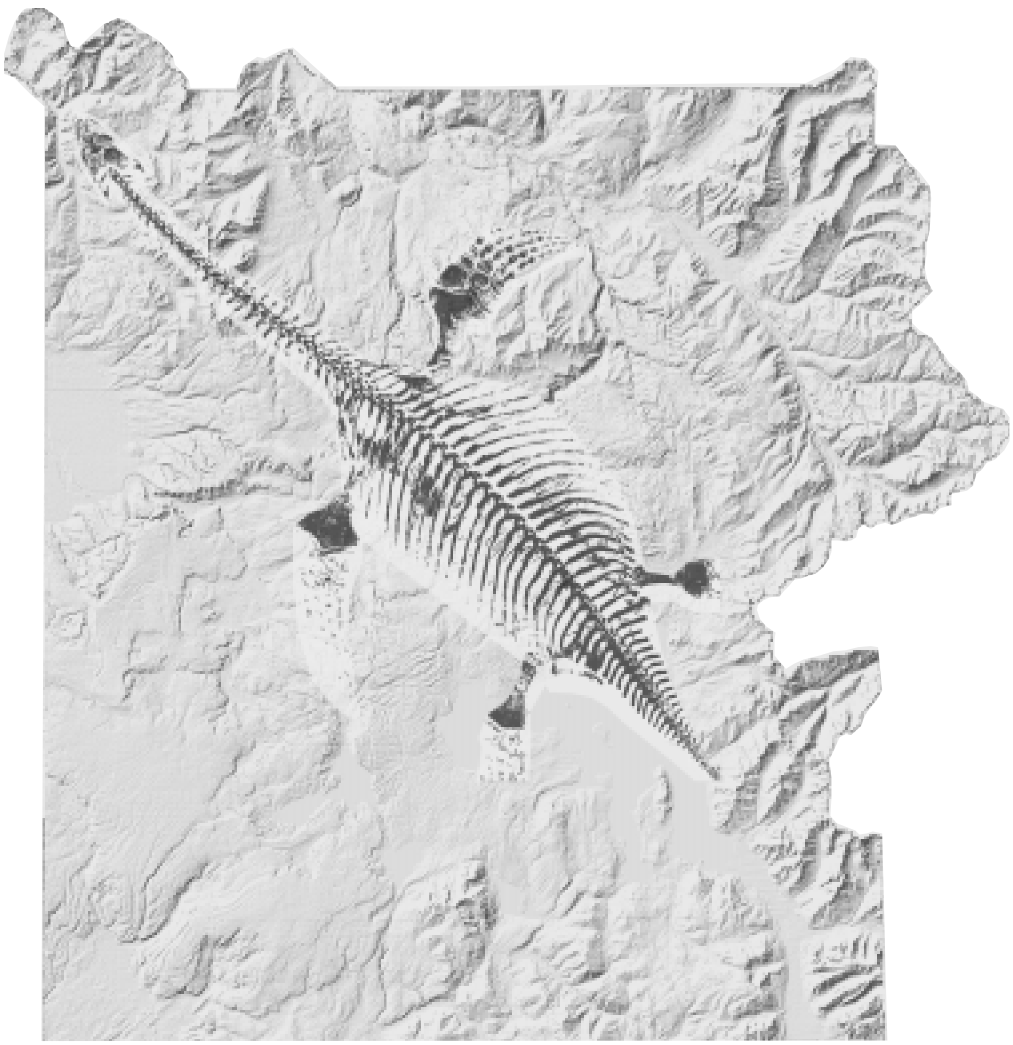
The Yellowstone Paleontological Survey



Vincent L. Santucci

Yellowstone Center for Resources
National Park Service
Yellowstone National Park, Wyoming

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Current address for Vincent L. Santucci is National Park Service, P.O. Box 592, Kemmerer, WY 83101.

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To Lt. Col. Luke J. Barnett, III

"Uncle by blood, brother in spirit!"

Vincent L. Santucci

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Introduction

A survey of Yellowstone's fossil resources was initiated in the same spirit of discovery demonstrated by Captain William Raynolds, Henry Washburn, and Ferdinand Hayden. Rumors of marine reptiles, trilobite mass death assemblages, and even dinosaurs in Yellowstone have lured a team of paleontologists in the same way that the legends of "Colter's Hell" and Jim Bridger's "Tall Tales" have attracted many before.

Compared to other natural resources at Yellowstone National Park, fossils have received little attention. Except for the research conducted on the petrified forests, Yellowstone's fossils have remained a relative "paleo-incognita" more than 125 years after the park's establishment. As this survey demonstrates, the lack of paleontological research is not due to a lack of significant fossils. Perhaps historian Aubrey Haines provided the best explanation in his comment, "Past administrations preferred that resources not in the public's eye be left alone" (pers. commun.).

Recognizing the contributions a paleontological survey could make to Yellowstone, we developed a research proposal for projects that would enhance the park staff's ability to manage Yellowstone's fossil resources (Appendix A). This report contains information compiled between 1995 and 1997, including field surveys begun in 1996. The work was accomplished through the voluntary efforts of the principle investigator, who had been previously employed as a national park paleontologist and is familiar with National Park Service paleontological resource management guidelines and methodologies, and the co-investigator, Bill Wall, who has conducted paleontological fieldwork and supervised field crews in numerous national parks.

It has been our privilege to work at Yellowstone. We hope that this document helps to increase the status and awareness of Yellowstone's paleontological resources, and provides a baseline from which future projects can be planned. We believe that the information available in this report can enhance management decision making and perhaps pave the way to further paleontological discoveries in Yellowstone.

The Significance of Yellowstone's Fossil Resources

Yellowstone National Park preserves an extensive geologic record ranging from the Precambrian through the Holocene epoch. Except for Silurian period deposits, rocks of nearly every geologic time period are exposed within the boundaries of the park.

More than 20 fossiliferous stratigraphic units have been identified at Yellowstone, containing fossil plants, invertebrates, vertebrates and trace fossils. The few fossil specimens in the park museum provide a glimpse into a record of life in the Yellowstone area that extends back hundreds of millions of years. Yellowstone fossil collections within the Smithsonian and other museums, including numerous "type" specimens, are recognized as scientifically and historically significant. (A "type" specimen is the reference specimen used to define a particular genus or species.)

Paleozoic and Mesozoic Rocks. Paleozoic and Mesozoic sedimentary rocks are well exposed in the northern range of Yellowstone. The Paleozoic sections measure 3,000-feet thick. Both marine and non-marine Triassic, Jurassic and Cretaceous units are mapped in the park. The late Cretaceous sections are 4,000-feet thick. Many fossil localities have been identified within these units.

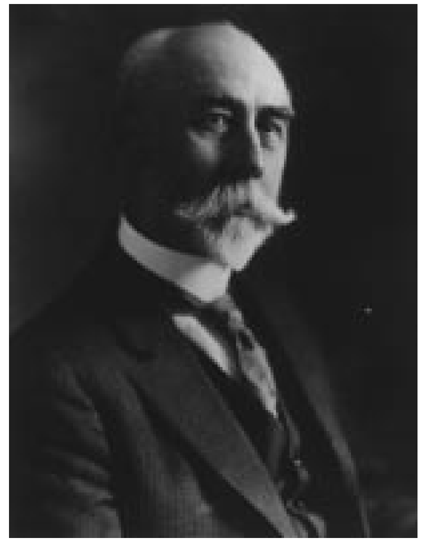
Petrified Forests. The most significant aspect of Yellowstone's petrified forests, which are probably the best studied aspect of its fossil resources, is that petrified wood and impressions of fossil leaves are present in the

The Importance of Yellowstone's Petrified Forests

- Petrified wood and fossil leaves are present at the same location.
- Many hundreds of fossil tree trunks are still standing upright.
- Successive stratigraphic layers of petrified forests are preserved.
- A great diversity of fossil plants has been preserved, including: fossil leaves, twigs, needles, cones and seeds.
- Large geographic areas of petrified forest are exposed.
- Its paleobotanical specimens provide data on one of the warmest portions of the Tertiary.

same location. This unusual association provides tremendous research opportunities for taxonomic and paleoecologic investigations. These fossil forests represent a life assemblage of trees, whereas areas such as Petrified Forest National Park show transported assemblages of fossil trees.

Lamar Cave Mammal Fossils. One of the most significant paleontological resources in Yellowstone is the subfossil material including 36 mammal species that were collected from Lamar Cave by Elizabeth Barnosky. This assemblage of fossils provides information related to late Holocene mammalian diversity (1994). The presence of the wolf (*Canis lupus*) in late Holocene deposits supports the belief that wolves have been part of the Yellowstone ecosystem for hundreds of years.


Portrait of William H. Holmes.

Historical Background

The first fossil collections from Yellowstone are attributed to the Hayden Survey of 1871. The fossil leaf material obtained during this expedition was described by Leo Lesquereux in 1872. Dr. William Henry Holmes was the first to report the occurrence of a great quantity of fossil wood near Junction Butte and in the cliffs of the Lamar River valley ("Reports of the 1878 Hayden Survey"), the first to interpret the existence of successively buried forests in Yellowstone, and the first to refer to animal fossils in Yellowstone. In 1878 he accompanied Henry Gannett to the summit of the peak now named Mount Holmes, where he found marine fossils and trilobites on a ridge just below the summit that was later named Trilobite Point.

Published accounts of earlier surveys include reports of fossils from areas outside of Yellowstone. Despite Hayden's great interest in paleontology and years of collecting fossils in the west, his early reports provide little direct discussion of fossils in the Yellowstone area. William Ludlow's "Reconnaissance" in 1875 included fossil surveys and descriptions of fossil discoveries outside of Yellowstone, but he did not report any fossil material observed in the park.

On August 1, 1883, the *Livingston Enterprise* reported, "The head of an extinct species of rhinoceros and vertebrae of a large fossil saurian in an excellent state of preservation were found in the bank of Yellowstone Lake near the camp of W.A. Forwood, surgeon to the president [Garfield]. Of course they are liable to be the bones of buffalo or elk but he considers them a great prize just the same." (Haines pers. commun.).

In 1896, while visiting Yancey's Camp, J. Felix collected some fossil plant material in the area and described a number of species of fossil wood in a short publication (1896).

F.H. Knowlton (1899) made the most complete study of the Yellowstone fossil forests in a comprehensive monograph that identified nearly 150 different species and provided a detailed taxonomic treatment of the fossil plants, especially the leaf impressions.

The Yellowstone archives include correspondence between geologist Clyde Max Bauer, the park's chief naturalist between 1932 and 1946, and famous paleontologists of the day. One letter reported the discovery of dinosaur bones around Geode Lake by park naturalist David De Lancey Condon in 1939. In his popular book, *Yellowstone, Its Underground World* (Bauer 1962), Bauer indicated that "a few dinosaurs" had been found in or near the park.

Erling Dorf and students from Princeton University conducted paleontological and geological field investigations in Yellowstone between 1955 and 1959 (Dorf 1964). In the mid-1970s, researchers from Loma Linda and Walla Walla Universities began a wide range of paleobotanical studies in the park (Arct 1979; Fisk 1976; Fritz 1977, 1982, 1986).

Most of what can be learned from Yellowstone's fossil record of life is yet to be discovered and remains buried within park sediments. Casual collecting has yielded evidence of late Cambrian extinction events, giant marine reptiles, and a glimpse at life in the Yellowstone area before man's arrival.

Arnold Hague and assistant along the Firehole River. In 1883, Hague was assigned to Yellowstone in charge of a Geologic Survey.

Acknowledgments

I came to realize after my first season with the National Park Service in 1985 that some of the best resources in the parks are the people. This belief has been reinforced at Yellowstone National Park. The Yellowstone Paleontological Survey has been greatly enhanced and inspired by many individuals.

My initial contact with Yellowstone regarding a proposal to conduct a paleontological survey of the park was with Stu Coleman, Branch Chief of Natural Resources. Although Stu is surrounded with issues such as wolves, grizzlies, geysers, and exotic species, he has conveyed a positive interest in Yellowstone's fossils. Likewise, Laura Joss, Branch Chief of Cultural Resources, provided great enthusiasm and support for a paleontological survey at Yellowstone. A sincere thanks to Stu and Laura for helping to get the ball rolling and facilitating our efforts along the way.

Thanks to the management and staff of Yellowstone National Park for providing support and suggestions for this survey, including: Marv Jensen, John Varley, Bob Lindstrom, Ann Johnson, Lee Whittlesey, Ron Thoman, Dan Sholly, Jennifer Whipple, Eleanor Williams, and Craig McClure. I gained insight into the issues related to protection of the petrified wood sites in the park during discussions with Brian O'Dea, Bob Seibert, Rick Bennett, Bonnie Gafney, and Colette Daigle-Berg.

The staff at the Yellowstone Park Museum and Yellowstone Park Research Library, especially Susan Kraft and Vanessa Christopher, have provided many contributions to this project. Despite their busy workloads, both Susan and Vanessa were always supportive to the frequent requests for assistance and information.

A special thanks to Sue Consolo Murphy, Rick Hutchinson, and Arvid Aase for editorial review of this document. The work of Mary Ann Franke and Sarah Broadbent has significantly improved the quality of this document. Additional thanks to Renee Evanoff for creating the Yellowstone Paleontological Survey logo that is used as the cover illustration for this document.

Eric Compas and the Geographic Information System (GIS) staff at Yellowstone donated their time to help map fossil locations. The production of a paleo-locality map using GIS was one of the most important components of

the paleontological survey. Eric's assistance is greatly appreciated.

Two retired Yellowstone employees, Wayne Hamilton and Aubrey Haines, still carry Yellowstone close to their hearts. Both men made contributions to the park during their time. The information they shared regarding Yellowstone's fossils provided the foundation on which this survey was built.

Lindsay McClelland, Bob Higgins, and Greg McDonald are NPS staff outside of Yellowstone working to promote paleontological resource management and research. Each has been very supportive of the Yellowstone Paleontological Survey and is actively searching for sources of funding.

I have been fortunate to have known Bill Wall for over a decade. We have worked together on numerous national park fossil projects including research at Badlands, Grand Canyon, Petrified Forest, Alaskan national parks and now Yellowstone. Bill and his field crews of students from Georgia College have trekked many miles into fossil parks. Their efforts have led to many important fossil discoveries.

Current and past park researchers involved in projects related to park fossils are recognized for their contributions. Their work helped us to better understand and interpret the paleobiology of the Yellowstone region. Information was obtained through conversations with researchers Scott Wing (Smithsonian), Kirk Johnson (Denver Museum of Natural History), Ken Cannon (Midwest Archeological Center), Barbara Stahl, Michael Hansen (Otho Geological Survey), David Brezinski (Maryland Geological Survey), Pat Leiggi and Jack Horner (both of The Museum of the Rockies).

I am grateful to Dennis Young for providing me the opportunity to come and work as a ranger at Madison Junction in Yellowstone during 1996. Without direct funding to support the paleontological survey, I was able to use my days off at Yellowstone to accomplish portions of the project. At Madison I discovered two energetic volunteers, Dr. Samuel "Neal" and Mary Cissel. The Cissels contributed their time to photograph fossil specimens in the park collections. Their assistance and friendship are greatly appreciated.

Finally, to my family, Bianca, Luke, and Jacob Santucci, who have travelled with me across country and out into the field, I express my love and appreciation for supporting my dreams.

STRATIGRAPHY

W.H. Weed produced the first paper on Yellowstone's sedimentary rocks in 1896, and with J. P. Iddings prepared maps that established the earliest stratigraphic column for the park in 1899. Later work by J. D. Love (1956), E. T. Ruppel (1982) and others established the need to consider the stratigraphy of the northern part of Yellowstone separately from the south-central part. See Figure 1, Stratigraphic nomenclature of sedimentary rock units in Yellowstone National Park (from Ruppel 1982).

Most of Yellowstone National Park is covered by Tertiary and Quaternary volcanic and glacial deposits. Older Paleozoic and Mesozoic rocks are exposed in a few areas where erosion and glacial scouring has uncovered these unites. Precambrian through Late Cretaceous rocks are exposed in the Gallatin Range. Jurassic and a thick section of Cretaceous rocks are found on Mount Everts. Precambrian and Paleozoic units outcrop in the northeast corner of the park. Paleozoic rocks are also exposed in the Birch Hills and Snake River areas along the southern boundary of Yellowstone.

Large portions of the park are covered by Tertiary volcanics. There is the potential for vertebrate fossils in the Absaroka Volcanic Supergroup (Middle Eocene). The Hoodoo Basin in the eastern portion of the park may have potential for vertebrate fossils. This area is remote, but it may be accessed by a Forest Service road or on the trail into the park at Bootjack Gap. The Wapiti and Aycross formations contain Bridgerian vertebrate fossils on the east flank of the Absarokas. Lower Tepee Trail Formation is late Bridgerian to early Uintan. Middle and Upper Tepee Trail Formation has yielded Uintan fauna. Tepee Trail flora is known from Kisinger Lakes area, Bridgerian fauna from Togwater Pass area.

Age	Northern part of the park (Ruppel, 1982)	Terminology of Iddings and Weed (1899)	South-centeral part of park (J. D. Love and W. R. Keefer, written commun, 1971)
Quaternary of Teritary			Heart Lake Conglomerate
Paleocene		Pinyon Conglomerate	Pinyon Conglomerate
Cretaceous	Landslide Creek Fm. (part)	Laramie Formation	Harabell Formation
	Everts Formation		
	Eagle Sandstone		
	Telegraph Creek Formation	Montana Formation	Bacon Ridge Sandstone
	Cody Shale		Cody Shale
	Frontier Sandstone	Colorado Formation	Frontier Formation
	Mowry Shale		Mowry Shale
	Ellis Group: upper sandstone member		Thermopolis Shale: Muddy Sandstone Member
	Ellis Group: middle shale member		Thermopolis Shale
	Ellis Group: lower sandstone member	Dakota Formation	rusty beds member
	Kootenai Formation		Cloverly and Morrison(?) formations
Jurassic	Morrison Formation		
	Ellis Group: Swift Formation	Ellis Formation	Sundance Formation
	Ellis Group: Rierdon Formation		
	Ellis Group: Sawtooth Formation		Gypsum Spring Formation
Triassic	Thaynes(?) Formation	Teton Formation	lower part Chugwater Formation
	Woodside Formation		
	Dinwoody Formation		Dinwoody Formation
Permian	Sherdron Sandstone		Phosphoria Formation and related rocks
Pennsyl-vanian	Quadrant Sandstone	Quadrant Quartzite	Tensleep Sandstone
	Amsden Formation		Amsden Formation
Missis-sippian	Madison Group: Mission Canyon Limestone	Madison Limestone	Madison Limestone
	Madison Group: Lodgepole Limestone		
Devonian	Three Forks Formation	Three Forks Formation	Darby Formation
	Jefferson Formation	Jefferson Formation	
Ordovician	Bighorn Dolomite	Gallatin Formation	Not exposed but present in subsurface: Bighorn Dolomite
Cambrian	Snowy Range Fm.: Grove Creek Lm. Mem.		Gallatin Limestone
	Snowy Range Fm.: Sage Lm. Mem.		
	Snowy Range Fm.: Dry Creek Shale Mem.		
	Pilgrim Limestone		
	Park Shale	Flathead Formation	Gros Ventre Formation
	Meagner Limestone		
	Wolsey Shale		
	Flathead Sandstone		Flathead Sandstone

Figure 1. Stratigraphic nomenclature of sedimentary units in Yellowstone National Park (adapted from Ruppel, 1982).

Fossil Chronology

The earliest fossils found in Yellowstone date from the middle Cambrian period, approximately 510 million years before the present.

