiological setting of the terrestrial animals and plants of the Late Cretaceous is presently the object of considerable effort within the monument.

Tertiary System

Claron Formation

According to Doelling and Davis (1989) fossils are rare in this formation, which is generally regarded as Paleocene-Eocene in age. Oysters, clams, snails, and a small assemblage of palynomorphs have been used to interpret paleoenvironmental conditions of deposition of this formation, but few of the fossils have been useful for correlation. The floral and faunal lists for the Claron Formation in the Grand Staircase-Escalante National Monument and vicinity include leaf impressions, palynomorphs, tree stems, snails, clams, oysters, and turtles (appendix B).
Importance: Fossils from the Claron Formation have been important for determination of age and correlation.

Quaternary System

Several sites with fossil bones of Pleistocene animals and their traces have been reported (Cluer and others, 1987; Agenbroad and Mead, 1989). These include mammoth and extinct bison (appendix B). Quaternary sediments throughout the Grand Staircase-Escalante National Monument are likely to produce important fossils.
Importance: All fossils from Quaternary sediments in the monument are potentially important. These sediments have not been thoroughly examined for their fossil content, which potentially could yield Ice Age organisms ranging in age from 1.8 million to 11,000 years old. Of particular concern are organisms that can be used for interpretations of paleoenvironmental conditions associated with the arrival of humans in North America roughly 12,000 to 9000 years ago.

CONCLUSIONS

Summary

Fossils occur throughout the Grand Staircase-Escalante National Monument. The paleontological record for several formations has been recognized in recent years as worthy of considerable research for purposes of stratigraphic correlation, understanding changing paleobiological conditions on the land and in the sea, and understanding the evolution of plants and animals during the waning stages of the reign of dinosaurs in North America in the Cretaceous Period. Additional research should be directed toward Triassic formations, which have high potential for critical discoveries relating to the origin of dinosaurs, and Quaternary sediments, which probably contain mammoths and their associated floras and faunas.

Knowledge of the paleontology of all the formations in the monument is still rudimentary, as indicated by the recent intensified interest in the fossils of the monument and vicinity. For all formations, fieldwork, museum curation, and laboratory analysis are essential.

Recommendations

Existing paleontological records are incomplete with respect to exact locality information. Additional research to establish more accurate information should include field verification to determine land ownership. Disturbance of sites on federal land within the Grand Staircase-Escalante National Monument should be conducted only with permission of the land managers who have permit responsibilities.

For School and Institutional Trust lands, resource assessment should include an active program including:

Preliminary analysis

- Literature research, database review, and communications with active researchers.
- On-the-ground prospecting and sampling.
- Specimen preparation and curation of samples in the Utah Museum of Natural History.
- Evaluation of the samples and prospecting results.

Excavation

- Excavation of selected important localities.
- Laboratory preparation of excavated specimens.
- Curation in the Utah Museum of Natural History.
- Research and publication by specialists as appropriate.

Final evaluation of sites and formations for their fossils

- Assessment of long-term potential for additional duction of important specimens.
- Assessment of scientific and educational values.
- Recommendations for mitigation.

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APPENDIX A: Presidential proclamation

THE WHITE HOUSE
Office of the Press Secretary

For Immediate Release
September 18, 1996

ESTABLISHMENT OF THE GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT

By the President of the United States of America

A Proclamation

The Grand Staircase-Escalante National Monument's vast and austere landscape embraces a spectacular array of scientific and historic resources. This high, rugged, and remote region, where bold plateaus and multi-hued cliffs run for distances that defy human perspective, was the last place in the continental United States to be mapped. Even today, this unspoiled natural area remains a frontier, a quality that greatly enhances the monument's value for scientific study. The monument has a long and dignified human history: it is a place where one can see how nature shapes human endeavors in the American West, where distance and aridity have been pitted against our dreams and courage. The monument presents exemplary opportunities for geologists, paleontologists, archeologists, historians, and biologists.

The monument is a geologic treasure of clearly exposed stratigraphy and structures. The sedimentary rock layers are relatively undeformed and unobscured by vegetation, offering a clear view to understanding the processes of the earth's formation. A wide variety of formations, some in brilliant colors, have been exposed by millennia of erosion. The monument contains significant portions of a vast geologic stairway, named the Grand Staircase by pioneering geologist Clarence Dutton, which rises 5,500 feet to the rim of Bryce Canyon in an unbroken sequence of great cliffs and plateaus. The monument includes the rugged canyon country of the upper Paria Canyon system, major components of the White and Vermilion Cliffs and associated benches, and the Kaiparowits Plateau. That Plateau encompasses about 1,600 square miles of sedimentary rock and consists of successive south-to-north ascending plateaus or benches, deeply cut by steep-walled canyons. Naturally burning coal seams have scorched the tops of the Burning Hills brick-red. Another prominent geological feature of the plateau is the East Kaibab Monocline, known as the Cockscomb. The monument also includes the spectacular Circle Cliffs and part of the Waterpocket Fold, the inclusion of which completes the protection of this geologic feature begun with the establishment of Capitol Reef National Monument in 1938 (Proclamation No. 2246, 50 Stat. 1856). The monument holds many arches and natural bridges, including the 130-foot-high Escalante Natural Bridge, with a 100 foot span, and Grosvenor Arch, a rare "double arch." The upper Escalante Canyons, in the northeastern reaches of the monument, are distinctive: in addition to several major arches and natural bridges, vivid geological features are laid bare in narrow, serpentine canyons, where erosion has exposed sandstone and shale deposits in shades of red, maroon, chocolate, tan, gray , and white. Such diverse objects make the monument outstanding for purposes of geologic study.

