THE GEOCHRONOLOGICAL STORY OF NATIONAL PARK SERVICE PALEONTOLOGY

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Abstract—The data assembled for the National Park Service's Paleontology Synthesis Project (PSP) have made it feasible to analyze the geochronological scope of NPS paleontological resources. Paleontological resources have been documented for 283 NPS units and affiliated areas; 245 have confirmed *in situ* or reworked fossils. From this subset, the NPS record of paleontological resources spans from the Mesoproterozoic to the Quaternary, well over a billion years of Earth's history. In general, record distribution is related to the recency of a given time division and its duration: more recent divisions are more frequently represented by park fossils than older divisions, and longer divisions are more frequently represented than shorter divisions. Other factors influencing distribution include the presence or absence of organisms with mineralized body structures; the geographic distribution of parks (e.g., there are relatively few large eastern NPS units); and existing knowledge (paleontological work has been more heavily focused on western parks). Dividing time by eras in the Precambrian, periods in the Paleozoic and Mesozoic, and epochs in the Cenozoic, it can be seen that the most frequently represented divisions are the Cretaceous Period (fossils confirmed from 73 NPS units) and the Pleistocene (107) and Holocene (121) epochs. Almost all other divisions are represented by 25–45 NPS units. Park size is a major factor in how many divisions are represented at a given park; the two parks with the most complete records are Death Valley National Park and Denali National Park & Preserve. This analysis is another illustration of the large-scale questions that can be studied by the PSP.

INTRODUCTION

The National Park Service (NPS) includes some of the most notable fossil localities and fossiliferous strata in the United States, with a record of life extending back in time from the Quaternary well into the Mesoproterozoic. A great deal of information exists for this fossil record, as scientific publications, internal memos, informal communications, researchers' field notes, museum records, photographs, newspaper articles, and other documentation. In 2012, the NPS Paleontology Program began an ambitious project to organize this information (Paleontology Synthesis Project, or PSP) and archive it (NPS Paleontology Archives and Library), as documented in Santucci et al. (2018). These efforts have greatly improved the capacity of the NPS Paleontology Program to assess the paleontological resources of each park, make comparisons between park units, respond to queries from NPS staff and others, support research, and prepare reports on park resources. The PSP format also provides a framework for adding new information on paleontological resources in parks, and has helped to identify deficiencies in the knowledge base and areas of high potential for future discoveries.

Several thematic files were created as part of the organization of the PSP, collating information pertaining to specific topics including: holotype specimens from NPS areas (Tweet et al., 2016); museum repositories holding NPS fossils; the taxonomic diversity of NPS fossils (Tweet and Santucci, 2021); and the subject of this report, the servicewide occurrence of fossils over geologic time. The temporal distribution of the fossils found in NPS units has never been systematically investigated, and there was no framework for investigating this topic before the initiation of the PSP. The assembled data presented here provide a picture of the breadth and depth of the collective NPS paleontological record through geologic time.

Acronyms for Park Designations: MEM, Memorial; **MEM PKWY**, Memorial Parkway; **NB**, National Battlefield; **NBP**, National Battlefield Park; **NBS**, National Battlefield Site; **NHA**, National Historic Area; **NHP**, National Historical Park; **NHRES**, National Historical Reserve; **NHS**, National Historic Site; **NHT**, National Historic Trail; **NL,** National Lakeshore; **NM**, National Monument; **NM&PRES**, National Monument and Preserve; **NMEM**, National Memorial; **NMP**, National Military Park; **NP**, National Park; **NP&PRES**, National Park and Preserve; **NPRES**, National Preserve; **NR**, National River; **NRA**, National Recreation Area; **NRES**, National Reserve; **NRR**, National Recreational River; **NRRA**, National River and Recreation Area; **NS**, National Seashore; **NSR**, National Scenic River or Riverway; **NST**, National Scenic Trail; **PKWY**, Parkway; **SRR**, Scenic and Recreational River; **WSR**, Wild and Scenic River.

Symbols and Abbreviations in Lists: *, reworked fossil of this age; †, subsurface record; ‡, NPS affiliate; hist. assoc., historical association.

METHODS

The methodology for creating the PSP was described in Tweet and Santucci (2021) and is paraphrased here. The PSP is based primarily on paleontological resources summaries prepared for the 32 NPS Inventory & Monitoring networks (I&M networks) between 2002 and 2012 and a small number of park-specific inventories and thematic inventories. These in turn were based on various sources (formal publications, dissertations, news items, park records, personal communications, etc.) that were further analyzed during the initial assembly of the PSP files. Refinement of the PSP files is an ongoing process as new discoveries are made, previously overlooked references are uncovered, and new park units are added.

The basic PSP files are 32 documents representing the 32 I&M networks. A given network document contains information for the parks that are formally included in that network, as well as units that are geographically within that network but not formally part of the I&M program, to ensure that all official NPS units are accounted for. Each park is documented using a summary table that is organized stratigraphically, including information on age and fossils known from the various stratigraphic units in that park. The tables are followed by additional notes that collect information that was either published or otherwise brought to light after the compilation of the network documents in 2012. The stratigraphic information from these network files has been used to assemble a geologic time spreadsheet including all parks

that have yielded fossils. This spreadsheet allows rapid parsing of information that can then be expanded upon using the more detailed information in the network documents.

Documenting park paleontological resources requires some practical considerations. The NPS administers, advises, recognizes, or is affiliated with a large number of sites, from the core official list (423 units as of February 2022), to a variety of national rivers and trails, to the National Natural Landmark (NNL) and National Historic Landmark (NHL) programs, to National Heritage Areas, to the National Register of Historic Places (NHRP). The PSP is primarily concerned with the core official units. Incomplete records exist for some of the other categories of units; affiliated areas are best understood at this point because they are the most manageable in terms of geography (most occupy small areas). National rivers and trails lack traditional boundaries, which makes documenting paleontological resources difficult, although it is known that some trails are associated with historical occurrences of fossils or cross fossiliferous areas. NNLs and NHLs with paleontological resources (more than 100) are currently being documented separately from the main PSP files and archives.

In the official list of 423 units, some units are seemingly "double-counted" because in administrative terms they include two distinct areas (e.g., several units in Alaska that include both a National Park or Monument as well as a National Preserve). For the purposes of the PSP, these "double" units are considered one unit. In other cases, various related units may be managed under an umbrella unit. This is particularly true in the District of Columbia and immediate surroundings, where there are numerous small properties managed by the NPS. The rule of thumb for the PSP was to count units separately if they are part of the 423. For example, Fort Washington Park is managed as part of National Capital Parks-East, but is considered a stand-alone unit in the official list. Exception to this rule are the three units managed under North Cascades National Parks Complex (Lake Chelan NRA, North Cascades NP, and Ross Lake NRA), which are so closely linked that the two recreation areas do not have their own NPS websites; Sequoia National Park and Kings Canyon National Park, again managed so closely that they share a website; and Roosevelt-Vanderbilt National Historic Sites (Eleanor Roosevelt NHS, Home of Franklin D. Roosevelt NHS, and Vanderbilt Mansion NHS), because existing information about a fossil occurrence does not specify the historic site. Units under a larger unit that are not stand-alone have been counted under their managing unit, except for certain units of National Capital Parks-East where it is more useful for administrative or management purposes to document them separately.

To compile the geologic time component of the PSP, it was first necessary to determine the bedrock geology of all official NPS units and affiliated units, using existing geologic maps and literature. The quality of the compiled information depends on the available resources, and some errors have doubtless been inadvertently propagated. Where possible it was also attempted to determine which of these geologic units would be exposed at the surface; bedrock is sometimes concealed by thick cover, for example in areas with recent glacial deposition. The geology and paleontology of each park have been documented in tabular form, including each formation, the formation's age, and associated paleontological resources (if present). A spreadsheet was prepared from this information with each park's record plotted against geologic time. Cells in the spreadsheet are color-coded to allow quick visual assessment using a simple trinary system. If a particular division of geologic time is known to be fossiliferous at a park (e.g., Late Cretaceous), it is coded green. If a park has potentially fossiliferous rocks of a certain age, but no confirmed fossils, the corresponding cell is coded yellow. If a park has rocks of a certain age that are regarded as unfossiliferous (e.g., most igneous and metamorphic rocks), the cell is coded red. Green has precedence over yellow, and yellow over red. If there is no geologic record, the cell is left blank. Other types of fossil occurrences, such as fossils found in a cultural resource context (Kenworthy and Santucci, 2006), fossiliferous building stone (Santucci et al., 2021), or reworked fossils, are noted with letters.

In geochronology, time is organized using a hierarchy of divisions. These are, from most inclusive to least inclusive, the eon, era, period, epoch, and age. (It should be noted that although geochronologic and chronostratigraphic terminology exist in parallel and are sometimes used interchangeably, they are not the same. Geochronologic terminology is used here.) In paleontology, the functional unit of geochronology depends on the topic being investigated. Periods (e.g., Cambrian), subperiods (e.g., Mississippian), and epochs (e.g., Late Cretaceous, Eocene) are widely used for broader scales. Researchers often use finer divisions when dealing with specific formations or assemblages. These include globally recognized ages (e.g., Campanian), local divisions (e.g., Meramecian), and various systems based on biostratigraphy. Among the latter are bivalve and ammonite stages in the Western Interior Seaway; schemes for palynomorphs, trilobites, graptolites, conodonts, foraminifera, nannoplankton, and so forth; and the well-known North American Land Mammal Ages (NALMAs) used for the late Late Cretaceous and Cenozoic. The biostratigraphic systems are independent of each other, and some overlap in time, so they may be used in combination to more precisely date a formation or fossil assemblage.

When compiling the PSP, formation ages were recorded to the level of epoch for the Paleozoic and Mesozoic and to the sub-epoch for the Cenozoic. Formation ages have been revised as necessary based on new information and revisions of geochronological divisions. For various reasons it was not always feasible to assign a given record to the level of epoch or sub-epoch. For example, a formation may have poor age control, or a record may derive from a reference using outdated terminology that cannot be "translated" without information that is not available. Paleontological records from formations that are sparsely fossiliferous and/or partially altered, or from areas of complex geology, are most affected by these issues. Alaskan parks, for example, frequently have extremely complex geology, and are also relatively understudied due to remoteness, limited access, and other logistical challenges. Holocene records have been included; although there is controversy in the paleontological community about the definition of "fossil", the definition of paleontological resources as "evidence of past life in a geologic context" encompasses a variety of Holocene records. Furthermore, many paleoecological records from the end of the Pleistocene continue unbroken into the early or middle Holocene (e.g., lacustrine pollen records and woodrat middens).

For this report the records have been divided into 19 geochronologic sections: the Mesoproterozoic and Neoproterozoic eras, the periods of the Paleozoic and Mesozoic (with the Carboniferous Period replaced by the Mississippian and Pennsylvanian subperiods), and the epochs of the Cenozoic. Subdivisions are discussed under each. Subdivisions identified as "early", "middle", or "late" are only capitalized if they have been formally defined, e.g., Middle Jurassic versus early Eocene. Ranks have not been written out, as a generally accepted shorthand. Dates in this document follow the most recent revision from the International Commission on Stratigraphy (2022/02) (see Fig. 1 for reference). Dates are subject to revision.

As with taxonomy (Tweet and Santucci, 2021), fossil occurrences can be attributed to five contexts or modes: *in situ*, reworked, museum, cultural, and building stone (a subset of fossils in a cultural context). The first and most common is *in situ*, which in practical terms also includes float that is not greatly displaced from its source formation. Reworked fossils

have been eroded from their original stratum and deposited in another. Both *in situ* and reworked fossils can be considered naturally occurring, and are the basis for this report. In both cases some records are questionable, for example due to stratigraphic uncertainty or vague provenance information. This uncertainty is reflected in the numbers. In some cases, it is possible to state that there are definitely fossils from a certain geochronological interval, but a finer determination is uncertain.

Of the other three contexts, the museum context includes specimens in a park's collections that came from outside of the park and would not otherwise have been found there naturally. Cultural specimens are fossils found with a cultural context, such as fossils associated with an archeological site. This mode includes a wide variety of fossils and occurrences (Kenworthy and Santucci, 2006). Specimens with a cultural context may be local or plausibly local to a park, or may have been transported from outside the park. The provenance of cultural specimens often cannot be established beyond generalities. Cultural specimens may fall under the museum mode as well. Finally, fossils have been found in building stone (Santucci et al., 2021). The classic example is marine invertebrates in limestone used for a monument or memorial. Human utilization of fossils and fossiliferous materials is an aspect of human dimensions of paleontological resources, as discussed in Santucci et al. (2016).

RESULTS IN GEOLOGIC TIME

Of the 283 NPS units with paleontological resources, *in situ* or reworked records are confirmed from 245, with an unconfirmed report from Coronado NMEM; see the Appendix to Tweet and Santucci (2021) for a list of units. Additions to the list in that publication are Dwight D. Eisenhower MEM, El Camino Real de los Tejas NHT, Flight 93 NMEM, Mill Springs Battlefield NM, and Old Spanish NHT, with NPS affiliate Ice Age NSCIRES split from Ice Age NST for accounting; in addition, Oxon Run Parkway was inaccurately listed as an affiliated unit. The 246 records are spread from the Mesoproterozoic to the Holocene, divided among the 19 geochronological divisions mentioned above and an "uncertain" category for a small number of records that are poorly constrained; the majority of these are reworked occurrences. Thirteen of the geochronological divisions have between 23 and 46 confirmed or potential records (Table 1; Fig. 2; see Appendix for all tables). Three have fewer, which can be attributed to either relatively short duration (Silurian) or the absence of biomineralization (Mesoproterozoic and Neoproterozoic). Three have significantly more than 46: the Cretaceous, Pleistocene, and Holocene. The number for the Cretaceous is partially a reflection of its duration (longer than any other Phanerozoic division used here), while the Pleistocene and Holocene benefit from recency. The totals for these three are not quite as stark if the Cenozoic epochs are lumped as the Paleogene (52 records), Neogene (51), and Quaternary periods (159), producing divisions of more comparable durations.

The distribution of the NPS paleontological records in geologic time is influenced by several factors. The duration of a given geochronological unit and its recency are important controls. All else being equal, shorter geochronological units will be represented by fewer geologic formations than longer geochronological units, and more recent geochronological units will be better represented by exposed rocks or sediments than older geochronological units. A further qualification is the

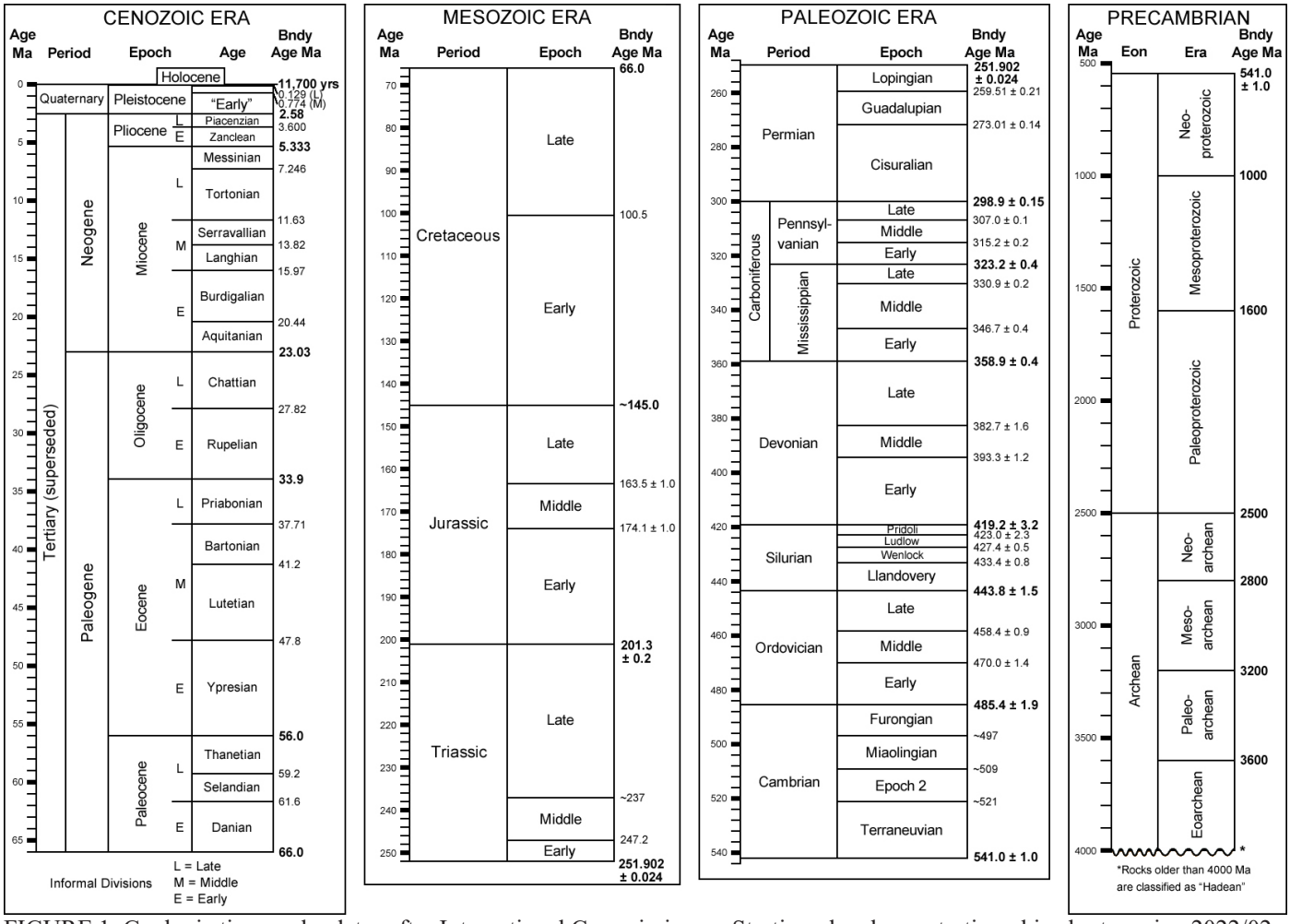

FIGURE 1. Geologic time scale; dates after International Commission on Stratigraphy chronostratigraphic chart version 2022/02.

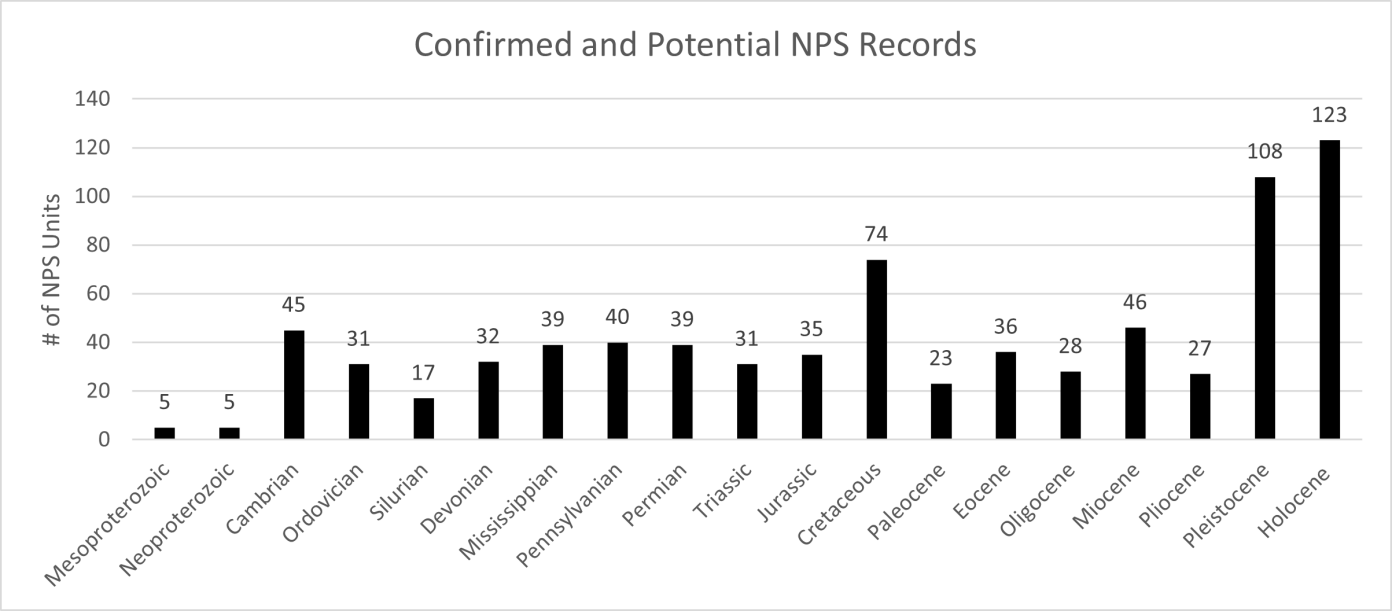

FIGURE 2. Comparison of NPS paleontological records (confirmed and potential) for various divisions of geologic time.

presence or absence of mineralized body fossils. The relative paucity of readily identifiable fossils affects the Precambrian, contributing to the small numbers for the Mesoproterozoic and Neoproterozoic despite their great durations (the Neoproterozoic was about 85% as long as the entire Phanerozoic, and the Mesoproterozoic was longer, yet only seven parks have confirmed fossil records for one or both). The geographic distribution of NPS units controls what geologic units are found in parks; certain areas have few NPS units, and other areas are primarily represented by small and/or culturally focused NPS units, with limited potential for finding fossils. Therefore, there are certain paleontological "holes" such as the Great Basin (exclusive of Great Basin NP), much of the eastern and central Midwest (Illinois, Indiana, Iowa, Michigan, Ohio, and Wisconsin), and the Atlantic and Gulf coastal plains, although the coastlines themselves are well-represented. The extent of study is another factor; in particular, several parks in the Southeast are known to overlie multiple Paleozoic formations, but have not been studied in great detail. It is likely that these parks are more fossiliferous than presently known. Finally, rivers and trails have not yet been sufficiently documented, in part due to complexities of boundaries, land ownership, and management. In the case of trails, PSP records are focused on historical records where geologists and others documented fossils along the original trails. Although these records may not be within a boundary, they are part of the historical stories these trails were established to recognize.

Lists of NPS units with confirmed or potential *in situ* or reworked occurrences are provided for each geochronological division discussed below. Maps showing the distribution of these units are also included; certain allowances have been made for river and trail units that are not readily translated to single points. These are represented by points near the middle of the river or trail in question, or by points corresponding to fossil occurrences on that unit. Records from sites outside Alaska, Hawaii, and the 48 contiguous states have been omitted from the maps for space.

PROTEROZOIC EON

Although there are pre-Mesoproterozoic rocks (1.6 Ga or older) in at least 25 NPS units (Table 2; Fig. 3), the NPS fossil record is only known to extend into the Mesoproterozoic. It is certainly possible that pre-Mesoproterozoic fossils will eventually be found in an NPS unit. However, most pre-Mesoproterozoic rocks in NPS units are unfossiliferous crystalline rock, and most pre-Mesoproterozoic fossils would be difficult for a non-specialist to recognize. There is an interesting historical report associated with Pipestone NM: Winchell (1885) named two putative invertebrate species ("trilobite" "*Paradoxoides barberi*" and "brachiopod" "*Lingula calumet*") from specimens obtained from the Paleoproterozoic Sioux Quartzite at the pipestone quarry. Neither "taxon" is today considered valid or biogenic (Darby, 1972), although with advances in knowledge of Precambrian fossils it may be worth re-examining the blebs representing "*Lingula calumet*".