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
PALEOZOIC	All known sedimentary rocks are marine; approx. thickness of 3,000 feet; exposures in Gallatin Range, Barronette Peak, Abiathar Peak, eastern portion of Buffalo Plateau, isolated outcrops along Slough and Soda Butte Creeks, Birch Hills, and the Snake River.	Fossils reported from Paleozic rocks by Deiss (1936), Duncan (1937), Girty (1899), Grant (1965), and Walcott (1899).
Middle Cambrian	Flathead Sandstone: outcrops in southern Gallatin Range, on Buffalo Plateau, and west of Bison Peak.	The Crowfoot Ridge section includes a one-foot thick zone of sandy oolitic hematite beds that contain small brachiopods (Deiss 1936), the only known fossils from Flathead Sandstone.
	Wolsey Shale: outcrops in Gallatin Range and on Buffalo Plateau.	Only the trilobite trace fossil *Cruziana;* evident in the Crowfoot Ridge area in the Gallatin Mountains. *Alokistocare*, *Anoria*, *Bolaspis*, *Glyhaspis*, *Hyolithes*, and *Westonia* reported from sections outside the park.
	Meagher Limestone: outcrops in southern Gallatin Range, on Buffalo Plateau, and west of Slough Creek.	Deiss (1936) indicates fossils are rare; a few fragments of trilobites have been observed. *Kootenia*, *Ehmania*, and *Glyphaspis* are reported from exposures outside the park.
	Park Shale: poorly exposed in the park; at Crowfoot Ridge in Gallatin Range and small outcrop at eastern-most Slough Creek.	None.
Late Cambrian	Pilgrim Limestone: Well-exposed in northeast corner of park along Soda Butte Creek, on east canyon wall of Buffalo Creek near Slough Creek, upper portion of Buffalo Plateau, and in Gallatin Range. Contains three units:	
	• Lower unit of interbedded ribboned limestone, glauconitic oolitic limestone, and less common limestone pebble conglomerate.	The ribboned limestone is rich in trilobite fragments.

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
Late Cambrian (continued)	• Middle unit consists of coarse-grained glauconitic limestone pebble conglomerate.	Contains abundant fossil fragments.
	• Upper unit of mottled oolitic limestone.	None.
	Snowy Range Formation: exposed in Gallatin Range and on Buffalo Plateau.	Wayne Hamilton collected trilobite spines in 1995 from a unit he believed to be Snowy Range (pers. commun.).
	• Dry Creek Shale Member.	None.
	• Sage Limestone Member: composed of algal columns as much as a foot in diameter.	*Collenia magna* beds occur on Buffalo Plateau (Grant 1965); includes many fossiliferous beds.
	• Grove Creek Limestone Member: only known exposure is on Three Rivers Peak; contains some algal dolomite or vertical algal columns.	Contains brachiopods and trilobite fragments in lower sections; *Billingsella* in the top sections.
	Gallatin Limestone: limited exposure in the Birch Hills area.	Park exposures not yet surveyed for fossils—currently no data available.
Ordovician		Crinoids, brachiopods, bryozoans, and ostracods.
Devonian	Jefferson Formation (late): exposed on Three Rivers Peak and in northeast corner of park.	Isolated beds containing stromatoporoids; one horizon with small horn corals.
	Three Forks Formation (late): well-exposed on Three Rivers Peak; also in Gallatin Range and in northeast corner of park.	Fossils are relatively rare. A few brachiopods have been identified.
	Darby Formation: small exposure just north of the Fox Creek patrol cabin in Snake River area.	None in the park.
Mississippian	Lodgepole Limestone (Madison Group): best exposure is on south face of Bannock Peak; thick exposures also near northeast entrance.	Abundant fossils, mainly corals, brachiopods, and crinoid fragments; coarse-grained beds made up almost entirely of fossils or fossil fragments are common. Biostratigraphy described in Girty (1899). Hamilton reported collecting horn corals and brachiopods in northeast section of park in 1995 (pers. commun.).

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
Mississippian (continued)	Mission Canyon Limestone (Madison Group): well-exposed on south face of Bannock Peak, Crowfoot Ridge and in northeast corner of park.	Many beds contain abundant brachiopods and corals; some beds of coquinas made up of fossil fragments.
	Madison Limestone (Madison Group): exposed in southern portion of park in Birch Hills and in Snake River area.	Park exposures not yet surveyed for fossils—no data available.
Pennsylvanian	Amsden Formation (early to middle Pennsylvanian): thickest section is on Bannock Peak.	None.
	Quadrant Sandstone: The type locality is on Quadrant Mountain.	None.
	Tensleep Sandstone: Exposed in southern portion of park in Birch Hills and Snake River area.	None.
Permian	Shedhorn Sandstone: widely exposed in Gallatin Range, especially on Quadrant Mountain and Bannock Peak.	Phosphatized fish bones common in some beds, especially the more phosphatic sandstone beds.
	Phosphoria Formation: limited exposures in Birch Hills and Snake River area of the park; equivalent to Park City Formation in Idaho, Utah, and Wyoming.	Remains of *Helicoprion*, a shark with a sprial tooth-whorl.
MESOZOIC	Exposed only in Gallatin Range and on east side of Mt. Everts.	Ruppel (1982) reports that extensive collections of fossils were described and illustrated by Stanton (1899) and Knowlton (1899).
Triassic	Dinwoody Formation (early): exposed south of Fawn Pass and on Quadrant Mountain; possibly present in Birch Hills and in Snake River area of park.	None.
	Woodside Formation (early): a red colored unit is exposed on Quadrant Mountain and in upper valley of Fawn Creek.	None.
	Thaynes Formation: exposed near Fawn Creek and south of Fawn Pass.	Ruppel reports the age is uncertain, as no fossils have been found.
	Chugwater Formation: known only from exposures in southern part of park; outcrops in Birch Hills and in Snake River area.	Park exposures not yet surved—no available data.

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
Jurassic	Jurassic rocks in Fawn Pass and at head of Fan Creek were described by Crickmay (1936), who also reported on fossils collected from them.	Extensive list reported by Crickmay (1936) and in Gallatin Range described by Stanton (1899).
	Sawtooth Formation (Ellis Group): marine unit with three lithologic units; best exposures are in Fawn Pass, head of Fan Creek, and East Fork of Fan Creek.	Middle limestone member contains abundant fossils.
	Rierdon Formation (Ellis Group: Late Jurassic): marine unit exposed in Fawn Pass, head of Fan Creek and East Fork of Fan Creek.	Not as richly fossiliferous as underlying Sawtooth Formation.
	Swift Formation (Ellis Group: Late Jurassic): marine unit exposed in Fawn Pass and Fan Creek.	Abundant fragments of fossils all cemented by calcite.
	Sundance Formation: possibly exposed in Snake River area along park's south boundary.	None.
	Morrison Formation: non-marine unit northwest of Fawn Pass, at head of Stellaria Creek, and possibly along park's south boundary in Snake River area. In 1995 George Engleman surveyed Little Quadrant Mountain, an area identified on park geologic map as having surficial Morrison exposures, but he could not find evidence of any Morrison outcrops or fossils (Engleman, pers. commun. 1996).	Upper beds yielded fragments from the end of a leg bone of a moderately large dinosaur, but these bone pieces were too fragmentary to permit more positive identification (G. Edward Lewis, written communication 1967); these same beds contain abundant fossil wood.
Cretaceous	Cretaceous sedimentary rocks in northern park measure nearly 4,000-feet thick. Kootenai Formation, Thermopolis Shale, Mowry Shale, Frontier Sandstone, Cody Shale, Telegraph Creek Formation, and Eagle Sandstone are best exposed on ridge southwest of Electric Peak. Cody Shale and younger Cretaceous units are well-exposed on Mount Everts. Cretaceous rocks were described by Fraser, Waldrop, and Hyden (1969).	

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
(Lower) Cretaceous	• Kootenai Formation	Upper part contains distinctive “gastropod limestone” with poorly preserved molds of gastropod shells.
	• Thermopolis Shale: composed of dirty sandstones and inter-bedded finer-grained rocks.	*Ostrea anomioides* Meek (Cobban, pers. commun. 1967).
	• Mowry Shale.	Some beds in upper part of formation contain abundant fish scales.
(Upper) Cretaceous	• Frontier Sandstone.	Fish teeth can be found in some of the sandstone beds.
	• Cody Shale.	The middle sandstone member contains distinct *Inoceramus* fauna and is much more fossiliferous than rest of Cody Shale (Cobban, pers. commun. 1967). Cody Shale on Mount Everts was studied in detail by Fox (1939), who described faunal zones.
	• Telegraph Creek Formation.	Possible remains of plesiosaur and tortoise come from just below Eagle Sandstone on Mount Everts.
	• Eagle Sandstone.	None.
	• Everts Formation: Type section is on Mount Everts.	None.
	• Bacon Ridge Sandstone: exposed in Snake River area.	None.
	• Landslide Creek Formation: exposed on the northeast slope of Mount Everts.	None.
	• Harebell Formation: widely exposed in Snake River area; present on Big Game Ridge, Mount Hancock, Chicken Ridge, Barlow Peak, and Channel Mountain.	Only from areas just outside park.
CENOZOIC	A thick sequence of tertiary volcanic and volcaniclastic rocks blanket much of the park.	Volcaniclastic and sedimentary beds contain abundance paleobotanical material; there is good potential for vertebrate fossils from the selayers.

Geologic Period	Type of Formation/ Location	Reported Fossils in Yellowstone
Tertiary (Eocene Epoch)	Absaroka Volcanic Supergroup.	
	• Sepulcher Formation: known from Gallatin Range, especially Sepulcher Mountain and Bighorn Peak; also exposed on Blacktail Deer Plateau and just west of Tower Junction.	Petrified wood deposits.
	• Lamar River Formation: well-exposed on cliffs in Lamar Valley including Specimen Ridge, along Soda Butte Creek, and throughout northeastern park.	Contains 27 layers of petrified forest.
	• Wapiti Formation: large exposures in upper Lamar River area, around Miller Creek and to east boundary near Hoodoo Basin.	East flank of Absarokas contain Bridgerian vertebrate fossils.
	• Langford Formation (Middle Eocene): Extensively exposed in park, including Lamar Valley, Mirror Plateau, Washburn Range, and throughout peaks east of Yellowstone Lake; characterized by William Fritz as one of younger Absaroka Volcanic Supergroup units; consists of extensive andesite pile of tuffaceous sandstone, volcanic conglomerate pyroclastic flow deposits, lava flows, and shallow intrusive bodies.	Contains fossil plant material uncovered during East Entrance road construction; all leaf material belongs to genus *Macginitiea*, in the sycamore family.
	• Wiggins Formation: extensive exposures in southeastern portion of park.	Uintan fossil mammals have been reported only in areas outside of park.

More Recent Fossils

Pleistocene. The primary paleontological resources from the Pleistocene epoch are fossil diatoms and pollen, including lacustrine deposits with sedges that date to 13,600 B.P. *Fontanallis* moss mats and diatomites on the shore of Mary Bay have been dated to 11,000 B.P. The windward side of Dot Island and possibly Stevenson Island have undated *Fontanallis* and diatomite.

Pleistocene gravels, such as those near the north boundary of the park, may have some potential for Pleistocene vertebrate fossils. An elk antler poacher in the park claimed to find very large bones that were thought to possibly be mammoth tusk. Paul Miller provided the park staff with a photo of the alleged site, which is believed to be within the park. Greg McDonald, who examined photographs of the alleged mammoth tusk, concluded that the specimen was travertine (pers. commun. 1996).

Dave Love collected a bison skull from Rainbow Hot Spring which Skinner at Harvard identified as *Bison occidentalis* and returned to the park museum. It was last seen hanging on the wall of the old research office before the Yellowstone Center for Resources moved to its present location; its current whereabouts are unknown.

A bison skull is exposed in a dune sand cap in the middle of the west side of Stevenson Island, which is lower in elevation than the north and south ends of the island. Paleosols (fossil soils) have also been reported on the island (Hamilton pers. commun. 1996).

Holocene. One of the most significant paleontological resources in Yellowstone is the subfossil material of 36 mammal species that were collected from ten stratigraphic units in Lamar Cave. This sequence of faunal remains provides information related to late Holocene mammalian diversity, with the oldest specimen dated to 1695 B.P. Except for the prairie vole (*Microtus ochrogaster*), all of the species found in the cave are present in Yellowstone today. The presence of the wolf (*Canis lupus*) in late Holocene deposits supports the belief that wolves have been part of the Yellowstone ecosystem for hundreds of years.

The paleontological material from Lamar Cave suggests the potential for additional fossil material from other caves in the park. At present the superintendent has closed all caves. Accounts dating back 120 years indicate that a sinkhole on Mammoth Terraces contained some faunal remains, and Hamilton has reported seeing bones there. The sinkhole must be entered using a ladder and in recent years has been barricaded.

After bones found in McCartney Cave in the parade ground across from the Superintendent's house and accessioned into the park collection were apparently discarded, Hamilton collected more in 1982. Larry Agenbroad at Northern Arizona University C14 dated (collagen) the material, probably *Bison*, to about 100 years ago (Hamilton pers. commun. 1996). Because of high carbon dioxide (CO_2) and radon gas levels, an air pack is required to enter the cave.

The Powerline fossil locality near Le Hardy Rapids preserves Holocene silicified plant fragments (*Carex*) and other leaf impressions that have been dated to before 7280 B.P. The material can be found on the surface near the road with log barricade (powerline access), across a dry creek approximately one-half mile upstream from the rapids (Hamilton pers. commun. 1996).

TAXONOMY

Paleobotany

Nearly 150 species of fossil plants from Yellowstone have been described (exclusive of palynological specimens), including ferns, horsetail rushes, conifers and many deciduous plants such as sycamores, walnuts, oaks, chestnuts, soapberries, maples, and hickories. *Seqouia* is the dominant conifer. This type of assemblage reflects a warm temperature subtropical environment (Dorf 1980).

The first fossil plants from Yellowstone were taken from Elk Creek by the early Hayden Survey parties and submitted to Lesquereux, who believed them to be Eocene (1872).

In his report in the Hayden Survey in 1878, Holmes made the first reference to Yellowstone's fossil forests. The report identified the petrified trees located on the north slope of Amethyst Mountain opposite the mouth of Soda Butte Creek, about eight miles southeast of Junction Butte.

Knowlton identified 147 species of fossil plants from Yellowstone, 81 of them new to science, and three stages of Tertiary fossil flora. The oldest (79 species) were equivalent to the lower Eocene Fort Union flora and associated with acid breccias; the intermediate included 30 species; and the youngest (70 species) were associated with the basic rocks.

Late Cretaceous plant fossil in northern Yellowstone.

Knowlton believed the most remarkable fossil forest was on the northwest end of Specimen Ridge, where it covers several acres on a steep hillside about opposite the mouth of Slough Creek, a mile southeast of Junction Butte. It was first brought to scientific attention by E. C. Alderson of Bozeman, Montana, who showed it to Knowlton in 1887. Most of the trees project well above the surface, including hundreds of trunks from 1 to 8 feet in diameter and from 1 to 20 feet high, with the tallest more than 40 feet. Just beneath the largest known tree in Yellowstone (26.5 feet by 12 feet), which contains large roots, are two trees that are 9 feet in circumference and 20 feet high. Fossilized bark is preserved at this locality.

Most petrified wood and other plant fossils come from Eocene deposits, which occur in many northern portions of the park, including the Gallatin Range, Specimen Creek, Tower, Crescent Hill, Elk Creek, Specimen Ridge, Bison Peak, Barronett Peak, Abiathar Peak, Mount Norris, Cache Creek, and Miller Creek. Petrified wood is also found along streams in areas east of Yellowstone Lake. The most accessible fossil forest is west of Tower Falls (Soldier's Station, Wylie Camp). Petrified wood can be seen today in the foundation of Roosevelt Lodge.

The Smithsonian Institute holds the primary research collections of paleobotanical specimens from Yellowstone. The collection includes fossil plants collected by the Hayden surveys. Erling Dorf's paleobotanical collections were transferred from Princeton to the Smithsonian.

Two new Late Cretaceous fossil plant locations were discovered on Mount Everts in 1997 by Bianca Cortez. Preliminary fieldwork has yielded a variety of deciduous leaves, including willow-like leaf (similar to *Salix*), and a fern. A single willow-like leaf was found in association with the plesiosaur remains excavated in 1997.

In 1994 fossil plants were discovered in Yellowstone during the East Entrance road construction project, which uncovered five areas preserving fossil sycamore leaves. Paleobotanists William Fritz (Georgia State University), Kirk Johnson (Denver Museum of Natural History) and Scott Wing (Smithsonian) visited the sites and fossils collected by them were put in the park museum collection.

Fossil pollen has been analyzed by Baker (1976) from various sites in the park, including Buckbean Fen and Blacktail Pond. Deglaciation was determined to be approximately 14,500 B.P. (Gennett and Baker 1986).

Fossil Invertebrates

Fossil invertebrates are abundant in Paleozoic rocks in the park and the limestones associated with the Madison Group are especially fossiliferous. Numerous "type" specimens are retained in collections at the Smithsonian and the Yale Peabody Museum. However, little attention has been given fossil invertebrates since the work of Walcott, Girty, and Stanton in the late 1800s.

The diversity of fossil invertebrates reported in the park includes:

- Corals: the Jefferson Formation (Devonian), Lodgepole Limestone and Mission Canyon Limestone (Mississippian).

- Bryozoans: the Bighorn Dolomite (Ordovician).

- Brachiopods: the Flathead Sandstone and Snowy Range Formation (Cambrian), Bighorn Dolomite (Ordovician), Three Forks Formation (Devonian), Lodgepole Limestone and Mission Canyon Limestone (Mississippian).

- Trilobites: the Meaghar Limestone (Middle Cambrian), Pilgrim Limestone and Snowy Range Formation (Late Cambrian).

- Gastropods: the Kootenai (Cretaceous).

- Crinoids: the Bighorn Dolomite (Ordovician).

- Pleistocene insects: Indian Creek Pond (Elias 1988).

Additional surveys are needed to document the distribution and diversity of fossil invertebrates in Yellowstone, and to increase our understanding of the park's stratigraphy and paleoecology.

Middle Cambrian trilobite Ogygopsis *cf.* klotzi *in Yellowstone Museum Colletction.*

Fossil Vertebrates

The lack of paleontological research has lead to the belief that fossils are rare in Yellowstone. Fossil remains of vertebrates are rare, but perhaps only because of insufficient field research. A one-day survey by a small group led by Jack Horner resulted in the discovery of a piece of turtle shell, the skeleton of a Cretaceous plesiosaur, and a dinosaur eggshell fragment. The only other fossil reptile remains known from the park are a few dinosaur bone fragments.

A cochliodont crushing tooth plate was discovered in the limestones of the Madison Group by a paleontological survey team during 1997. Cochliodonts were a primitive group of holocephalian chondrichthys fish common during the Mississippian. The Yellowstone specimen was identified by Michael Hansen and Barbara Stahl (pers. commun., 1997). According to Stahl, the crushing tooth appears similar to those identified as "Helodus."

Other fossil fish are present in both Paleozoic and Mesozoic sediments, with phosphatized fish bones in the Permian Shedhorn Sandstone, fish scales reported in the Cretaceous Mowry Shale, and fish teeth discovered in the Cretaceous Frontier Formation.

No paleontological surveys for fossil vertebrates have been reported for Yellowstone's Tertiary rocks. The extensive exposures of Wapiti and Wiggins formations that occur in the Absaroka Range are rich in fossil vertebrates outside of the park, but these units are somewhat isolated. These units exposed in the Hoodoo Basin area are recommended for systematic fossil surveys.

A possible Pleistocene horse, *Equus nebraskensis*, was reported by Lewis in 1939 and has been assigned the catalog number YPM-PU 14673 (Malcolm McKenna, pers. commun., 1996).

There is a possible *Bison occidentalis* skull from the

Recommended Taxonomy Projects

- Complete a thorough literature review and record all fossil taxa identified from the park.