The monument includes world class paleontological sites. The Circle Cliffs reveal remarkable specimens of petrified wood, such as large unbroken logs exceeding 30 feet in length. The thickness, continuity and broad temporal distribution of the Kaiparowits Plateau's stratigraphy provide significant opportunities to study the paleontology of the late Cretaceous Era. Extremely significant fossils, including marine and brackish water mollusks, turtles, crocodilians, lizards, dinosaurs, fishes, and mammals, have been recovered from the Dakota, Tropic Shale and Wahweap Formations, and the Tibbet Canyon, Smoky Hollow and John Henry members of the Straight Cliffs Formation. Within the monument, these formations have produced the only evidence in our hemisphere of terrestrial vertebrate fauna, including mammals, of the Cenomanian-Santonian ages. This sequence of rocks, including the overlaying Wahweap and Kaiparowits formations, contains one of the best and most continuous records of Late Cretaceous terrestrial life in the world.

Archeological inventories carried out to date show extensive use of places within the monument by ancient Native American cultures. The area was a contact point for the Anasazi and Fremont cultures, and the evidence of this mingling provides a significant opportunity for archeological study. The cultural resources discovered so far in the monument are outstanding in their variety of cultural affiliation, type and distribution. Hundreds of recorded sites include rock art panels, occupation sites, campsites and granaries. Many more undocumented sites that exist within the monument are of significant scientific and historic value worthy of preservation for future study.

The monument is rich in human history. In addition to occupations by the Anasazi and Fremont cultures, the area has been used by modern tribal groups, including the Southern Paiute and Navajo. John Wesley Powell's expedition did initial mapping and scientific field work in the area in 1872. Early Mormon pioneers left many historic objects, including trails, inscriptions, ghost towns such as the Old Paria townsite, rock houses, and cowboy line camps, and built and traversed the renowned Hole-in-the-Rock Trail as part of their epic colonization efforts. Sixty miles of the Trail lie within the monument, as does Dance Hall Rock, used by intrepid Mormon pioneers and now a National Historic Site.

Spanning five life zones from low-lying desert to coniferous forest, with scarce and scattered water sources, the monument is an outstanding biological resource. Remoteness, limited travel corridors and low visitation have all helped to preserve intact the monument's important ecological values. The blending of warm and cold desert floras, along with the high number of endemic species, place this area in the heart of perhaps the richest floristic region in the Intermountain West. It contains an abundance of unique, isolated communities such as hanging gardens, tinajas, and rock crevice, canyon bottom, and dunal pocket communities, which have provided refugia for many ancient plant species for millennia. Geologic uplift with minimal deformation and subsequent downcutting by streams have exposed large expanses of a variety of geologic strata, each with unique physical and chemical characteristics. These strata are the parent material for a spectacular array of unusual and diverse soils that support many different vegetative communities and numerous types of endemic plants and their pollinators. This presents an extraordinary opportunity to study plant speciation and community dynamics independent of climatic variables. The monument contains an extraordinary number of areas of relict vegetation, many of which have existed since the Pleistocene, where natural processes continue unaltered by man. These include relict grasslands, of which No Mans Mesa is an outstanding example, and pinon-juniper communities containing trees up to 1,400 years old. As witnesses to the past, these relict areas establish a baseline against which to measure changes in community dynamics and biogeochemical cycles in areas impacted by human activity. Most of the ecological communities contained in the monument have low resistance to, and slow recovery from, disturbance. Fragile cryptobiotic crusts, themselves of significant biological interest, play a critical role throughout the monument, stabilizing the highly erodible desert soils and providing nutrients to plants. An abundance of packrat middens provides insight into the vegetation and climate of the past 25,000 years and furnishes context for studies of evolution and climate change. The wildlife of the monument is characterized by a diversity of species. The monument varies greatly in elevation and topography and is in a climatic zone where northern and southern habitat species intermingle. Mountain lion, bear, and desert bighorn sheep roam the monument. Over 200 species of birds, including bald eagles and peregrine falcons, are found within the area. Wildlife, including neotropical birds, concentrate around the Paria and Escalante Rivers and other riparian corridors within the monument.

Section 2 of the Act of June 8, 1906 (34 Stat. 225, 16 U.S.C. 431) authorizes the President, in his discretion, to declare by public proclamation historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon the lands owned or controlled by the Government of the United States to be national monuments, and to reserve as a part thereof parcels of land, the limits of which in all cases shall be confined to the smallest area compatible with the proper care and management of the objects to be protected.

NOW, THEREFORE, I WILLIAM J. CLINTON, President of the United States of America, by the authority vested in me by section 2 of the Act of June 8, 1906 (34 Stat. 225, 16 U.S.C. 431), do proclaim that there are hereby set apart and reserved as the Grand Staircase-Escalante National Monument, for the purpose of protecting the objects identified above, all lands and interests in lands owned or controlled by the United States within the boundaries of the area described on the document entitled "Grand Staircase-Escalante National Monument" attached to and forming a part of this proclamation. The Federal land and interests in land reserved consist of approximately 1.7 million acres, which is the smallest area compatible with the proper care and management of the objects to be protected.