Given the unpromising pre-Mesoproterozoic bedrock of NPS units, a more likely potential source is transported fossils. For example, the Biwabik Iron Formation of northeastern Minnesota, dated to approximately 1.9 Ga, is noted for stromatolite fossils known as Mary Ellen jasper. Glaciation could have transported cobbles of this material into regional parks (Mississippi NRRA, Saint Croix NSR, etc.) just as it transported Lake Superior agates to the same areas.

NPS records of Proterozoic fossils include several significant areas of research, such as Death Valley NP, Glacier NP, and Grand Canyon NP. Both macroscopic fossils (typically stromatolites and other large-scale microbial structures) and microfossils are well-represented at these sites. At this time, only a handful of parks are known to have Proterozoic fossils. It would not be surprising if there are actually more, especially from the Neoproterozoic; Proterozoic fossils are less obvious to casual observers than many other types of fossils.

Mesoproterozoic Era

Because of the few NPS records for the Mesoproterozoic (1.6–1.0 Ga), it has not been divided for the purposes of the PSP. The existing divisions of the Mesoproterozoic are arbitrary and based on round numbers, as are the dates for the beginning and end of the Mesoproterozoic itself. Broadly speaking, the beginning and ending of the Mesoproterozoic coincide with the assembly of supercontinents. At the beginning of the Mesoproterozoic a supercontinent dubbed Columbia had assembled. This supercontinent broke up during the Mesoproterozoic and was replaced by another supercontinent, Rodinia, which assembled by or near the end of the era. The configurations of both supercontinents are uncertain. On a more local scale, the Mesoproterozoic of North America is marked by the Midcontinent Rift system, a failed continental rift centered

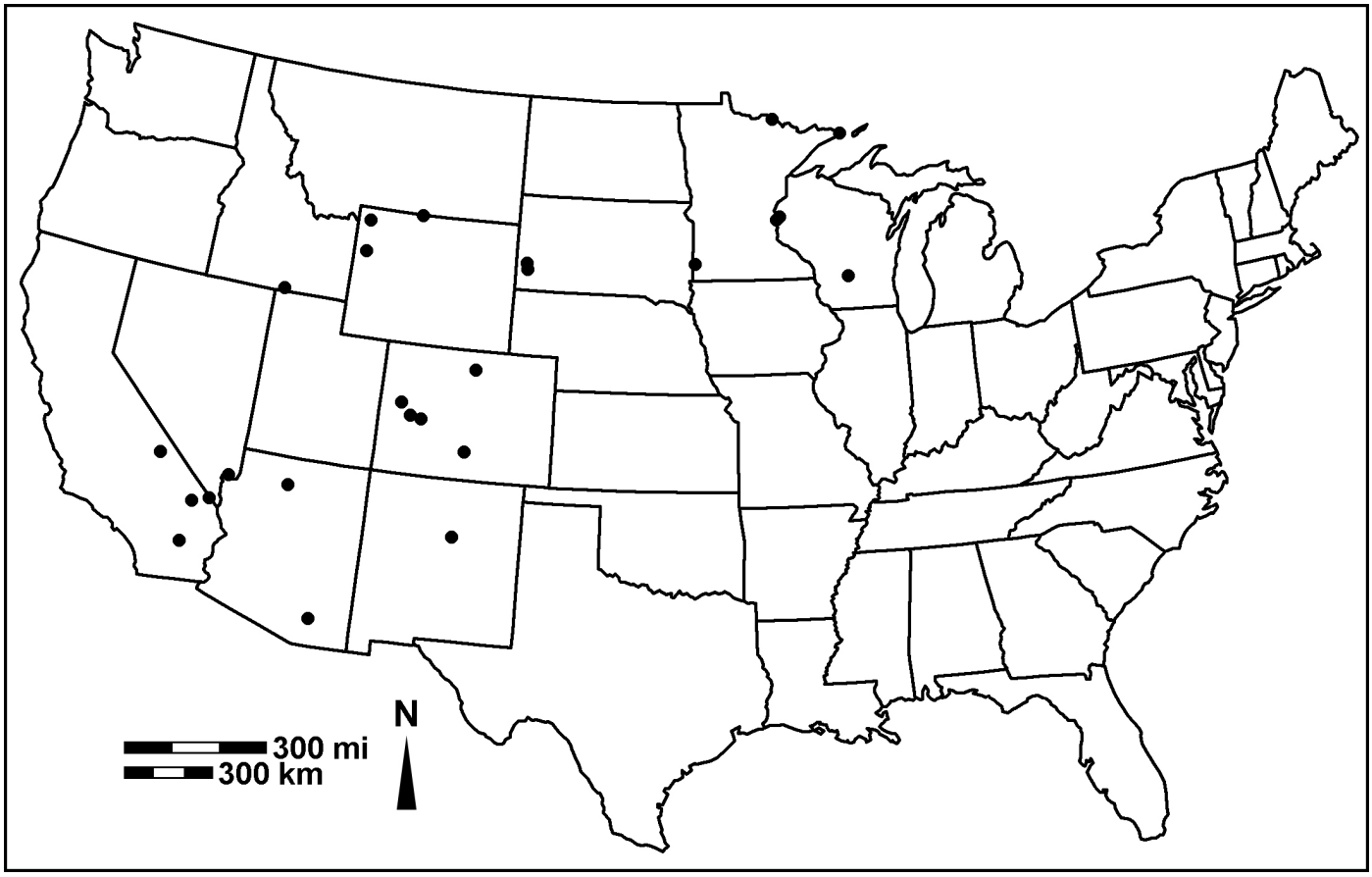

FIGURE 3. Distribution of NPS units with Paleoproterozoic or older rocks; fossils have not yet been confirmed from these rocks at any of these park units.

on a curved line from Kansas north to Minnesota and then east to the Lower Peninsula of Michigan. This rift system was active approximately 1.1 billion years ago and appears to have been overcome by compressional forces of the contemporaneous Grenville Orogeny on the east (for convenience directions are presented according to the modern orientation of the continent). Rocks of the Midcontinent Rift system can be seen in Saint Croix NSR and NPS affiliate Ice Age NSCIRES.

So far as can be determined from the fossil record, Mesoproterozoic life was dominated by cyanobacteria and other microbial organisms, represented by stromatolites and other biogenic sedimentary structures. Mesoproterozoic fossils have been found at four NPS units (Table 3; Fig. 4): Death Valley NP, Glacier NP, Grand Canyon NP, and Tonto NM. A fifth unit, Apostle Islands NL, is the source of an unconfirmed report of burrow-like trace fossils (Galston and Havholm, 2008). The three National Parks have extensive Mesoproterozoic fossils, and stromatolites are a signature attraction at Glacier NP. Eleven taxa of Mesoproterozoic stromatolites have been named from Glacier NP.

Dating Proterozoic rocks can be a challenging proposition, but to date, the oldest NPS fossils are stromatolites from the Belt Supergroup at Glacier NP, at least 1.4 Ga. It is possible that free carbon in the roughly coeval Dripping Spring Quartzite at Tonto NM is also evidence of life (R. Raup, unpubl. report for Tonto NM, 1959). Otherwise, the fossiliferous rocks of the other three confirmed NPS units, the lower Pahrump Group at Death Valley NP, the Unkar Group of the Grand Canyon Supergroup at Grand Canyon NP, and the Mescal Limestone at Tonto NM, have broadly comparable ages in the 1.2–1.1 Ga frame. Stromatolites are the primary fossils from these rocks.

Neoproterozoic Era

As with the Mesoproterozoic, there are few NPS records for the Neoproterozoic Era (1.0 Ga–541.0 Ma), and it has not been divided for the purposes of the PSP. Similar to the Mesoproterozoic, the Neoproterozoic began with one supercontinent (Rodinia) and ended with another (Pannotia). The later Neoproterozoic was marked by multiple extensive glaciations, of which the largest were the Sturtian, centered approximately 700 million years ago, and the Marinoan, centered approximately 640 million years ago. These two glaciations are thought to have produced either a full "Snowball Earth" or a "Slushball Earth" with areas of open seas. At least one additional large-scale glacial episode occurred before the end of the Neoproterozoic. The end of the Marinoan glaciation occurred at approximately the same time as the beginning of the Ediacaran Period of the Neoproterozoic, approximately 635 million years ago, and may have been a factor in the proliferation of complex multicellular life. The unique soft-bodied Ediacaran biota flourished between approximately 600 and 545 million years ago.

Five NPS units are known to have Neoproterozoic fossils: Boston Harbor Islands NRA, Death Valley NP, Grand Canyon NP, Mojave NPRES, and Yukon-Charley Rivers NPRES (Table 3; Fig. 3). The NPS fossil record has a gap on the order of 300 million years between late Mesoproterozoic occurrences of around 1.1 Ga and middle Neoproterozoic occurrences beginning around 780 Ma, with fossils from at least two components of the ChUMP assemblage (Chuar Group, Uinta Mountain Group, and middle Pahrump Group). The Chuar Group of Grand Canyon NP is the best known of these productive units, with stromatolites and similar structures, and a diverse assemblage of microfossils.

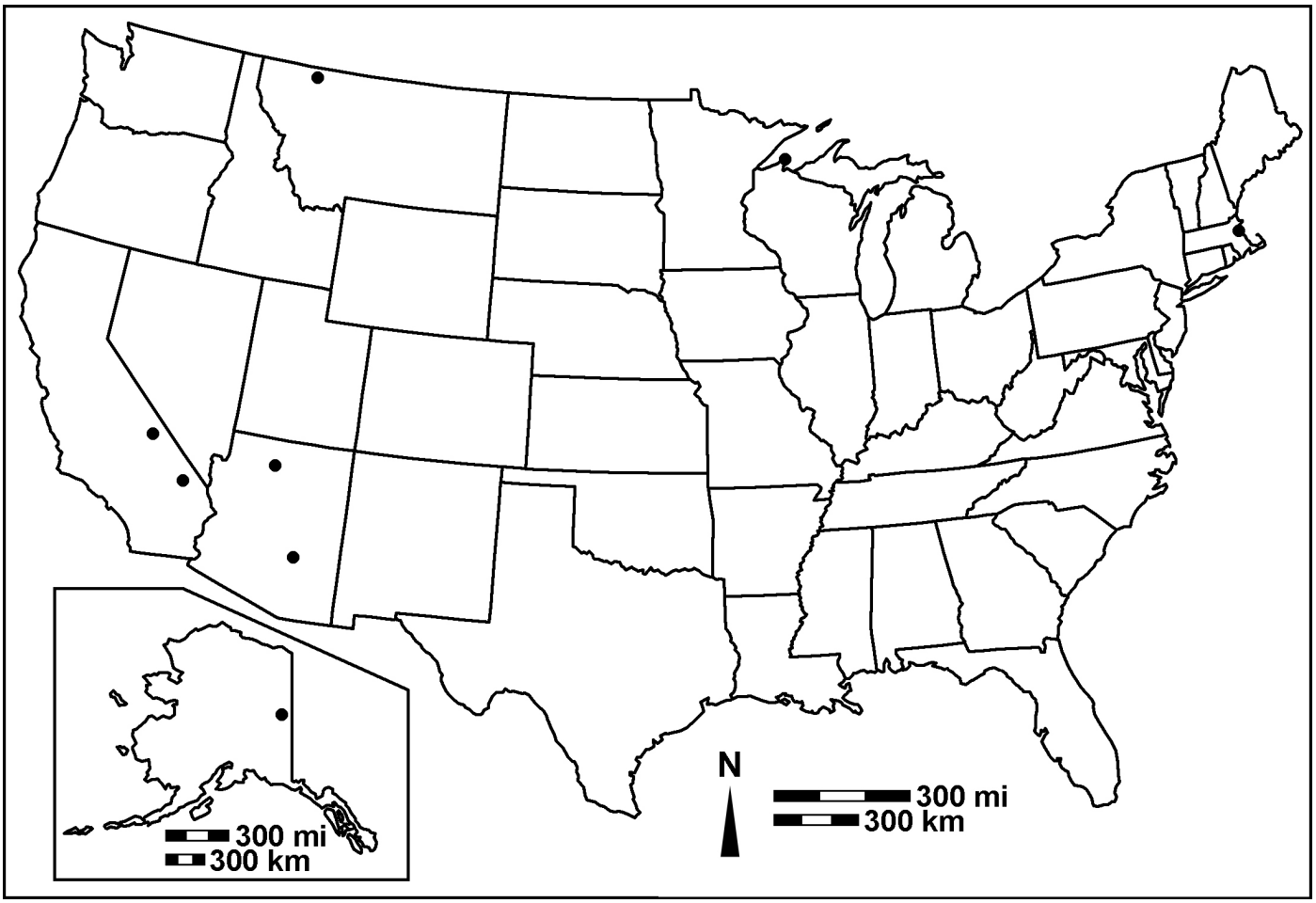

FIGURE 4. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Mesoproterozoic or Neoproterozoic fossils.

Eighteen microfossil taxa have been named from Chuar Group fossils found in Grand Canyon NP, from the unusually large *Chuaria circularis* to the first descriptions of vase-shaped microfossils. At Death Valley NP and Mojave NPRES, fossils of similar age have been found in the middle Pahrump Group. The third component of the ChUMP, the Uinta Mountain Group, is exposed in Dinosaur NM, but fossils have not yet been reported there.

Younger Neoproterozoic rocks at Death Valley NP and Mojave NPRES, along with the lower Tindir Group of Yukon-Charley Rivers NPRES, document life during the ice-laden Cryogenian, primarily stromatolites and other microbial structures. Their records continue into the Ediacaran, joined by the Cambridge Argillite of Boston Harbor Islands NRA. No NPS unit is known to have an extensive Ediacaran fauna, although Boston Harbor Islands NRA does include examples of *Aspidella* (McMenamin et al., 2007), and possible cloudiniids have been found in the Stirling Quartzite at Death Valley NP (Waggoner and Hagadorn, 2002). In addition, late-surviving *Swartpuntia* has been reported from the Cambrian portion of the Wood Canyon Formation at Mojave NPRES (Hagadorn et al., 2000). The stratigraphic records of Death Valley NP, Mojave NPRES, and Yukon-Charley NPRES cross into the Cambrian.

PALEOZOIC ERA

At the beginning of the Paleozoic, that part of North America today occupied by the contiguous United States was broadly similar in extent to the present, with the exception of areas that were accreted later and today make up the margins of the continent. The Atlantic and Pacific coasts represent areas assembled over multiple tectonic events during the Phanerozoic. The complex tectonic assembly of the area east of the Appalachian Mountains during the Paleozoic is often a focus of college-level historical geology classes. This history of tectonism is part of why there are few NPS Paleozoic records east of the Appalachians: much of the Paleozoic bedrock is either metamorphic or igneous. In addition, great quantities of sediments shed from the Appalachians since the opening of the Atlantic Ocean have draped the bedrock in a thick sedimentary wedge that preserves an excellent Cretaceous–Cenozoic record, obscuring the underlying rocks. Nevertheless, there are some reports of Paleozoic fossils in Atlantic coast and coastal plain parks, albeit representing material transported from elsewhere. Transported Cambrian-age *Skolithos*-bearing quartzite cobbles are scattered throughout the Potomac River corridor.

Considering the entire Paleozoic, the numbers of NPS occurrences for each period and subperiod are similar and approximate the relative durations of the divisions, with perhaps a slight overrepresentation of the Mississippian and Pennsylvanian compared to their durations. Geographically there are some areas that are underrepresented in comparison to their importance, as a result of the distribution of NPS units. In particular, there are relatively few NPS units with significant bedrock outcrops from northern Missouri and Iowa east to Ohio and north to Michigan, limiting the record of the abundantly fossiliferous Paleozoic rocks found in this region. The Great Basin and much of Texas are similarly underrepresented. In addition, although there are numerous NPS units in the Cumberland Plateau, many have had little paleontological study. Further research will likely enhance the record in that area.

No NPS units have been designated primarily for Paleozoic fossils, unless Guadalupe Mountains NP is considered due to the eponymous mountains being the remains of a Permian reef system. This is in part a reflection of the relative popularities of different types of fossils. One notable absence is any Paleozoic Konservat-Lagerstätten. However, there are some NNLs and NHLs that were established in recognition of Paleozoic fossils, and several parks have very significant Paleozoic records (e.g., Death Valley NP, Grand Canyon NP, Guadalupe Mountains NP, Mississippi NRRA, Yellowstone NP, and Yukon-Charley Rivers NPRES). Three NPS units have fossils from all seven Paleozoic periods or subperiods: Death Valley NP, Gates of the Arctic NP&PRES, and Yukon-Charley Rivers NPRES. Four others have six of the seven: Grand Teton NP, Noatak NPRES, Wind Cave NP, and Yellowstone NP. These parks with long records are well-suited to examining changes over a long interval of time.

Cambrian Period

In North America, the Cambrian (541.0–485.4 Ma) has historically been divided into three epochs: Early, Middle and Late. The beginning of the period was based on the appearance of trilobites. More recently, an additional pre-trilobite interval, the Terreneuvian, has been added to the Cambrian, with the Precambrian–Cambrian boundary established at the first appearance of the trace fossil *Treptichnus pedum*. In practical terms, the historic North American usage of Early, Middle, and Late Cambrian corresponds approximately to the present global "Series 2", Miaolingian, and Furongian epochs. For convenience, the use of early, middle, and late Cambrian (uncapitalized as informal) in this document will follow this historic division, with Terreneuvian records included in the early Cambrian. In most cases the early Cambrian records pertain to Series 2. The historic Cambrian divisions of North America include two epoch names coined in recognition of geology in NPS units: the Waucoban (early Cambrian) is based on rocks in northwestern Death Valley NP, and the Croixan (late Cambrian) is based on rocks in the Saint Croix Valley, within Saint Croix NSR (Walcott, 1912).

The Cambrian is justifiably famous for the "Cambrian Explosion", the proliferation of animals with mineralized body parts (calcium carbonate and calcium phosphate). It was also a time of rapid turnover; characteristic animals from earlier in the Cambrian such as archaeocyathid sponges and radiodonts were extinct or greatly reduced by the late Cambrian. A relatively depauperate fauna dominated by brachiopods, trilobites, and soft-bodied bioturbators was prevalent between the various Cambrian extinctions and the "Great Ordovician Biodiversification Event". During the early and middle Cambrian, shallow continental seas encroached on the continent (the Sauk transgression), submerging much of the landmass by the Early Ordovician. The marine transgression produced a typical sedimentary sequence going from sandstone to finer clastics to carbonates preserving various body and trace fossils, described in McKee and Resser (1945) for the Tonto Group of Grand Canyon NP. There are also instances of ancient shores preserved as wave-rounded boulders adjacent to resistant remnants of older rocks, as seen at Ozark NSR, Saint Croix NSR, and units of NPS affiliate Ice Age NSCIRES. These conglomeratic shores preserve unusual assemblages, sometimes with relatively abundant mollusks. No NPS units are known to host a Burgess Shale-type fauna in either content or preservation, although a few locations have yielded fossils of soft-bodied Cambrian organisms, notably Mojave NPRES (Hagadorn et al., 2000).

Although no parks have been specifically designated for Cambrian fossils, the Cambrian is one of the best-represented periods in the NPS, with numerous significant fossil localities. Forty-five NPS units have confirmed Cambrian records (Table 4; Fig. 5). Early Cambrian fossils have been found at 14 NPS units (Table 5). In addition, many if not all of the 13 park records of reworked *Skolithos* cobbles in the Potomac region here placed as Cambrian undivided likely pertain to the early Cambrian. Middle Cambrian fossils have been found at 17 NPS units, and late Cambrian fossils are present at 20 NPS units (Table 5).

For the most part, the early Cambrian fossil record in the NPS is dominated by invertebrate trace fossils. These early Cambrian occurrences include some that are continuous with the late Neoproterozoic, or nearly so: Death Valley NP, Mojave NPRES, and Yukon-Charley Rivers NPRES. Death Valley NP and Mojave NPRES both have examples of *Treptichnus pedum* within the Wood Canyon Formation (Bahde et al., 1997; Corsetti and Hagadorn, 2000), marking the Neoproterozoic–Cambrian boundary. On the other side of the continent, Great Smoky Mountains NP probably has the most diverse Cambrian record of any eastern NPS unit. Great Smoky Mountains NP and Death Valley NP are two examples of areas now in the NPS that were investigated by Charles Doolittle Walcott in his pursuit of the history of early life in North America. Other NPS areas that Walcott either investigated personally or were the sources of fossils he described include Glacier NP (Mesoproterozoic), Grand Canyon NP (Proterozoic and Cambrian), Grand Teton NP, Ozark NSR, Saint Croix NSR, Yellowstone NP, and NPS affiliate Ice Age NSCIRES.

By the middle Cambrian, invertebrate body fossils are more abundant in the NPS record. Five parks are particularly noted for middle–late Cambrian fossils: Death Valley NP, Grand Canyon NP, Saint Croix NSR, Yellowstone NP, and Yukon-Charley Rivers NPRES. To date, 201 Cambrian taxa have been named from these five units, including brachiopods, hyoliths, trilobites, and more enigmatic invertebrates.

Ordovician Period

The Ordovician (485.4–443.8 Ma) is divided into Early, Middle, and Late epochs, although in much of North America it may be useful to consider the period as including an early interval (corresponding to the end of the Sauk sequence) and a late interval (corresponding to the onset of the Tippecanoe sequence), punctuated by low sea levels between them during the Middle Ordovician. This relative lowstand is noted for the last widespread cratonic sheet sandstones in North America (e.g., the St. Peter Sandstone). The development of further sheet sandstones was probably limited by the appearance of land plants, which were establishing a limited "roothold" in the second half of the Ordovician.

A number of significant geological and paleobiological events took place during the Ordovician. After the experimentation and extinctions that marked the Cambrian, the typical Paleozoic marine assemblage appeared during the Ordovician as part of the "Great Ordovician Biodiversification Event". A major mass extinction occurred at the end of the Ordovician; unlike some other major extinctions, this did not eliminate high-level taxonomic groups but reduced diversity across the biota. However, prominent Cambrian holdovers such as trilobites and inarticulate brachiopods do appear to have suffered disproportionally. The Late Ordovician also featured enormous volcanic eruptions as marked by bentonite beds found across much of eastern North America. Volcanism was a side effect of the "conveyor belt" tectonics of eastern North America that led to the accretion of multiple terranes and the multi-stage growth of the Appalachian Mountains throughout the Paleozoic. Extensive glaciation took place during the Late Ordovician, but did not extend to North America, at that time obliquely straddling the Equator.