- Inventory all Yellowstone fossil collections in the park museum and outside repositories.

- Identify any "type" fossil specimens from the park.

- Produce a paleo-taxa list of all known park fossil specimens.

- Create a paleo-taxa database including all known park fossils and associated data.

Petrified stump in Lamar Valley.

park. Bison have become smaller as the species has evolved, with *Bison bison antiquus* the largest, *Bison occidentalis* intermediate, and *Bison bison bison* the most recent and smallest. Hawken's *Bison occidentalis* was discovered in northeast Wyoming and dated to 6470 B.P. There are various other reports of *Bison* from the park including: McCartney's Cave and Stephenson's Island (Wayne Hamilton, pers. commun., 1996).

The most significant collection of fossil vertebrates are the Holocene subfossil mammals recovered from Lamar Cave (Barnosky 1994).

Trace Fossils

Tillman (1893) provided the first report of trace fossils in the park. Evidence of channeling and burrowing of worms or other insects occur in some petrified tree bark. Deiss (1936) reports *Cruziana* trace fossils in the Wolsey Shale.

LOCALITIES

Fossil localities have been known in Yellowstone prior to the Hayden surveys. The long ridge separating Lamar Valley and Mirror Plateau has been referred to as Specimen Ridge since before 1870. The name was probably established by prospectors who were aware that the area contained an abundance of amethysts and silicified wood (Whittlesley 1988).

As part of the 1996–97 Yellowstone Paleontological Survey, the park was divided into paleontological resource regions that reflect areas of geologic or stratigraphic affinities. The boundaries of these regions do not correspond to the administrative boundaries established by the park. Fossil localities within each paleontological region are identified in quotation marks.

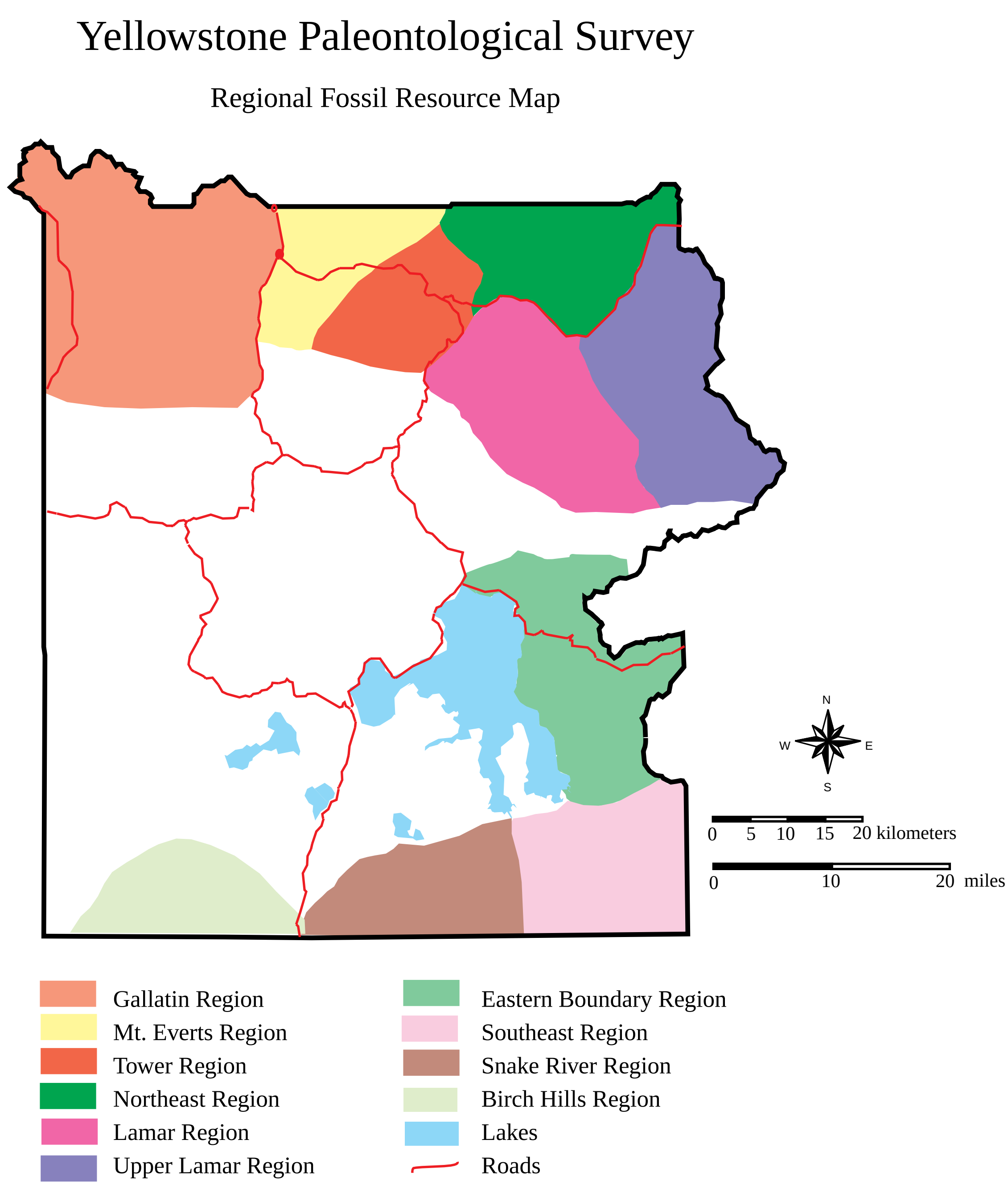
Gallatin Region

The Gallatin Region is an extremely large mountainous area in the northwest part of the park that includes some of the best exposures of Paleozoic and Mesozoic sedimentary rocks. Mount Holmes is the southernmost point of this region. Potentially fossiliferous outcrops occur throughout this mountain range extending to the northern and western boundaries of the park.

Paleozoic sediments are widespread throughout the Gallatin Range, including units in Wolsey Shale, Meagher Limestone, Pilgrim Limestone, Snowy Range Formation, Bighorn Dolomite, Jefferson Formation, and Madison Group. Mesozoic units include Ellis Group, Morrison Formation, Mowry Shale, Frontier Shale and other unidentified Cretaceous units. The Sepulcher Formation is the only known fossil-bearing unit from the Tertiary epoch of this region.

"Specimen Creek": The first known map of the Gallatin Petrified Forest is found in a 1935 report, "Petrified Sequoia Trees in the Northwest Corner of Yellowstone National Park" by Dr. Paul A. Young of Bozeman. He identified and mapped 21 standing trees in the Gallatin/Specimen Creek area and noted the discovery of leaf impressions of poplar, willow, and magnolia trees. Most of the previous paleobotanical fieldwork had been conducted in the Lamar River Valley.

Andrews (1939) surveyed the Gallatin region of the park in the 1930s, collecting specimens in the Gallatin Petrified Forest in 1936. He reported at least 12 successive layers of fossil forest around Bighorn Peak, predomi-


Yellowstone Paleontological Survey
Regional Fossil Resource Map
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0 5 10 15 20 kilometers
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Gallatin Region
Mt. Everts Region
Tower Region
Northeast Region
Lamar Region
Upper Lamar Region
Eastern Boundary Region
Southeast Region
Snake River Region
Birch Hills Region
Lakes
Roads

nantly consisting of *Sequoia magnifica*, and fossil impressions of *S. langsdorfi* along Bighorn Creek. The petrified trees are preserved in the Eocene Sepulcher Formation.

"Crowfoot Ridge": The Crowfoot Ridge section provides the most complete and best exposed section of Cambrian rocks between the Flathead Sandstone and the Pilgrim Limestone in the park and contains more Upper Cambrian fossils than any other section in Montana. The fossil brachiopods from the Flathead Sandstone in this area are the only known fossils from this unit in Montana.

"Three Rivers Peak": Excellent exposures of the Snowy Range Formation and the Pilgrim Limestone occur on Three Rivers Peak at the head of the Gallatin River. Algae, brachiopods, and trilobites are known from the Snowy Range Formation and fossil fragments from the Pilgram Limestone.

"Mount Holmes" (Trilobite Point): Mt. Holmes contains good exposures of Cambrian units, including Wolsey Shale, Meagher Limestone, Pilgrim Limestone and Snowy Range Formation. These units also occur on adjacent Dome Mountain and Three Rivers Peak. In 1878, William Henry Holmes named a 10,003 foot high point in the Gallatin Range of Yellowstone "Trilobite Point." A sedimentary exposure on the lower eastern summit of Mt. Holmes contains trilobite fossils.

The Gallatin Region has many other localities, including "Fawn Pass" and "Fan Creek," that occur near exposures of Jurassic strata and are often mentioned in regard to the presence of fossils.

Mount Everts Region

This region is dominated by Mount Everts, where a thick sequence of Cretaceous marine and non-marine rocks are well exposed. The north entrance road in Gardner Canyon marks the western extent of this region. Its western and northern faces have outcrops of Landslide Creek Formation, Everts Formation, Eagle Sandstone, Telegraph Creek Formation, Cody Shale and Frontier Sandstone; on its eastern slope are small outcrops of Madison Group (Mississippian), Ellis Group and possible Morrison Formation (Jurassic) rocks.

Although the stratigraphy of Mount Everts is not well established, preliminary surveys suggest the potential for significant paleontological discoveries. Numerous fossil plant and vertebrate localities have been recently identified on Mount Everts. During 1997, Bianca Cortez discovered two new fossil leaf localities that have yielded fern, willow and other broadleaf fossils. The remains of an unidentified plesiosaur, a turtle carapace, and a dinosaur eggshell fragment have also been recovered from Mount Everts (Jack Horner, pers. commun., 1995). A systematic collection of fossils from this area would assist efforts in interpreting the Late Cretaceous geology of Yellowstone.

Tower Region

This region, which includes Tower Falls, Tower Junction, Elk Creek, Crescent Hill and the northeast face of Prospect Peak, contains petrified trees, large exposures of Sepulcher Formation and small outcrops of Lamar River Formation.

"Petrified Tree": This fossil is located 1.5 miles east of Tower Junction, just east of Yancey Creek at the end of a small spur road off the Grand Loop Road. After souvenir hunters destroyed one petrified tree in the area, the remaining one was enclosed by an iron fence in 1907.

"Yancey's Forest": A group of fossil stumps below Lost Lake, approximately 1.5 miles by road from Tower Falls Ranger Station.

"Roosevelt Lodge": Pieces of petrified wood are incorporated into the foundation of the Roosevelt Lodge.

Lamar Region

The Lamar Region is limited to the ridge on the south side of the Lamar River, and includes well-exposed Lamar River Formation and Langford Formation. Small exposures of Sepulcher Formation occur at the northwest end of "Specimen Ridge." Its fossiliferous exposures extend from the northwest edge of "Specimen Ridge" to Timothy Creek just south of Mirror Plateau and include "Amethyst Mountain," "Fossil Forest," and "Mirror Plateau."

"Amethyst Mountain/Specimen Ridge": This locality is 10 miles long, lies 2,000 feet above the valley, and exposes 27 successive layers of fossil forest.

"Fossil Forest": The paleontological significance of the region comes from the presence of standing fossil tree trunks and a stratigraphic succession of at least two dozen fossil forests that were first recognized by Knowlton (1914). "Fossil Forest" has been extensively studied by Dorf and other paleobotanists.

Northeast Region

The Northeast Region extends from Buffalo Plateau to the extreme northeast corner of the park, including the area north of the Lamar River and north of Soda Butte Creek. The Buffalo Plateau, especially the east edge near Slough Creek, contains fossiliferous units, with middle Cambrian rocks overlain by the Snowy Range Formation. Ordovician and Devonian units occur above the Snowy Range Formation and the section is capped by the Eocene Langford Formation.

The ridge between Slough Creek and Pebble Creek, including Bison Peak and Mount Hornaday, is covered by large exposures of Lamar River Formation and Wiggins Formation. Standing fossil trunks and petrified wood is reported from the area around Bison Peak.

Barronette Peak and Meridian Peak have exposures of Cambrian Snowy Range Formation and the Mississippian Madison Group and are capped by Lamar River Formation. Barronette Peak has standing petrified tree trunks.

The Pebble Creek campground provides fossiliferous exposures of the Madison Group. This unit is easily accessible and should be monitored for impacts from park visitors.

"Lamar Cave": A sequence of late Holocene faunal remains, including 36 mammal species, was collected from 10 stratigraphic units in this cave, which is located in the northern part of the park.

Upper Lamar Region

The Upper Lamar Region includes the area east of the Lamar River and south of Soda Butte Creek and extends to the east boundary. The Eocene Wiggins Formation is extensively exposed near the east boundary, including Hoodoo Basin, Saddle Mountain, Upper Lamar River, Calfee Creek, Mount Norris, and Amphitheater Mountain. Important fossil vertebrate assemblages have been found in this unit just east of the park. This area should be considered a high priority for future paleontological surveys.

The Lamar River Formation is widely exposed along Miller Creek, Cache Creek, and on Cache Mountain, where petrified wood and stumps are reported. At least six levels of standing stumps could be identified at the petrified forest located about four miles above the mouth of Miller Creek, on the north side, at an elevation of about 7,300 feet.

Limited exposures of the Mississipian Madison Group occur just northeast of Soda Butte and on the west slope of Abiathar Peak. The Cambrian Snowy Range Formation is present on the north slope of Abiathar Peak.

"Cache Creek": Petrified wood deposits covering several acres are located about seven miles above the mouth of Cache Creek, on the south bank. The wood is scattered on a slope that extends for 800 feet, with most of the trunks standing upright only two to three feet above the surface. The largest stump is six-feet tall and four feet in diameter.

"The Thunderer": This locality bears numerous fossil trunks, most standing upright about two feet above the surface.

Eastern Boundary Region

The Middle Eocene Langford Formation, which is widely exposed in the area between the park's eastern boundary and Yellowstone Lake, includes volcaniclastic rocks (approximately 46 million years B.P.) that contain paleobotanical specimens. Five sites identified at the "Lake Butte" locality have yielded both fossil leaf impressions and petrified wood. All of the leaf material was identified as sycamore of the genus *Macginitiea*.

Accumulations of transported petrified wood can be found along the banks of the streams and rivers on the eastern boundary Paleontological surveys for the sources of this material, both within and outside the park, have not yet been done.

Southeast Region

Large exposures of the Eocene Wiggins Formation occur in the southeast corner of the park on Two Ocean Plateau and near the Trident. According to Aubrey Haines, a ranger named Harry Trischman indicated that he found "sea shells" on the Trident during the 1930s. Although fossils have not been documented from this area, they are known from adjacent areas just outside of the park.

Snake River Region

Large exposures of Paleozoic and Mesozoic sedimentary rocks occur in the Snake River area. Two exposures of potentially fossiliferous rocks occur along the park's southern boundary. One of them forms a triangle between the south slope of Mount Sheridan, the Harebell Patrol Cabin, and along the south boundary to just east of the South Entrance. This area contains exposures of Madison Limestone (Mississippian), Phosphoria Formation (Permian), possible Morrison Formation (Jurassic), Mowry Shale (Lower Cretaceous), and Frontier Forma-

Recommended Mapping Projects

- Establish a database for all known fossil localities within the park.
- Establish a standardized system for cataloging and identifying park fossil localities with cross-references for any previously used numbers or site names.
- Map all fossil localities with GPS and incorporate the data into Yellowstone's GIS System.
- Use digital mapping system to generate a paleontological locality map for the park.

tion, Cody Shale and Harebell Formation (Upper Cretaceous).

The other more eastern and slightly larger triangular exposure extends between Channel Mountain on the north, to just west of Fox Creek Patrol Cabin, and along the south boundary to the Harebell Patrol Cabin. This section contains exposures of the Morrison Formation (Jurassic), Mowry Shale (Lower Cretaceous), and Frontier Formation, Cody Shale and Harebell Formation (Upper Cretaceous).

Birch Hills Region

Birch Hills, which has limited outcrops of Gallatin Limestone (Cambrian), Madison Limestone (Mississippian), and Phosphoria Formation (Permian). is the only region in the southwest part of the park that has the potential for fossiliferous exposures. The area has not been surveyed for paleontological resources and no specimens have been reported from this area. A systematic survey is recommended.

INTERPRETATION

It is believed that mountain man Jim Bridger's report of Yellowstone's fossil trees in the 1830s was their first sighting by a white man. His account of the Yellowstone's Fossil Forest may have become embellished over the years, but it provides an interesting interpretation of the cultural history associated with the fossil resource. According to one version of his tale, "…peetrified birds a sittin' on peetrified trees a singin' peetrified songs in the peetrified air. The flowers and leaves and grass was peetrified, and they shone in a peculiar moonlight. That was peetrified too." (Chapman and Chapman 1935).

Current Efforts

"Interpretive planning documents say nothing about paleontological resources," according to former Yellowstone Chief Naturalist Ron Thoman. "There is currently almost nothing done in media or personal services interpretation." The easiest places for visitors to view Yellowstone fossils are the petrified tree stump displayed in front of Albright Visitor Center, the standing stump in the Tower area, and the petrified wood in the foundation of Roosevelt Lodge. A small exhibit of fossil leaves from the East Entrance road construction was temporarily displayed on the second floor of the Albright Visitor Center in 1994.

During the 1996 season, I observed two interpretations of paleontological resources: a park staff member mentioned the fossil forests during an evening slide program on "The Geology of Yellowstone"; and a TW guide mentioned the Yellowstone Petrified Forest as horseback riders passed the fenced petrified tree in the Tower area.

Possible Themes

Fossils, paleontology, and the history of life on earth provide exciting opportunities for interpretation. Both children and adults are interested by fossils. If the public was aware that dinosaur remains have been discovered in Yellowstone, there would be considerable visitor inquiries about them.

Public misconceptions, media misinformation, controversial scientific opinions, and issues associated with evolution and geologic time can present obstacles when interpreting paleontology. This has frequently been the case in other parks with fossil resources, such as Agate Fossil Beds National Monument, Badlands National Park, Dinosaur National Monument, Fossil Butte National Monument, Hagerman Fossil Beds National Monument, John Day Fossil Beds National Monument, and Petrified Forest National Park. Strategies related to paleontological interpretation have been discussed during previous National Park Service Paleontological Resource Conferences. Specific training

Dinosaur bone fragments in the Yellowstone Museum Collection.

associated with interpreting fossils has been conducted at many of the NPS units that preserve fossil resources.

A variety of interpretive themes could be developed for Yellowstone's paleontological resources. Pick a moment in time when Yellowstone's story is best told. The Yellowstone story is dynamic and not yet finished. The fossil record of life provides evidence of the ancient wildlife and ancient forests of Yellowstone. The fossilized remains of plants and animals hold some of the secrets of Yellowstone's past that are yet to be discovered. Here are some examples of possible themes:

- **Biological History of Yellowstone.** The public's interest in the current wildlife and vegetation of Yellowstone may indicate their potential interest in the ancient wildlife and forests of the area. More than 200 species of fossil plants are known from the Eocene epoch (approximately 50 million years ago). This resource, including fossil wood, leaves, seeds, cones, and pollen, provides an opportunity to compare the ancient forests with the extant forest. What would the public's response be to learning that before the grizzlies, wolves and bison, the Yellowstone area was home to giant reptiles, including dinosaurs and the marine reptile called the plesiosaur?

- **Geological History of Yellowstone.** Fossils provide information that help geologists to understand past geologic events, processes, and environmental conditions. Fossils can yield information related to the depositional environment of a rock unit (lake, stream, ocean beach, desert, etc.). The presence of fossils in a particular layer and the changes in fossils over the successive layers can provide valuable information about ancient Yellowstone.

- **Paleoecology of Yellowstone.** The short-term changes evident in Yellowstone, such as those resulting from geothermal activity and forest fires, can markedly effect the visitor's view of the park and provide for continued sources of public inquiry. The fossil record, dating back many millions of years, can assist the interpreter's efforts to present Yellowstone as a dynamic and naturally evolving area. A greater understanding of Yellowstone's past and how the recent setting has evolved may increase the public's appreciation for the park.