All Federal lands and interests in lands within the boundaries of this monument are hereby appropriated and withdrawn from entry, location, selection, sale, leasing, or other disposition under the public land laws, other than by exchange that furthers the protective purposes of the monument. Lands and interests in lands not owned by the United States shall by reserved as a part of the monument upon acquisition of title thereto by the United States.

The establishment of this monument is subject to valid existing rights.

Nothing in this proclamation shall be deemed to diminish the responsibility and authority of the State of Utah for management of fish and wildlife, including regulation of hunting and fishing, on Federal lands within the monument.

Nothing in this proclamation shall be deemed to affect existing permits or leases for, or levels of, livestock grazing on Federal lands within the monument; existing grazing uses shall continue to be governed by applicable laws and regulations other than this proclamation.

Nothing in this proclamation shall be deemed to revoke any existing withdrawal, reservation, or appropriation; however, the national monument shall be the dominant reservation.

The Secretary of the Interior shall manage the monument through the Bureau of Land Management, pursuant to applicable legal authorities, to implement the purposes of this proclamation. The Secretary of the Interior shall prepare, within 3 years of this date, a management plan for this monument, and shall promulgate such regulations for its management as he deems appropriate. This proclamation does not reserve water as a matter of Federal law. I direct the Secretary to address in the management plan the extent to which water is necessary for the proper care and management of the objects of this monument and the extent to which further action may be necessary pursuant to Federal or State law to assure the availability of water.

Warning is hereby given to all unauthorized persons not to appropriate, injure, destroy, or remove any feature of this monument and not to locate or settle upon any of the lands thereof.

IN WITNESS WHEREOF, I have hereunto set my hand this eighteenth day of September, in the year of our Lord nineteen hundred and ninety-six, and of the Independence of the United States of America the two hundred and twenty-first.

WILLIAM J. CLINTON

APPENDIX B

Faunal and floral lists for the fossiliferous formations in the Grand Staircase-Escalante National Monument are presented below, in order from oldest to youngest. These records represent confirmed taxa. No attempt has been made to evaluate taxonomic categories.

Kaibab Formation

algae
stromatolites
sponges
corals
- *Campophyllum*?
- *Chonetes* sp.
- *Favosites* sp.
- *Lithostrotion*?
- *Lophophyllum* sp.

crinoids
echinoids
- *Echinocrinus* sp.

bryozoans
- *Batostomella* sp.
- *Fenestella* sp.
- *Hemitrypa* sp.
- *Lioclema* sp.
- *Phyllopora* sp.
- *Polypora* sp.
- *Rhombopora* sp.
- *Septopora* sp.
- *Tabulipora* sp.

brachiopods
- inarticulates
- Lingula sp.
- Terabratula sp.
- Peniculauris bassi
- *Productus (Dictyoclostus) occidentalis*
- *Echinauris subhorrida*
- *Koslowskia meridionalis*
- *Cliothyridina*?
- *Composita* sp.
- *Derbya* sp.
- *Dielasma* sp.
- *Marginifera* sp.
- *Orthotetes* sp.
- *Productus* sp.
- *Pugnax* sp.
- *Pustula* sp.
- *Schizophoria* sp.
- *Spiriferina* sp.
- *Spirorbis* sp.

bivalves
- *Acanthopecten* sp.
- *Astartella* sp.
- *Aviculopecten* sp.
- *Deltopecten* sp.
- *Edmondia* sp.
- *Leda* sp.
- *Lima* sp.
- *Myalina* sp.
- *Myoconcha*?
- *Nucula* sp.
- *Parallelodon*?
- *Pernipecten* sp.
- *Pleurophorus* sp.
- *Pleurophorella*?
- *Pseudomonotis* sp.
- *Pteria* sp.
- *Schizodus* sp.
- *Solenomya*?
- *Squamularia*?
- *Squamularia* sp.

gastropods
- *Aclisina* sp.
- *Bellerophon* sp.
- *Girtyella*?
- *Goniospira* sp.
- *Bucanopsis* sp.
- *Euomphalus* sp.
- *Euphemus* sp.
- *Naticopsis*?
- *Platyceras* sp.
- *Pleurotomaria* sp.

ammonoids and nautiloids
- *Metacoceras* sp.
- *Nautilus* sp.
- *Orthoceras*?
- *Meekoceras* sp.
- nautiloids

scaphopods
- *Plagioglypta* sp.

trilobites
- *Delaria* sp.
- *Griffithides* sp.

conodonts
- *Anchignathodus*
- *Ellisonia*
- *Neogondolella*
- *Neostreptognathodus*
- *Xariognathu*