There are fewer NPS units with Ordovician fossils compared to the preceding Cambrian (31 versus 45) (Table 6; Fig. 6), although this can be attributed in part to the greater duration of the Cambrian. Also, the Cambrian number is

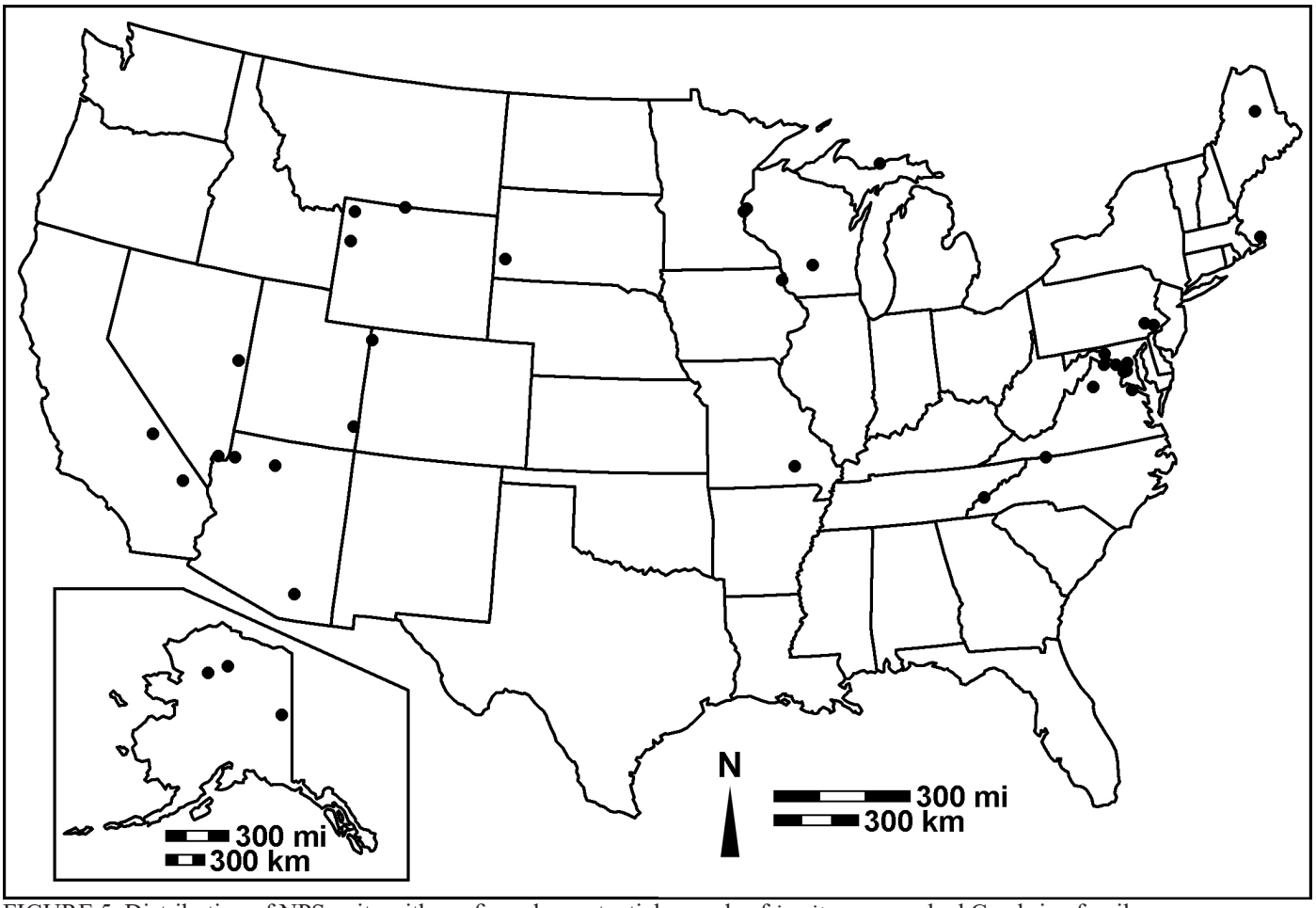

FIGURE 5. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Cambrian fossils.

boosted by the Potomac River distributing resistant quartzite cobbles bearing *Skolithos* across an area with numerous NPS units. If only bedrock occurrences are considered, both periods are represented by 31 NPS units. Early Ordovician fossils are confirmed from 14 NPS units and potentially one more; 10 units are confirmed to have Middle Ordovician fossils, with one potential occurrence; and 22 units have Late Ordovician fossils, with one potential record (Table 7).

The geographic distribution of records for the Ordovician and succeeding Silurian is biased to the eastern half of the United States, in strong contrast to much of the Mesozoic and Cenozoic. The most productive exceptions for both periods are Death Valley NP and Great Basin NP, which have strong records throughout the Ordovician and into the Silurian. These two parks probably have the best records for the Early and Middle Ordovician in the NPS, with Buffalo NR and Chesapeake and Ohio Canal NHP also having fossil records of high quality and abundance for these epochs. The oldest known vertebrate fossil material in the NPS as of this publication is *Anatolepis* armor reported from the Early Ordovician Au Train Formation of Pictured Rocks NL (Miller et al., 2006).

The Late Ordovician is one of the best-represented epochs in the first half of the Paleozoic in the NPS. There are notable Late Ordovician records at a variety of parks, such as Chesapeake and Ohio Canal NHP, Chickasaw NRA, Natchez Trace PKWY, and Yukon-Charley Rivers NPRES, but by far the best Late Ordovician record is documented at Mississippi NRRA. The paleontology of this park is roughly comparable to the famous and slightly younger Cincinnatian fossil sites of the Ohio River Valley, and is the source of the type specimens of at least 117 Ordovician taxa, with another 258 taxa named from specimens potentially collected within its boundaries. Another NPS unit has a connection to a significant Late Ordovician site: the Appalachian National Scenic Trail passes near the former Swatara Gap fossil collecting site (Martinsburg Formation) in Pennsylvania.

Silurian Period

Dividing the Silurian (443.8–419.2 Ma) is not as clear-cut as for other geochronological periods. The Silurian is formally divided into four epochs; from oldest to youngest, these are the Llandovery, Wenlock, Ludlow, and Pridoli. However, these epochs do not have a long history of use in North America, where a variety of provincial epochs have been used instead, as well as an informal early/middle/late division. Because the latter scheme is frequently encountered in the literature, it has been used here, uncapitalized due to its informal nature. For the purposes of this report, the early Silurian approximates the Llandovery, the middle Silurian approximates the Wenlock, and the late Silurian approximates the Ludlow and Pridoli.

The Silurian began with the end pulse of the extinction event that began in the Late Ordovician. This was followed by the recovery of the global biosphere. Life continued to spread on land, with arthropods joining early plants, and fishes diversified in aquatic settings. No NPS unit is known to have fossils from Silurian terrestrial settings, but invertebrates and trace fossils from fluvial settings have been found at Delaware Water Gap NRA. Sea levels remained generally high, and there continued to be episodic additions of new terranes on the East Coast.

Silurian fossils have only been reported from 17 NPS units (Table 8; Fig. 7), which in part reflects its relative brevity. In addition, the distribution of NPS units is a poor match for the

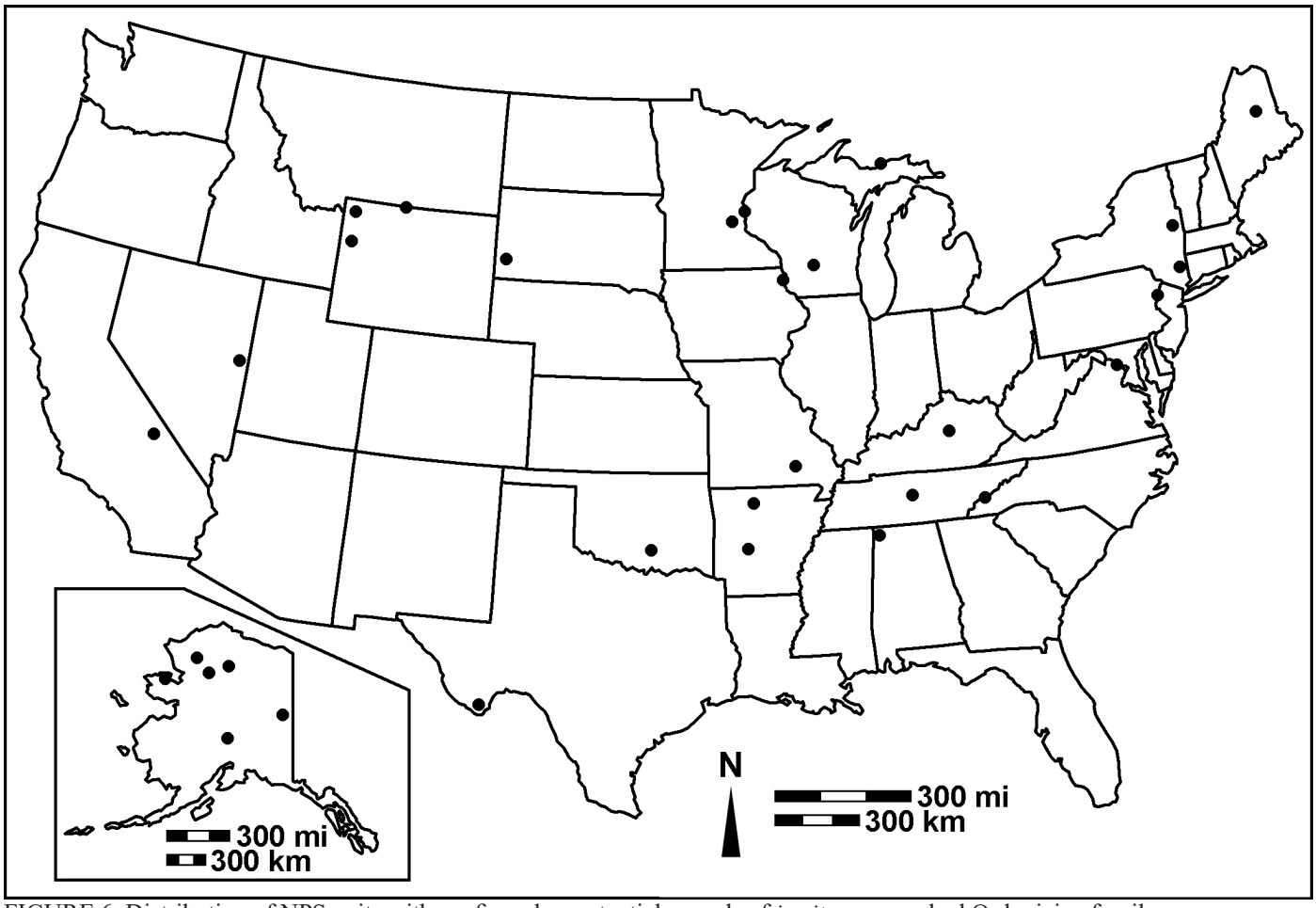

FIGURE 6. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Ordovician fossils.

distribution of Silurian rocks in the United States. This relative disconnect continues into the Devonian. The NPS record of the Silurian is the most east-focused of any of the geochronologic intervals featured here, with only Death Valley NP and Great Basin NP representing the western contiguous United States. The distribution of records among the Silurian subdivisions is nearly even; early and middle Silurian fossils have been found at 10 NPS units, and nine units have late Silurian fossils (Table 9).

The Silurian has not been as much of a focus of study in NPS areas as other periods. This is reflected in the relatively small number of taxa that have been named from Silurian rocks in the NPS. To date there are only 33 confirmed and three potential taxa, almost all of which are from Death Valley NP. Glacier Bay NP&PRES, and Yukon-Charley Rivers NPRES. The NPS units with the most productive Silurian rocks include these three units mentioned above as well as Chickasaw NRA and Delaware Water Gap NRA.

Devonian Period

The Devonian (419.2–358.9 Ma) is divided into Early, Middle, and Late epochs. The Devonian is particularly noted for the first terrestrial forests, the first tetrapods on land, the proliferation of fishes, and a series of extinctions collectively known as the Late Devonian extinction. The tectonic assembly of eastern North America and the growth of the Appalachians continued, and the Tippecanoe sequence came to a close in the Early Devonian, to be succeeded by the Kaskaskia sequence later in the period. Most NPS fossils from the Devonian are marine invertebrates or trace fossils made by marine invertebrates, but plants and vertebrates became more important components of the paleobiota compared to previous periods. Significant Devonian fish fossils have been discovered at Death Valley NP and Grand Canyon NP, and Devonian plant fossils have been found at several parks, most notably Chesapeake and Ohio Canal NHP, Cuyahoga Valley NP, Gates of the Arctic NP&PRES, Upper Delaware SRR, and Yukon-Charley Rivers NPRES.

Devonian fossils are confirmed from 29 NPS units, with three potential records (Table 10; Fig. 8), somewhat less than may be expected by duration (it is the longest of the seven periods or subperiods of the Paleozoic). This relative paucity can be partially attributed to the geographic distribution of NPS units vis-à-vis Devonian rocks. Representation improves greatly from the Early Devonian to the Late Devonian. Early Devonian fossils are known from 13 NPS units, and 14 (potentially one more) have Middle Devonian fossils, whereas Late Devonian fossils are known from 22 units (potentially four more) (Table 11).

Although there are relatively few notable Devonian localities in NPS units, the record is geologically and temporally diverse. The single most significant locality is the Falls of the Ohio, now on the route of Lewis & Clark National Historic Trail after its 2019 expansion. Hundreds of species of Early–Middle Devonian invertebrates have been found here. Several other parks have very strong records. Marine fossils are abundant in the Early Devonian of Chickasaw NRA, Delaware Water Gap NRA, Glacier Bay NP&PRES, and Yukon-Charley Rivers NPRES; the significant paleontological records of Delaware Water Gap and Glacier Bay continue into the Middle Devonian, joined by Noatak NPRES. Late Devonian fossils are well represented at Cuyahoga Valley NP and Upper Delaware SRR, both of which have a significant paleobotanical component. Death Valley NP has a strong record throughout the Devonian.

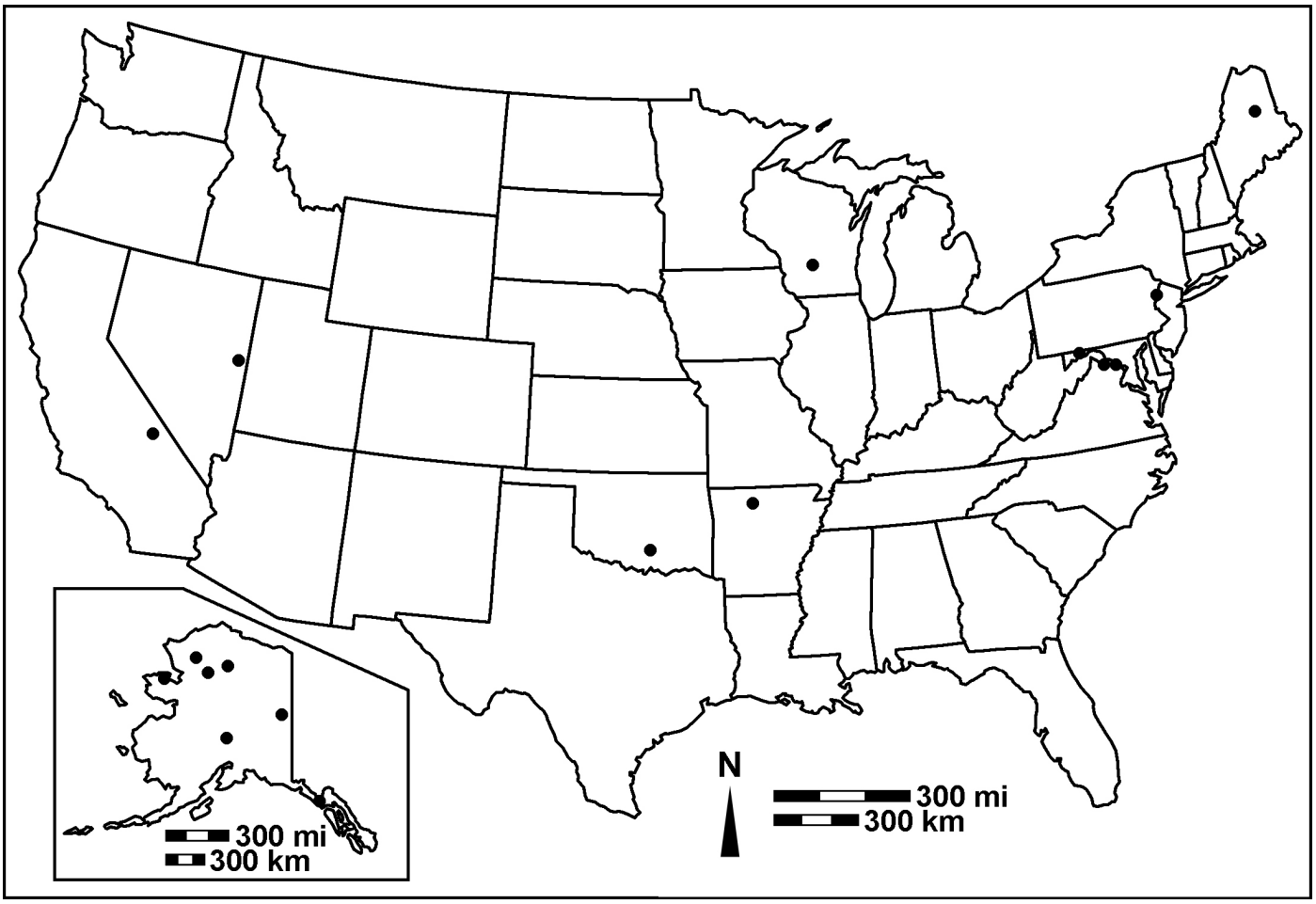

FIGURE 7. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Silurian fossils.

Mississippian Subperiod

In North America, the Mississippian and Pennsylvanian, formally considered subperiods, generally function as periods as opposed to the unified Carboniferous used internationally. The Mississippian (358.9–323.2 Ma) is divided into Early, Middle, and Late epochs, corresponding to the global Tournaisian, Viséan, and Serpukhovian Ages. These do not exactly correlate to the four-part North American ages: the Kinderhookian is equivalent to much but not all of the Early Mississippian; the Osagean is equivalent to the rest of the Early Mississippian and the early Middle Mississippian; the Meramecian is equivalent to the middle Middle Mississippian; and the Chesterian is equivalent to the late Middle Mississippian and Late Mississippian.

The Mississippian is marked by one of the most extensive Phanerozoic marine transgressions in North America. This transgression is reflected by the abundance of marine limestones in the NPS Mississippian record. As a much later consequence of the transgression and carbonate deposition, many of the famous caves of the NPS formed in Mississippian limestones (e.g., Jewel Cave NM, Mammoth Cave NP, Russell Cave NM, Timpanogos Cave NM, Wind Cave NP). The seas retreated toward the end of the Mississippian, in some cases leading to erosion and paleokarst formation on the former marine limestones (e.g., the unconformity between the Redwall Limestone and uppermost Mississippian Surprise Canyon Formation at Grand Canyon NP).

Mississippian fossils are known from 37 NPS units (potentially two more) (Table 12; Fig. 9). Many parks, including those with the most outstanding Mississippian records, have records for two or all three epochs. Early Mississippian fossils are confirmed from 23 NPS units, with one potential record; Middle Mississippian fossils are confirmed from 22 units, with two potential records; and Late Mississippian fossils are confirmed from 18 units, with one potential record (Table 13). In addition, many urban or battlefield parks in the eastern United States have buildings, memorials, and monuments constructed using fossiliferous Middle Mississippian Salem Limestone ("Indiana limestone"), particularly in the Washington, D.C. area.

Significant Mississippian records have been found at parks throughout the United States. Some of the most notable are at Buffalo NR, Death Valley NP, Gates of the Arctic NP&PRES, Grand Canyon NP, Mammoth Cave NP, Noatak NPRES, Yellowstone NP, and Yukon-Charley Rivers NPRES. These records are predominately marine and extend through the Mississippian. The regression toward the end of the Mississippian is reflected by the appearance of plant assemblages in the Late Mississippian. Death Valley NP, Grand Canyon NP, and New River Gorge NP&PRES are good examples of this phenomenon.

Pennsylvanian Subperiod

The Pennsylvanian (323.2–298.9 Ma) is divided into Early, Middle, and Late epochs, corresponding to the global Bashkirian, Moscovian, and Kasimovian plus Gzhelian ages. In the North American regional system, the Morrowan is approximately equivalent to the Early Pennsylvanian; the Atokan and younger Desmoinesian are approximately equivalent to the Middle Pennsylvanian; and the Missourian and younger Virgilian are approximately equivalent to the Late Pennsylvanian.

The Pennsylvanian is unlike the preceding periods of the Paleozoic because of the greater terrestrial component, not only featuring well-developed forests but also diversifying

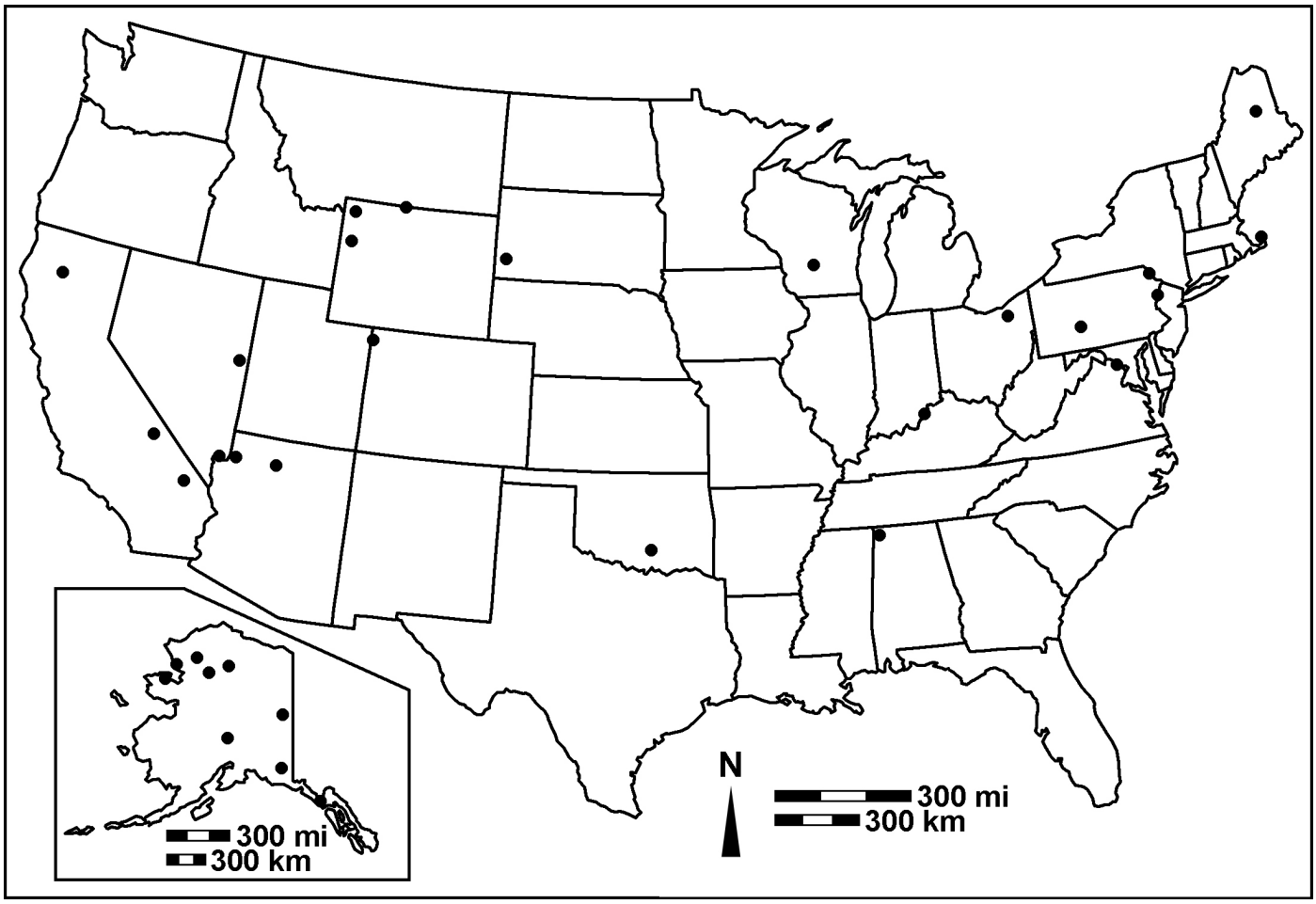

FIGURE 8. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Devonian fossils.

terrestrial invertebrates and vertebrates. An example of early terrestrial vertebrate fossils in the NPS are fossil tracks from the Middle Pennsylvanian Manakacha Formation of Grand Canyon NP (Rowland et al., 2020). Sea level was relatively low at the beginning of the Pennsylvanian but rose as it progressed (Absaroka transgression); however, great epicontinental seas did not return to the eastern interior. During the Pennsylvanian, North America was incorporated into Pangaea following a continental collision along what is now the Atlantic Coast, providing the culminating force for the formation of the Appalachian Mountains. Instead of marine carbonates, the lands to the west of the mountains became areas of terrestrial deposition, with vast forests that later became coal beds. The climate of the supercontinent's interior became hotter and drier, and the forests shrank by the end of the Pennsylvanian; this is reflected by the reduction of NPS Pennsylvanian plant sites from the Early and Middle Pennsylvanian to the Late Pennsylvanian.