- **Wolves in Yellowstone.** Although some people object to the release of wolves, many park visitors support the wolf reintroduction. The fossil evidence from Lamar Cave provides some of the strongest proof that wolves are a natural component of the Yellowstone's ecosystem.

Some fossil material from Yellowstone, especially the fossilized leaves, are exceptionally well preserved. Some

Recommendations for Interpretation

- Provide paleontological training to the park's interpretive staff.
- Develop and incorporate paleontological resources into park interpretive planning documents.
- Develop interpretive themes associated with Yellowstone's paleontological resources.
- Consider developing an interpretive exhibit incorporating Yellowstone's paleontological resources.

of these specimens would be ideal for use in an exhibit. However, it is important to recognize that increasing public awareness of and interest in fossils should be accompanied by information about resource protection. Specific fossil locations should not be given in interpretive contacts or other information, including slides or photos that would reveal the location of sensitive fossil sites. Wayside exhibits should not be placed where they could direct the public to fossil exposures.

Paleontological Resource Management

National Park Service Policy

Fossils are non-renewable resources that require specific actions for appropriate management. Paleontological resource management on federal lands has gained considerable attention over the past decade, including recognition as an independent discipline by the scientific community and land management agencies. Within the National Park Service, the Paleontological Resources Management Program received initial direction through the Natural Resources Management Guidelines (NPS-77). The NPS program objectives for paleontological resources management call on the park to:

- identify paleontological resources within NPS units;
- evaluate the significance of those resources;
- adequately protect significant resources so that their historical value is not degraded; and
- use research to support management objectives.

National Park Service Management Policies state that "Management actions will be taken to prevent illegal collecting [of fossil resources] and may be taken to prevent damage from natural processes such as erosion. Protection may include construction of shelters over specimens for interpretation in situ, stabilization in the field or collection, preparation, and placement of specimens in museum collections. The localities and geologic setting of specimens will be adequately documented when specimens are collected…Protection may also include, where necessary, the salvage collection of threatened specimens that are scientifically significant."

Specific management actions that are recommended in NPS-77 for paleontological sites include:

- **Monitoring**: Periodic re-examination of a known fossil locality to assess stability and need for management action. Photodocumentation is essential to monitor changes.
- **Cyclic Prospecting**: In high erosion areas, periodic surveys should be undertaken to check for the appearance of new fossil material at the surface.
- **Stabilization/Reburial**: If excavation of fossil material is not recommended or feasible at a particular time, reburial may be utilized as an interim measure. Reburial can assist in slowing down erosion and the destruction of fossil material. Stabilization of a fossil can be accomplished through a wide range of paleontological techniques and methodologies.
- **Excavation**: The removal and collection of a fossil from a rock unit may be the appropriate management action in many cases. Depending upon the scientific significance, immediate threats or other variables, the careful collection of a fossil specimen may be warranted. Appropriate collecting permits must be secured with all collections.
- **Closure**: A fossil locality may be better managed through the closure of the local area. Closed areas may be completely withdrawn from public use or

restricted to ranger-led activities or research purposes.

- **Patrols**: Significant fossil sites may require periodic checks by park staff or patrol rangers. Patrols may be important in preventing or reducing theft and vandalism.

Management of paleontological resources should be distinguished from the management of archeological resources. Paleontological resources are typically recognized as natural resources and should be managed accordingly. The Archeological Resources Protection Act (1979) and the NPS Cultural Resources Management Guidelines (NPS-28) provide guidance for cases when paleontological specimens occur in an archeological context.

Except for a few parks, fossils have often been a forgotten resource within the NPS. Limited funding and staff and insufficient legislation have left fossils to fend for themselves. The lack of basic data involving significance, distribution, threats, and research needs is not sound management.

Recommended Management Actions

- Assign one staff member from each district to coordinate paleontological resource management and research.
- Continue inventory and monitoring of the park's fossil resources.
- Identify threats to paleontological resources.
- Adopt recommended RMP project statements for paleontological resources.
- Provide paleontological resource management training at the park level or by participation in the NPS Paleontological Resource Management Training, which is offered every two years.

Obtaining Baseline Data

The inventory and monitoring of paleontological resources serves as the foundation of any paleontological resource management program. Without the baseline data available from a paleontological survey, any further actions or management decisions would be based upon insufficient information.

During the summer of 1996, a field team of paleontologists and students initiated a paleontological survey to identify and document the geographic and stratigraphic distribution of fossils in the park. More than 20 stratigraphic units have been identified that possess significant paleontological resources. Fossils have been identified across the entire northern portion of the park, within the Absaroka Range along the eastern side, and in the Snake River area in the south. To map the fossil localities more precisely, GPS measurements were obtained at several sites. This data will be incorporated into the park's GIS system.

To complete the survey, the following information is needed:

- Geographic data on fossil localities, including topographic coordinates, UTMs, the geographic extent of the locality, maps, GPS measurements, etc.
- Stratigraphic data related to the geology of the localities, including the formations or subunits and the age of the units.
- Paleontological data related to the identification of paleotaxa present at the localities.
- Geologic data related to the lithology or the depositional environment of the fossiliferous units.

All fossil localities should be documented using both ground and aerial photos wherever possible. Ground photos should include close-up details showing the fossils, sedimentary structures, and general setting of the locality. Aerial photos should be at a scale appropriate to the physical characteristics of the locality.

Natural erosion is a principle threat to all paleontological resources. Fossils exposed at the surface are subjected to physical and chemical forces that can often be destructive. Continued inventory and monitoring of fossil areas subject to significant erosion is recommended.

Construction and visitor use may cause erosion, although in some cases these activities may also expose additional fossil resources. In 1994, the East Entrance road construction was altered slightly because of a significant fossil plant discovery. Fossil sycamore leaves from this site were well-preserved and extremely large in size. Information gained from this site supports research into the Eocene volcanic deposition and climate history.

Two specific project statements related to paleontological resources were drafted by Santucci in 1996 and recommended to replace the general and outdated project statement in the currently approved Yellowstone Resource Management Plan (Appendix C). The first statement pertains to the inventory and photo-documentation of Yellowstone's paleontological resources. The second project statement addresses the issues associated with paleontological resource protection.

Fossil Resource Protection

The problem of human damage to Yellowstone's fossil forests was recognized early in the park's history. "Although easily reached by a fairly good wagon road, which forms the mail route to the little mining camp of Cooke, Montana, the locality is seldom visited, save by those vandals who have carted away its treasures by the wagon load to be shipped to the dealer in 'specimens'," Walter Weed reported in a 1892 issue of the Columbia College, School of Mines Quarterly. "When first discovered in 1878 the beds of breccia contained great quantities of agate, amethyst and chalcedony, but these minerals are now rarely seen, having been carried away by visitors in search of 'specimens'. In recent years even the fossil trees themselves have been taken away when small enough to be readily transported."

An iron fence was placed around the petrified tree in the Tower area in 1907. There were originally two standing petrified trees in this area. One was dismantled by souvenir hunters and the enclosure was designed to protect the other standing tree.

A principal reason for adding land outside the original northwest park boundary was to protect the Gallatin fossil forest, which was pillaged by specimen hunters after the opening of the Gallatin River road in 1911 provided access to the fossil-rich exposures. But the establishment of a ranger station in that corner of the park did little to stop the theft. One of the first actions taken by park management to reduce the illegal removal of fossils was the closure of the public campground at the mouth of Specimen Creek. Later the ranger station was also removed. Then in the 1960s, returning the "addition" to the U.S. Forest Services was seriously considered as a way to get rid of the problem (Aubrey Haines, pers. commun., 1996).

In his 1935 report, "Petrified Sequoia Trees in the Northwest Corner of Yellowstone National Park," Dr. Paul A. Young concluded, "May the Officials of Yellowstone National Park please guard these secrets until they can adequately protect the Sequoias."

Michael Arct (Loma Linda University), who has studied the Yellowstone petrified forests for 18 years, has observed human impacts on the fossil trees in the Gallatin portion of the park (Arct, pers. commun., 1996).

Discussions with Dr. Roger D. Hoggan, Chairman of the Department of Natural Sciences at Rick's College in Rexburg, Idaho, whose students visit the Gallatin Petrified Forest as part of their studies, indicated the school's commitment to resource protection during field trips. Environmental ethics is part of the curriculum, the faculty are familiar with Yellowstone's natural resource policies, and students are made aware that collection of any natural features is prohibited. Dr. Hoggan would also like to see student internship opportunities at Yellowstone similar to those which have been used for paleontological resources projects at Badlands and Petrified Forest National Parks. Students could assist in inventorying Yellowstone fossil resources by mapping and photodocumenting localities, obtaining baseline data

Recommendations for Fossil Protection

- Assess the commercial value of the petrified wood and other paleontological resources of Yellowstone.
- Review park records over the past decade related to paleontological theft or vandalism.
- Provide paleontological resource protection training for staff working in park areas with fossiliferous exposures.
- Establish interagency cooperative efforts to protect fossils on the federal lands in the Yellowstone area.
- Conduct undercover investigations involving local rock shops, fossil dealers, and souvenir stores for possession of Yellowstone fossils.

that is essential for paleontological resource management.

The increasing public interest in fossils and corresponding escalation in the commercial fossil market create additional pressures in managing park fossils. Although the current baseline data is insufficient to assess paleontological theft and vandalism in Yellowstone, recent investigations have demonstrated that both casual and commercial illegal collecting is occurring in NPS areas. Fossiliferous exposures of the Madison Group in the Pebble Creek campground are easily accessible and should be monitored for visitor impacts. Park researchers need to be involved in an effort to determine the level of fossil theft. David A. Kubichek, Assistant U.S. Attorney, a dynamic speaker with experience in paleontological resource theft cases, would be effective in a training program on paleontological resource investigations and could be consulted if a fossil theft case occurs in the park.

RESEARCH

According to the National Park Service Natural Resources Management Guidelines (NPS-77), "Paleontological research by the academic community will be encouraged and facilitated under the terms of a permit…."

In Yellowstone, a Collecting Permit is required for research that includes field collection of fossils. A Special Use Permit (Form 10-114) is required for any other research. The Special Park Uses Guidelines (NPS-53) provide details on the issuance of permits.

Current Research

The following descriptions of recent research projects related to Yellowstone's paleontological resources are based on the Investigators' Annual Reports. See Appendix D for a list of the principal investigators' addresses.

Arct, Michael. "Dendrochronology of the Yellowstone Fossil Forest": Map petrified wood localities and interpret ecological and depositional histories of various fossil forests using annual growth ring series, taxonomy, taphonomy, and rock descriptions. Attempts have been made to use botanical features from the Specimen Creek area to determine stratigraphically equivalent horizons at an exposure 1.3 km to the southeast.

Barnosky, Elizabeth Hadly. "Resiliency and stability of Holocene fauna on Yellowstone's northern range": Identify paleontological sites in Yellowstone likely to contribute to a continuous record of the prehistoric fauna of the area; excavate and analyze the paleontological resources and interpret them in light of climate change, biogeographic change, and resiliency of modern biota; discern taphonomic pathways of fossil accumulations through small mammal trapping and analysis of raptor pellets and carnivore scats.

Cannon, Kenneth. "Archeological investigations in Yellowstone National Park": Develop a collection for identification of archeologically recovered faunal material.

Cannon, Kenneth "A review of the archeological and paleontological evidence for the prehistoric presence of wolf and related prey species in the Northern and Central Rockies physiographic province": Review all available paleontological and archeological evidence from the published and unpublished literature for evidence of wolves and prey species.

Elias, Scott A. "Later Quaternary environments and insect fossils, Yellowstone National Park": Delineate late Quaternary environments and insect species composition of the Yellowstone National Park region. Attention will be directed toward the intervals of the end of the last glaciation and the Holocene. Fossil insects from lake shore exposures along Yellowstone Lake and from archeological studies will be examined.

Fritz, William J. "Investigations of Lake Butte Fossil Locality, Eocene, Absaroka Volcanic Supergroup": Investigate the depositional environments, stratigraphy, and paleoclimates of the "fossil forests" preserved in the Eocene Absaroka Volcanic Supergroup with a focus on newly discovered fossils in volcanic conglomerate and sandstone of the Langford Formation between Lake Butte and Sylvan Pass.

Jones, Timothy. "Charcoal production of different ecosystems in Yellowstone National Park": Compare modern forest floor debris after a wildfire with that in the fossil record, and Yellowstone material with fossil material from the British Jurassic.

Lowe, Donald R. "The structure, facies, and deposition of siliceous sinter around thermal springs: Implications for the recognition of early life on earth & mars": Examine the textures and structuring of siliceous sinter deposited around hot springs and determine its physical and chemical controls; attempt to characterize the role of organisms in sinter deposition; compare the structure of sinter with that of putative biological structures in the oldest sedimentary rocks on earth.

Powell, C.L. "An integrated approach to the reconstruction of a Devonian terrestrial ecosystem": Collect samples and data in the form of photographs and observations of Yellowstone's thermal features with a focus on the structure and texture of siliceous sinters, plant proximity to sites of activity, preservation and mode of permineralization of biota, for comparison to features present in the Devonian Rhynie cherts of New Zealand.

Richmond, Gerald. "Glacial geology in Yellowstone National Park": Map glacial geology in the park; attempt to date glacial and interglacial events through palynology and paleoclimate data.

Runnegar, Bruce. "Sequence stratigraphy and biostratigraphy of the Snowy Range Formation, Wyoming and Montana".

Saltzman, Matthew R. "Trilobite mass extinctions in Yellowstone National Park": Investigate the changes in global carbon cycling and sea level that are preserved in carbonate rocks spanning a mass extinction horizon during the Late Cambrian. Unusually fossiliferous strata are well exposed in the Gallatin Range at Three Rivers Peak and Crowfoot Ridge and can be used to correlate sections in Yellowstone with sections in China, Australia and Kazakstan.

Santucci, V.L., Wall, W., and Breithraupt, B. "A Paleontological Survey of Yellowstone National Park": Conduct a systematic paleontological survey of Yellowstone; inventory fossil localities; produce a paleo-species list; identify threats to the paleontological resources; present an historical review of paleontological research; compile related bibliographic information; review paleontological specimens in park collections and outside repositories; identify paleontological research needs; and prepare a paleontological resources management document for the park.

Theriot, Edward. "Diatoms in Yellowstone National Park": Describe the evolution of *Stephanodiscus yellowstonensis*, a diatom endemic to Yellowstone Lake from the fossil record, in the context of regional post-glacial climate change.

Webster, Clyde L. "Eruption history of the Sepulcher Formation as determined by geochemistry": Assess the breccia, rock, and ash samples from Yellowstone's Fossil Forest (Specimen Creek Area); use geochemical analyses and statistical methods to clarify the origin and history of breccia flows and the petrified trees that are buried by them.

Proposed Research

Background research, including bibliographic reviews and direct communication with paleontological researchers, has generated many ideas for future research at Yellowstone. These five projects are considered to have the highest priority.

- **Inventory Yellowstone Paleontological Localities.** Other than this survey and limited work on the fossil forests, fossil sites at Yellowstone have not been inventoried. This lack of data on the distribution and diversity of Yellowstone's paleontological resources limits park management's ability to plan research and protect fossil resources.

- **Collect GIS data on Yellowstone Fossil Resources.** In conjunction with a park-wide inventory of fossil resources, GPS measurements of fossil localities should be obtained for inclusion in the park's GIS system, including all known standing petrified tree stumps and mapping distributions of fossil localities. This data will serve as a baseline record to support research and planning, and to monitor changes to the resources.

- **Correlate Eocene volcaniclastics with Absaroka fossil vertebrates.** Extensive research has been done on the east flank of the Absarokas, just outside of the park, where significant collections of fossil vertebrates have been obtained. A correlation of this data with fossil surveys and collection of paleomagnetic samples from units in the park would provide valuable information about the geologic events that shaped Yellowstone during the Eocene.

- **Survey Yellowstone's Cretaceous biostratigraphy.** Vertebrate and paleobotanical fossils from preliminary surveys of the thick sequence of Cretaceous sedimentary rocks that is exposed in the northern parts of the park have provided valuable stratigraphic data. Jack Horner of the Museum of the Rockies believes that the park may contain exposures of a unit that is possibly Judith River Formation, which is recognized as an important fossil producing unit in Montana, or an equivalent formation.

- **Map Fossiliferous limestone formations of Yellowstone.** Limestone rocks in the Gallatin and

Northeast Regions of Yellowstone contain information about changes in oceanic chemistry since the first animals appeared on Earth half a billion years ago. Mapping and study of these Paleozoic limestones will enable correlation of Yellowstone rocks with those worldwide.

Permit System

Fossil parks within the NPS often benefit from the information obtained through park-related research. New discoveries and interpretations of the resource have expanded park management's and the public's understanding of the resource significance.

The research permit serves as an administrative tool to help ensure resource protection by identifying the limitations on and responsibilities of researchers in the park. One difficulty in surveying information related to the history of paleontological research at Yellowstone has been the lack of compliance with the permit requirements. In some cases researchers have not appropriately curated their specimen collections and reported their findings to the park. Yellowstone should consider denying permits to researchers that have not complied with the permit rules.

Funding

Funding for paleontological research has traditionally been difficult to secure within the NPS. Fossils do not have specific legislation that provides for financial support of resource-related projects. Most financial support for paleontological resource projects has come from park cooperating associations, park donation accounts, or support from academic institutions.

The NPS has moved toward a greater recognition of paleontological resources within the last few years. A staff position in Washington was created to oversee geologic and paleontological resource issues. The newly created Geological Resources Division in Denver is working towards securing sources of funding to support paleontological research in the national parks.

Publication Needs

Discussions with researchers reveal a wealth of paleontological data from Yellowstone that has not been published and many suggestions for research that would be published if funding or a publication source were available.

A possible solution would be for Yellowstone to support a Paleontological Resource Symposium to bring together for the first time all of those involved in paleontological research in the park, provide a catalyst for future research, and produce a publication of articles that would provide an up to date interpretation of the park's paleontological resources.

Literature Surveys

As part of this survey, searches of biological, geological, paleontological, and government bibliographic databases were conducted to locate any published information related to paleontological resources at Yellowstone. The Yellowstone National Park research library provided access to copies of unpublished material and park archives. Current and past paleontological researchers were contacted directly to obtain copies of their published and unpublished research. The bibliographic information obtained through this search was-cross referenced with the collections at the park's research library. Park librarian Vanessa Christopher is attempting to obtain copies of any relevant publications not within the park library collections.

COLLECTIONS AND CURATION

Museum Collections

Because of the limited amount of paleontological research which has been done at the park, the park's museum fossil x5collection is relatively small. However, an examination of the few dozen fossil specimens curated into the museum collection and the associated records provides an initial insight into the geographic and taxonomic diversity of the fossils preserved in the park. See Appendix E for a list of fossil specimens in the park's museum collection.

The park has four types of fossil collections: museum storage in the Albright Visitor Center basement; a warehouse in Gardiner (Building 2009); interpretive collections throughout the park; and collections made by Wayne Hamilton in the Physical Sciences trailer. Surveys of these collections have included a consideration of the scope of collection, security, and organization.

Scope. The scope of the fossil collections for Yellowstone's museum collection may become better refined through the data presented in this document. In

Recommendations for Park Fossil Collections

- Acquire better representative fossil specimens for research and interpretion.
- Examine interpretive collections for significant fossil specimens and determine if these specimens should be placed into the museum collection.
- Locate and assess fossil collections stored in the Physical Sciences trailer and incorporate significant specimens into the park's museum collection.
- Reorganize storage of park fossil specimens (museum intern working on this project in September 1996).
- Ensure that researchers submit field records associated with paleontological resources and collections.

general, the fossil collection is inadequate in terms of both the quality of the specimens and the diversity of the fossils included. More representative specimens should be obtained for research and interpretive purposes. In addition, the museum has specimens from localities outside the park, including fossil horse elements from Chalk Cliffs north of Gardiner, that may be beyond the desired scope of its collection, given storage limitations.