Moenkopi Formation

- algal debris
- plants
- crinoids
- *Isocrinus* sp.
    - *Pentacrinus* sp.
- echinoids
- brachiopods
    - *Discina* sp.
    - *Hemiprionites* sp.
    - *Pugnax* sp.
    - *Pugnoides* sp.
    - *Spirorbis* sp.
- gastropods
    - naticoid gastropod
    - *Aviculopecten* sp.
    - *Eucyclus*?
    - *Macrochilina*?
    - *Natica* sp.
    - *Naticopsis* sp.
    - *Neritina*?
    - *Pleurotomaria* sp.
    - *Pseudomelania* sp.
    - *Solariella*?
    - *Turritella* sp.
    - *Worthenia*?
- bivalves
    - coquina beds
    - dysodont bivalve
    - pectens
    - *Bulimorpha* sp.
    - *Entolium* sp.
    - *Myalina* sp.
    - *Monotis* sp.
    - *Myophoria* sp.
    - *Pseudomonotis* sp.
- ammonoids and nautiloids
    - *Anasibirites* sp.
    - *Cordillerites* sp.
    - *Hungarites* sp.
    - *Meekoceras* sp.
    - *Paranannites* sp.
    - *Pinna*?
    - *Pleurophorus* sp.
    - *Submeekoceras* sp.
    - *Tirolites* sp.
    - *Wasatchites* sp.
    - *Xenoceltites* sp.
- scaphopods
    - *Laevidentalium*?
- arthropods
    - ostracodes
    - *Limulus* tracks
    - *Halicyne* sp.
- worm tubes and trails
- vertebrates
    - fish scales and vertebrae
    - reptile footprints
    - *Parotosaurus* sp.
    - *Rotodactylus* tracks
    - *Chirotherium* tracks
    - *Trigonodus* sp.

Chinle Formation

- plants
    - *Araucarioxylon* sp.
    - charcoal fragments
    - *Ephedra chinleana* (pollen)
    - ferns
    - *Neocalamites* sp.
    - petrified wood and logs
    - *Sphenozamites* leaf
    - *Woodworthia* sp.
    - gastropods
    - *Lioplacodes* sp.
    - *Lymnaea* sp.
    - *Triasammicola* sp.
    - *Valvata* sp.
- bivalves
    - *Diplodon* sp.
    - *Unio* sp.
- insect burrows
    - *Paleobyprestis* sp.
    - *Paleeoscolytus* sp.
    - *Paleopidus* sp.
    - insect wing
- limuloid trails
    - *Kouphichinium* sp.
- ostracodes
    - *Cyzicus* sp.
- worm trails
- fish
    - *Lepidotes* sp.
    - *Lepidotus* sp.
    - lungfish burrows
    - *Pholidophorus* sp.
    - *Semionotus kanabensis*, n. sp.
- reptiles
    - phytosaurs
    - dinosaur bones and teeth
- reptile tracks
    - *Eubrontes* sp.
    - *Grallator* sp.
    - *Anchisauripes* sp.

Moenave Formation-Wingate Sandstone

stromatolites
palynomorphs
- *Callialasporites* sp.
- *Chasmatosporites* sp.
- *Cordlina* sp.
- *Corollina* sp.
- *Cycadopites* sp.
- *Granulatisporites* sp.
- *Podocarpidites*?
- *Todisporites* sp.
- Triassic bisaccates

petrified wood fragments
vertebrates
- fish
- fish scales
- *Lepidotes* sp.
- *Lepidotus* sp.
- *Lepidotus walcotti*
- *Pholodophorus* sp.
- *Seminotus kanabensis*
- *Semionotus* sp.
- *Protosuchus* sp.

trace fossils
- arthropod traces
- bioturbation
- worm borings

Kayenta Formation

petrified wood fragments
bivalves
- *Unio* sp.

traces
- worm holes or root casts

vertebrates
- tritylodontid reptile
- dinosaur? tracks, 3-toed
- other reptile tracks

Navajo Formation

plants
land shells
crustaceans
vertebrates
- dinosaur tracks
- dinosaurs
- vertebrate trackways

Carmel Formation

plants
algal stromatolites
corals
- *Astrocoenia?*

crinoids
- *Pentacrinus* sp.

echinoids
brachiopods
- *Rhynochonella* sp.

bivalves
- *Astarte*
- bivalve micrite
- *Camptonectes* sp.
- *Cardinia* sp.
- *Dosinia* sp.
- *Eumicrotis* sp.
- *Gervillia* sp.
- *Gresslya?*
- *Inoceramus* sp.
- *Isocyprina?*
- *Lima* sp.
- *Modiola* sp.
- *Myalina* sp.
- *Myophoria* sp.
- *Nerinea*
- *Ostrea* sp.
- *Pecten* sp.
- *Pholadomya* sp.
- *Pinna* sp.
- *Pleuromya* sp.
- *Quenstedtia* sp.
- *Tancredia* sp.
- *Trigonia* sp.

gastropods
- *Natica* sp.
- *Neritina* sp.
- *Solarium*?
- *Volsella* sp.

ammonoids
arthropods
- ostracodes

worm tubes, trails, and borings

Morrison Formation

plants
- cycads
- petrified wood
- plant impressions
- plant fragments

reptiles
- dinosaurs
- bones of other reptiles

Dakota Formation

plants
- petrified wood and logs
- coalified vegetal debris
- plant fragments carbonized
- plant fragments and impressions
- root imprints

palynomorphs:
- *Appendicisporites* sp.
- *Araucariacites* sp.
- *Baltisphaeridium* sp.
- *Camarozonosporites* sp.
- *Cicatricosisporites* sp.
- *Circulina* sp.
- *Classopollis* sp.
- *Concavosporites* sp.
- conifer pollen type
- *Cyathidites* sp.
- *Deltoidospora* sp.
- *Dichastopollenites reticulatus*, n. gen., n. sp.
- *Ephedripites* sp.
- *Eucommidites* sp.
- fungus spore types A & B
- *Gleicheniidites* sp.
- *Inaperturpollenites* sp.
- *Laevigatosporites* sp.
- *Liliacidites*?
- *Matonisporites* sp.
- *Monosulcites*?
- *Palmaepollenites* sp.
- *Parvisaccites*?
- *Peromonoletes*?
- *Piceapollenites*?
- *Pinuspollenites*
- *Pistillipollenites*?
- *Podocarpitites* sp.
- *Punctatisporites*?
- *Retitricolpites* sp.
- *Retitriletes* sp.
- *Schizosporis* sp.
- *Sphagnumsporites* sp.
- *Syncolporites*?
- *Syncolporopollenites* sp.
- *Tricolpites* sp.
- *Trilobozonosporites* sp.
- *Triporopollenites*?