Pennsylvanian fossils are confirmed from 39 NPS units, with one potential park record (Table 14; Fig. 10). Although this is quantitatively essentially the same as the Mississippian and Permian, qualitatively the Mississippian and Permian have better NPS fossil records. For example, out of the entire Phanerozoic the Pennsylvanian has the second fewest taxa named from NPS areas, with 12 confirmed and three potential taxa. One of these, *Amplexus zaphrentiformis* White, 1876, is notable as the first fossil taxon reported and named from what is now Dinosaur NM. Within the Pennsylvanian the distribution of NPS records is fairly even between the subdivisions (Table 15). Early Pennsylvanian fossils are confirmed from 20 NPS units, with one potential record; Middle Pennsylvanian fossils are confirmed from 23 units; and Late Pennsylvanian fossils are confirmed from 17 units, with one potential record. Geographically, the Pennsylvanian is the last division with significant representation of the eastern half of the United States until the Cretaceous, when most eastern records are for the Atlantic and Gulf coasts. The eastern interior ceases to be an area of preserved deposition until the Quaternary.

The best NPS paleontological records for the Pennsylvanian are found in the southwestern states, where there was prolonged marine deposition. Deposition was marine for the Bird Spring Formation of Death Valley NP and Mojave NPRES. To the east, Grand Canyon NP, Lake Mead NRA, and Parashant NM preserve rocks and fossils deposited in the shifting terrestrial–open marine system represented by the Callville Formation and Supai Group. In the eastern interior, several parks preserve fossils of the Early–Middle Pennsylvanian forests, notably Big South Fork NRRA and New River Gorge NP&PRES.

Permian Period

The Permian (298.8–251.9 Ma) is divided internationally into the Cisuralian, Guadalupian, and Lopingian epochs. These divisions are frequently treated as interchangeable with early/middle/late divisions of the Permian, which have not been formally adopted and are here used uncapitalized. The Guadalupian has long been in use in North America and is based on rocks in what is now Guadalupe Mountains NP (Girty, 1902). The early Permian includes the North American Wolfcampian and succeeding Leonardian, while the late Permian has been called the Ochoan in North America, although it should be noted that the late Permian is poorly represented in North America.

The Permian was the height of Pangaea. Much of North America was part of a climatically harsh continental interior

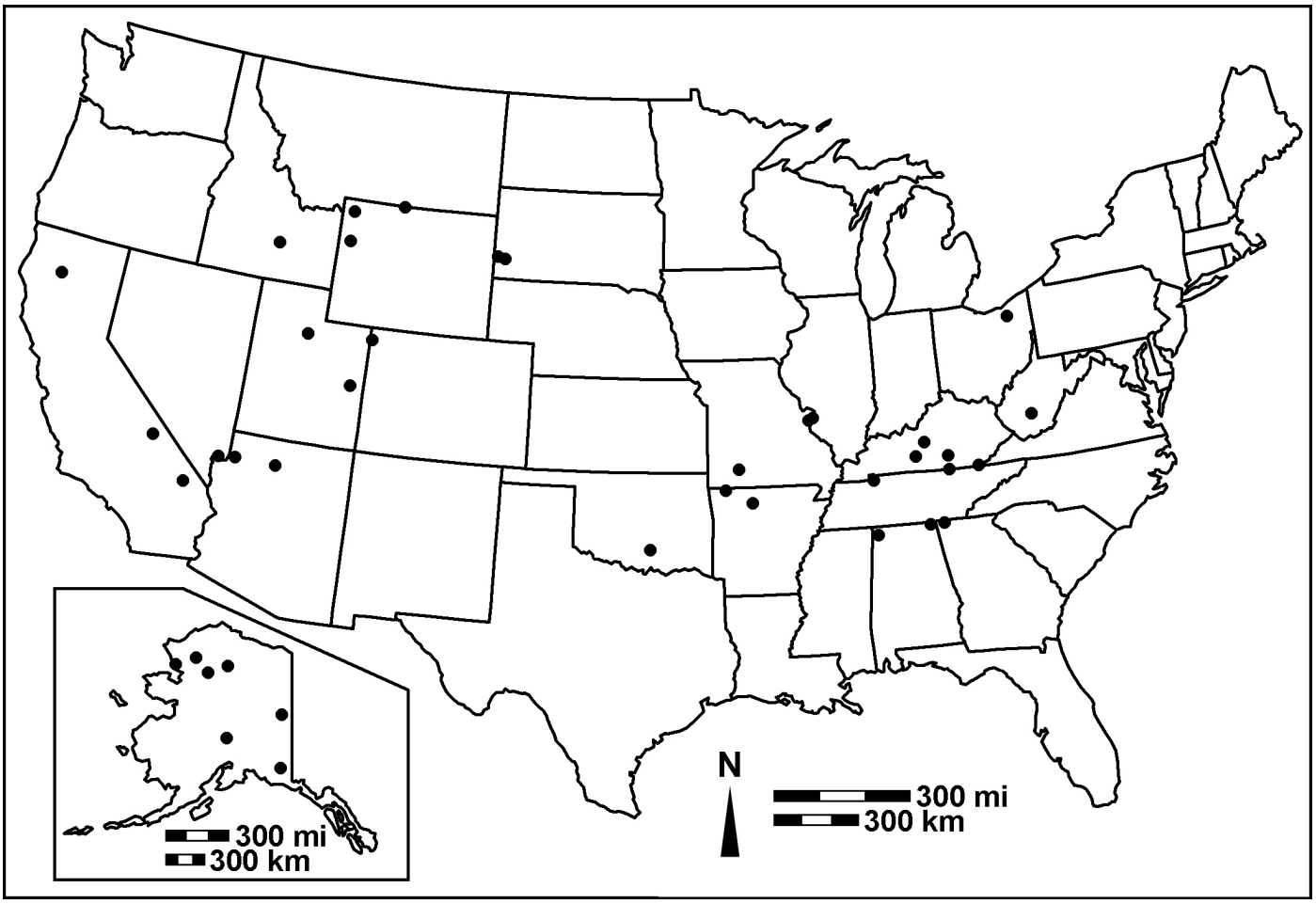

FIGURE 9. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Mississippian fossils.

featuring the Appalachians, with some shallow seas and depositional basins toward the western part of the continent. The signature event of the Permian is the multi-phase end-Permian mass extinction that devastated marine and terrestrial ecosystems.

Permian fossils are confirmed from 37 NPS units, with two potential records (Table 16; Fig. 11). These records are strongly biased to the early Permian, which in part can be attributed to duration (the early Permian is longer than the other two epochs combined). Early Permian fossils are confirmed from 31 NPS units, with two potential records, compared to 11 confirmed and one unit for the middle Permian, and a single potential park record for the late Permian (Table 17), the fewest for any division considered here. The single potential late Permian record is from the Alibates Dolomite at Alibates Flint Quarries NM (KellerLynn, 2011); it is known to be fossiliferous at the monument, but the age is poorly constrained (dates of 252.2 ± 0.6 Ma and 252.3 ± 0.6 Ma have been reported from the overlying Quartermaster Formation [Tabor et al., 2011]). There is also some possibility that part of the Phosphoria rock complex, fossiliferous at Dinosaur NM, Grand Teton NP, and Yellowstone NP, is late Permian in age (Davydov et al., 2018). Another notable feature is the geographic distribution of parks with Permian fossils: none are from east of eastern Kansas, paralleling the general distribution of Permian rocks in the United States as a whole.

Several NPS units have outstanding Permian fossil records. Guadalupe Mountains NP, a key part of the Capitan Reef Complex, has been an area of study for more than a century. Nearby Carlsbad Caverns NP has similar fossils. To the northwest, Grand Canyon NP preserves a diversity of early Permian fossils unparalleled in the NPS, representing everything from eolian dunes (tetrapod and invertebrate traces of the Coconino Sandstone), to coastal plains (plant fossils and traces of the Hermit Formation), to marine deposition (the marine invertebrates and vertebrates of the Toroweap and Kaibab formations). Some or all of the same Permian formations are present at several NPS units in the area, including Capitol Reef NP, Lake Mead NRA, Parashant NM, Walnut Canyon NM, Wupatki NM, and Zion NP, although they have not yet received as much study. Permian marine fossils are also prominent at Death Valley NP, Mojave NPRES, Tallgrass Prairie NPRES, and Yukon-Charley Rivers NPRES. Several parks aside from Grand Canyon NP preserve a variety of fossils from the terrestrial Permian realm. Permian plants have been found at Denali NP&PRES, and early Permian terrestrial vertebrate bones and tracks have been found at Canyon de Chelly NM, Canyonlands NP, Glen Canyon NRA, Pecos NHP, and Salinas Pueblo Missions NM.

MESOZOIC ERA

At the beginning of the Mesozoic, North America was part of the supercontinent Pangaea, bordering South America on the south, Africa on the east, and Europe on the northeast. The breakup of the supercontinent began during the Triassic Period with spreading between North America on the northwest and Africa on the southeast. By the end of the Early Jurassic, a narrow Atlantic Ocean had opened between them. As part of the tectonic activity, North America acquired a Gondwanan fragment that is now Florida and adjacent areas of the southeastern U.S., marking the last addition to the eastern part of the continent to date. Over the rest of the Mesozoic North America continued to separate

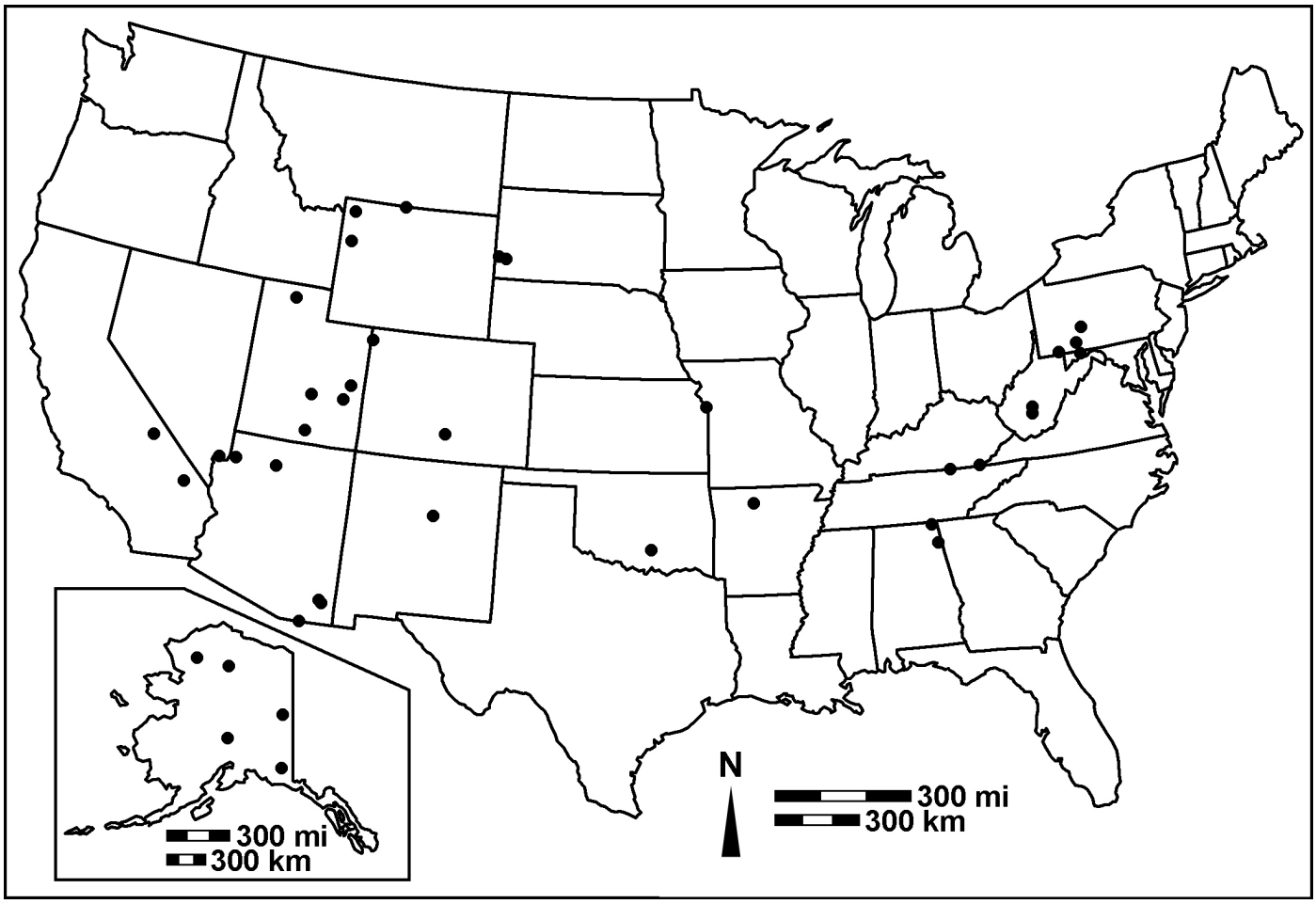

FIGURE 10. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Pennsylvanian fossils.

from the other continents on the south and east while growing along its western margin by the accumulation of terranes. After having been near the Equator and rotating significantly during much of the Paleozoic, the continent attained a location and orientation similar to the present by the end of the Mesozoic.

It may seem odd that although there are many well-known occurrences of Triassic and Jurassic fossils in NPS units, there are fewer parks with Triassic or Jurassic fossils compared to most of the periods of the Paleozoic. This apparent dissonance can be attributed to the relatively restricted distribution of Triassic and Jurassic rocks in North America as a whole. Unlike the Paleozoic, which is dominated by shallow marine rocks from continental seas that stretched across the continent, Triassic and Jurassic rocks are largely confined to the North American Cordillera and narrow Triassic–Early Jurassic basins of the Atlantic coastal region. The distribution of Triassic and Jurassic rocks coincides with the distribution of many of the NPS's most prominent parks, which offsets the relatively restricted geographic distribution of the rocks. The Cretaceous differs from the two preceding periods by its greater duration, the presence of the vast Western Interior Seaway, and more extensive coastal inundation and deposition. The number of NPS units with Cretaceous fossils trails only the Pleistocene and Holocene, and is more than double the number for either the Jurassic or the Triassic. As with North America in general, there are essentially no reports of Mesozoic or pre-Quaternary Cenozoic rocks and fossils between the Missouri River and Appalachian Mountains with the exception of the Western Interior Seaway.

Two extant NPS units have been designated in recognition of Mesozoic fossils: Petrified Forest NP and Dinosaur NM. In addition, the abolished Fossil Cycad NM was established for its Cretaceous paleobotanical fossils. The most significant NPS Mesozoic records are concentrated in the Colorado Plateau (e.g., Arches NP, Colorado NM, Dinosaur NM, Glen Canyon NRA, Petrified Forest NP). Notable exceptions include Big Bend NP and Denali NP&PRES. Because there are only three periods in the Mesozoic, a relatively large number of parks have fossils from all three (15): Arches NP, Capitol Reef NP, Colorado NM, Denali NP&PRES, Dinosaur NM, Gates of the Arctic NP&PRES, Glen Canyon NRA, Grand Teton NP, Katmai NP&PRES, Lake Clark NP&PRES, Noatak NPRES, Wrangell-St. Elias NP&PRES, Yellowstone NP, Yukon-Charley Rivers NPRES, and Zion NP.

Triassic Period

The Triassic (251.9–201.3 Ma) is divided into Early, Middle, and Late epochs. With a duration of approximately 36 million years, the Late Triassic is much longer than either the Early Triassic (approximately 5 million years) or the Middle Triassic (approximately 10 million years).

The Triassic was an unusual interval of Earth's history. It began in the aftermath of the Permian mass extinction and ended with another of the "big five" extinctions, the end-Triassic mass extinction. In between, reptiles diversified into niches left vacant by various synapsids, amphibians, and reptiles that went extinct at the end of the Permian. Many of the new Triassic groups, such as aetosaurs, phytosaurs, and placodonts, fell victim to the end-Triassic extinction. Others of the new Triassic groups were initially less prominent but would go on to sustained success. Famous Mesozoic groups such as dinosaurs, ichthyosaurs, plesiosaurs, and pterosaurs all evolved during the Triassic. Many

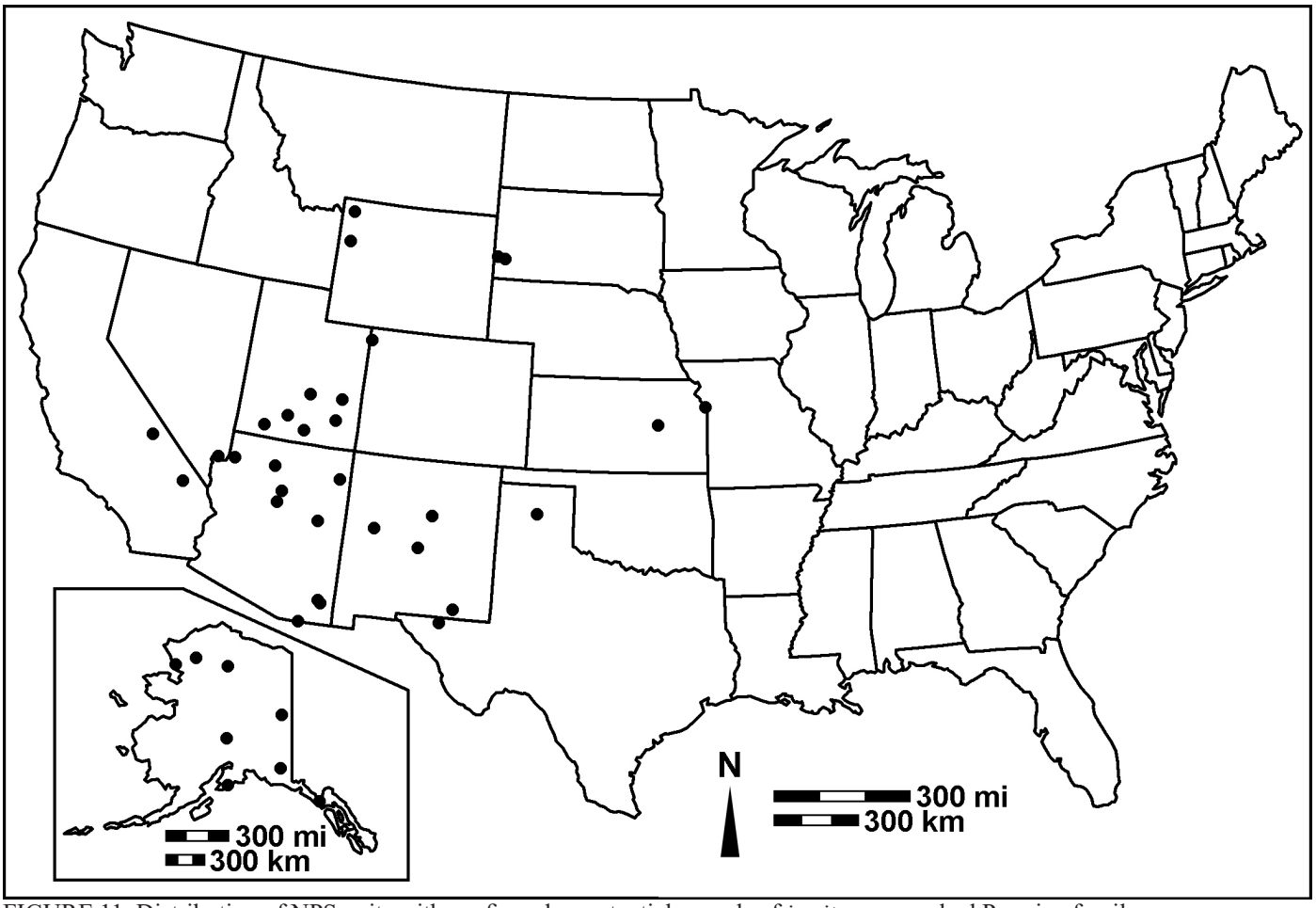

FIGURE 11. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Permian fossils.

modern groups or their immediate ancestors also first appeared during the Triassic, such as frogs, salamanders, turtles, lizards, crocodilians, and mammals. Tectonically, North America began to diverge from Africa, leading to the opening of the proto-Atlantic and the development of a number of narrow rift valleys flanking the main rift. The end of the Triassic is associated with a sudden and geologically brief but massive volcanic event, producing what is known as the Central Atlantic magmatic province. This event is frequently regarded as the likely cause of the end-Triassic extinction event. Another volcanic event, on the western margin of the continent, produced the flood basalts of the Nikolai Greenstone near the Middle–Late Triassic boundary. These rocks can be seen at Wrangell-St. Elias NP&PRES.

Triassic fossils are confirmed from 30 NPS units, with one potential record (Table 18; Fig. 12). The Late Triassic is best represented; 11 NPS units have Early Triassic fossils, 12 have Middle Triassic fossils, and 24 to 25 have Late Triassic fossils (Table 19). As noted, the durations of the Early and Middle Triassic epochs are much shorter than the Late Triassic. They are also short compared to most Mesozoic and Paleozoic epochs, and their rocks have geographically limited distributions, being concentrated in the Great Basin, Colorado Plateau, and adjoining areas to the north. It would thus be unsurprising if the two epochs had very few NPS paleontological records. However, the epochs are if anything overrepresented in the NPS, probably because many parks are located within the depositional area of the Early–Middle Triassic Moenkopi Formation and its equivalents in the Colorado Plateau and adjoining areas.