Security. Although the security of the park's collections at Mammoth and Gardiner is very good, that of specimens in the interpretive collections is unknown and may vary. Because of lack of storage space and pending receipt of the collector's field notes, the specimens in the Physical Sciences trailer have not been formally added to the collection and are not adequately secured.

Organization. Specimens are arranged in a single cabinet. As the fossil collections expand, a different organization may better accommodate research needs. From a research perspective, the best approach would be based on stratigraphy or taxonomy. If warranted by the size of the collection and space availability, stratigraphy should be the primary subdivision and taxonomy the secondary subdivision. Storage cabinets can be arranged according to the geologic time scale, and the stratigraphic unit (e.g., Mississippian Lodgepole Limestone) can be represented sequentially within each geologic time period. Within each stratigraphic unit, specimens can be arranged taxonomically (e.g., corals, brachiopods, crinoids, etc.).

Another issue related to fossil acquisition is the need to obtain copies of field notes and sketches. These records can be valuable for future research and should be routinely incorporated into the museum records.

Photographic Archives

Historic photos. A 1996 database search of Yellowstone's photographic archives found 63 historic photos related to the park's paleontological resources, all of them of Tertiary petrified wood.

Museum specimens. The 1996 photographs taken of fossil specimens in the park's museum collection satisfy NPS collections management policies and will facilitate future paleontological research.

Interpretive slides. Most of the paleontology-related slides in the interpretive files at Mammoth Hot Springs and Old Faithful are of fossils or fossil reconstructions from outside the park. A handful of slides show Yellowstone's petrified wood and fossil leaves. The park photographer, Jim Peaco, has some photos of the fossil plant material discovered during the East Entrance Road Construction that have not been cataloged into the park's archives.

Recommendations for Photo Archives

- Photodocument all specimens curated into the park's collections.
- Photodocument all Yellowstone fossil specimens in outside collections.
- Attempt to locate historic photos of park fossils in outside collections (e.g., Smithsonian, Loma Linda University).
- Photodocument all known fossil localities.
- Produce slides of representative park fossils for the interpretive collections.

Additional photographic resources. More comprehensive documentation of paleontological localities would enhance efforts in research, protection, and interpretation of the historic record of life in Yellowstone. Historic photos may exist in collections held by past researchers or outside museums. Such photos of petrified wood localities could provide significant baseline data for monitoring impacts that result from erosion or illegal collection.

Recommendations for Fossil Collections in Outside Repositories

- Organize meeting with park curator and relevant staff to discuss issues related to managing the park's fossil collections at the park or in an outside repository.
- Inventory the park's fossil collections and associated data or field notes in outside repositories; incorporate into the Yellowstone Museum collections database.
- Review status of recent park fossil collections and evaluate with regard to compliance with permits and NPS standards.

Options for Specimen Storage

The question of whether to retain park specimens within the park's collections or loan them to outside repositories emerges repeatedly throughout the National Park Service. Five options are offered below for the management of Yellowstone's paleontological collections.

1. **The Yellowstone National Park Museum.** Although many factors need to be taken into consideration, if adequate staff, space, funding and environmental conditions are present, park collections are generally best retained within the park museum. Park-based collections greatly facilitate research and make it easier to ensure that museum objects are curated according to NPS standards.

2. **The Museum of the Rockies.** This is a possible alternative for invertebrate and vertebrate fossils. The collections are well managed and the museum in Bozeman is relatively close to Yellowstone.

3. **The Midwest Archeological Center.** This facility in Lincoln, Nebraska currently has collections of Holocene fauna from Yellowstone that have been evaluated by Ken Cannon and curated in accordance with NPS standards.

4. **The Museum of Paleontology, Berkeley.** This world-renowned institution employs excellent curators and collections managers.

5. **Smithsonian Institution, Washington, D.C.** This museum, which has historically been considered the primary national repository for fossil collections, holds nearly all of the significant paleobotanical specimens from Yellowstone, including the material described by Knowlton, Dorf's collections, numerous fossil invertebrates collected in the late 1800s, including a few "type" specimens. The consolidation of all Yellowstone paleobotanical research material at the Smithsonian, with a long-term commitment to the collections, would greatly facilitate future research.

As part of the 1996 Paleontological Survey, an intensive search was conducted for Yellowstone specimens in outside repositories and several previously unknown collections were located, including some "type" specimens. (See Appendix F for a list of these collections.) Information on four "type" specimens of fossil plants described by Beyer (1954) indicate that they are still located at the University of Cincinnati. The status and location of these specimens should be confirmed. The Yale Peabody Museum may also have a small collection of Yellowstone fossils, including a large number of fossil brachiopod specimens and possibly the Pleistocene horse *Equus nebraskensis* (YPM-PU 14673). Paleobotanical specimens collected by William Fritz in association with his research are currently at Georgia State University and a small collection at Montana State University.

According to 36 CFR 2.5, all natural resource objects placed in exhibits or collections must be accessioned and cataloged into the park's museum collection. These collections should be inventoried and any whose current status and location is unknown should be investigated.

PALEONTOLOGICAL RESOURCES NEAR YELLOWSTONE

Gallatin Petrified Forest

Extensive outcrops of petrified forest are exposed within national forest areas just north and northwest of Yellowstone National Park. The Gallatin National Forest includes approximately 25,980 acres of land designated as a special management zone referred to as the Gallatin Petrified Forest, which is geologically equivalent to similar exposures within Yellowstone. The U.S. Forest Service has developed an interpretive trail along cliffs containing petrified wood fragments. Although collection of petrified wood is prohibited along the trail, up to 20 cubic inches can legally be collected for non-commercial purposes per person per year elsewhere in the Gallatin National Forest. A self-serve permit station is located at the entrance to the Tom Miner Petrified Forest or at one of the U.S. Forest Service district offices.

Yellowstone River Valley

The Middle Miocene Hepburn's Mesa Formation north of Yellowstone National Park preserves the remains of fossil vertebrates. Tony Barnosky (Montana State University) has studied Barstovian mammals from this formation.

The Chalk Cliffs, north of Gardiner near Old East River Road, contain Miocene fossil vertebrate remains including horse, turtle and shark's teeth. Fossil equid limb bones from Chalk Cliffs are in the Yellowstone Park Museum.

Beartooth Mountains

The area surrounding Cooke City just outside the northeast park entrance contains extremely rich fossil deposits, primarily Paleozoic sedimentary layers that contain an abundance of invertebrate fossils. From the Devonian Beartooth Butte Formation, which contains Lower Devonian plant and fish fossils representing a estuary along an ancient sea coast, five ostracoderm fish species have been identified.

Wapiti Valley

Early and Middle Eocene fossil vertebrates have been collected in Wapiti Valley just east of the park. Fossils ranging in age from Wasatchian through Bridgerian have been collected by paleontologists from the University of Michigan in the exposed sediments and volcaniclastic rocks exposed in the north and south forks of the Shoshone River.

Other fossil vertebrate localities east of the Absaroka Mountains which have been studied by Jeff Eaton have yielded primarily Eocene fauna. Paleontological surveys along the eastern boundary of Yellowstone, especially the Hoodoo Peak and Bootjack Gap areas, may yield similar age deposits and fossils.

Bridger-Teton National Forest

Exposures of the Cretaceous Harebell Formation can be found just south of the park. Dinosaur footprints were recently discovered by Kirk Johnson (Denver Museum of Natural History) in the Bridger-Teton Wilderness Area.

Eocene, Oligocene and Miocene vertebrate fossils are known from the Emerald Lake area, three miles south of the park. The White River and Colter Formations contain Chadronian through Arikareean fossil mammals (Love et al. 1976).

The Hominy Peak Formation, which is exposed along the southern boundary of Yellowstone National Park, contains Eocene flora and vertebrate fossils corresponding to Bridgerian A-B fauna (Love et al. 1978).

Gravelly Range

Vertebrate fossils ranging from Uintan through Whitneyan are known from the Gravelly Range, west of the park.

Bibliography

Aguirre, M.R. 1977. Coniferous leaves from the Amethyst Mountain “Fossil Forest,” Yellowstone National Park, Wyoming. Unpublished senior thesis, Walla Walla College, College Park, Washington. 16pp.

Aguirre, M.R. 1980. An Eocene leaf florule from the Amethyst Mountain “Fossil Forest”, Yellowstone National Park, Wyoming. M.S. Thesis, Walla Walla College, College Park, Washington. 83pp.

Ammons, R., W.J. Fritz, R.B. Ammons and A. Ammons. 1987. Cross identification of Ring Structures in Eocene Tree (*Sequoia magnifica*) from the Specimen Ridge Locality of the Yellowstone Fossil Forests. Paleogeography, Paleoclimatology, Paleoecology 60:97-108.

Andrews, H.N. 1939. Notes on the fossil flora of Yellowstone National Park with particular reference to the Gallatin region. American Midland Naturalist 21(2):454-460.

Andrews, H.N. and L.W. Lenz. 1946. The Gallatin Fossil Forest (Yellowstone National Park). Missouri Botanical Gardens Annual 33:309-313.

Arct, M. 1979. Dendrochronology in the Yellowstone Fossil Forests. Masters Thesis, Loma Linda University, Loma Linda, California. 65pp.

Baker, R.G. 1969. Later Quaternary pollen and plant macrofossils from abandoned lagoon sediments near Yellowstone Lake, Wyoming. Ph.D. Dissertation, University of Colorado, Boulder. 114pp.

Baker, R.G. 1970. Pollen sequence from late Quaternary sediments in Yellowstone National Park. Science 168 (3938):1449-1450.

Baker, R.G. 1976. Late Quaternary vegetation history of the Yellowstone Lake Basin, Wyoming. U.S. Geological Survey Professional Paper 729-E. 48pp.

Baker, R.G. 1986. Sangamonian and Wisconsinian paleoenvironments in Yellowstone National Park. Geological Society of America Bulletin 97:717-736.

Barnosky, A. and W.J. Labar. 1989. Mid-Miocene (Barstovian) environmental and tectonic setting near Yellowstone Park, Wyoming and Montana. Geological Society of America Bulletin 101:1448-1456.

Barnosky, E.H. 1992. A positive role for taphonomy and time-averaging as illustrated by mammalian fossils from Lamar Cave, Yellowstone National Park, Wyoming. Geological Society of America Abstracts with Programs 24(2):2.

Barnosky, E.H. 1994. Ecosystem dynamics through the past 2000 years as revealed by fossil mammals from Lamar Cave in Yellowstone National Park. Historical Biology 8:71-90.

Bauer, C. 1962. Yellowstone, its underground world. University of New Mexico Press, Albuquerque. 122 pp.

Beyer, A.F. 1954. Some petrified wood from the Specimen Ridge area of Yellowstone National Park. American Midland Naturalist 51(2):553-567.

Bown, T.M. 1982. Geology, Paleontology, and correlation of Eocene volcaniclastic rocks, southeast Absaroka Range, Hot Springs County, Wyoming. U.S. Geoligical Survey Professional Paper 1201-A. 89pp.

Burbank, D.W. and A.D. Barnosky. 1990. The magnetochronology of Barstovian mammals in southwestern Montana and implications for the initiation of Neogene crustal extension in the northern Rocky Mountains. Geological Society of America Bulletin 102:1093-1104.

Chadwick, A. and T. Yamamoto. 1984. A paleoecological analysis of petrified trees in the Specimen Creek area of Yellowstone National Park, Montana, U.S.A. Paleogeography, Paleoclimatology, Paleoecology 45:39-48.

Chapman, W. and L. Chapman. 1935. The petrified forest. Natural History Magazine, May:382-393.

Coffin, H. 1976. Orientation of trees in the Yellowstone Petrified Forests. Journal Paleontology 50(3):539-543.

Conrad, H.S. 1930. A *Pityoxylon* from Yellowstone National Park. American Journal of Botany 17:547-553.

Crickmay, C.H. 1936. Study in the Jurassic of Wyoming. Geological Society of America Bulletin 47(4): 541-564.

DeBord, P.L. 1977. Gallatin Mountain “Petrified Forest”: A palynological investigation of the *in situ* model. Ph.D. Thesis, Loma Linda University, Loma Linda, California. 86pp.

DeBord, P.L. 1979. Palynology of the Gallatin Mountain “Fossil Forest” of Yellowstone National Park, Montana: Preliminary Report. Pages 159-164 *in* R. Linn, ed. Proceedings First Conference Scientific Research in the National Parks. U.S. Department of Interior. National Park Service Transactions and Proceedings Series 5.

Deiss, C.F. 1936. Revision of type Cambrian formations and sections of Montana and Yellowstone National Park. Geological Society of America Bulletin 47(8):1257-1342.

Demarest, D.F. 1940. Vertebrate fossils as a key to the age of the Yellowstone-Absaroka Volcanic Rocks. Senior Thesis, Princeton University. 70pp.

Dorf, E. 1960. Tertiary fossil forests of Yellowstone National Park, Wyoming. Pages 253-260 *in* 11th Annual Field Conference Guidebook. Billings Geological Society.

Dorf, E. 1964. The petrified forests of Yellowstone Park. Scientific American 210(4):106-114.

Dorf, E. 1974. Early Tertiary fossil forests in Yellowstone Park. Pages 108-110 *in* Rock Mechanics: The American Northwest, Third International Congress on Rock Mechanics.

Dorf, E. 1980. Petrified forests of Yellowstone. U.S. Government Printing Office, Washington, D.C. 12pp.

Duncan, D.C. 1937. Upper Cambrian trilobites from Montana and Yellowstone National Park. M.S. Thesis, University of Montana, Missoula.

Elias, S. 1988. Late Pleistocene paleoenvironmental studies from the Rocky Mountain region: a comparison of pollen and insect fossil records. Geoarcheology 3: 147-153.

Felix, J. 1896. Zeitschr. Deutsch. d. Geol. Gessell. p.249-260.

Field, L.G. 1983. The Gallatin Petrified Forest. Lapidary Journal 37(8):1218-1223.

Fisk, L.H. 1976. Palynology of the Amethyst Mountain "Fossil Forest", Yellowstone National Park, Wyoming. Ph.D. Thesis, Loma Linda University, Loma Linda, California. 340pp.

Fisk, L.H. 1976. The Gallatin "Petrified Forest": A review. Montana Bureau of Mines Geology Special Publication 73:53-72.

Fisk, L.H. 1976. Paleoenvironmental interpretations of the Eocene "Fossil Forests" of Yellowstone National Park, Montana and Wyoming. 25th International Geological Congress, abstract. 1:303.

Fisk, L.H., M.R. Aguirre and W.J. Fritz. 1978. Additional conifers from the Eocene Amethyst Mountain "Fossil Forest," Yellowstone National Park, Wyoming. Rocky Mountain Section, Geological Society of America Meetings, abstract.

Fisk, L.H. and P. DeBord. 1974. Palynology of the "Fossil Forest" of Yellowstone National Park, Wyoming. American Journal of Botany, abstract, 61:15-16.

Fisk, L.H. and P. DeBord. 1974. Plant microfossils from the Yellowstone Fossil Forests: Preliminary Report. Geological Society of America, Abstracts with Programs, 6(5):441-442.

Fisk, L.H. and W.J. Fritz. 1984. Pseudoborings in Petrified Wood from the Yellowstone "Fossil Forests." Journal Paleontology 58(1):58-62.

Fox, S.K. 1939. Stratigraphy and micropaleontology of the Cody Shale in southern Montana and northern Wyoming. Ph.D. Dissertation, Princeton University.

Fraser, G.D., H.A. Waldrop, and H.J. Hyden. 1969. Geology of the Gardiner area, Park County, Montana. U.S. Geological Survey Bulletin 1277. 118pp.

Fritz, W.J. 1977. Paleoecology of petrified woods from the Amethyst Mountain "Fossil Forest" Yellowstone National Park, Wyoming. Ph.D. Thesis, Walla Walla College, College Park, Washington. 57pp.

Fritz, W.J. 1980. Reinterpretation of the depositional environment of the Yellowstone "fossil forests." Geology 8:309-313.

Fritz, W.J. 1982. Geology of the Lamar River Formation, northeast Yellowstone National Park. Pages 73-101 *in* M. Rucker and F. Drago, eds. Wyoming Geological Association Guidebook, Casper, Wyoming.

Fritz, W.J. 1984. The puzzle of Yellowstone's petrified forest. Montana Magazine, January-February:15-16.

Fritz, W.J. 1986. Plant taphonomy in areas of explosive volcanism in land plants: Notes for a short course. T.W. Broadhead, ed. Department of Geological Sciences, University of Tennessee, Knoxville. Studies in Geology 15:1-9.

Fritz, W.J. and L.H. Fisk. 1977. Paleoecology of some Eocene woods from the Amethyst Mountain "Fossil Forest," Yellowstone National Park, Wyoming. Botanical Society of America Abstracts 154:37.

Fritz, W.J. and L.H. Fisk. 1978. Eocene petrified woods from one unit of the Amethyst Mountain "fossil forest." Northwest Geology 7:10-19.

Fritz, W.J. and L.H. Fisk. 1979. Paleoecology of petrified wood from the Amethyst Mountain "Fossil Forests," Yellowstone National Park, Wyoming. National Park Service Proceedings 5(2):743-749.

Gennett, J.A. and R.G. Baker. 1986. A Late Quaternary pollen sequence from Blacktail Pond, Yellowstone National Park, Wyoming. Palynology 10: 61-71.

Girty, G.H. 1899. Devonian and Carboniferous fossils [of Yellowstone National Park]. U.S. Geological Survey

Monograph 32:479-599.

Grant, R.E. 1965. Faunas and stratigraphy of the Snowy Range Formation (Upper Cambrian) in southwestern Montana and northwestern Wyoming. Geological Society of America Memoire 96. 171pp.

Hadley, E. 1990. Late Holocene mammalian fauna of Lamar Cave and its implications for ecosystem dynamics in Yellowstone National Park, Wyoming. M.S. Thesis, Northern Arizona University, Flagstaff. 127pp.

Hague, A., J.P. Iddings, W.H. Weed, C.D. Walcott, G.H. Girty, T.W. Stanton, and F.H. Knowlton. 1899. Descriptive geology, petrology, petrography, and paleontology. Part II of Geology of the Yellowstone National Park. U.S. Geological Survey Monograph. 32. pp. 1-23.

Hague, A. 1904. Atlas to accompany monograph XXXII on the geology of the Yellowstone National Park. U.S. Geological Survey Monograph 32.

Holmes, W.H. 1878. Report on the geology of the Yellowstone National Park. Pages 1-57 *in* U.S. Geological Survey, territories of Wyoming and Idaho. 1883 ed. 12th annual report, part 2.

Holmes, W.H. 1879. Fossil forests of the volcanic tertiary formations of Yellowstone National Park. U.S. Geological Survey Territories Bulletin 2:125-132.

Iddings, J.P. and W.H. Weed. 1899. Descriptive geology of the Gallatin Mountains. U.S. Geological Survey Monograph 32:1-59.

Knowlton, F.H. 1895. Fossil forests of Yellowstone National Park. The Epoch 1(1):15-50.

Knowlton, F.H. 1896. The Tertiary floras of Yellowstone National Park. American Journal of Science, 4th Series 2:51-58.

Knowlton, F.H. 1898. The standing fossil forests of the Yellowstone National Park. Plant World 1(4):53-55.

Knowlton, F.H. 1899. Fossil flora of the Yellowstone National Park. U.S. Geological Survey Monograph 32:651-882.

Knowlton, F.H. 1914. Fossil forests of the Yellowstone National Park. Department of the Interior, Office of the Secretary. 31pp.