corals
- *Astroconia*?

brachiopod
- *Ampullina*?

gastropods
- *Aporrhais* sp.
- *Cerithiopsis* sp.
- *Euspira* sp.
- *Fasciolaria*?
- *Nerinea* sp.
- *Neritina* sp.
- *Perissoptera* sp.
- *Ringicula* sp.
- *Turbonilla* sp.
- *Turitella* sp.

bivalves
- *Avicula* sp.
- *Anomia* sp.
- *Barbatia* sp.
- *Callista* sp.
- *Camptonectes* sp.
- *Cyrena* sp.
- *Corbula* sp
- *Dosinia*?
- *Exogyra* sp.
- *Gresslya*?
- *Gryphaea* sp.
- *Inoceramus* sp.
- *Isocyprina*?
- *Lima* sp.
- *Lucina* sp.
- *Modiolus*?
- *Ostrea* sp.
- *Pholadomya* sp.
- *Pleuromya* sp.
- *Plicatula* sp.
- *Psilomya* sp.
- *Pteria* sp.
- *Quenstedtia* sp.
- *Solemya*?
- *Tancredia* sp.
- *Trigonarca* sp.
- *Trigonia* sp.
- *Volsella* sp.

ammonoids
- *Allocrioceras* sp.
- *Dunveganoceras pondi*
- *Dunveganoceras conditum*
- *Dunveganoceras albertense*
- *Kanabiceras* sp.
- *Metoicoceras* sp.
- *Prionocyclus* sp.
- *Sciponoceras gracilis*

worm tubes, tracks, borings
- *Cliona* (boring in shell)
- *Serpula* (worm tube)

ostracodes
- *Bythocypris* sp.
- *Cythereis* sp.
- *Cytherella* sp.

sharks and rays
- *Hybodus* sp.
- *Myledaphus*?
- *Lonchidion* n. sp.

fish
- Amiidae
- *Ceratodus gustasoni*
- *Colobodus* sp.
- *Dapedius*?
- *Lepidotes* n. sp.
- Lepisosteidae
- lungfish
- pycnodonts
- *Semionotus* sp.
- *Synechodus striatus*

salamanders
- *Albanerpeton* sp.
- *Batrachosauroides* sp.

turtles
- *Dinochelys* sp.
- *Glyptops* sp.
- *Naomichelys* sp.
- pleurosternid turtles

lizards
- Anguidae
- Cordylidae
- *Leptochamops*?
- *Saurilodon* sp.
- Scincidae
- Teiidae

crocodiles
- *Bernissartia* sp.
- *Goniopholis* sp.
- *Teleorhinus* sp.

dinosaurs
- Ankylosauridae
- Dromaeosauridae
- Hadrosauridae
- Hypsilophodontidae
- Nodosauridae
- *Paronychodon* sp.
- *Richardoestesia* sp.
- *Troodon* sp.

mammals
- *Alphadon clemensi*
- *Alphadon lillegraveni*
- *Alphadon* sp.
- *Cimolodon* sp.
- *Dakotadens morrowi*
- *Dakotamys malcolmi*
- *Paracimexomys* sp.
- *Pariadens kirklandi*
- *Protalphadon* sp.
- Spalacotheriidae
- Taeniolabidoidea?

Tropic Shale

plants
- charophytes: *Atopochara* sp.
- dicotyledons
- plant fragments
- plant remains, macerated

corals
- *Trochocyathus* sp.

bivalves
- *Anatina* sp.
- *Barbatia* sp.
- *Breviarca* sp.
- *Callista*?
- *Camptonectes* sp.
- *Cardium* sp.
- *Corbula* sp.
- *Cymbophora* sp.
- *Cyprena* sp.
- *Exogyra* sp.
- *Gryphaea* sp.
- *Inoceramus labiatus*
- *Inoceramus* sp.
- *Legumen* sp.
- *Lima* sp.
- *Liopistha* sp.
- *Lucina* sp.
- *Mactra* sp.
- *Modiolus* sp.
- *Ostrea* sp.
- *Parapholas* sp.
- *Pholadomya* sp.
- *Plicatula* sp.
- *Protarca* sp.
- *Psilomya* sp.
- *Solemya* sp.
- *Unio* sp.
- *Veniella* sp.

gastropods
- *Achura* sp.
- *Admetopsis* sp.
- *Anchura* sp.
- *Anomia* sp.
- *Aporrhais* sp.
- *Cerithiopsis* sp.
- *Eulimella*?
- *Euspira* sp.
- *Fasciolaria*?