The records of Early and Middle Triassic age almost all pertain to the Moenkopi Formation mentioned above. This formation was long regarded as dating to the Early Triassic only, but is now known to continue into the Middle Triassic (e.g., Rasmussen et al., 2020; Haque et al., 2021). It is a heterogeneous unit with marine members yielding invertebrates and terrestrial members with fossils of terrestrial vertebrates and ichnofossils. Ten parks are currently known to have fossils from the Moenkopi Formation: Arches NP, Canyonlands NP, Capitol Reef NP, Dinosaur NM, Glen Canyon NRA, Grand Canyon NP, Lake Mead NRA, Mojave NPRES, Wupatki NM, and Zion NP. Similarly, the Late Triassic record is dominated by the succeeding Chinle Formation, which has yielded fossils in 12 parks: Arches NP, Canyon de Chelly NM, Canyonlands NP, Capitol Reef NP, Colorado NM, Dinosaur NM, Glen Canyon NRA, Grand Canyon NP, Lake Mead NRA, Petrified Forest NP, Wupatki NM, and Zion NP. Several other NPS units in the Colorado Plateau have reworked petrified wood that likely came from the Chinle Formation, and Lake Meredith NRA has fossils from equivalent rocks. Note that the Moenkopi and Chinle lists are largely the same. Many of the same units also have fossils from the overlying Glen Canyon Group of latest Triassic–Early Jurassic age. To the east, two NPS units have fossils from Triassic rocks of the Newark Supergroup rift basin system: Chesapeake and Ohio Canal NRA and Manassas NBP. There is an interesting depositional dichotomy: apart from the Chinle, terrestrial Moenkopi, and Newark Supergroup records, the great majority of NPS Triassic records are marine. This is especially true in Alaska, the other major source of Triassic NPS fossils apart from the Colorado Plateau.

By far the best record of Triassic fossils in the NPS is found at Petrified Forest NP. At this park the Chinle Formation has yielded an astonishing array of plant, invertebrate, vertebrate, and trace fossils over close to 20 million years of the Late Triassic.

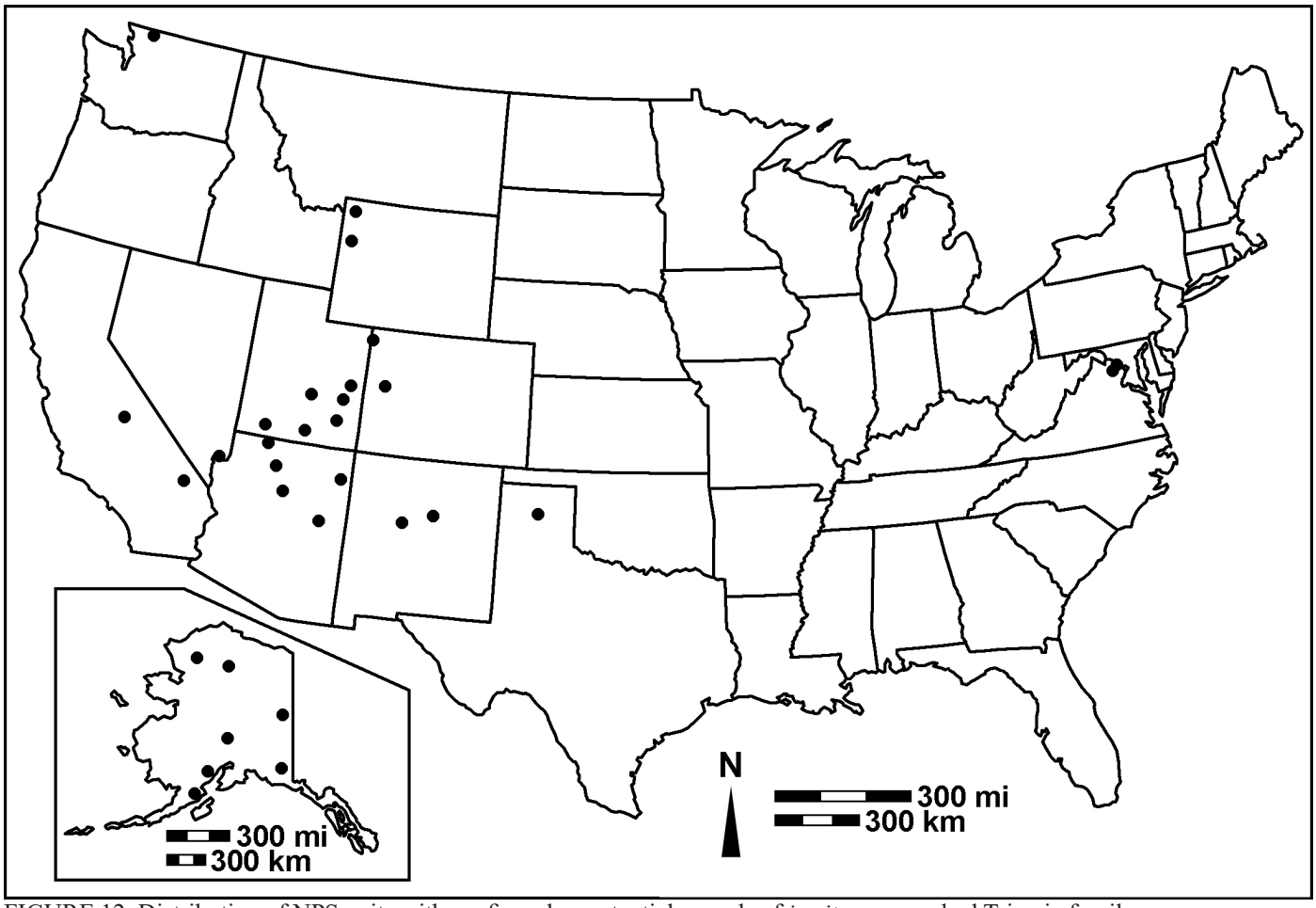

FIGURE 12. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Triassic fossils.

Ninety-eight of the 120 fossil taxa named from specimens found in NPS areas are based on Petrified Forest NP specimens. The remainder come from Canyon de Chelly NM, Wrangell-St. Elias NP&PRES, and Yukon-Charley Rivers NPRES. Other parks with significant Triassic records include four others from the Colorado Plateau with rocks of the Moenkopi and Chinle formations: Canyonlands NP, Capitol Reef NP, Glen Canyon NRA, and Zion NP.

Jurassic Period

The Jurassic (201.3–~145.0 Ma) is divided into Early, Middle, and Late epochs. They are of distinctly different durations, but the differences are not as stark as for the preceding Triassic; the Early Jurassic was approximately 27 million years long versus 11 million years for the Middle Jurassic and 19 million years for the Late Jurassic. These differences are not reflected in the NPS records for each epoch.

Little is known about the Jurassic of eastern North America because of the general absence of Jurassic-aged rocks, apart from Newark Supergroup deposition in rift valleys during the early Early Jurassic and Jurassic rocks found in deep cores. Therefore, this discussion focuses on the western half of the continent. At the onset of the Jurassic, North America was still significantly south of its modern location and well within arid latitudes. The Four Corners region was the heart of a terrestrial system that is most famous for its eolian deposition, culminating in the Aztec–Navajo–Nugget erg. Erosion of Lower and Middle Jurassic terrestrial rocks has provided many NPS units of the Four Corners with their iconic features. Tectonic activity in western North America allowed a seaway to spread into the western interior from the north, reaching a maximum in the Sundance Sea of the Middle and early Late Jurassic, after which the seaway largely retreated. North America had by that time moved far enough north that the climate of the midsection of the continent was no longer as arid. Terrestrial deposition of the well-known Morrison Formation began west of the Sevier orogenic belt that was then developing. This formation is today exposed in several western states and numerous NPS units.

The dominantly eolian terrestrial rocks of the Early and Middle Jurassic preserve large numbers of ichnofossils representing arthropods, archosaurs, synapsids, and other groups, but have yielded relatively few body fossils. Going from these trace fossils to the body fossils of the Morrison Formation, a much younger formation representing substantially different environments, is something of a shock. Offshore, the marine rocks are dominated by fossils of bivalves, ammonites, and belemnites, replacing the Paleozoic fauna.

Jurassic fossils are confirmed from 34 NPS units, with one potential record (Table 20; Fig. 13). Each epoch is represented by similar numbers (Table 21). Early Jurassic fossils have been reported from 19 NPS units; Middle Jurassic fossils have been found at 17 units, with one potential record; and Late Jurassic fossils have been found at 22 units, with one potential record. Almost all of the records come from the contiguous United States west of approximately 102° W or Alaska, except for one Early Jurassic find historically associated with Springfield Armory NHS and probable Late Jurassic fossils found in a deep core taken at Cape Hatteras NS. As with the Triassic, outside of the two widely distributed terrestrial depositional units (Glen Canyon Group and Morrison Formation), the great majority of the records are marine.

About half of the Early Jurassic park occurrences (10 of 19)

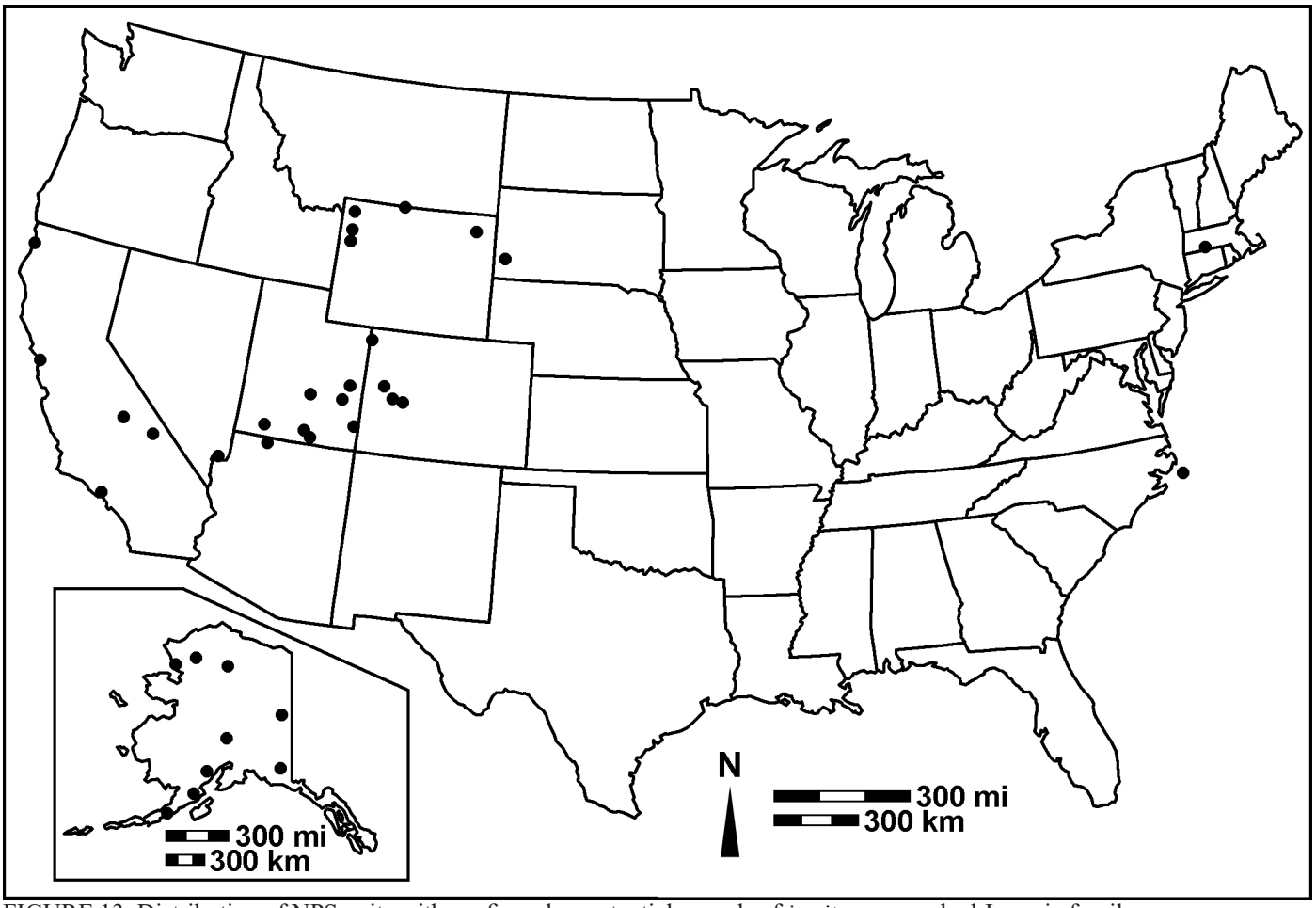

FIGURE 13. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Jurassic fossils.

pertain to the Glen Canyon Group, composed of (in ascending order) the Wingate Sandstone and partially equivalent Moenave Formation, the Kayenta Formation, and Navajo Sandstone. The Aztec Sandstone and Nugget Sandstone are regarded as equivalent to at least the Navajo Sandstone and potentially the rest of the divided Glen Canyon sequence. Tridactyl dinosaur tracks are the iconic fossils of these rocks, although many other types of fossils are known. Glen Canyon Group rocks have yielded fossils at Arches NP, Canyonlands NP, Capitol Reef NP, Colorado NM, Dinosaur NM, Glen Canyon NRA, Lake Mead NRA, Pipe Spring NM, Rainbow Bridge NM, and Zion NP, with perhaps the best record fittingly at Glen Canyon NRA. Another noteworthy Early Jurassic record is the original holotype of *Anchisaurus polyzelus*, discovered at Springfield Armory in 1855 on part of the property that is not currently within Springfield Armory NHS. This was one of the most complete early dinosaurs specimens found in North America. The specimen has since been superseded by a neotype from a different locality (ICZN, 2015).

Middle Jurassic NPS records include a mix of marine fossils and terrestrial trace fossils from post-Glen Canyon Group eolian rocks. Several parks located in a strip from Yellowstone to the Black Hills have fossils from formations deposited in the last expansion of the Sundance Sea (late Middle–early Late Jurassic), including Bighorn Canyon NRA, Devils Tower NM, Grand Teton NP, John D. Rockefeller, Jr. MEM PKWY, Wind Cave NP, and Yellowstone NP. The best Middle Jurassic fossils in the NPS come from marine formations exposed at Lake Clark NP&PRES in Alaska.

The Late Jurassic NPS record is dominated by the Morrison Formation. Morrison Formation fossils have been found at Arches NP, Bighorn Canyon NRA, Black Canyon of the Gunnison NP, Capitol Reef NP, Colorado NM, Curecanti NRA, Devils Tower NM, Dinosaur NP, Glen Canyon NRA, and Yellowstone NP. There is also a notable historical association: the Old Spanish Trail, now memorialized as Old Spanish NHT, is within a quarter mile of the discovery site of *Dystrophaeus viamalae* in 1859. By far the most iconic Morrison NPS unit is Dinosaur NM, famous for the Carnegie Quarry wall and its abundant dinosaur bones. Parks with Morrison outcrops were the subject of a detailed investigation in the 1990s, the Morrison Formation Extinct Ecosystems Project (e.g., Turner et al., 1998). Other Late Jurassic occurrences of note include the Curtis Formation tracks of Arches NP and the Naknek Formation marine fossils of Katmai NP&PRES.

Cretaceous Period

The Cretaceous (~145.0–66.0 Ma) is divided into two epochs, the Early and Late Cretaceous. Although the term "middle Cretaceous" (with or without capitalization of "middle") is encountered in the literature, a formal Middle Cretaceous has not been designated. In much of North America it is possible to informally divide the Cretaceous into rough early, middle, and late intervals based on the presence or absence of the Western Interior Seaway (see below), but the timing is not synchronous.

The Cretaceous is difficult to summarize. It is the longest period, with only two epochs (both of which are as long or longer than some periods), and many notable events occurred during it. At the level of the NPS, there are far more parks with Cretaceous fossils than for any other period or epoch aside from the Pleistocene and Holocene. These parks are distributed across the United States, and their Cretaceous rocks record many different

depositional settings, preserving a bewildering variety of fossils. Perhaps the most useful framework for examining these occurrences is the Western Interior Seaway, which at its height extended from the Arctic to the Gulf of Mexico. The seaway not only divided the contiguous United States geographically, but chronologically it divides the Cretaceous of much of the country into three intervals: before the seaway, during the seaway, and after the seaway, with allowance for regressions during a dominantly marine sequence or transgressions during a dominantly terrestrial sequence. Exceptions to this division are Alaska and areas on the Atlantic or Pacific coasts, which were outside of the area affected by the seaway.

The Cretaceous is marked by high sea levels driven by the geologically rapid dissection of Pangaea. Shallow young ocean basins and relatively low continental interiors led to inland seas reaching extents not seen since the Paleozoic. North America was split into an eastern and a western landmass by the Western Interior Seaway from the late Early Cretaceous to the late Late Cretaceous. Toward the close of the Cretaceous the seaway regressed as ocean basins deepened and the Laramide Orogeny began to push up what would become the Rocky Mountains. Biologically, the Cretaceous is noted for the advent, spread, and diversification of flowering plants. Birds also became common after having evolved during the Jurassic from theropod dinosaurs. Marine organisms were affected by two major anoxic events during the "middle" Cretaceous, but these events paled in comparison to the Cretaceous–Paleogene mass extinction event. The catastrophic event that closed the Cretaceous resulted in the extinction of a wide variety of previously dominant groups (e.g., ammonites, belemnites, reef-forming rudist bivalves and enormous inoceramid oysters, mosasaurs, plesiosaurs, pterosaurs, non-avian dinosaurs, and many early bird clades), as well as sharp reductions in many groups that survived.

Overall, the NPS has a strong fossil record for the Cretaceous: 73 NPS units are known to have Cretaceous fossils, with one potential record (Table 22; Fig. 14). Early Cretaceous fossils are confirmed from 40 NPS units, with two potential records, and Late Cretaceous fossils are confirmed from 59 units, with one potential record (Table 23). Unlike the Permian, Triassic, and Jurassic, Cretaceous records are not limited to the western contiguous United States and Alaska. In the eastern United States, the Potomac area may be over-represented due to the concentration of NPS units with Potomac Group fossils. There is one notable absence in the overall picture: there are no NPS units that include fossils of the classic Judithian and Lancian terrestrial vertebrate assemblages. There are, though, several NHLs and NNLs that recognize these fossils (as well as one recognizing the type locality of *Hadrosaurus foulkii*), and Big Bend NP has fossils of a distinctive southern equivalent.

The NPS records for the Early Cretaceous are heavily weighted to the later part of the epoch (Aptian and Albian). Overall, the contiguous United States has a poor record of the first 20 or so million years of the Early Cretaceous, and this is reflected in the NPS record. One former exception is Fossil Cycad NM, deauthorized as a unit of the NPS in 1957. The namesake fossil cycads derived from the lower Inyan Kara Group, dating to the early Early Cretaceous. The situation is different in Alaska, where early Early Cretaceous fossils have been found at several parks, including Gates of the Arctic NP&PRES, Katmai NP&PRES, Noatak NPRES, Wrangell-St. Elias NP&PRES, and Yukon-Charley Rivers NPRES.

In the contiguous United States, the NPS's Early Cretaceous

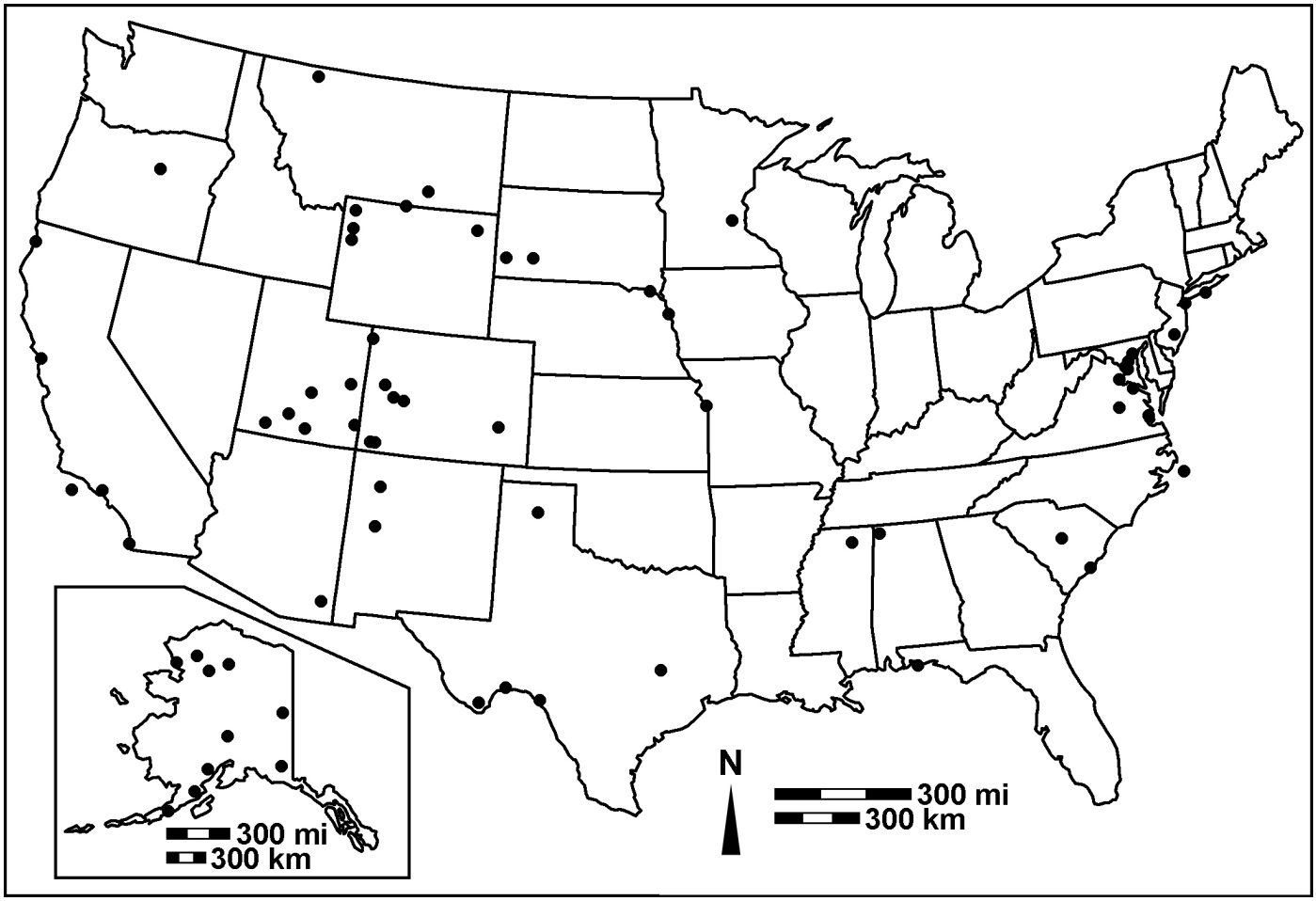

FIGURE 14. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Cretaceous fossils.

record begins in earnest with terrestrial deposition in the Burro Canyon/Cedar Mountain Formation system of Colorado and Utah and the Cloverly/Kootenai Formation system of Montana and Wyoming. These rocks have yielded fossils at Arches NP, Bighorn Canyon NRA, Capitol Reef NP, Colorado NM, Dinosaur NM, Glacier NP, Yellowstone NP, and Zion NP. At this time, Arches NP has the best record, being in the heart of classic Cedar Mountain Formation exposures. The succeeding interval is transitional to the Western Interior Seaway. It has often been assigned solely to the Dakota Formation or Group, but recent work supports distinguishing rocks of the western shore as the Naturita Formation (following Carpenter, 2014). The age of the stratigraphic interval varies from location to location as the seaway spread but is close to the Early–Late Cretaceous boundary. Leaves and vertebrate tracks are well-known from this interval, but at this time no unusually productive localities are known from NPS areas, although perhaps a dozen parks are known to have occurrences (Arches NP, Black Canyon of the Gunnison NP, Bryce Canyon NP, Capitol Reef NP, Colorado NM, Curecanti NRA, Glen Canyon NRA, Mesa Verde NP [subsurface], Missouri NRR, Old Spanish NHT, Santa Fe NHT, and possibly Devils Tower NM). To the east, the Potomac Group was also deposited near the Early–Late Cretaceous boundary. Because of the density of NPS units in the Potomac Group's depositional area, it is well-represented by fossils. Parks with surficial records include Baltimore-Washington PKWY, Fort Foote Park, Fort Washington Park, Greenbelt Park, Oxon Run PKWY, Prince William Forest Park, Richmond NBP, and Rock Creek Park, and subsurface cores have recovered Potomac Group fossils at Colonial NHP, Fort McHenry NM and Historic Shrine, President's Park, and NPS affiliate New Jersey Pinelands NRES. Fort Foote and Rock Creek have perhaps the best records, both paleobotanical.