Lesquereux, L. 1872. An enumeration with descriptions of some Teritiary fossil plants from specimens procured in the explorations of Dr. F. V. Hayden in 1870: U.S. Geol. and Geog. Surv. Terr. (Hayden) Ann. Rept. 5, Suppl., p. 283-318.

Love, J.D. 1956. Summary of geologic history of Teton County, Wyoming, during Late Cretaceous, Tertiary, and Quaternary times. Pages 140-150 *in* Wyoming Geological Association Guidebook, 11th Annual Field Conference.

Love, J.D., E.B. Leopold, and D.W. Love. 1978. Eocene Rocks, Fossils, and Geologic History, Teton Range, Northwestern Wyoming. U.S. Geological Survey Professional Paper 932-B. 40pp.

Love, J.D., M. McKenna, and M.R. Dawson. 1976. Eocene, Oligocene, and Miocene rocks and vertebrate fossils at the Emerald Lake Locality, 3 miles south of Yellowstone National Park, Wyoming. U.S. Geological Survey Professional Paper 932-A. 28 pp.

Ludlow, W. 1876. Report of a Reconnaissance from Carroll, Montana Territory, on the Upper Missouri to the Yellowstone National Park and Return, made in the Summer of 1875 by William Ludlow. Government Printing Office, Washington, D.C.

Lugenbeal, M.P. 1968. Evidence bearing on the time involved in the deposition of the fossil forests of the Specimen Creek area, Yellowstone National Park, Montana. M.A. Thesis, Andrews University, Michigan. 85pp.

Read, C.B. 1930. Fossil floras of the Yellowstone National Park, Part 1, Coniferous woods of Lamar River flora. Carnegie Institute of Washington Publication 416:1-19, 416-468.

Retallack, G. 1981. Reinterpretation of the depositional environment of Yellowstone fossil forest: Comment. Geology 9:52-53.

Ritland, J.H. 1968. Fossil forests of Specimen Creek area, Yellowstone National Park, Montana. M.A. Thesis, Andrews University, Michigan. 62pp.

Rohrer, W.L. 1974. An early middle Eocene flora from the Yellowstone-Absaroka volcanic province, northwestern Wind River Basin, Wyoming. Pages 10-18 *in* MacGinite, ed. Stratigraphy and stratigraphic relations of the fossil floras. University of California Publications in the Geological Sciences, volume 108.

Ruppel, E.T. 1982. Geology of Pre-Tertiary rocks in the northern part of Yellowstone National Park, Wyoming. Pages 111-137 *in* Proc. Thirty-third Annual Field Conference, Wyoming Geological Association Guidebook.

Sills, Mary, 1984. The fossil forests of Yellowstone National Park. Yellostone National Park, National Park Service.

Smedes, H.W. and H.J. Prostka. 1972. Stratigraphic framework of the Absaroka volcanic supergroup in the Yellowstone National Park region. U.S. Geological Survey Professional Paper 729-C. 33pp.

Stanton, T.W. 1899. Mesozoic fossils [of Yellowstone National Park]. U.S. Geological Survey Monograph 32:600-650.

Tillman, S.E. 1893. Fossil forests of the Yellowstone. Popular Science Monthly 43:301-307.

Tysdal, R.G. and D.J. Nichols. 1991. Biostratigraphic correlation of Santonian and Campanian formations in the northwestern part of Yellowstone National Park, and the Madison Range and Livingston area of southwestern Montana. Pages 11-19 *in* T.S. Dyman et al., eds. Contributions to Late Cretaceous stratigraphy and paleontology, western Montana. U.S. Geological Survey Bulletin 1962.

Walcott, C.D. 1899. Cambrian fossils [of Yellowstone National Park]. U.S. Geological Survey Monograph 32:440-478.

Weed, W.H. 1892. The fossil forests of the Yellowstone. School of Mines Quarterly, Columbia College, New York. 13:230-236.

Weed, W.H. 1896. Yellowstone National Park: Sedimentary Rocks. U.S. Geological Survey Atlas, Geol. Folio. 30:4-5.

Wheeler, E. 1993. Fossil dicotyledonous woods of Yellowstone National Park, Wyoming. Pages 113-116 *in* V. Santucci, ed. National Park Service Paleontological Research Technical Report NPS/NRPEFO/NRTR-93/11.

Wheeler, E. 1995. Systematic and ecologic significance of fossil hardwoods: Examples from Big Bend National Park, Yellowstone National Park, and Florissant Fossil Beds National Monument. Pages 113-117 *in* V. Santucci and L. McClelland, eds. National Park Service Paleontological Research Technical Report. NPS/NRPO/NRTR-95/16.

Wheeler, E., R.A. Scott and E.S. Barghoorn. 1977. Fossil dicotyledonous woods from Yellowstone National Park Region. Journal Arnold Arboretum 58:280-302.

Wheeler, E., R.A. Scott and E.S. Barghoorn. 1978. Fossil dicotyledonous woods from Yellowstone National Park Region. Part II. Journal Arnold Arboretum 59:1-26.

Yamamoto, T. and A.V. Chadwick. 1982. Identification of fossil wood from the Specimen Creek area of the Gallatin Petrified Forest, Yellowstone National Park. Part I. Gymnosperms. Journal San-iku Gakuin J C. 10:25-42.

Yamamoto, T. and A.V. Chadwick. 1983. Identification of fossil wood from the Specimen Creek area of the Gallatin Petrified Forest, Yellowstone National Park. Part II. Angiosperms. Journal Sn-iku Gakuin J C. 11:49-66.

Young, P.A. 1935. Petrified sequoia trees in the northwest vorner of Yellowstone National Park. Research Report in Yellowstone National Park Archives. 4pp.

Yuretich, R.F. 1984. Yellowstone fossil forests: New evidence for burial in place. Geology 12:159-162.

Appendix A
Yellowstone Paleontological Survey Proposal

1995

I. Project Title: Paleontological Survey of Yellowstone National Park, Wyoming

II. Principle Investigators

Vincent L. Santucci
National Park Service
P.O. Box 592
Kemmerer, WY 83101
(307) 877-4455

William P. Wall
Department of Biology
Georgia College
Milledgeville, GA 31061
(912) 454-0818

Brent Breithaupt
Museum of Geology
University of Wyoming
P.O. Box 3006
Laramie, WY 82070
(307) 766-2646

III. Support Staff

Graduate and undergraduate students from Georgia College and Slippery Rock University will work under direct supervision of the principle investigators. Both faculty and students will participate in all phases of literature review, field investigations, museum research, report writing and preparation of final publication. Graphics illustrator will be employed to produce maps, figures and illustrations for publications.

IV. Research Statement

Yellowstone National Park is recognized for its natural, cultural and scenic resources. Management of the park's resources presents interesting challenges to the park staff. Although wildlife, vegetation and geothermal features predominate, a wealth of other resource types occur in the park. A diverse and scientifically significant assemblage of paleontological resources are preserved at Yellowstone National Park.

Yellowstone geology spans from the Precambrian through the recent. Paleozoic, Mesozoic and Cenozoic deposits have yielded many types of fossilized plants, invertebrates and vertebrates. Paleontological research projects conducted over the last century have identified numerous localities within the park. Most of the research has been isolated to specific stratigraphic units or taxonomic groups. A comprehensive paleontological survey has not yet been accomplished at Yellowstone National Park.

A paleontological survey will provide documentation that would assist park staff with the development of appropriate and specific management strategies related to the non-renewable fossil resources. The survey can serve to assist in the resource management, research, protection, interpretation, etc. of the wide range of fossil types present at Yellowstone National Park. A detailed list of goals and objectives anticipated are listed below in Section V.

V. Goals and Objectives

The primary goal of this project is to produce a detailed paleontological resource management document that will assist the park staff in the management, research, protection, interpretation of fossils in Yellowstone National Park. The survey will include numerous components which will be provided to the park in the form of written reports, maps and/or photographs. The survey components are directly linked to specific goals/objectives and include:

1. *Inventory of Fossil Sites*

All known paleontological sites will be inventoried. Each site will be reviewed in terms of paleontological significance, geographic location, stratigraphic range, types of fossil specimens collected, previous research at site, etc. Inventory will include the production of a paleontological resources map for the park. The paleoresource map will become available for incorporation into the park's Geographic Information System (GIS). Additionally, an attempt will be made to photodocument as many of the park's known paleontological sites as possible. Recommendations will be provided towards establishing a Paleontological Resource Inventory and Monitoring Program at Yellowstone National Park.

2. *Produce a Paleo-Species List*

A list of all known and described species of fossils, including paleofauna, paleoflora and ichnofossils will be produced. Each fossil taxon will be listed with descriptive information including significance, stratigraphic occurrence, localities collected, associated references, type specimen references, relevant curatorial data (including catalog numbers).

3. *Identification of Threats to Park Paleo Resources*

The fossil resources at Yellowstone National Park will be evaluated in regards to the types of resource threats. Fossil sites will be assessed regarding rates of erosion, potential for theft or vandalism, and other potential threats to the paleontological resources. An historical review of any past cases of paleontological resource theft will be conducted. Recommendations will be provided to assist park staff in the mitigation of the various threats and adverse impacts to the fossil resources.

4. *Historical Review of All Previous Paleo Related Research at Yellowstone National Park*

A comprehensive review and documentation of all previous paleontological research conducted at Yellowstone will be performed. Compilation of this data will help to establish a research baseline from which future research needs may be established. Information will include names of investigators and institutions involved in research projects. Dates, geographic areas, stratigraphic ranges, taxonomic groups, etc. will be identified for each project. A chronology of park paleo-research will be established.

5. *Compile Paleo-Bibliography for Yellowstone*

An intensive bibliographic search of all known bibliographic references pertaining to any paleontological resources at Yellowstone will be undertaken. The bibliography will be annotated and published in the final Paleo Resource Publication provided to Yellowstone. Copies of any relevant paleo-related reference that may not be available in the Yellowstone Library will be provided to the park if possible (at least a photocopy).

6. *Curatorial Review of All Park Paleo-Specimens*

A review of all known fossil specimens collected from Yellowstone National Park will be accomplished. Fossils specimens in the park collection and in outside repositories will be inventoried. If possible, outside repositories will be visited and specimens examined, photographed and data collected. This component will support the curatorial program in the park. Recommendations specific to curatorial management and preservation of fossil specimens will be provided to park.

7. *Paleontological Research Needs*

The accumulation of paleo-related data from a wide range of sources will assist in the recognition of specific paleo resource/research needs at Yellowstone National Park. These recommendations will be provided to the park in the form of Resource Management Plan Project Statements. This format should be in support of the overall management objectives of Yellowstone National Park.

8. *Final Oral Presentation/Training for Park Staff*

Upon completion of the research and production of Yellowstone Paleo Resource Document, the principle investigators will arrange with park to conduct a training/presentation for park staff. Presentations can be designed to highlight interpretive potential, resource significance, management issues, research past and future, protection strategies, etc.

9. *Production of a Yellowstone Paleontological Resources Report*

The final component of the survey is the production of a Yellowstone Paleontological Resources Report. This publication will document all of the information gained through each of the other survey components (i.e., site inventories, paleo-species list, identification of fossil threats, bibliography, etc.). This document will be prepared in a format that is most suitable for park staff. Draft copy will be provided to park for review prior to publication.

VI. Park Support

This project is anticipated to take three years to complete. Multiple trips to the park will be necessary to consult with park staff, conduct field surveys and site documentation, examine museum collections, utilize library research materials, provide training, etc. Interviews with park staff and researchers with knowledge of park paleo resources will be valuable. Expenses including transportation, equipment, photographic supplies, etc. are requested. If park housing or group campsites are available, they would be greatly appreciated and would help to reduce expenses.

Requested funding: $66,000

Smaller funding can be directed towards one or more of the component portions of the proposal. These can be channelled towards the greatest needs at Yellowstone National Park.

Appendix B
Yellowstone Paleo-Species List

Geologic Time Codes:	
[C]	Cambrian
[D]	Devonian
[M]	Mississippian
[P]	Permian
[T]	Triassic
[J]	Jurassic
[K]	Cretaceous
[E]	Eocene
[Q]	Quaternary
[H]	Holocene

CHLOROPHYTA

Hydrodictyaceae

Pediastrum sp. [Q]

CHAROPHYTA

Characeae

Chara sp. [Q]

BRYOPHYTA

Aulacomniaceae

Aulacomnium palustre [Q]

Hypnaceae

Climacium dendroides [Q]

Drepanocladus sp. [Q]

Sphagnaceae

Sphagnum warnstorfianum [Q]

PTERIDOPHYTA

Aspidaceae

Dryopteris xantholithense [E]

Cyatheaceae

Cyathidites minor [E]

Davalliaceae

?*Davallia montana* [E]

Equisetaceae

Equisetum canaliculatum [E]

Equisetum deciduum [E]

Equisetum sp. [E]

Gleicheniaceae

Cardioangulina sp. [E]

Hymenophyllaceae

Hymenophyllumsporites sp. [E]

Lycopodiaceae

Lycopodium sp. [E]

Marattiaceae

Punctatosporites scabratus [E]

Polypodiaceae

Laevigatosporites haardti [E]

Laevigatosporites ovatus [E]

Laevigatosporites sp. [E]

Schizaeaceae

Lygodium kaulfussii [E]

Lygodium sp. [E]

Schizaea sp. [E]

Triplanosporites microsinosis [E]

Selaginellaceae

Neoraistrickia sp. [E]

Selaginella sp. [E]

Selaginella densa [Q]

Selaginella selaginoides [Q]

Thelypteridaceae

Thelypteris iddingsi [E]

Thelypteris weedii [E]

SPERMATOPHYTA

GYMNOSPERMAE

Cupressaceae

Cupressinoxylon lamarense [E]

Libocedrus decurrenoides [E]

Thuja xantholitica [E]

Juniperus sp. [E]

Juniperus communis [Q]

Juniperus virginiana [Q]

Cycadaceae

Cycadopites sp. [E]

Monosulcites sp. [E]

Zamites pollardi [E]

Ephedraceae

Ephedra torreyana [Q]

Ephedra viridis [Q]

Ephedra sp. [E]

Pinaceae

Abies lapidea [E]

Abies lasiocapra [Q]

Cedrus sp. [E]

Larix sp. [E]

Picea engelmannii [Q]

Piceoxylon laricinoides [E]

Pinus albicaulis [Q]

Pinus baumani [E]

Pinus contorta [Q]
Pinus fallax [E]
Pinus flexilis [Q]
Pinus gracilistrobus [E]
Pinus macrolepis [E]
Pinus ponderosa [Q]
Pinus premurrayana [E]
Pinus pseudotsugoides [E]
Pinus wardii [E]
Pinus wheeleri [E]
Pityoxylon sp. [E]
Pseudotsuga menziesii [Q]
Tsuga heterophylla [Q]
Tsuga mertensiana [Q]
Tsuga minisacca [E]
Tsuga viridifluminipites [E]

Podocarpaceae

Podocarpus sp. [E]

Taxaceae

?*Taxus* sp. [E]

Taxodiaceae

Glyptostrobus nordenskioeldii [E]
Sequoia affinis [E]
Sequoia lapillipites [E]
Sequoia magnifica [E]
Taxodiaceaepollenites hiatus [E]
Taxodium hiatipites [E]

ANGIOSPERMAE MONOCOTYLEDONAE

Areaceae

Arecipites sp. [E]
Monocolpopollenites sp. [E]

Cyperaceae

Carex aquatilis [Q]
Carex canescens [Q]
Carex diandra [Q]
Carex geyeri [Q]
Carex hoodii [Q]
Carex limosa [Q]
Carex phaeocephala [Q]
Carex utriculata [Q]
Carex vesicaria [Q]
?*Cyperacites* sp. [E]
Eleocharis macrostachya [Q]
Eriophorum sp. [Q]
Scripus acutus [Q]

Gramineae

Agropyron sp. [Q]
Bromus inermis [Q]
Calamagrostis canadensis [Q]
Calamagrostis inexpansa [Q]
Deschampsia caespitosa [Q]
Elymus sp. [Q]
Glyceria borealis [Q]
Glyceria maxima [Q]
Graminidites sp. [E]
Poa sp. [Q]
Sitanion longifolium [Q]
Stipa sp. [Q]

Juncaceae

Luzula parviflora [Q]
Luzula spicata [Q]

Liliaceae

Liliacidites sp. [E]
Smilax lamarensis [E]

Najadaceae

Najas flexilis [Q]
Potamogeton alpinus [Q]
Potamogeton filiformis [Q]
Potamogeton gramineus [Q]
Potamogeton illinoensis [Q]
Potamogeton pectinatus [Q]
Potamogeton vaginatus [Q]

Pandanaceae

Pandanus sp. [E]

Potamogetonaceae

Potamogeton sp. [E]

Sparganiaceae

Sparganium angustifolium [Q]
Sparganium minimum [Q]

Typhaceae

Typha angustifolia [Q]
Typha latifolia [Q]
Typha leaquiereuxi [E]

DICOTYLEDONAE

Aceraceae

Acer bendierei [E]
Acer sp. [Q]

Anacardiaceae

Rhus crystallifera [Q]

Aquifoliaceae

Ilex sp. [Q]

Araliaceae

Aralia notata [Q]
Aralia wrightii [Q]

Betulaceae

Alnus tenuifolia [Q]

Alnus sp.	[E]
Betula claripites	[E]
Betula glandulosa	[Q]
Betula occidentalis	[Q]
Betula sp.	[Q]
Carpinus absarokensis	[E]
Carpinus ancipites	[E]
Corylus macquarrii	[E]
Bombacaceae	
Bombacacidites sp.	[E]
Boraginaceae	
Mertensia sp.	[Q]
Burseraceae	
Canarium leonis	[E]
Callitrichaceae	
Callitriche sp.	[Q]
Campanulaceae	
Campanula rotundifolia	[Q]
Chenopodiaceae	
Atriplex sp.	[Q]
Chenmopodipollis sp.	[E]
Sarcobatus vermiculatus	[Q]
Combretaceae	
?*Terminalia* sp.	[E]
Compositae	
Achillea lanulosa	[Q]
Ambrosia	[Q]
Antennaria	[Q]
Artemisia tridentata	[Q]
Aster sp.	[Q]
Chrysothamnus sp.	[Q]
Cornaceae	
Cornus wrightii	[E]
?*Mastixia* sp.	[E]
Crassulaceae	
Sedum lanceolatum	[Q]
Sedum rhodanthum	[Q]
Sedum rosea	[Q]
Cruciferae	
Arabis glabra	[Q]
Descurainia californica	[Q]
Rorippa islandica	[Q]
Cyrillaceae	
Cyrilloxylon eocenicium	[E]
Ebenaceae	
Diospyros brachysepala	[E]
Diospyros lamarensis	[E]
Eleagnaceae	
Shepherdia canadensis	[Q]
Ericaceae	
Arctostaphylos uva-ursi	[Q]
Kalmia polifolia	[Q]
Ledum glandulosum	[Q]
Phyllodoce empetriformis	[Q]
Vaccinium myrtillus	[Q]
Euphorbiaceae	
Amamoa sp.	[E]
Fagaceae	
Castanea castaneaefolia	[E]
Castanopsis longipetiolatum	[E]
Fagopsis longifolia	[E]
Fagus grandiporosa	[E]
Nothofagus sp.	[E]
Quercinium amthystianum	[E]
Quercinium knowltonii	[E]
Quercinium lamarense	[E]
Quercus furcinervis americana	[E]
Quercus grossidentata	[E]
Quercus rubida	[E]
Quercus simulata	[E]
Quercus weedii	[E]
Quercus sp.	[Q]
Gentianaceae	
Gentianopsis thermalis	[Q]
Grossulariaceae	
Ribes sp.	[Q]
Haloragidaceae	
Myriphyllum sp.	[E]
Hamamelidaceae	
Hamamelis sp.	[E]
Hydrophyllaceae	
Phacelia sp.	[E]
Icacinaceae	
Phytocrene sordida	[E]
Juglandaceae	
Carya antiquorum	[E]
Juglans crescentia	[E]
Juglans rugosa	[E]
Juglans sp.	[Q]
Momiptes coryloides	[E]
Momiptes trenuipolus	[E]
Momiptes triorbicularis	[E]
Momiptes triradiatus	[E]
Pterocarya roanensis	[E]
Pterocaryoxylon knowltonii	[E]
Lauraceae	
Cinnamomum spectabile	[E]
Laurophyllum grandis	[E]