Fusus sp.
Gyrodes sp.
Lunatia sp.
Mesostoma sp.
Perissoptera sp.
Physa sp.
Pleurotoma sp.
Polinices sp.
Sigaretus sp.
Tritonium sp.
Turritella sp.
scaphopods
Dentalium sp.
ammonoids
Acanthoceras sp.
Allocrinoceras sp.
Baculites sp.
Buchiceras sp.
Calycoceras sp.
Collignoniceras sp.
Collignoniceras woollgari
Collignoniceras hyatti
Dunveganoceras pondi
Dunveganoceras conditum
Dunveganoceras albertense
Eucalycaceras sp.
Exiteloceras sp.
Helicoceras sp.
Kanabiceras sp.
Mammites sp.
Metoicoceras sp.
Neocardioceras sp.
Placenticeras sp.
Proplacenticeras sp.
Scaphites sp.
Sciponoceras sp.
Sciponoceras gracile
Selwynoceras sp.
Watinoceras sp.
arthropods
crabs
worms
Serpula sp.
traces: bored wood
worm? tubes
sharks
Ondontaspis?
Otodus?
Orthacodus?
Ptychodus sp.
fish
reptile
mosasaur?
pleisiosaur

Straight Cliffs Formation

plants
angiosperm leaf imprints
carbonized wood
leaf casts
log casts
petrified wood and logs
plant debris, macerated
plant impressions
Populophyllum sp.
Populus sp.
palynomorphs
Abietineaepollenites sp.
Aequitriradirtes sp.
Apiculatisporis sp.
Appendicisporites sp.
Araucariacites sp.
Baltisphaerdium sp.
Cicatricosisporites sp.
Cingulatisporites sp.
Cirratriradites sp.
Classopollis sp.
Concavisporites sp.
Concavissimisporites sp.
Cupanieidites sp.
Cycadopites sp.
Deflandrea sp.
Deltoidospora sp.
Densoisporites sp.
Dictyophyllidites sp.
Ephedripites sp.
Foveoinaperturites sp.
Gleicheriidites sp.
Hymenophyllumsporites sp.
Inaperturopollenites sp.
Klukisporites sp.
Laevigatosporites sp.
Laevigatosporites sp.
Laricoidites sp.
Liliacidites sp.
Lycopodiacidites sp.
Lycopodiumsporites sp.
Lygodiumsporites sp.
Microdinium sp.
Microreticulatisporites sp.
Monosculcites sp.
Nyssapollenites sp.
Osmundacidites sp.
Palaeoperidinium sp.
Palmaepollenites sp.
Paravisaccites sp.

- *Piceapollenites* sp.
- *Pinuspollenites* sp.
- *Podocarpidites* sp.
- pollen exines
- *Proteacidites* sp.
- *Proteacidites* sp.
- *Pseudoplicapollis* sp.
- resinous bodies
- *Reticuloidosporites* sp.
- *Retitricolpites* sp.
- *Rugulatisporites* sp.
- *Schizosporis* sp.
- *Sporapollis* sp.
- spores
- *Stephanocolpites* sp.
- *Stereisporites* sp.
- *Taxodiaceaepollenites* sp.
- *Todisporites* sp.
- *Tricolparites* sp.
- *Tricolpites* sp.
- *Trilirites* sp.
- *Trilites* sp.
- *Trilobosporites* sp.
- *Triplanosporites* sp.
- *Vacuopollis*?
- *Verrucosisporites* sp.
- *Vitipites* sp.
- vitrinized and fusinized material
- waxy cuticles
- *Zonalapollenites* sp.

sponge

corals
- horn coral

bryozoa
- *Membranipora* sp.

gastropods
- *Admetopsis* sp.
- *Anomia* sp.
- *Campeloma* sp.
- *Cerithium* sp.
- *Cryptorhytus* sp.
- *Fusus* sp.
- *Glauconia* sp.
- *Gyrodes* sp.
- *Lunatia* sp.
- *Neritina* sp.
- *Physa* sp.
- *Planorbis*?
- *Sigaretus* sp.
- *Tritonium* sp.
- *Turbonilla*?
- *Turritella* sp.
- *Viviparus* sp.

bivalves
- *Barbatia* sp.
- *Cardium* sp.
- *Chemmitzla* sp.
- clams
- *Corbula* sp.
- *Crassostrea* sp.
- *Cymbophora* sp.
- *Cyrena* sp.
- *Inoceramus* sp.
- *Liopistha* sp.
- *Lucina* sp.
- *Mactra* sp.
- *Nemodon* sp.
- *Nucula* sp.
- *Ostrea* sp.
- *Plicatula* sp.
- *Tellina* sp.
- *Volsella* sp.

ammonoids
- *Collignoniceras* sp.
- *Placenticeras* sp.
- *Protexanites* sp.

arthropods
- crabs

worms and traces
- *Ophiomorpha* sp.
- *Serpula* sp.
- tree boles, molds

sharks, skates, and rays
- *Brachaelurus* sp.
- *Hybodus* n. sp.
- *Ischyrhiza* sp.
- *Ischyrhiza* sp., cf. *I. avonicola*
- *Lissodus selachos*
- *Lissodus* sp.
- *Lonchidion*, n. sp.
- *Myledaphus*, n. gen. & sp.
- *Ptychodus mortoni*
- *Ptychotrygon* sp., cf. *P. triangularis*
- *Pseudohypolophus* sp.
- *Scapanorhynchus* sp.
- *Squatirhina* sp.
- *Squalicorax* sp.

fish
- Amiidae
- Elopidae
- *Lepidotes* sp.
- *Lepisosteus* sp.
- *Melvius* sp.
- *Paralbula* sp.
- Phyllodontidae
- *Platacodon* sp.
- *Platysomus* sp.
- Pycnodontidae
- Semionotidae

salamanders
- *Albanerpeton* sp.
- *Batrachosauroides*?

frogs
- *Eopelobates* sp.
- *Scotiphryne postulosa*

turtles
- Adocidae?
- *Adocus* sp.