The NPS's Late Cretaceous record is dominated by the Western Interior Seaway. Reported occurrences are primarily marine invertebrates, with some vertebrate fossils and microfossils; it is likely that microfossils are much more abundant than presently reported. To date perhaps 27 parks from Montana to Texas have fossils from seaway rocks, making the seaway a significant unifying theme of NPS paleontology. The list includes Amistad NRA, Arches NP, Badlands NP, Bent's Old Fort NHS, Big Bend NP, Black Canyon of the Gunnison NP, Bryce Canyon NP, Capitol Reef NP, Chaco Culture NHP, Curecanti NRA, Dinosaur NM, El Camino Real de los Tejas NHT, Glacier NP, Glen Canyon NRA, Grand Teton NP, John D. Rockefeller, Jr. MEM PKWY, Little Bighorn Battlefield NM, Mesa Verde NP, Mississippi NRRA, Missouri NRR, Old Spanish NHT, Rio Grande WSR, Santa Fe NHT, Yellowstone NP, Yucca House NM, potentially Bighorn Canyon NRA, and a historical association with Lewis & Clark NHT. In addition, Gulf Coast Late Cretaceous records at Brices Cross Roads NBS and Natchez Trace PKWY are related, representing a contemporaneous and geographically linked marine transgression. The best-documented Western Interior Seaway NPS records come from Badlands NP, Big Bend NP, Chaco Culture NHP, Glen Canyon NRA, and Mesa Verde NP. The record at Lewis & Clark NHT includes fish and marine reptile fossils discovered during the Lewis & Clark expedition, representing the first documented fossil occurrences in the western United States as well as some of the earliest fossils in the history of NPS units (Santucci, 2017).

Terrestrial Late Cretaceous records postdating the seaway are comparatively rare in the NPS. The best record is found at Big Bend NP, where the Aguja–Javelina–lower Black Peaks stratigraphic sequence preserves a Campanian–Maastrichtian assemblage of plants, invertebrates, and vertebrates, a number of dinosaur taxa among them. Other parks with terrestrial post-seaway Cretaceous fossils include Bryce Canyon NP, Glen Canyon NRA, Grand Teton NP, and Yellowstone NP; all of these coincidentally represent areas on the western extreme of the marine transgression. Outside of the seaway, significant Late Cretaceous occurrences have been found at Aniakchak NM&PRES and Denali NP&PRES in Alaska (both noted for paleobotanical fossils and abundant vertebrate tracks). Extensive subsurface sampling within NPS affiliate New Jersey Pinelands NRES has produced a detailed record of the Atlantic Coastal Plain sequence throughout the Late Cretaceous, including the Cretaceous–Paleogene boundary.

CENOZOIC ERA

By the beginning of the Cenozoic, North America was close to its present location, and its outline would have been broadly similar to the present. Sea level was still comparatively high, so coastal areas were still submerged, but the last remnants of the Western Interior Seaway were regressing. Alaska was largely assembled. There were still significant differences, though. The Rockies had just begun to build, the Basin and Range would not begin to take shape for tens of millions of years, many prominent volcanic features had yet to form (the Greater Yellowstone region would undergo two major volcanic episodes during the Cenozoic, with Eocene stratovolcanoes being overprinted by Pleistocene caldera eruptions), and drainage patterns were much different in many areas. Biologically, the extinction of non-avian dinosaurs and other groups at the end of the Cretaceous opened the door for the radiation of what became the modern biosphere, with mammals and birds proliferating. Occasional contact with Eurasia allowed interchange with the Eastern Hemisphere throughout the Cenozoic.

The Cenozoic fossil record in the NPS is dominated by parks in states in the western half of the country, with lesser but still significant contributions from Atlantic and Gulf coastal parks and Alaska. This is a reflection of the general pattern in North America: there are few areas of Cenozoic deposition in the interior east (Appalachians to the line formed by the western borders of Minnesota south to Louisiana), except for areas reached by marine incursions of the Mississippi Embayment. Only with the widespread presence of young Quaternary surficial sediments do we see the return of paleontological records from these areas, almost invariably of Late Pleistocene or Holocene age (except for isolated caves). In addition, after having been major contributors to NPS fossil resources of Paleozoic and Mesozoic age, parks in the interior of Alaska have much more limited Cenozoic records.

Several NPS units were established in recognition of outstanding Cenozoic fossil sites: Agate Fossil Beds NM, Florissant Fossil Beds NM, Fossil Butte NM, Hagerman Fossil Beds NM, John Day Fossil Beds NM, Tule Springs Fossil Beds NP, and Waco Mammoth NM. In addition, several others are recognized for notable Cenozoic fossils, such as Badlands NP, Big Bend NP, Channel Islands NP, Colonial NHP, Death Valley NP, Glen Canyon NRA, Grand Canyon NP, Niobrara NSR, Potomac Heritage NST, Santa Monica Mountains NRA, Theodore Roosevelt NP, Valley Forge NHP, Vicksburg NMP, and Yellowstone NP. Each one includes localities that would be worthy of protection and recognition on their own. The Eocene and Quaternary are particular high points in the geochronological story of NPS paleontology.

If the Pleistocene and Holocene are combined as the Quaternary, there are four NPS units with fossils from the resulting six Cenozoic geochronological divisions: Big Bend NP, Colonial NHP (with subsurface records included), Denali NP&PRES (including units with poor age control), and Santa Monica Mountains NRA. Seven others have five of six: Channel Islands NP, Death Valley NP, Denali NP&PRES, Fort Pulaski NM (primarily subsurface records), NPS affiliate New Jersey Pinelands NRES (primarily subsurface records), Olympic NP, and Wrangell-St. Elias NP&PRES.

Paleocene Epoch

The Paleocene (66.0–56.0 Ma) is divided into early, middle, and late subdivisions, corresponding respectively to the Danian, Selandian, and Thanetian ages. In terms of North American Land Mammal Ages (NALMAs), the early Paleocene includes the Puercan and younger Torrejonian, as well as the earliest Tiffanian. The middle Paleocene and much of the late Paleocene are also included in the Tiffanian, and the Clarkforkian encompasses the rest of the late Paleocene. Biologically this epoch is most noted for the recovery from the Cretaceous–Paleogene extinction event, during which the survivors (particularly mammals) radiated into newly vacated ecological niches. The end of the Paleocene is marked by the Paleocene–Eocene Thermal Maximum, a geologically brief global thermal spike.

After the spike in paleontological records for the Cretaceous, the Paleocene is one of the most sparsely represented geochronological divisions for NPS fossils. Part of this is a function of its relatively brief geochronological duration (approximately 10 million years). With the retreat of the Western Interior Seaway, the Paleocene also had much less marine deposition compared to some other intervals of the Phanerozoic (e.g., much of the Paleozoic or the Cretaceous). Because marine strata tend to be much more fossiliferous than terrestrial strata, the reduction of marine deposition further limits the paleontological potential. The distribution of NPS units with Paleocene fossils versus the overall distribution of fossiliferous Paleocene rocks in the United States shows a strong bias for areas that were located within or near shallow marine deposition. Only two parks have substantial Paleocene terrestrial records: Big Bend NP and Theodore Roosevelt NP. This does not closely reflect the United States as a whole.

Paleocene fossils are known from 23 NPS units (Table 24; Fig. 15). The early Paleocene is particularly sparsely represented, with only two records, only one of which has a surficial component (Table 25). Big Bend NP's Black Peaks Formation crosses the Cretaceous–Paleogene boundary, although to date no fossils have been found in the earliest early Paleocene section. Fossil-bearing K–Pg-spanning cores have been taken from NPS affiliate New Jersey Pinelands NRES. The middle Paleocene record expands to five NPS units, including areas on the Pacific Coast (Channel Islands NP and Santa Monica Mountains NRA) and Theodore Roosevelt NP (Table 25). Late Paleocene fossils are known from 12 units, with the additions almost exclusively from the Atlantic and Gulf coastal plains (Table 25). It is likely that the individual divisions of the Paleocene are better represented than currently known, because another 10 units have records that cannot be assigned to one of the divisions at this time (Table 25), and there are of course various other parks with Paleocene rocks that are known to produce fossils outside of NPS boundaries.

The two most significant Paleocene NPS records are those from Big Bend NP and Theodore Roosevelt NP, both of which preserve abundant fossils of nonmarine plant life, mollusks, and vertebrates. The nonmammalian vertebrates of the Torrejonian–Tiffanian portion of the Black Peaks Formation at Big Bend NP are broadly comparable to their counterparts in the Tiffanian Bullion Creek and Sentinel Butte formations at Theodore Roosevelt NP. Both feature gars, turtles, choristoderes, and large and small crocodilian taxa. Paleocene mammals are poorly known at Theodore Roosevelt NP to date, but microvertebrate sampling would likely improve the record substantially; recent investigations at the park have uncovered two previously undocumented mammal taxa and the first bird skeletal and ichnological material (Salcido et al., 2022).

Eocene Epoch

The Eocene (56.0–33.9 Ma) is divided into early, middle, and late subdivisions, corresponding to the Ypresian, Lutetian plus Bartonian, and Priabonian ages, respectively. In terms of NALMAs, the early Eocene includes the Wasatchian and Bridgerian; the middle Eocene includes the Uintan and Duchesnean; and the late Eocene is essentially equivalent to the Chadronian.

In North America, the Eocene saw the establishment of many modern groups of mammals and the proliferation of large-bodied land mammals such as the brontotheres. This group of horned perissodactyls went extinct at the close of the Eocene, but other perissodactyls that evolved in the Eocene or latest Paleocene fared better, such as equids and rhinocerotids. Artiodactyls also evolved and diversified; many groups that had early prominence, such as the oreodonts of Badlands NP and John Day Fossil Beds NP, have since gone extinct. The close of the Eocene is marked by an extinction event potentially associated with an ongoing cooling trend.

The Laramide Orogeny, which had begun near the end of the Cretaceous, persisted through the Eocene before coming to a close near the end of the epoch. Within the area affected by the orogeny, large persistent inland lakes formed during the early Eocene, as exemplified by the rocks of the Claron Formation (Bryce Canyon NP and Cedar Breaks NM), Florissant Formation (Florissant Fossil Beds NM), and Green River Formation (Fossil Butte NM). Extensive deposition began east of the young mountains, punctuated by volcanic events that dumped ash into the depositional systems. The fossiliferous rocks of the White River Group (late Eocene–late Oligocene age) are an example. The White River Group is widespread in the northern Great Plains and can be seen at Badlands NP, NPS affiliate Chimney Rock NHS, Niobrara NSR, Scotts Bluff NM, and Wind Cave NP. Volcanism was significant in the interior of the western United States, including the activity that produced the Absaroka Volcanic Supergroup in Yellowstone NP between approximately 55 and 44 Ma, and the ignimbrite flare-up from Colorado to Nevada that began approximately 40 Ma and continued through the Oligocene.

Eocene fossils are known from 34 NPS units, and two others have potential records (Table 26; Fig. 16). Although areas of coastal deposition again dominate, the record from the interior of the continent is much stronger than in the Paleocene. The early Eocene is the best-represented part of the epoch, with fossils at 22 NPS units (Table 27). It is notable for the Green River Formation at Fossil Butte NM, the beginning of the extensive record of deposition at John Day Fossil Beds NM, and the fossil forests of Yellowstone NM. Middle Eocene fossils have been found at 15 units, almost entirely holdovers from the early Eocene (Table 27); the most notable addition is the Stone City Bluff site on a crossing of El Camino Real de los Tejas NHT. Late Eocene fossils have been found at 15 units, with one potential record (Table 27). Among the records are the iconic fossil assemblages of the Chadron Formation at Badlands NP and Florissant Formation at Florissant Fossil Beds NM.

In some ways the Eocene may be considered the most outstanding time interval of the NPS fossil record. Two of the most renowned paleontological NPS units are the Eocene Lagerstätten of Florissant Fossil Beds NM and Fossil Butte NM. Several others have very substantial records (e.g., Badlands NP, Big Bend NP, El Camino Real de los Tejas NHT, John Day Fossil Beds NP, and Yellowstone NP), and Glacier NP's western boundary cuts through outcrops of the middle Eocene Coal Creek Member of the Kishenehn Formation, recently recognized as a Lagerstätte (the outcrops on the park side have not been explored in as much detail as those on the other side). The rocks and fossils of these units have been described in great detail, and have played significant roles in the history of paleontology. One reflection of this is the great number of Eocene fossil species named from NPS units. Despite a relatively brief duration of

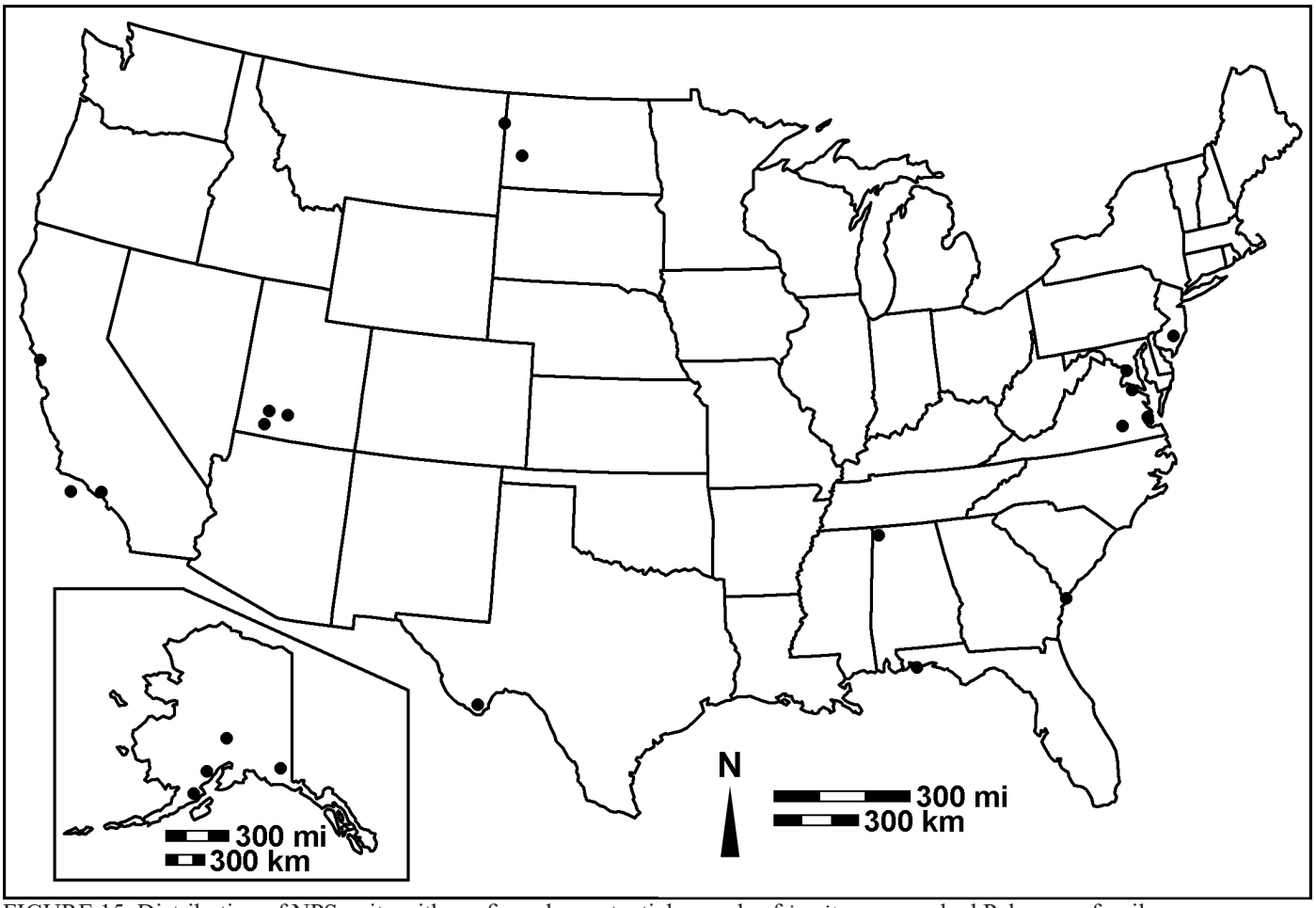

FIGURE 15. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Paleocene fossils.

approximately 22 million years, at least 755 Eocene taxa have been named from fossils confirmed from NPS units, and as many as 1,413 more may have been named from NPS units (this number is due to vague reporting of localities in 19th and early 20th century publications, when description of new taxa from the areas now included in the above-mentioned parks was at its height; see Tweet et al. [2016] for more discussion). Both numbers are by far the largest for any time interval, and the total will only increase when data from the Stone City Bluff site (El Camino Real de los Tejas NHT) have been fully integrated.

Oligocene Epoch

The Oligocene (33.9–23.03 Ma) is divided into early and late subdivisions, corresponding to the Rupelian and Chattian ages, respectively. These divisions do not neatly correspond to NALMAs. The early Oligocene includes the Orellan, Whitneyan, and early Arikareean. The Arikareean then continues through the entire late Oligocene and into the early Miocene.

The Oligocene can be seen as a transition from the early Cenozoic to the late Cenozoic, particularly in terms of climate. The cooling and drying trends of the Eocene continued with a corresponding replacement of forested areas with more open landscapes across the midcontinent. The compressional stresses that produced the Laramide Orogeny had waned, to be replaced by extension. Oligocene extension is seen in the Rio Grande Rift east and southeast of the Colorado Plateau. This rift is also associated with volcanic activity.

After the highlights of the Eocene, the NPS paleontological record for the Oligocene is not as well represented. Oligocene fossils have been reported from 27 NPS units, with one potential record (Table 28; Fig. 17). Badlands NP and John Day Fossil Beds NM are still both very significant, and the coastal marine invertebrate fauna from Vicksburg NMP represents an important early area of paleontological investigation in North America. Compared to preceding or succeeding epochs, the Oligocene NPS record is more terrestrial and is skewed toward sites in the continental interior. There are relatively few Oligocene occurrences at Atlantic and Gulf coast parks (primarily in cores), presumably a function of relatively low Oligocene sea levels.

Early Oligocene fossils are known from 14 NPS units, with one potential record (Table 29). Several of these park records pertain to the White River Group, including Badlands NP, Chimney Rock NHS, Scotts Bluff NM, and Wind Cave NP. The best records for the early Oligocene are probably those of Badlands NP, John Day Fossil Beds NM, and Vicksburg NMP, representing two terrestrial sites and one marine site, distributed respectively in the Columbia Plateau region, northern Great Plains, and Gulf Coastal Plain. Late Oligocene fossils have been reported from 13 NPS units, with two potential NPS records (Table 29). Although this is essentially the same as the early Oligocene in terms of numbers, the late Oligocene is comparatively fallow in terms of significant sites.

Miocene Epoch

The Miocene (23.03–5.333 Ma) is divided into early, middle, and late subdivisions. The early Miocene corresponds to the Aquitanian and Burdigalian ages; the middle Miocene corresponds to the Langhian and Serravallian; and the late Miocene corresponds to the Tortonian and Messinian. In terms of NALMAs, the early Miocene includes the late Arikareean (roughly equivalent to the Aquitanian) and Hemingfordian (roughly equivalent to the Burdigalian); the middle Miocene

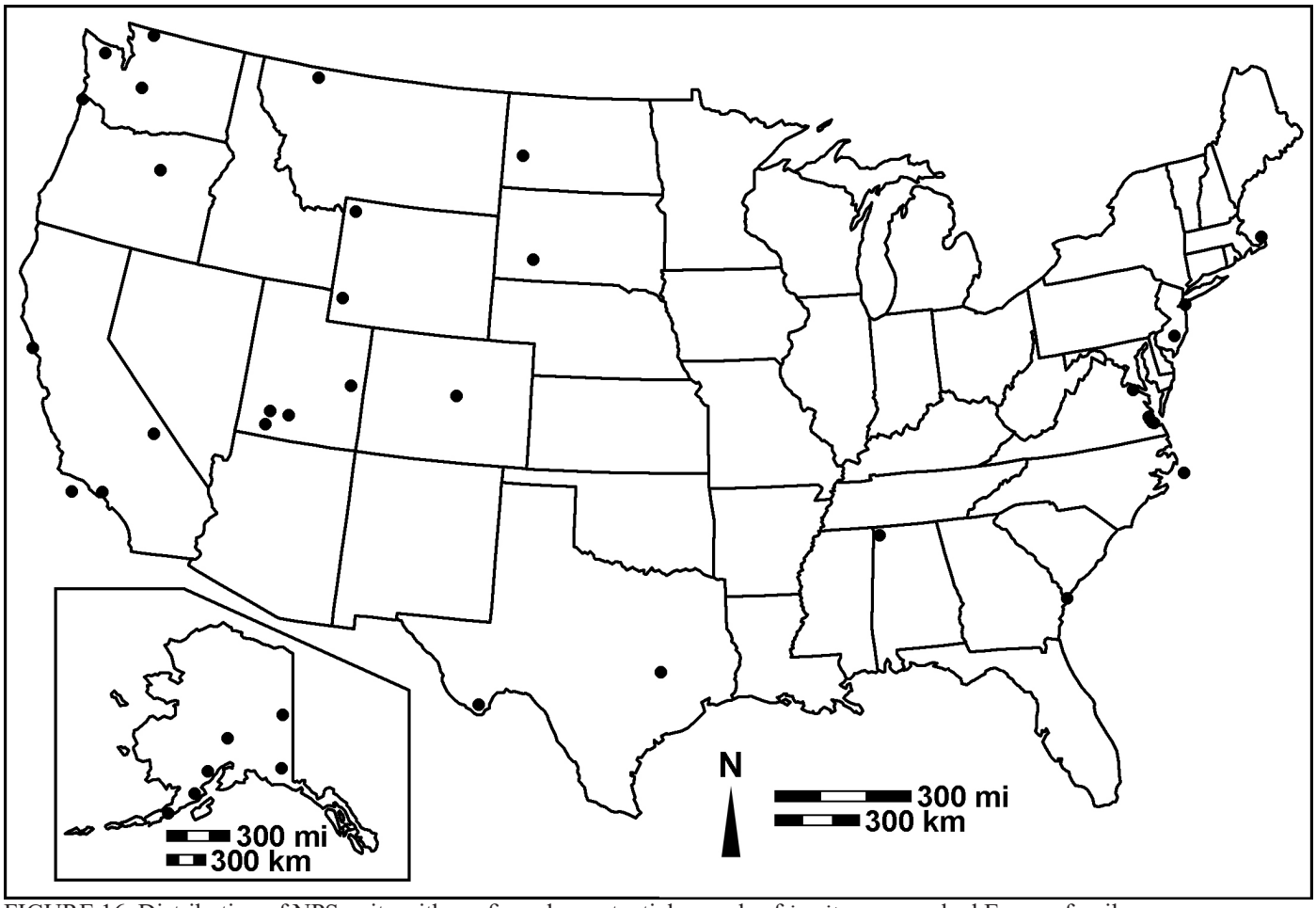

FIGURE 16. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Eocene fossils.

includes the Barstovian (roughly equivalent to the Langhian) and most of the Clarendonian; and the late Miocene includes the end of the Clarendonian and almost all of the Hemphillian.