Laurus ?*primigenia*	[E]
Lindera varifolia	[E]
Litsea lamarensis	[E]
Persea pseudocarolinensis	[E]
Perseaoxylon aromaticum	[E]
Ulminium eocenicum	[E]
Ulminium parenchumatosum	[E]
Ulminium porosum	[E]
Leguminosae	
Acacia lamarensis	[E]
Acacia macrosperma	[E]
Acacia wardii	[E]
Leguminosites inlustris	[E]
Leguminosites lamarensis	[E]
Lupinus argenteus	[Q]
Lentibulariaceae	
Utricularia minor	[Q]
Utricularia vulgaris	[Q]
Loranthaceae	
Arceuthobium americanum	[Q]
Arceuthobium campylopodum	[Q]
Arceuthobium douglasii	[Q]
Magnoliaceae	
Magnolia californica	[E]
Magnolia culveri	[E]
Magnolia spectabilis	[E]
Menyanthaceae	
Menyanthes trifoliata	[Q]
Moraceae	
?*Artocarpus* sp.	[E]
Broussonetia sp.	[E]
Ficus asiminaefolia	[E]
Ficus densifolia	[E]
Ficus haquei	[E]
Ficus shastensis	[E]
Myricaceae	
Myrica absarokensis	[E]
Myrica lamarensis	[E]
Myrica wardii	[E]
Myrtaceae	
Myrtaceidites sp.	[E]
Nymphaeaceae	
Nuphar luteum	[Q]
Nuphar sp.	[E]
Nyssaceae	
Nyssa puercoensis	[E]
Nyssa saximontana	[E]
Oleaeceae	
Fraxinus sp.	[E]
Onagraceae	
Epilobium adenocaulon	[Q]
Epilobium glandulosum	[Q]
Epilobium lactiflorum	[Q]
Platanaceae	
Plataninium haydenii	[E]
Plantanophyllum whitneyi	[E]
Plantanus appendiculata	[E]
Plantanus browni	[E]
Plantanus sp.	[E]
Polemoniaceae	
Phlox multiflora	[Q]
Polemonium sp.	[Q]
Polygonaceae	
Bistorta bistortoides	[Q]
Bistorta vivipara	[Q]
Eriogonum sp.	[Q]
Persicaria amphibia	[Q]
Persicaria maculata	[Q]
Polygonum ramosissimum	[Q]
Rumex fueginus	[Q]
Rumex paucifolius	[Q]
Rumex salicifolius	[Q]
Ranunculaceae	
Aconitum columbianum	[Q]
Anemone multifida	[Q]
Ranunculus aquatilis	[Q]
Rhamnaceae	
Ceanothus velutinus	[Q]
Rhamnacinium radiatum	[E]
Rhamnus eorectinervis	[E]
Rhizophoraceae	
?*Rhizophora* sp.	[E]
Rosaceae	
Cercocarpus sp.	[Q]
Frageria sp.	[Q]
Geum macrophyllum	[Q]
Pentaphylloides floribunda	[Q]
Potentilla biennis	[Q]
Potentilla gracilis	[Q]
Potentilla norvegica	[Q]
Potentilla palustris	[Q]
Prunus gummosa	[E]
Sibbaldia procumbens	[Q]
Rubiaceae	
Galium trifidum	[Q]
Salicaceae	
Populus balsamifera	[Q]
Populus balsamoides	[E]

Populus tremuloides	[Q]
Populus trichocarpa	[Q]
?*Populus vivaria*	[E]
?*Populus* sp.	[E]
Salix angusta	[E]
Salix arctica	[Q]
Salix liqulifolia	[Q]
Salix subcoerulea	[Q]
Salix varians	[E]
Salix sp.	[E]
Sapindaceae	
?*Cupanieidites* sp.	[E]
Koelreuteria mixta	[E]
Sapindus grandifoliolus	[E]
Sapindus wardii	[E]
Saxifragaceae	
Saxifraga caespitosa	[Q]
Saxifraga rhomboidea	[Q]
Staphyleaceae	
Turpinia Lamarense	[E]
Sterculiaceae	
Fremontia sp.	[E]
Pterospermites haguei	[E]
Reevesia sp.	[E]
Tiliaceae	
Tilia sp. Type 1 & Type 2	[E]
Triumfetta sp.	[E]
Ulmaceae	
Planera sp.	[E]
Trema sp.	[E]
Ulmus? *Pseudofulva*	[E]
Ulmus or *Zelkova* sp.	[E]
Zelkkova browni	[E]
Zelkovoxylon occidentale	[E]
Utricaceae	
Utrica sp.	[Q]
Vitaceae	
Cissus haguei	[E]
Parthenocissus sp.	[E]
Vitis sp.	[E]

INSERTAE SEDIS

Pteridophyta	
Deltoidospora diaphana	[E]
Deltoidospora hallii	[E]
?*Leiotriletes* sp.	[E]
Spermatophyta	
Phyllites crassifolia	[E]
Thomsonipollis sp.	[E]

PROTOZOA

Endothyra baileyi	[M]

PORIFERA

Holasterella wrighti	[M]

COELENTERATA

Actinostroma sp.	[D]
Aulopora geometrica	[M]
Cladopora sp.	[D]
Clisiophyllum teres	[M]
Cyathophyllum caespitosum	[D]
Favosites sp.	[D]
Lithostrotion sp.	[M]
Menophyllum excavatum	[M]
Michelinia placenta	[M]
Pachyphyllum sp.	[D]
Syringopora aculeata	[M]
Syringopora surcularia	[M]

BRYOZOA

Anisotrypa sp.	[M]
Eridopora sp.	[M]
Fenestella sp.	[M]
Ptilopora sp.	[M]
Stictoporella sp.	[M]

ARTHROPODA

Insecta	
Amara sp.	[Q]
Aphodius sp.	[Q]
Bembidion sp.	[Q]
Daphnia sp.	[Q]
Ichthebius sp.	[Q]
Tachinus elongatus	[Q]
Trilobitomorpha	
Agnostus bidens	[C]
Agnostus interstrictus	[C]
Agnostus tumidosus	[C]
Arionellus sp.	[C]
Crepicephalus texanus	[C]
Liostracus parvus	[C]
Proetus loganensis	[M]
Proetus peroccidens	[M]
Ptychoparia antiquata	[C]
Ptychoparia penfieldi	[C]
Solenopleura weedi	[C]
Zaconthoides sp.	[C]

MOLLUSCA

Cepalpoda

Baculites sp.	[K]
Belemnites densus	[J]
Scaphites sp.	[K]

Gastropoda

Amnicola cretacea	[K]
Goniobasis increbescens	[K]
Goniobasis pealei	[K]
Loxonema delicatum	[D]
Loxonema sp.	[M]
Lysoma powelli	[J]
Naticopsis sp.	[M]
Platyceras primordialis	[C]
Platyceras sp.	[M]
Platystoma minutum	[D]
Pleurotomaria isaacsi	[D]
Straparollus utahensis	[M]

Pelecypoda

Anatina punctata	[J]
Astarte meeki	[J]
Camptonectes distans	[J]
Camptonectes pertenuistriatus	[J]
Camptonectes stygius	[J]
Corbula subtrigonalis	[K]
Cypricardia haguei	[J]
Gervillia dolabrata	[J]
Gervillia montanensis	[J]
Gryphaea sp.	[J]
Homomya gallatinensis	[J]
Inoceramus acuteplicatus	[K]
Inoceramus flaccidus	[K]
Inoceramus umbonatus	[K]
Inoceramus undabundus	[K]
Ostrea sp.	[J;K]
Pholadomya inaequiplicata	[J]
Pholadomya kingi	[J]
Pinna jurassica	[J]
Pleuromya hectica	[J]
Pleuromya subcompressa	[J]
Pleuromya weberensis	[J]
Thracia montanaensis	[J]
Thracia weedi	[J]
Unio sp.	[K]

Rostrochonchia

Conocardium pulchellum	[M]

HYOLITHA

Hyolithes primordialis	[C]

BRACHIOPODA

Acrotreta gemma	[C]
Athyris incrassata	[M]
Athyris lamellosa	[M]
Athyris vittata	[D]
Atrypa missouriensis	[D]
Atrypa reticularis	[D]
Billingsella coloradoensis	[C]
Camarophoria ringens	[M]
Camarotoechia camarifera	[M]
Camarotoechia herrickana	[M]
Camarotoechia metallica	[M]
Camarotoechia sappho	[M]
Chonetes loganensis	[M]
Chonetes ornatus	[M]
Cliothyris crassicardinalis	[M]
Cliothyris roissyi	[M]
Crania laevis	[M]
Derbya keokuk	[M]
Dicellomus nanus	[C]
Dielasma utah	[M]
Eumetria verneuiliana	[M]
Iphidea sculptilis	[C]
Kallirhynchia myrina	[J]
Leptaena rhomboidalis	[M]
Lingula sp.	[T]
Lingula subspatulata	[K]
Lingulella acuminatus	[C]
Lingulella desideratus	[C]
Liorhynchus haguei	[M]
Martinia rostrata	[M]
Orthis remnicha	[C]
Orthis sandbergi	[C]
Orthothetes inaequalis	[M]
Productella alifera	[M]
Productella cooperensis	[M]
Productus gallatinensis	[M]
Productus laevicosta	[M]
Productus parviformis	[M]
Productus scabriculus	[M]
Productus semireticulatus	[M]
Reticularia cooperensis	[M]
Rhipidomella michelini	[M]
Seminula humilis	[M]
Seminula immatura	[M]
Seminula madisonensis	[M]
Spirifer centronatus	[M]
Spirifer engelmanni	[D]
Spirifer marionensis	[M]

Spirifer striatus	[M]
Spirifer subattenuatus	[M]
Spiriferina solidirostris	[M]
ECHINODERMATA	
Pentacrinus asteriscus	[J]
Platycrinus symmetricus	[M]
Scaphiocrinus sp.	[M]
FISH	
indeterminate fish bone, teeth and scales	[P,K]
cf. *Helodus* sp.	
REPTILIA	
CHELONIA	
indeterminate turtle shell	[K]
DINOSAURIA	
indeterminate dinosaur bones and eggshell	[K]
PLESIOSAURIA	
Plesiosaur (unidentified)	[K]
MAMMALIA	
INSECTIVORA	
Soricidae	
Sorex cinereus	[H]
Sorex vagrans	[H]
Sorex palustris	[H]
Sorex merriami	[H]
Sorex hoyi	[H]
CHIROPTERA	
Vespertilionidae	
Myotis sp.	[H]
LAGOMORPHA	
Leporidae	
Sylvilagus nuttallii	[H]
Sylvilagus audubonii	[H]
Lepus americanus	[H]
Lepus townsendii	[H]
RODENTIA	
Scoirodae	
Tamias sp.	[H]
Marmota flaviventris	[H]
Spermophilus armatus	[H]
Tamiasciurus hudsonicus	[H]
Geomyidae	
Thomomys talpoides	[H]
Castoridae	
Castor canadensis	[H]
Cricetidae	
Peromyscus cf. *maniculatus*	[H]
Neotoma cinerea	[H]
Clethrionomys cf. *gapperi*	[H]
Phenacomys intermedius	[H]
Ondatra zibethicus	[H]
Microtus pennsylvanicus	[H]
M. montanus/longicaudus	[H]
Microtus ochrogaster	[H]
Zapodidae	
Zapus cf. *priceps*	[H]
CARNIVORA	
Canidae	
Canis latrans	[H]
Canis lupus	[H]
Vulpes vulpes	[H]
Ursidae	
Ursus arctos	[H]
Mustelidae	
Mustela cf. *frenata*	[H]
Taxidea taxus	[H]
Mephitis mephitis	[H]
ARTIODACTYLA	
Cervidae	
Cervus elaphus	[H]
Antilocapridae	
Antilocapra americana	[H]
Bovidae	
Bison bison	[H]
Ovis canadensis	[H]

Appendix C
RMP Paleontological Project Statements

Project Statement #1

Project Number: **YELL-N**

Title: Inventory and Photodocument Paleontologic Resources

Funding Status: Funded: 0; Unfunded: 96.00

Servicewide Issues:
N20 - Lack of Basic Data; Insufficient Understanding of Park Ecosystems and Threats to Them
N23 - Loss of Paleontologic Resources

Problem Statement:

Preliminary research reveals that paleontological resources are abundantly preserved at Yellowstone National Park. In 1996, at least twenty stratigraphic units were identified containing significant fossil resources. Parkwide the number and distribution of paleontological localities are unknown, however, due to the lack of a comprehensive and systematic field inventory.

The lack of basic data regarding the significance, distribution and threats related to the paleontological resources limits park staff's ability to properly manage this non-renewable resource. The scientific and interpretive value of Yellowstone's fossils, excluding paleoflora, remains relatively unrecognized. The ancient Yellowstone Ecosystem remains to be discovered within the park's sedimentary rocks.

Description of Recommended Project or Activity:

A detailed literature search and should be conducted at the beginning of the project, to provide an inventory of known sites and specimens.

A paleontological locality inventory and monitoring program needs to be established for Yellowstone National Park. Most of the park's fossil localities are not recorded and are unknown to park management. These fossil localities should be documented to allow their distribution and significance to be integrated into park management programs.

The park needs to establish and develop a paleonotologic resource database. The paleo-database will include all geographic, stratigraphic, taxonomic and taphonomic information related to Yellowstone's fossil record. Additionally, a paleontologic resources locality map would be produced and incorporated into the park's GIS system. The development of a paleontological inventory and monitoring program includes the establishment of a cyclic locality monitoring schedule.

The program includes the hiring of a staff paleontologist to direct the Inventory and Monitoring Program. The paleontologist will supervise a team of students and volunteers to photodocument and map all unrecorded fossil localities, to record all relevant associated data, develop paleo-resource database, to preserve or collect any significant fossil specimens, and assist curatorial staff with paleo-specimen curation.

Year 1: Hire paleontologist. Inventory park paleontological localities and photodocument.

Year 2: Continue to inventory paleontological localities and photodocument.

Year 3: Complete inventory of paleontological localities and publish photojournal with descriptions of all park fossil localities. Produce paleo-locality map through GIS. Incorporate paleontologic resource data into park management and planning documents.

Budget and FTEs

		Unfunded		
Year	**Source**	**Act Type**	**Budget ($1000s)**	**FTEs**
1	PKBASE-NR	MON	32.00	1.0
2	PKBASE-NR	MON	32.00	1.0
3	PKBASE-NR	MON	32.00	1.0

Alternative Actions/Solutions and Impacts

1) No Action. Continue to manage Yellowstone's paleontological resources without the benefits of an inventory and monitoring program. The lack of a cyclic monitoring schedule will be inefficient and thereby increase the potential that valuable fossil specimens will remain undiscovered and lost through erosion or theft.

2) Develop a Paleontological Locality Inventory and Monitoring Program for Yellowstone National Park. Photodocument and map all park fossil localities and develop a paleontological locality database. Establish a cyclic monitoring schedule for fossil localities.

Compliance Code: EXCL
Explanation: 516 DM2 APP. 2, 1.6

Project Statement #2

Project Number: YELL-N

Title: Preserve Threatened Paleontological Resources

Funding Status: Funded: 0; Unfunded: 36.00

Servicewide Issues:
N20 - Lack of Basic Data; Insufficient Understanding of Park Ecosystems and Threats to Them
N23 - Loss of Paleontologic Resources

Problem Statement:
Management of paleontological resources present intriguing challenges. The balance between conflicting demands of preservation, research and visitor access must be recognized. The principle threats to paleontological resources include loss due to erosion and development, and illegal fossil collecting. Each of these threats impact the integrity of paleontological localities for research and visitor education.

Erosion is a natural process that continually destroys exposed fossils and uncovers previously buried material. The natural erosion cycle is often disrupted by excessive visitor traffic, construction, or other developments. Paleontological resources are not typically considered in pre-construction surveys, which may result in the unnecessary loss of fossil material.

An increasing interest in fossils by the public, coupled to a growing commercial fossil market, is becoming a significant threat to fossil resources preserved in national parks. Illegal fossil collecting can be classified into three categories: 1) inadvertent casual collecting, 2) intentional casual collecting, and 3) intensive intentional collecting. These range from souvenir hunting to systematic removal of the most valuable specimens to be sold in the commercial fossil market.

Although Yellowstone National Park contains significant paleontological resources, there is not an ongoing program to mitigate the threats to paleontological resources. Such a program would address all aspects of park management, including interpretation, protection, maintenance and resource management.

Description of Recommended Project or Activity:
A paleontological resources protection program should be integrated into the environmental review process at Yellowstone National Park. The program should identify and mitigate the threats to known paleontological resources and contain a strategy for identifying impacts on previously unrecorded fossil resources (through surveys, literature review, etc.).

The park program should also establish a member(s) of the park staff to evaluate paleontological resource threats and develop strategies to reduce these threats. In particular, to identify ongoing programs or existing practices that impact park fossils.

Budget and FTEs

		Unfunded		
Year	**Source**	**Act Type**	**Budget ($1000s)**	**FTEs**
1	PKBASE-NR	MON	12.00	0.3
2	PKBASE-NR	MON	12.00	0.3
3	PKBASE-NR	MON	12.00	0.3

Alternative Actions/Solutions and Impacts:

1) No Action. Continue to manage and protect Yellowstone's paleontological resources based on a cursory understanding of the threats. Fossil resources may remain unrecognized and be lost through development, theft or neglect. Scientifically significant localities may experience adverse impacts.

2) Develop a park level paleontological resource program for the management and protection of threatened paleontological resources. Incorporate paleontological resources into management planning and decision making.