- *Basilemys* sp.
- *Bothremys*?
- *Baena nodosa?*
- Baenidae
- *Bothremys* sp.
- Chelydridae
- *Compsemys*?
- *Naomichelys*?
- Trionychidae
- *Trionyx* sp.

lizards
- Anguidae
- *Chamops* sp.
- *Contogenys sloani*
- *Contogenys* sp.
- *Dorsetisaurus*?
- Necrosauridae
- *Odaxosaurus piger*
- *Oxydaxosaurus piger*
- *Odaxosaurus*?
- *Polyglyphanodon* sp.
- Teiidae
- Varanidae

crocodiles
- *Bernissartia*?
- *Brachychampsa* sp.
- Goniopholidae
- *Leidyosuchus* sp.
- *Teleorhinus*?

pterosaurs (flying reptiles)
- dinosaurs
- Ankylosauridae?
- Dromeosaurinae
- Fabrosauridae?
- Hadrosauridae
- *Paronychodon* sp.
- *Richardoestesia* sp.
- Troodontidae
- Velociraptorinae

mammals
- *Alphadon* sp.
- *Anchistodelphys delicatus*
- *Bryceomys fumosus*
- *Bryceomys hadrosus*
- Cimolodontidae
- *Cimolodon* sp., cf. *C. similis*
- *Cimexomys* sp.
- *Dakotadens* sp.
- Eutheria?
- *Paracimexomys* sp., cf. *P. robisoni*
- Peradectidae
- *Picopsis* sp.
- *Protalphadon* sp.
- *Spalacotheridium mckennai*
- Stagodontidae
- *Symmetrodontoides oligodontos*
- Taeniolabidoidea

Wahweap Formation

plants
- leaf casts and carbon fragments
- leaf impressions
- petrified wood
- plant fragments
- plant fragments
- reed impressions
- tree branches, molds
- wood, carbonized

bivalves
- *Anomia* sp.
- shells and molds
- *Ostrea* sp.
- oysters
- *Unio* sp.

gastropods
- *Admetopsis* sp.
- *Campeloma* sp.
- *Neritina* sp.
- *Physa* sp.
- *Turritella*?
- *Viviparus* sp.

ostracodes

sharks, skates, and rays
- Batoidea
- Elasmobranchii
- Hybodontoidea?
- *Hybodus* sp.
- *Ischyrhiza arenicola*
- *Ischyrhiza* sp.
- *Lissodus* sp.
- *Lonchidion* sp.
- *Myledaphus* sp.
- *Squatirhina* sp.

fish
- *Amia* sp.
- *Atractosteus* sp.
- *Brachaelurus estesi*
- Lepisosteidae
- *Lepisosteus* sp.
- *Melvius* sp.
- *Paralbula* sp.
- *Paralbula* sp., cf. *P. casei*

amphibians
- *Opisthotriton*?

turtles
- *Adocus* sp.
- *Baena* sp., cf. *B. nodosa*
- Chelonia
- *Compsemys* sp.
- *Naomichelys* sp.

lizards
- *Chamops segnis*
- Glyptosaurinae
- Squamata
- Varanidae

crocodilians
- Atoposauridae?
- *Bernissartia* sp.
- *Brachychampsa* sp.
- Crocodylia

dinosaurs
- Ankylosauria
- Ceratopsia
- Fabrosauridae
- Hadrosauridae
- Nodosauridae?
- Ornithischia
- ornithopod
- Theropoda
- *Troodon* sp.
- Tyrannosauridae

mammals
- *Alphadon* sp.
- *Anchistodelphys* sp.
- *Anchistodelphys archibaldi*
- *Anchistodelphys* sp., cf. *A. archibaldi*
- *Cimexomys* sp.
- *Cimolodon* sp.
- *Cimolomys* sp.
- Didelphidae
- Eutheria
- *Iugomortiferum* sp.
- *Iugomortiferum thoringtoni*
- Marsupialia
- *Meniscoessus*?
- *Mesodma* sp.
- metatherian- eutherian grade mammals (2 genera)
- Multituberculata
- *Paracimoxomys* sp.
- *Paranyctoides* sp.
- peradectid marsupial
- *Protalphadon* sp.
- *Protalphadon crebreforme*
- stagodontid marsupial
- Stagodontidae?
- Symmetrodonta
- *Symmetrodontoides* sp.
- Tribosphenida
- Triconodonta?