The Miocene of North America is crowded with significant geological and paleontological events. On the Pacific Coast, North America overrode a segment of the East Pacific Rise. This event resulted in tectonic reorganization along the western edge of the North American Plate, producing the San Andreas fault system. The Baja California Peninsula was rifted from the mainland, and smaller crustal blocks such as the one that includes Channel Islands NP and Santa Monica Mountains NRA were wrenched out of place. The extensional stresses on the margin of the plate probably contributed to another signature event of the Miocene, the development of the Basin and Range. To the north, the Columbia River flood basalts began erupting 17 Ma; the hotspot magma source has continued to erupt, its progressive track leading more recently to the Yellowstone caldera system. In the biological realm, cooling during the Miocene promoted the spread of grasslands. Limited interchange with South America led to the arrival of ground sloths near the end of the epoch, while proboscideans entered North America from Asia.

Miocene fossils have been reported from 44 NPS units, and two more have potential records (Table 30; Fig. 18). The NPS record for the Miocene has great breadth, as evidenced by the numerous parks with Miocene fossils, but has relatively few singular sites apart from Agate Fossil Beds NM.

Early Miocene fossils are known from 26 NPS units, with one potential record (Table 31). The most notable is Agate Fossil Beds NM, where the faunal assemblages of the Harrison Formation and Anderson Ranch Formation have been studied in great detail since the early 20th century. The fossils of Agate Fossil Beds NM were regarded by Wood et al. (1941) as typical of the Arikareean. Other notable occurrences include the terrestrial vertebrates of the Delaho Formation at Big Bend NP and the marine fossils of several formations found at Channel Islands NP and Santa Monica Mountains NRA, as well as the continuation of the stratigraphic sequence at John Day Fossil Beds that finally ends with the upper Miocene Rattlesnake Formation.

Middle Miocene fossils are known from 27 NPS units, with two potential records (Table 31). Again, there are several prolific units, such as the shallow marine formations at Channel Islands NP and Santa Monica Mountains NRA, the marine Calvert Formation of George Washington Birthplace NM, and the terrestrial Valentine Formation of Niobrara NSR. Niobrara NSR in particular passes through a rich and historically significant area heavily sampled for fossils since the mid-19th century, although it intersects relatively few sites due to its narrow boundaries centered on the Niobrara River.

Late Miocene fossils are known from 26 NPS units, with one potential record (Table 31). Several of the previously mentioned park records continue through to this interval, including at John Day Fossil Beds NM, Niobrara NSR, and Santa Monica Mountains NRA. Significant occurrences of coastal marine fossils at Golden Gate NRA and Point Reyes NS that continue into the Quaternary begin in the late Miocene.

Pliocene Epoch

The Pliocene (5.333–2.58 Ma) is divided into early and late subdivisions, corresponding to the Zanclean and Piacenzian ages. In terms of NALMAs, the early Pliocene includes the latest Hemphillian, but otherwise the Pliocene is represented

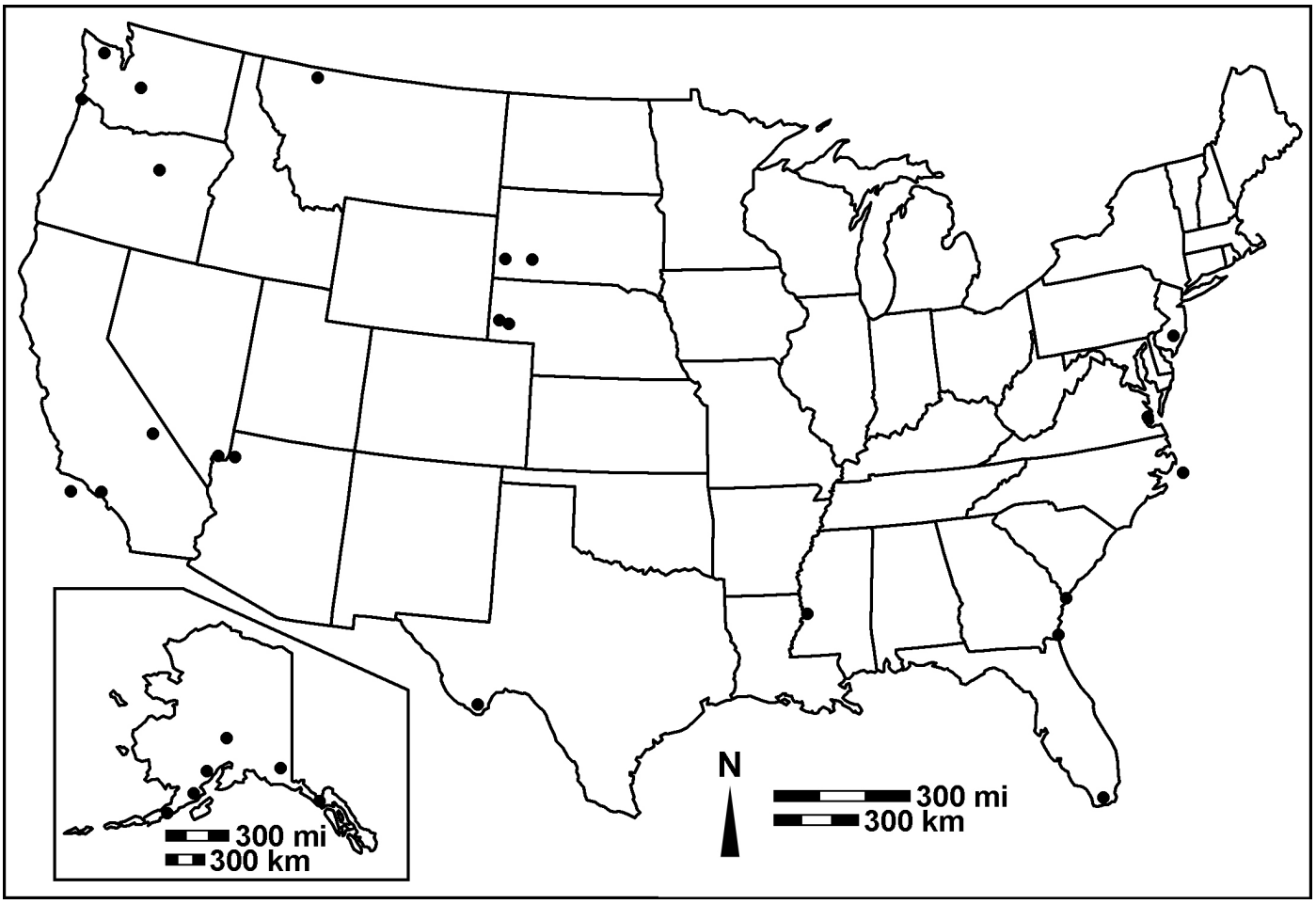

FIGURE 17. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Oligocene fossils.

by the Blancan, which continues into the early Pleistocene. The completion of the Isthmus of Panama allowed a much greater interchange of organisms between the two landmasses during the Pliocene. Continued cooling led to the glaciation of Greenland late in the epoch, a precursor to the continental ice sheets that crossed northern North America multiple times during the Pleistocene.

The Pliocene is a geologically brief interval, less than 3 million years in duration. It is therefore not surprising that it is among the least represented major geochronological intervals in the NPS. Pliocene fossils have been reported from 26 NPS units, with one potential record (Table 32; Fig. 19). Despite this relatively small number, some of the most outstanding NPS paleontological records are Pliocene in age. Because of the brevity of the Pliocene, there is both a great deal of overlap between the early and late Pliocene lists (eight), and numerous Pliocene records in which a subdivision is not specified (12 confirmed and one potential). The Pliocene of the NPS is dominated by coastal and marine records, with relatively few records from the interior of the continent. Early Pliocene fossils are confirmed from 12 NPS units, with one potential record, and late Pliocene fossils are confirmed from 13 NPS units (Table 33).

The three most significant NPS records of Pliocene fossils represent three distinct geologic settings and geographic areas: the shallow marine fossils of the Yorktown Formation at Colonial NHP in Virginia, the vertebrate tracks of the arid Copper Canyon Formation at Death Valley NP in California, and the terrestrial fossils of the more equable setting of the Hagerman Formation at Hagerman Fossil Beds NM in Idaho. The Yorktown Formation fossils at Colonial NHP are likely to include the earliest illustrated fossil specimen from the Western Hemisphere, an example of what is now known as *Chesapecten jeffersonius* (Lister, 1687; Say, 1824; Ward and Blackwelder, 1975). Even if the specific fossil illustrated was not from within Colonial NHP, the area of the park was one of the first places in North America where fossils were collected for study. The same formation is also exposed in Petersburg to the west, and many fossils were collected there in the 19th century, but due to vague provenance data it is unclear if any came from what is now Petersburg NB. Other areas of paleontological study include the coastal rocks of Golden Gate NRA and Point Reyes NS and the marine Tamiami Formation of Big Cypress NPRES.

Quaternary Period (Pleistocene and Holocene Epochs)

The Quaternary (2.58 Ma–present), the last period of the Cenozoic, is by far the briefest geochronological period at 2.58 million years in duration, but because it is also the most recent period, it is the most thoroughly documented period. It is divided into two epochs, the older Pleistocene and more recent Holocene. The Pleistocene is divided into early, middle, and late ages, while the Holocene is considered undivided for the purposes of the PSP. There has been a great deal of revision of the Quaternary in recent decades, so care must be taken when translating past usage to the present. The early Pleistocene corresponds to the international Gelasian and Calabrian ages and the middle Pleistocene corresponds to the Chibanian (former Ionian). In terms of NALMAs, the late Blancan roughly corresponds to the Gelasian, the Irvingtonian takes the rest of the early Pleistocene and most of the middle Pleistocene, and the Rancholabrean essentially takes the rest of the Pleistocene. Additional NALMAs have recently been put forward for the

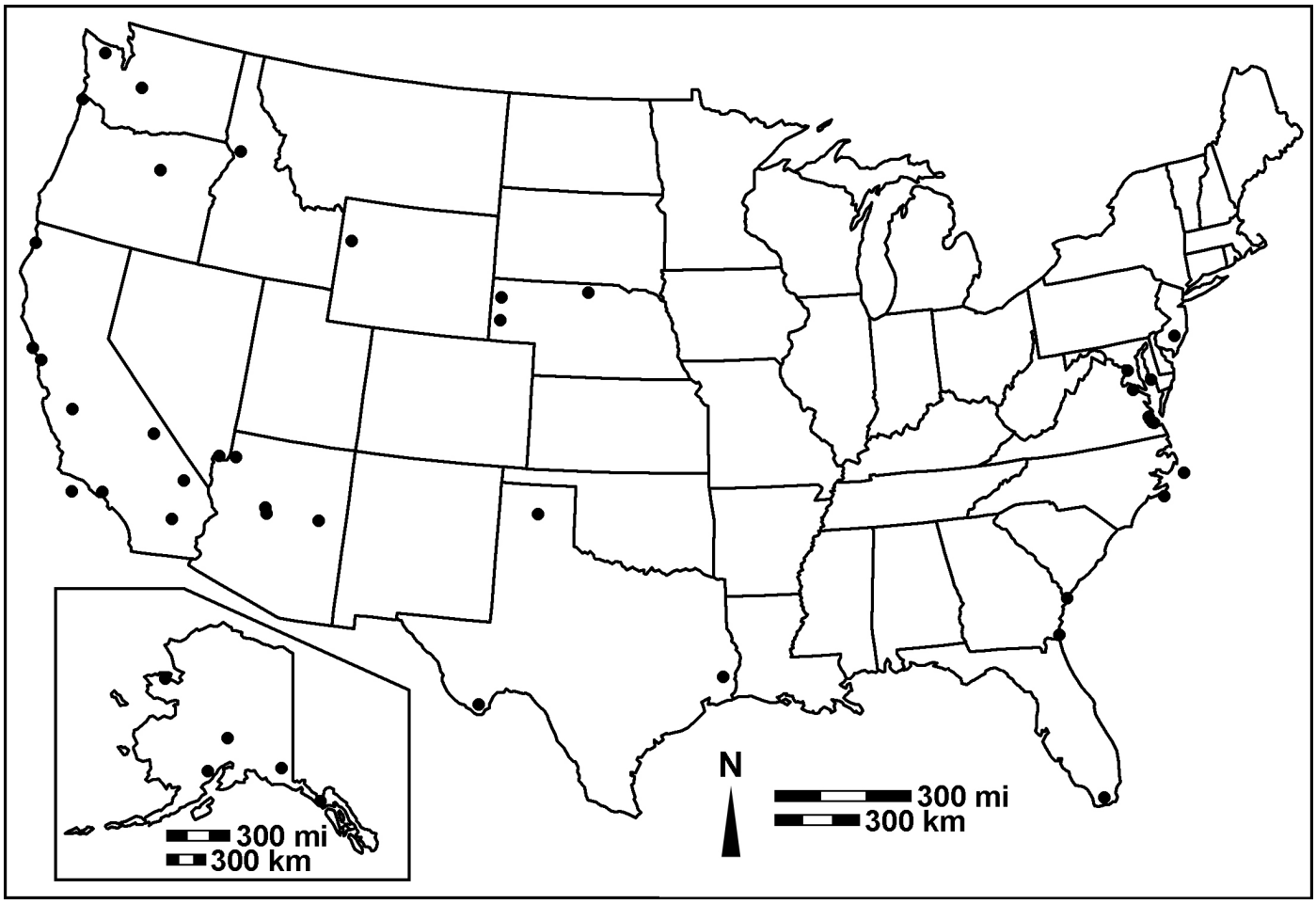

FIGURE 18. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Miocene fossils.

latest Pleistocene and Holocene (Barnosky et al., 2014): the Santarosaean, beginning with the arrival of humans in subarctic North America and roughly contemporaneous megafaunal losses (and named after Santa Rosa Island in Channel Islands NP, in recognition of "Arlington Man" dated to approximately 13 ka); and the Saintaugustinean, representing the arrival of domesticated African and Eurasian animals as part of the colonizing efforts of European maritime powers.

The Quaternary is famous for the episodic glaciation of significant parts of Eurasia and North America and high elevations elsewhere. The planet shifted between glacial and interglacial climatic extremes numerous times, with glacial maxima occurring on the order of every 40,000 to 100,000 years. At one point in time, a given high latitude location might be under a thick continental glacier; 20,000 years later, it might be ice-free or, if near the coast, it might be underwater if isostatic rebound had not caught up to it. Similarly, at glacial maxima vast swaths of continental shelves were subaerially exposed, only to be submerged by rising sea levels during interglacials. Drainage patterns in areas affected by glaciation were subject to profound reorganization each time glaciers arrived. In the biological realm, interchange between North America, Asia, and South America continued. The most significant new arrival occurred during the most recent glaciation, when humans arrived in North America from northeastern Asia. Their arrival coincides closely with the extinction of most of North America's megafauna.

Because of the recency of the Quaternary and the widespread distribution of Quaternary deposits, there are far more records of Pleistocene and Holocene fossils in the NPS than any other division of geologic time. Pleistocene fossils have been found at 107 NPS units, with one potential record (Table 34). The majority of the parks have late Pleistocene fossils; 13 NPS units have early Pleistocene records, 17 have middle Pleistocene records, and 86 have late Pleistocene records (Table 35). Holocene fossils have been reported from 121 NPS units and may be present at two more (Table 36). Finally, 27 NPS units have fossils of undetermined Quaternary age (Table 37). In total, 159 NPS units have confirmed records of Quaternary fossils, with one potential record (Table 38; Fig. 20). These records are distributed across the United States, including areas in the eastern interior that otherwise have no fossiliferous bedrock younger than the mid-Paleozoic.

As the numbers above indicate, the early and middle Pleistocene are relatively less represented in NPS units, which is unsurprising given their brevity and the burial of deposits by recent sediments. The most notable sites are two Irvingtonian-aged bone cave sites in the Northeast: Cumberland Cave along Potomac Heritage NST and Port Kennedy Bone Cave within Valley Forge NHP. Both sites are significant for their age and geography, providing windows on the Irvingtonian vertebrate faunas of the northeastern United States. Otherwise, the next best NPS records of this interval are found in marine rocks in coastal California (Golden Gate NRA) and Florida (the group including Big Cypress NPRES, Biscayne NP, Dry Tortugas NP, and Everglades NP). The only NPS unit with a significant nonmarine fossil record throughout the Pleistocene and into the Holocene is Yellowstone NP, where palynomorphs and other microfossils have been studied.

The late Pleistocene into the Holocene is a much different story. Many parks have fossils from the past 50,000 or so years (roughly the limit of radiocarbon dating). Two have been designated in recognition of their late Pleistocene fossils: Tule

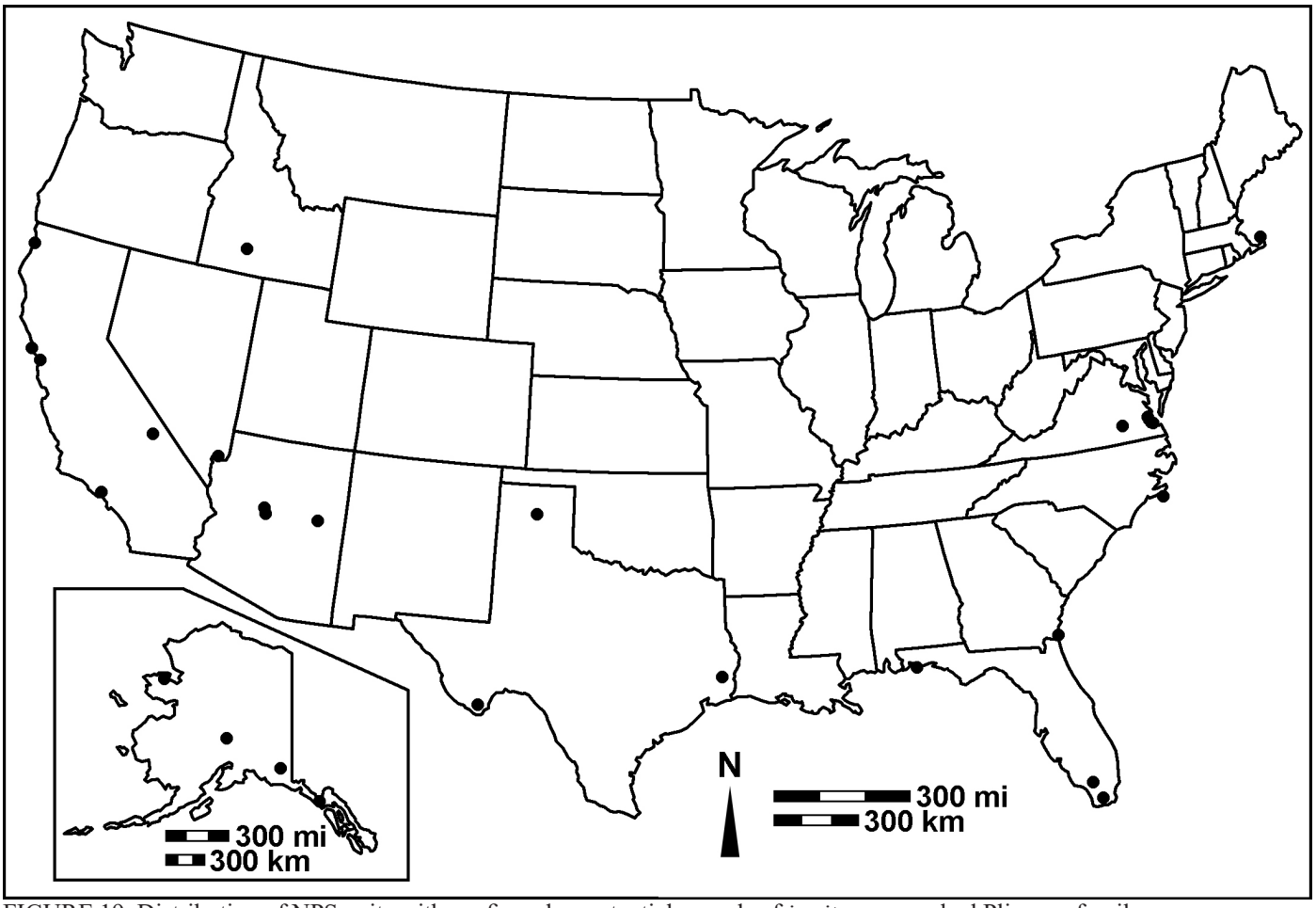

FIGURE 19. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Pliocene fossils.

Springs Fossil Beds NM and Waco Mammoth NM. Others have late Pleistocene fossil records that would have merited recognition in their own right, such as the island fauna of Channel Islands NP (an outstanding bird record as well as pygmy mammoths and Arlington Man); the cave faunas of Glen Canyon NRA and Grand Canyon NP, noted for not only bones but dung and soft tissues; and the recently discovered late Pleistocene tracks of White Sands NP, including pre-Clovis human tracks (Bennett et al., 2021). The 2019 expansion of Lewis & Clark National Historic Trail puts Big Bone Lick on its route. This is one of the most significant early North American paleontological localities, and was visited on separate occasions by both Lewis and Clark to collect fossils for Thomas Jefferson. Several parks in the desert Southwest (e.g., Death Valley NP, Joshua Tree NP, and Tule Springs Fossil Beds NM) preserve fossils and deposition from wetland systems that are now rare. Many parks have palynomorph records from the latest Pleistocene into the Holocene, studied to provide data on previous ecosystems and climate states and information for management. Lakes and various types of wetlands are important sources of these fossils in much of the NPS. Another major source in dry areas of the West is packrat middens, which include materials such as fragments of plant macrofossils, small vertebrate bones, arthropods, pollen, and packrat droppings. Tweet et al. (2012) is an inventory of these notable Quaternary accumulations in NPS units. Another inventory, Mead et al. (2020), documents the NPS records of a classic group of Pleistocene megafauna: mammoths, mastodons, and other proboscideans.

UNCERTAIN AGE

There are some records for which the age has not been determined, generally because of inadequate provenance information. This is especially true of reworked fossils, which frequently are durable but only broadly age-diagnostic. There are 46 parks with records of fossils of uncertain age; of these, more than half of the park records (25) are of reworked fossils (Table 39; Fig. 21).

OVERALL

As mentioned previously, 245 NPS units have at least one confirmed report of *in situ* or reworked fossils. The records for six of these (Aztec Ruins NM, Fort Stanwix NM, Hovenweep NM, Perry's Victory & International Peace MEM, Thomas Edison NHP, and War in the Pacific NHP) cannot be dated with great precision, so they are omitted from the following discussion, leaving a total of 239 parks. Similar to taxonomic records (Tweet et al. 2020), most parks with fossils only have occurrences from one or two of the major geochronological divisions used here, with the number of divisions represented decreasing to a long tail (Fig. 22). With the Pleistocene and Holocene lumped as the Quaternary for counting purposes (due to the brief duration of both and the cross-epoch continuity of many records) to produce 18 major divisions, the average number of major geochronologic divisions represented is 2.9 and the median is 2.