Compliance Code(s): EXCL
Explanation: 516 DM2 APP. 2, 1.6

Appendix D
Paleontology Researchers at Yellowstone

Dr. Michael Arct
Department of Natural Science
Loma Linda University
Loma Linda, CA 92350
(909) 824-4530

Kenneth K. Cannon
National Park Service
Midwest Archeological Center
100 Centennial Mall North, Rm 474
Lincoln, NE 68508-3873
(402)437-5392

Scott A. Elias
INSTAAR, University of Colorado
Box 450
Boulder, CO 80309-0450
(303)492-5158

William J. Fritz
Department of Geology
Georgia State University
340 Kell Hall
Atlanta, GA 30303
(404) 651-2272

Jack Horner
Museum of the Rockies
600 West Kagy Blvd.
Bozeman, MT 59717
(406) 994-2251

Dr. Timothy Jones
Universitat Tubingen
Institute for Geology & Paleontology
Sigwartstrasse IO
Tubingen, Germany 7400

Mr. Donald R. Lowe
Standford University
Department of Geology
Stanford University
Stanford, CA 94305

Ms. C.L. Powell
Kings College
Department of Geology and Petroleum
Meiton Building
Aberdeen, Scotland AB92UE

Dr. Bruce Runnegar
University of California, Los Angeles
405 Hilgard Ave.
Los Angeles, CA 90024-1567
(310) 825-3880

Vincent L. Santucci
National Park Service
P.O. Box 592
Kemmerer, WY 83101
(307) 877-4455

Dr. Clyde L. Webster, Jr.
Loma Linda University
Geoscience Research Institute
Loma Linda, CA 92350

Scott Wing
Dept. Paleobiology
NHB-121
Smithsonian Institute
Washington, DC 20560

Appendix E
Fossil Specimens in Park Collections

Acc#	Cat#	Description	Locality
121	1304	Mollusc	Absaroka Mt, Cooke City*
	1330	Mollusc	Absaroka Mt, Cooke City *
	2317	Trilobite	YNP
	2318	Mollusc	Absaroka Mt, Cooke City*
	2322	Petrified wood	
	2323	Leaf	Elk Creek
152	1202	Fossil horse bones	Chalk Cliff
170	7471	Petrified wood	
200	2315	Mollusc	Gallatin
239	1250	Pelecypod	Gravel Peak
	1251-57	Pelecypod	Cinnabar Mt
	1258-63	Pelecypod	Swan Lake Valley
	1264-65	Pelecypod	Fawn Pass
	1266-73	Brachiopod (Ellis)	SW of 2nd Crossing of Snake
	1274	Pelecypod (Ellis)	Fawn Creek Pass
	1275	Pelecypod	Flagstaff Creek
	1276	Pelecypod (Ellis)	Head of Gardiner River
	1277-80	Pelecypod	Cinnabar Mt
	1281	Pelecypod	Swan Lake Valley
	1282	Pelecypod	Flagstaff Creek, Castle Mt
	1283	Pelecypod	Flagstaff Creek, Castle Mt
	1284	Pelecypod	2nd Crossing Snake River
	1285-86	Pelecypod	Cinnabar Mt
	1287	Pelecypod	Swan Lake Valley
	1288-89	Pelecypod	Cinnabar Mt
	1290	Echinoderm	East Slope Sheridan Peak
	1291	Brachiopod (Ellis)	NE Spur Peak W Coulton Creek
	1292-93	Pelecypod	Fawn Creek
	1294-96	Pelecypod (Ellis)	Saddle W Gardner River
	1297-1302	Pelecypod	Gardiner River
	2464	Pelecypod	Fawn Creek Pass
	2465	Pelecypod	Foothills S of Glade Creek
	2471	Coelenterata	Valley bottom upper Gallatin Canyon
	11391	Brachiopod	Fort Belkamp
	11392-93	Brachiopod	Gallatin Valley
	11394-95	Brachiopod	People Creek Canyon, Fort Belkamp
	11396	Brachiopod	Gallatin Valley
	11397-98	Brachiopod	Triangle Peak, Fork E Border
	11399	Brachiopod	Ridge N Gallatin Bridge
	11400-01	Brachiopod	Teton Creek
	11402	Brachiopod	Logan

Acc#	Cat#	Description	Locality
239 (cont.)	11403-04	Brachiopod	South side Gallatin Valley
	11405	Brachiopod	Logan
	11406	Brachiopod	East side of Gallatin River
	11442	Pelecypod and fish scale	Foothills south of Glade Creek**
	11443	*Inoceramus*	East Bluff Mission Creek
	11444	*Inoceramus*	Foothills S Glade Creek
	11445	*Baculites*	Cinnabar Mountain
	11446-50	Gastropod	Ridge N Gardiner River (Dakota)
	11451-56	Gastropod	Gallatin Range (Dakota SS)
	11457-59	*Ostrea*	N Head Gardiner River
	11460-61	*Baculites*	Cinnabar Mountain
	11462-64	Pelecypod *Corbula*	South base of Electric Peak***
	11465-66	Gastropod	Ridge N Gardiner River (Dakota)
257	2451-55	*Inoceramus*	South face of Mount Everts
277	4063	Dinosaur bone	Hill East Gardiner Road*****
313	11359-61	Petrified wood	
354	4064	Dinosaur bone	N Mt Sepulcher****
	4065	Dinosaur bone	N Mt Sepulcher****
362	3064	Petrified wood	Green Lake
390	2477	Dragonfly wing cast	Riverside Geyser?
442	10289	Pelecypod	Mount Everts
	10319	Leaf	Crescent Hill
450	3100	Leaf	Specimen Ridge
495	8312	Leaf	Specimen Ridge
	8313	Leaf	Specimen Ridge
	11380	Petrified wood	Gallatin Fossil Forest
626	1910	Limb cast	Specimen Ridge Fossil Forest
655	11626	Leaves	Mount Everts
663	2501-06	Hickory nut impress	Mount Hornaday

* Removed/deaccessioned.

** Now in National Museum of Natural History; collected by Hayden in 1872.

*** Cretaceous fossils in drift in valley holding headwaters of Gardiner River, south base of Electric Peak.

**** Found north of Mount Sepulcher in foothills from light brown soft shale; collected in 1946.

***** West side of round brown mud (Shale) hill east of Old Gardiner Road, just north of Beaver Ponds parking area; collected in 1936.

Appendix F
Yellowstone Fossils in Outside Repositories

Abies lapidea (Beyer, 1954)
Specimen Ridge
Type: CINC B-788 with slides; Isotypes: B-710, B-717, B-759, B-793

Cupressinoxylon lamarense (Read, 1930)
Specimen Ridge, Yancey's Forest
Univ.Calif.Col.Pal.Bot. no. 1281, slides 1281a-g

Equus nebraskensis (McKenna, 1996, pers. commun.)
YPM-PU 14673

Fagus grandiporosa (Beyer, 1954)
Specimen Ridge
Type: CINC B-807 with slides

Huenella weedi (Walcott, 1899)
Smithsonian Institution
Type: I-069797
Smithsonian Miscellaneous Collections, vol. 67, p.522

Libocedrus decurrenoides (Beyer, 1954)
Specimen Ridge
Type: CINC B-718 with slides; Isotypes: B-681, B-700, B-724, B-754, B-813

Pinus baumani (Read, 1930) (possibly type)
Fossil Forest/Specimen Ridge
Univ.Calif.Col.Pal.Bot. no. 1278, slides 1278a-f

Pinus fallax (Felix, 1896)
Fossil Forest/Specimen Ridge, Yancey's Forest, Crescent Hill
USNM Col Pal Bot. no. 110-112, 122-124, 131-133, 158-163
Univ.Calif.Col.Pal.Bot. no. 1279, slides 1279a-b, 1280a-e

Pinus pseudotsugoides (Beyer, 1954)
Specimen Ridge
Type: CINC B-725; Isotype: CINC B-763 with slides

Piceoxylon laricinoides (Beyer, 1954)
Specimen Ridge
Type: CINC B-714 with slides

Quercus rubida (Beyer, 1954)
Specimen Ridge
Type: CINC B-229 with slides (Ohio University Museum); CINC B824a

Sequoia magnifica (Knowlton, 1899)
Fossil Forest/Specimen Ridge, Yancey's Forest, Crescent Hill
USNM Col Pal Bot. no. 143-150, 155-157
Univ.Calif.Col.Pal.Bot. no. 1282, slides 1282a-d, 1041a-b

Thuja xantholitica (Beyer, 1954)
Specimen Ridge
Type: CINC B-782 with slides; Isotypes: B-736, B-740, B-757, B-784

Other Outside Repositories

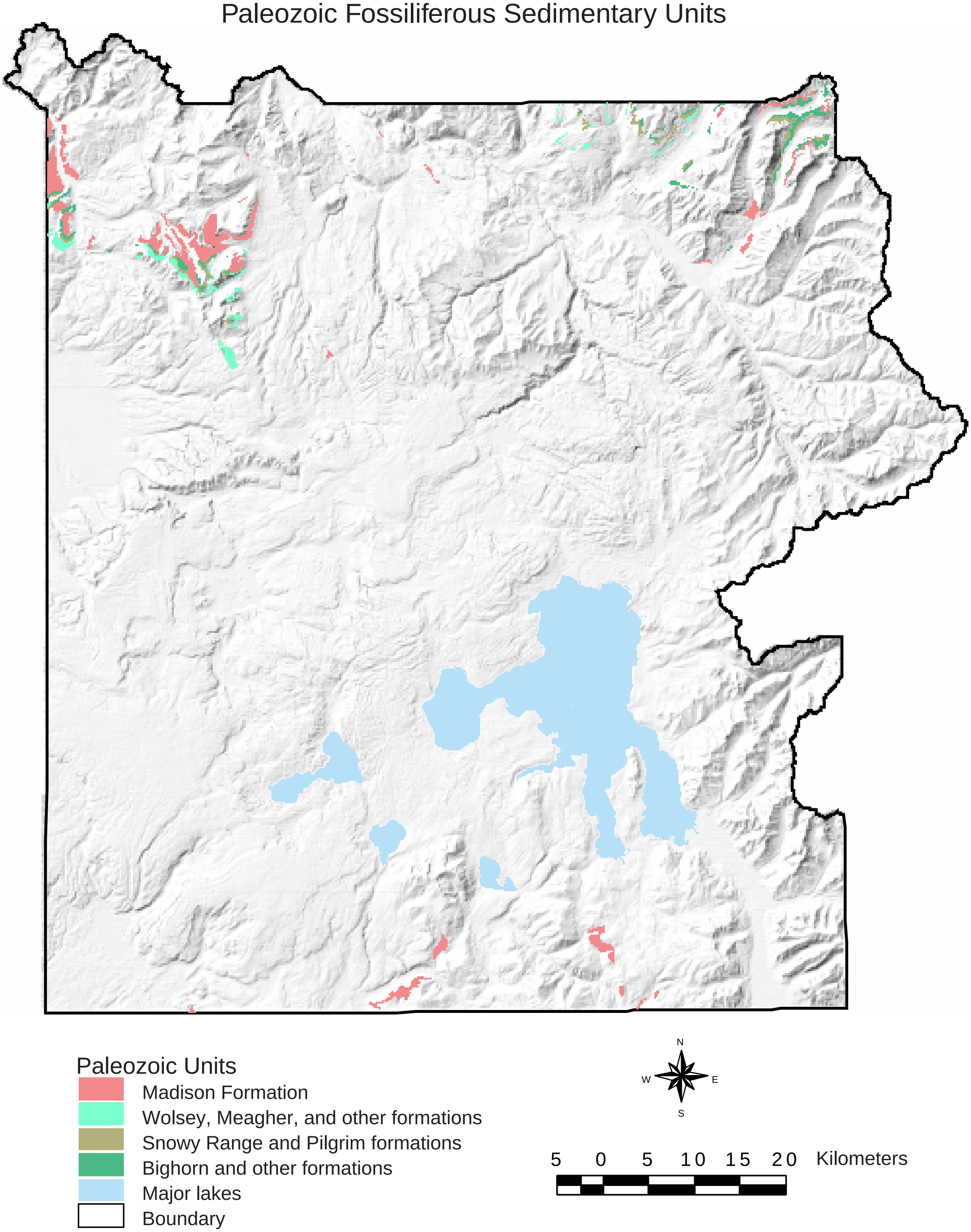
Paleobotanical collections at the University of California (Read, 1930). Specimen numbers include 1278, 1279, 1281, 1282 with slides.

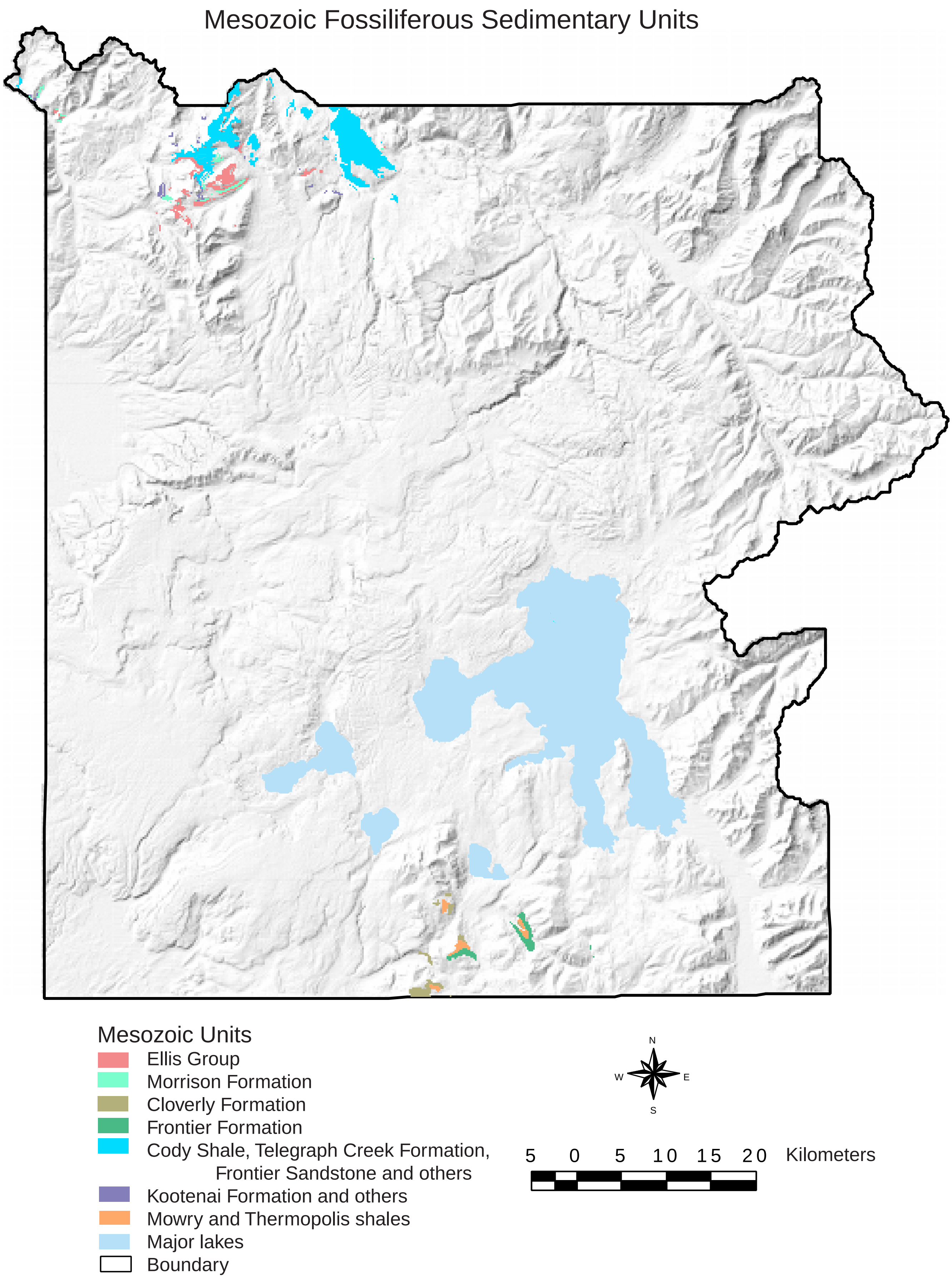
Paleobotanical collections of the University of Cincinnati (Beyer, 1954). Fossil plant material was collected in 1941, by Dr. J.H. Hoskins, Univ. Cincinnati, Dr. Th.K. Just, Chicago Museum of Natural History, Dr. A.T. Cross, West Virginia Geological Survey & WV University, and Dr. A.H. Blickle, Ohio University. Specimen numbers include B641-B824a. Specimen B-229 holotype for *Quercus rubida* is housed in the Museum of Ohio University, Athens, Ohio.

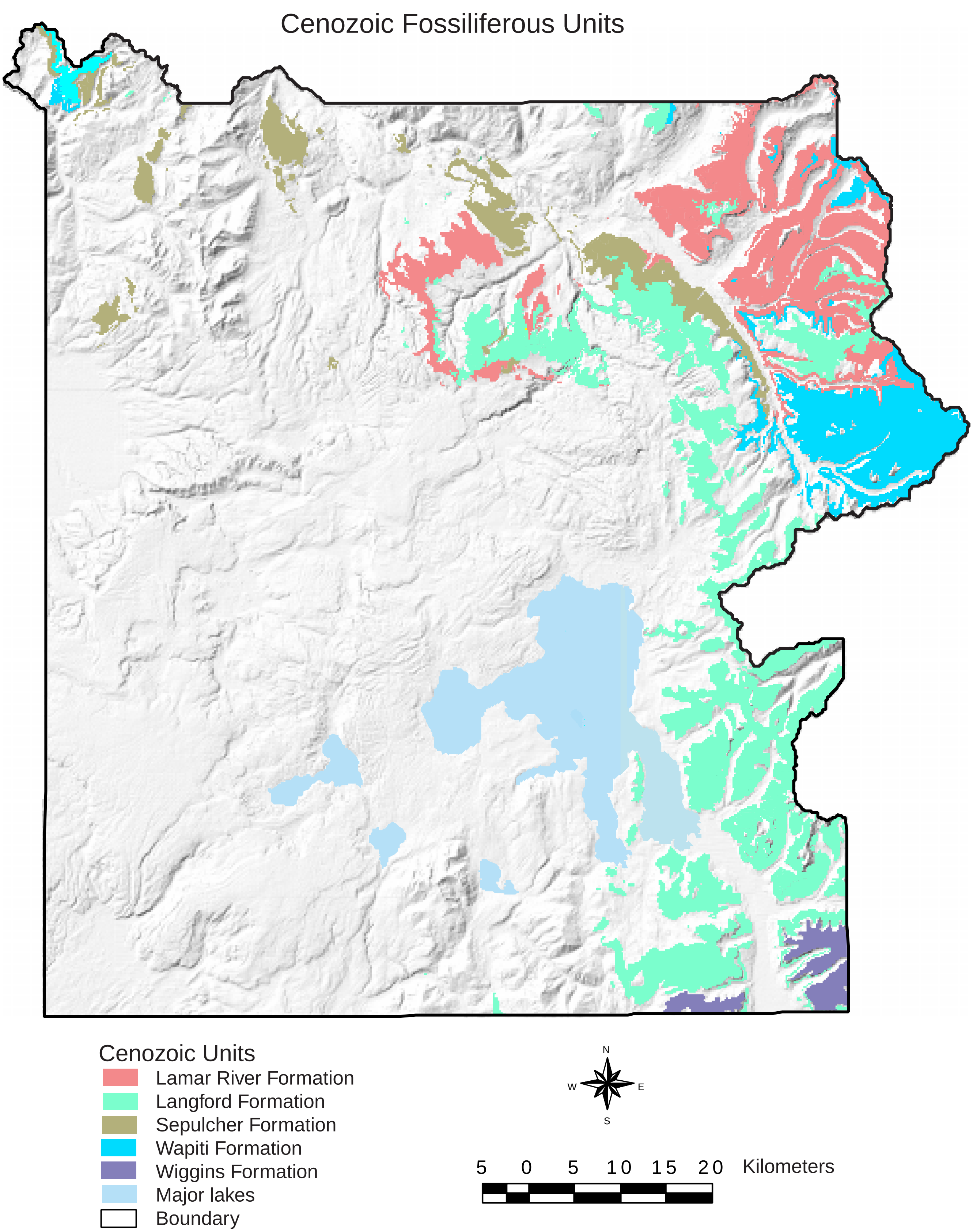
Yale Peabody Museum collections include numerous brachiopods which may include one "type" specimen. There is also a report that a Pleistocene horse *Equus nebraskensis* from Yellowstone is in the collections.

Appendix G. GIS Stratigraphy Maps

Paleozoic Fossiliferous Sedimentary Units




Mesozoic Fossiliferous Sedimentary Units
Mesozoic Units
Ellis Group
Morrison Formation
Cloverly Formation
Frontier Formation
Cody Shale, Telegraph Creek Formation, Frontier Sandstone and others
Kootenai Formation and others
Mowry and Thermopolis shales
Major lakes
Boundary
N
W
E
S
5 0 5 10 15 20 Kilometers


Cenozoic Fossiliferous Units
Cenozoic Units
Lamar River Formation
Langford Formation
Sepulcher Formation
Wapiti Formation
Wiggins Formation
Major lakes
Boundary
N
W
E
S
5 0 5 10 15 20 Kilometers