Kaiparowits Formation

palynomorphs
- *Acanthotriletes* sp.
- *Aquilapollenites* sp.
- *Araucariacites* sp.
- *Azolla* sp.
- *Balmeisporites* sp.
- *Ceratosporites* sp.
- *Cicatricosisporites* sp.
- *Cinculatisporites* sp.
- *Concavisporites* sp.
- *Cyathidites* sp.
- *Cycadopites* sp.
- *Deltoidospora* sp.
- *Entylissa* sp.
- *Ericaceoipollenites* sp.
- *Extratriporopollenites* sp.
- *Foveotriletes* sp.
- *Hymenozonotriletes* sp.
- *Inaperturopollenites* sp.
- *Intertriletes*
- *Laevigatosporites* sp.
- *Laricoidites* sp.
- *Leiotriletes* sp.
- *Liliacidites* sp.
- *Lycopodiumsporites* sp.
- *Monocolpopollenites* sp.
- *Monosulcites* sp.
- *Phyllocladidites* sp.
- *Piceaepollenites* sp.
- *Pityosporites* sp.
- *Podocarpidites* sp.
- *Porocolpopollenites* sp.
- *Proteacidites* sp.
- *Reticulatasporites* sp.
- *Schizosporis* sp.
- *Sphagnumsporites* sp.
- *Tetracolporollenites* sp.
- *Tricolpites* sp.
- *Tricolpopollenites* sp.
- *Tricolporites* sp.
- *Tricolporopollenites* sp.
- *Triplanosporites* sp.

plants
- *Dammarites* sp.
- *Podozamites* sp.
- *Platanus* sp.
- *Betula* sp.
- *Menispermites* sp.
- *Cinnamomum* sp.
- *Viburnum* sp.

bivalves
- *Unio* sp.

gastropods
- *Bulinus* sp.

Campeloma sp.
Goniobasis sp.
Helix sp.
Physa sp.
Planorbis?
Tulotoma sp.
Viviparus sp.
Valvata?

sharks, skates, and rays
Brachaelurus sp.
Hybodus sp.
Ischyrhiza sp.
Lissodus sp.
Lonchidion sp.
Myledaphus sp.
Squatirhina sp.
Squatirhina?

fish
Acipenser sp.
Amia sp.
Astractosteus sp.
Elopidae
Lepisosteus sp.
Melvius sp.
Palaeolabrus?
Paralbula sp.
Platacodon sp.

amphibians
Albanerpeton sp., cf. *A. nexuosus*
Albanerpeton sp.
Eopelobates sp.
Habrosaurus dilatus
Scapherpetontidae
Scotiphryne pustulosa

turtles
Adocus sp.
Aspideretes sp.
Baena nodosa
Basilemys sp.
Boremys sp.
Chelydridae
Compsemys sp.
Kinosteridae
Naomichelys sp.
Neurankylus sp.
Trionychidae
Trionyx sp.

lizards
Anguidae
Chamops sp.
Chamops segnis
Contogenys?
Gerrhonotinae?
Leptochamops denticulatus
Leptochamops sp.
Litakis sp.
Meniscognathus sp.
Odaxosaurus piger
Parasaniwa sp.
Peneteius sp.
Polyglyphanodon sp.
Scincidae?
Utahsaurus russelli

crocodiles
Bernissartia sp.
Brachychampsa sp.
Leidyosuchus sp.

dinosaurs
Albertosaurus sp.
Ceratopsidae
Euoplocephalus sp.
Hadrosauridae
nodosaurian dinosaurs
Ornithomimus sp.
Pachycephalosauridae?
Parasaurolophus sp.
Paronychodon sp.
Struthiomimus sp.
Theropoda indeterminate
Troodon sp.
Tyrannosauridae

birds

mammals
Aenigmadelphys archeri
Aenigmadelphys sp.
Alphadon sp.
Alphadon sahnii
Alphadon attaragos
Alphadon halleyi
Avitotherium utahensis
Avitotherium sp.
Bryceomys?
Cimexomys sp.
Cimolestes sp.
Cimolodon sp.
Cimolomys sp.
Cimoxomys sp.
Eodelphis sp.
Gypsonictops sp.
Iqualadelphis lactea
Iqualadelphis sp., cf. *I. lactea*
Iqualadelphis sp.
Leptictidae
Meniscoessus?
Mesodma sp.
Paracimexomys sp.
Paranyctoides sp.
Pediomyidae
Picopsis sp.
Protalphadon wahweapensis
Stagodontidae
Turgidodon sp.
Turgidodon lillegraveni
Turgidodon madseni

Claron Formation

leaf impressions
palynomorphs
- *Abietineaepollenites* sp.
- *Aequitriadites* sp.
- *Anemia* sp.
- *Appendicisporites* sp.
- *Aquilapollenites* sp.
- *Araucariacites* sp.
- *Azolla* sp.
- *Classopollis* sp.
- *Ephedra* sp.
- *Erdtmanipollis* sp.
- *Eucommudites* sp.
- *Ghoshispora* sp.
- *Inaperturopollenites* sp.
- *Interporopollenites* sp.
- *Kuylisporites* sp.
- *Proteacidites* sp.
- *Rugubivesiculites* sp.
- *Schizaea* sp.
- *Tricolpites* sp.
- *Zlinsporis* sp.

plant impressions
root casts
tree stems
gastropods
- *Bulinus* sp.
- *Celliforma* sp.
- *Helix* sp.
- *Limea* sp.
- *Physa* sp.
- *Planorbis* sp.
- *Valvata* sp.
- *Vivipara* sp.
- *Viviparus* sp.

bivalves
- oysters
- *Unio* sp.

turtles

Quaternary sediments

plant material
Bison sp.
Mammuthus sp.
mammoth dung