Of the 239 park units, 95 have confirmed records from only one of the 18 major divisions and 55 have records from only two; combined this is slightly less than two-thirds of the total. A brief geologic record is of course no measure of quality; for example, Guadalupe Mountains NP has only Permian and Quaternary fossils, but its Permian paleontological record is one of the best in the NPS and the Quaternary cave record is also substantial. Other notable units that have fossils from

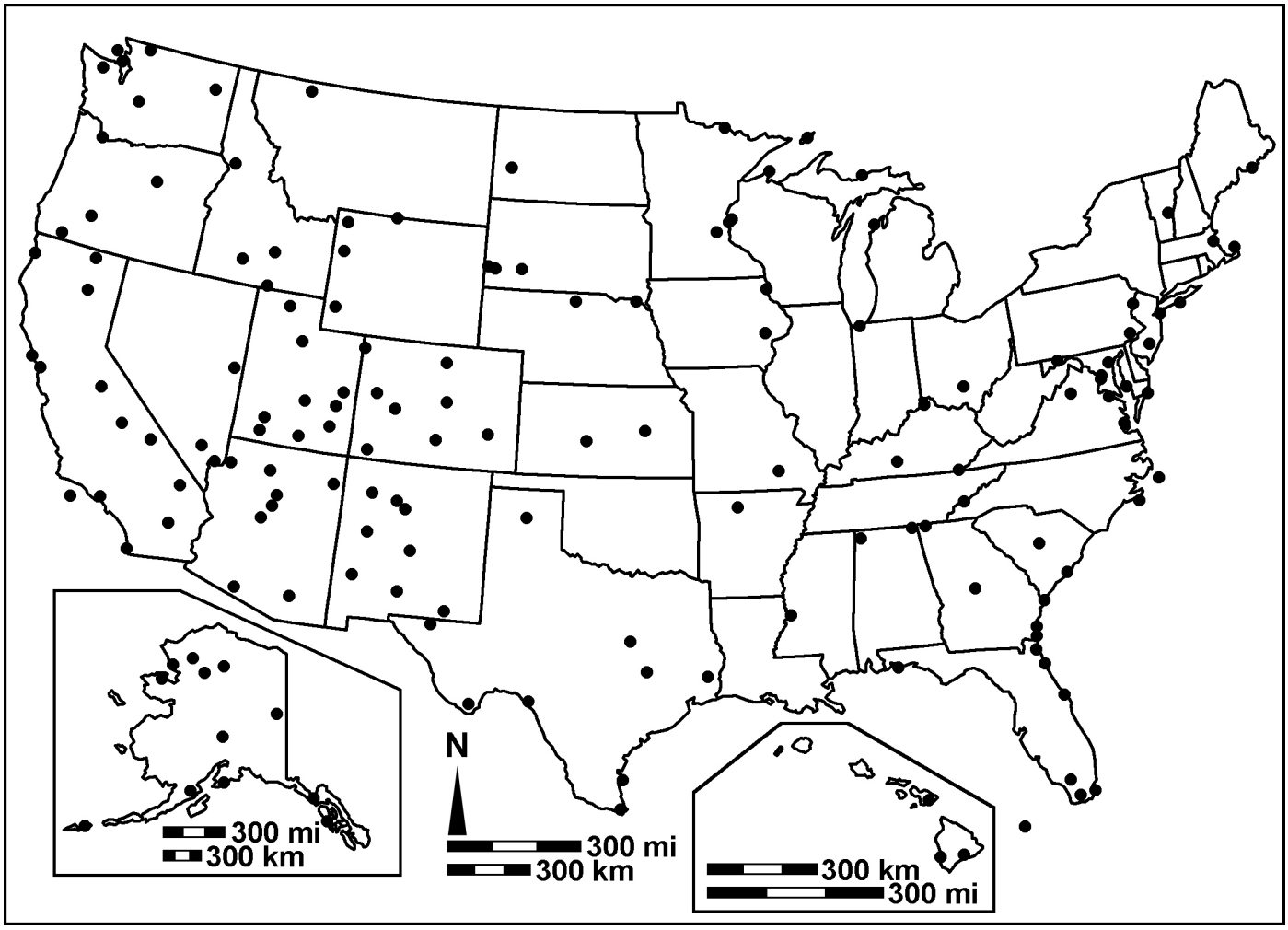

FIGURE 20. Distribution of NPS units with confirmed or potential records of *in situ* or reworked Quaternary fossils.

only one or two geochronological divisions include Agate Fossil Beds NM, Carlsbad Caverns NP, Chaco Culture NHP, Florissant Fossil Beds, Fossil Butte NM, Hagerman Fossil Beds NM, Mammoth Cave NP, Mesa Verde NP, Tule Springs Fossil Beds NM, Valley Forge NHP, Vicksburg NMP, and Waco Mammoth NM. A short geologic record is often a function of the distribution of fossiliferous rocks in a park; if a park has only Permian bedrock, it is unlikely that Silurian fossils would ever be found there except as reworked material. In other cases, only limited paleontological exploration has occurred at a park that has more geochronologically diverse bedrock, so additional study may expand the temporal range of its paleontological record. Examples where there is significant potential include Appalachian NST, Fredericksburg and Spotsylvania NMP (currently only known to have fossils in building stone), Great Sand Dunes NP&PRES, Lake Roosevelt NRA, Richmond NBP, and Saguaro NP.

Eighty-nine of the 239 NPS units have confirmed records from three to as many as 15 geochronological units, with an average of 5.4 and a median of 5. No park has paleontological records for all 18 major divisions, but some come close. Ten NPS units have fossils representing at least 10 of 18 divisions:

- 15 Death Valley NP
- 15 Denali NP&PRES
- 13 Yukon-Charley Rivers NPRES
- 12 Wrangell-St. Elias NP&PRES
- 11 Gates of the Arctic NP&PRES
- 11 Grand Teton NP
- 11 Lake Mead NRA
- 11 Yellowstone NP
- 10 Noatak NPRES
- 10 Wind Cave NP

Of this group, five are from Alaska, two are from the desert Southwest, two are from the greater Yellowstone region, and one is from the Black Hills. All of these units share diverse (and often extremely complex) geology. Not coincidentally, almost all of them are also among the largest NPS units by area; eight of them exceed 1.495 million acres. The exceptions are Grand Teton NP at slightly more than 310,000 acres and Wind Cave NP, almost an order of magnitude smaller at slightly less than 34,000 acres. The Wind Cave record may be inflated by the presence of fossiliferous units spanning two periods, but even with that caveat the park is practically a microcosm of the complex Black Hills geology. Incorporating the next 12 (those NPS units with seven to nine divisions represented), the geographic distribution expands but is still confined almost entirely to Alaska, southern California, the Colorado Plateau, and the greater Yellowstone region, with Big Bend NP, Bighorn Canyon NRA, Colonial NHP (including subsurface records), and Wind Cave NP as outliers.

CONCLUSIONS

The PSP was developed in part to provide a convenient means to synoptically assess the scope of NPS paleontological resources within and between parks. The PSP files, supplemented with the NPS Paleontology Archives & Library, allow rapid assessment of park records servicewide and facilitate detailed analysis of specific resource information and categories. This publication is an example, using the PSP to compile and assess

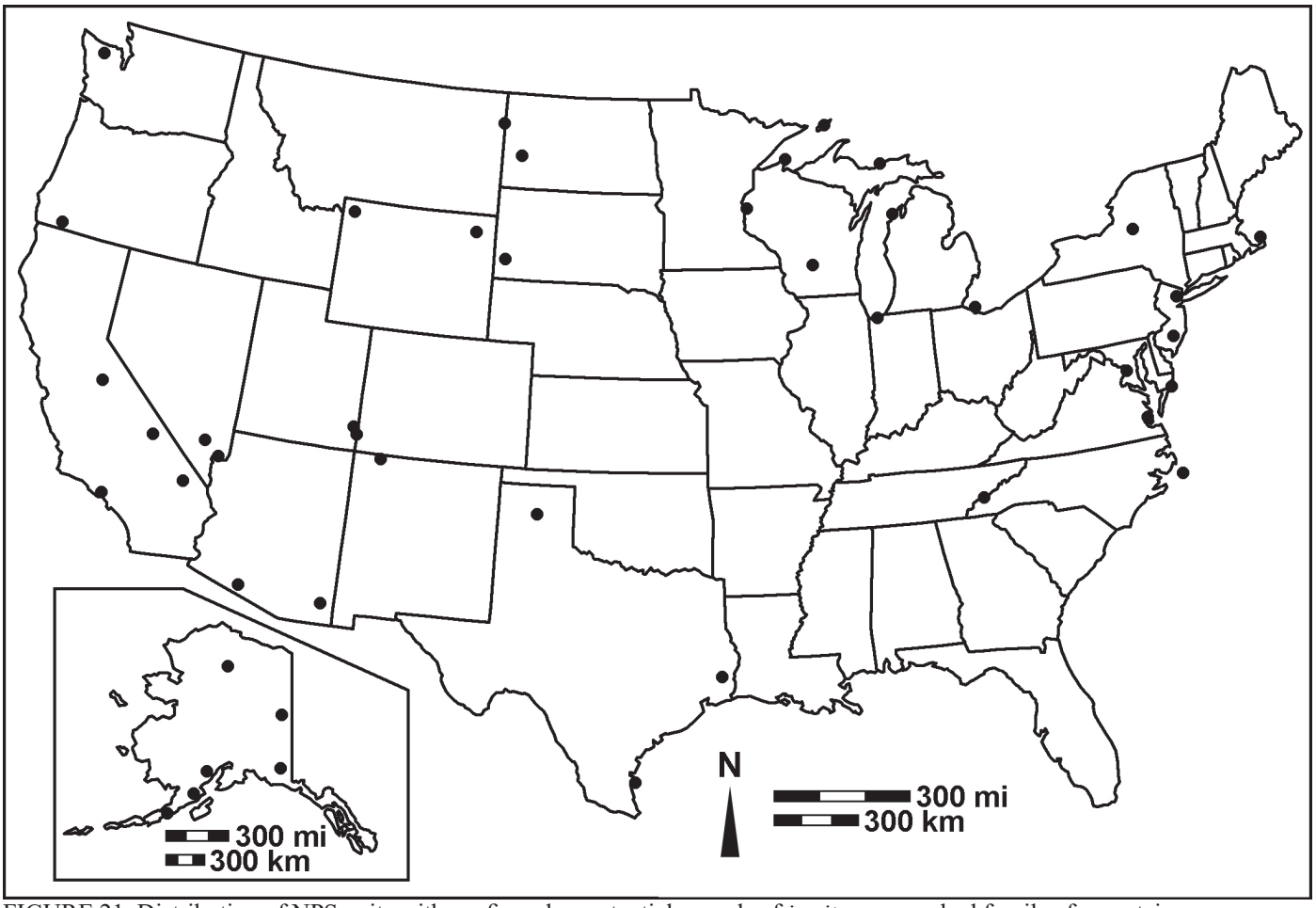

FIGURE 21. Distribution of NPS units with confirmed or potential records of *in situ* or reworked fossils of uncertain age.

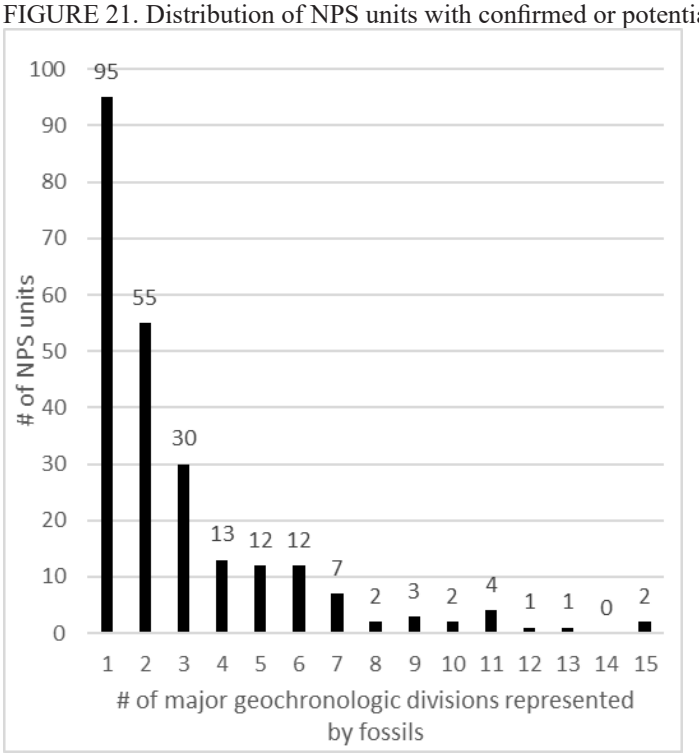

FIGURE 22. Distribution of major geochronologic divisions represented by fossils in NPS units.

NPS geochronological data to illustrate the scope and extent of the NPS fossil record. At least 283 NPS units and affiliated areas have some kind of paleontological resources, and of that group 245 have confirmed *in situ* or reworked resources documenting the history of life throughout the United States from the Mesoproterozoic to the Quaternary (Fig 23). The NPS record is a broadly representative sample across geologic time compared to the United States as a whole, with perhaps some underrepresentation of the middle Paleozoic due to the geographic distribution of NPS units. Because paleontological resources have not been a primary focus of attention at most NPS units, it should be anticipated that the numbers and lists presented above will change over time. In most cases numbers will increase, but there is also the potential for decreases due to revisions of formation ages and the dates assigned to geochronologic division boundaries.

The fossil record of the NPS encompasses a significant cross-section of North American paleontology, and the public visibility of the NPS makes it an excellent venue for educating the public about paleontology. At the same time, the NPS is charged with managing and protecting paleontological resources. Tools like the PSP improve our ability to effectively gather and retrieve relevant information, which can then be used to improve paleontological resource management, support scientific investigation, and inform and inspire the public, fulfilling our operational mandates.

ACKNOWLEDGMENTS

In the previous thematic inventory based on the PSP (Tweet and Santucci, 2021), we recognized a number of collaborators from 2012 to 2021. For this article, we continue with more

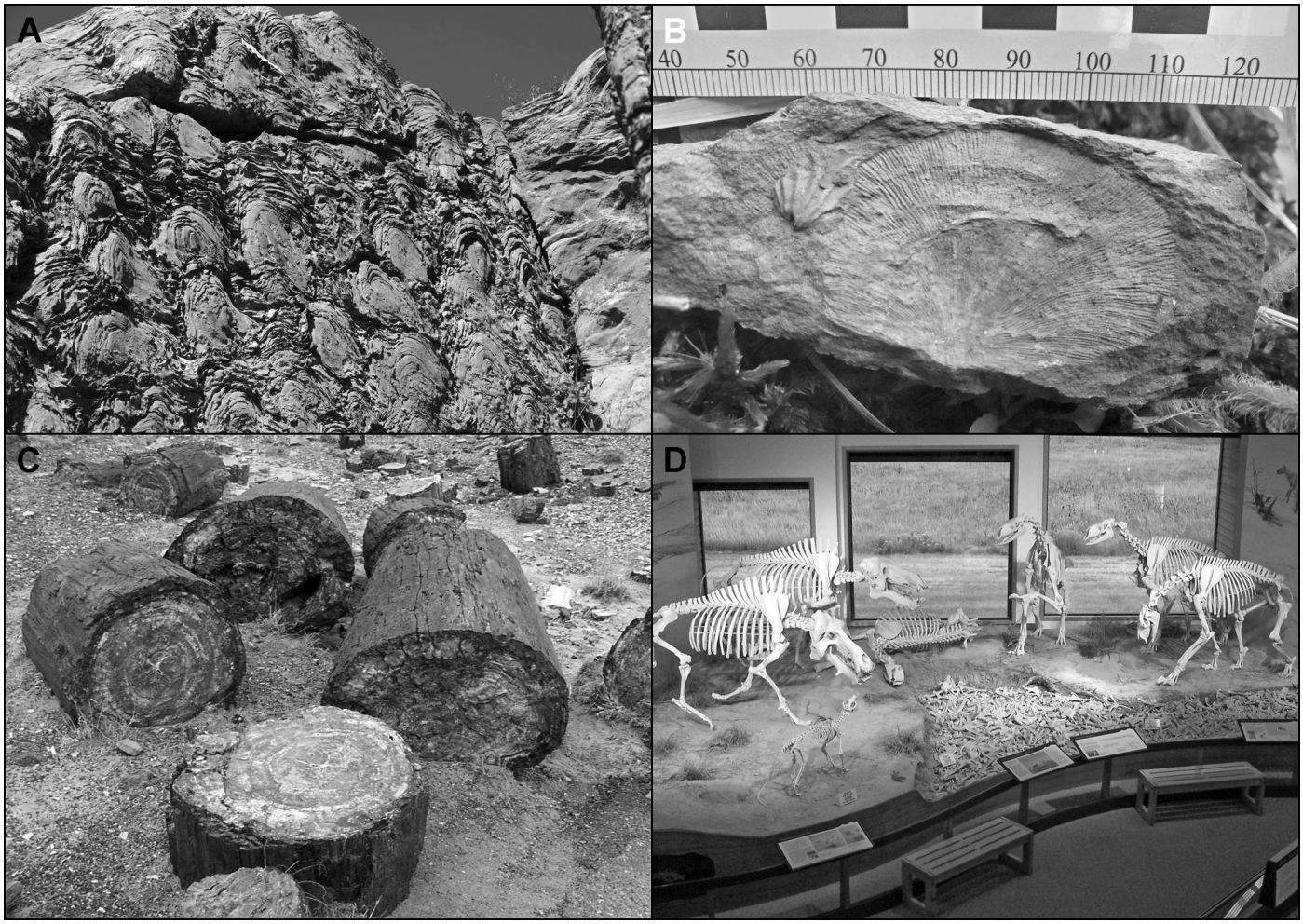

FIGURE 23. Examples of fossils representing the geochronological range of NPS paleontological occurrences. A. Mesoproterozoic stromatolites, Glacier NP (ReBecca Hunt-Foster/NPS); B. Devonian brachiopods, Katahdin Woods and Waters NM (Vincent Santucci/NPS); C. Triassic petrified wood, Petrified Forest NP (NPS); D. various Miocene mammals, Agate Fossil Beds NM (NPS).

recent collaborators: Sofia Andeskie, Isabel Ashton, Charles Beightol, Michael Clinton, Victoria Crystal, Holley Flora, Eric Hendrickson, Kelly Irick, Emily Johnson, Alexander Kim, Amanda Lanik, Robert Marvinney, Marc Ohms, Rick Olson, Megan Rich, Kelli Tolleson, Chunzeng Wang, and Summer Rose Weeks. Reviews by Robert Blodgett, Spencer G. Lucas and Donald Prothero are acknowledged.

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APPENDIX

TABLE 1. NPS units and affiliates with confirmed or potential paleontological records for major divisions of geologic time (abbreviated for space).

	Mesoprot.	Neoprot.	Cambrian	Ordov.	Silur.	Devon.	Miss.	Penn.	Permian
Confirmed	4	5	45	31	17	29	37	39	37
Potential	1	0	0	0	0	3	2	1	2
Total	5	5	45	31	17	32	39	40	39

	Tria.	Jura.	Cret.	Paleo.	Eocene	Olig.	Miocene	Plio.	Pleis.	Holo.
Confirmed	30	34	73	23	34	27	44	26	106	121
Potential	1	1	1	0	2	1	2	1	1	2
Total	31	35	74	23	36	28	46	27	107	123

TABLE 2. NPS units with Paleoproterozoic or older rocks.

Paleoproterozoic or older rocks		
Bighorn Canyon NRA	Grand Teton NP	Pecos NHP
Black Canyon of the Gunnison NP	Great Sand Dunes NP&PRES	Pipestone NM
Castle Mountains NM	Ice Age NST	Rocky Mountain NP
City of Rocks NRES	Ice Age National Scientific Reserve‡	Saguaro NP
Colorado NM	Joshua Tree NP	Saint Croix NSR
Curecanti NRA	Lake Mead NRA	Voyageurs NP
Death Valley NP	Mojave NPRES	Wind Cave NP
Grand Canyon NP	Mount Rushmore NMEM	Yellowstone NP
Grand Portage NM		

TABLE 3. NPS units with Proterozoic paleontological records.

Mesoproterozoic	**Neoproterozoic**
Apostle Islands NL?	Boston Harbor Islands NRA
Death Valley NP	Death Valley NP
Glacier NP	Grand Canyon NP
Grand Canyon NP	Mojave NPRES
Tonto NM	Yukon-Charley Rivers NPRES

TABLE 4. NPS units with Cambrian paleontological resources.

Cambrian Overall		
Anacostia Park*	George Washington MEM PKWY*	Oxon Run PKWY*
Antietam NB	Greenbelt Park*	Ozark NSR
Appalachian NST	Grand Canyon NP	Parashant NM
Bighorn Canyon NRA	Grand Teton NP	Pictured Rocks NL
Blue Ridge PKWY	Great Basin NP	Piscataway Park*
Cape Cod NS*	Great Smoky Mountains NP	Rock Creek Park*
Chesapeake and Ohio Canal NHP	Hopewell Furnace NHS	Saint Croix NSR
Death Valley NP	Ice Age NST	Saguaro NP
Dinosaur NM	Ice Age National Scientific Reserve‡	Shenandoah NP
Effigy Mounds NM	Katahdin Woods and Waters NM	Suitland PKWY*
Fort Foote Park*	Kobuk Valley NP	Theodore Roosevelt Island*
Fort Washington Park*	Lake Mead NRA	Valley Forge NHP
Frederick Douglass NHS*	Mojave NPRES	Wind Cave NP
Gates of the Arctic NP&PRES	Old Spanish NHT	Yellowstone NP
George Washington Birthplace NM*	Oxon Cove Park & Oxon Hill Farm*	Yukon-Charley Rivers NPRES

TABLE 5. NPS records by division of the Cambrian.

Early Cambrian	Middle Cambrian	Late Cambrian	Undivided Cambrian
Appalachian NST	Bighorn Canyon NRA	Antietam NB	Anacostia Park*
Blue Ridge PKWY	Chesapeake and Ohio Canal NHP	Bighorn Canyon NRA	Cape Cod NS*
Chesapeake and Ohio Canal NHP	Death Valley NP	Chesapeake and Ohio Canal NHP	Fort Foote Park*
Death Valley NP	Dinosaur NM	Death Valley NP	Fort Washington Park*
Grand Canyon NP	Gates of the Arctic NP&PRES	Effigy Mounds NM	Frederick Douglass NHS*
Great Basin NP	Grand Canyon NP	Grand Canyon NP	Gates of the Arctic NP&PRES
Great Smoky Mountains NP	Grand Teton NP	Grand Teton NP	George Washington Birthplace NM*
Hopewell Furnace NHS	Great Basin NP	Great Basin NP	George Washington Memorial PKWY*
Katahdin Woods and Waters NM	Kobuk Valley NP	Ice Age NST	Greenbelt Park*
Mojave NPRES	Lake Mead NRA	Ice Age National Scientific Reserve‡	Oxon Cove Park & Oxon Hill Farm*
Old Spanish NHT	Mojave NPRES	Kobuk Valley NP	Oxon Run PKWY*
Shenandoah NP	Parashant NM	Mojave NPRES	Piscataway Park*
Valley Forge NHP	Saguaro NP	Ozark NSR	Rock Creek Park*
Yukon-Charley Rivers NPRES	Saint Croix NSR	Parashant NM	Suitland PKWY*
	Valley Forge NHP	Pictured Rocks NL	Theodore Roosevelt Island*
	Yellowstone NP	Saint Croix NSR	
	Yukon-Charley Rivers NPRES	Saguaro NP	
		Wind Cave NP	
		Yellowstone NP	
		Yukon-Charley Rivers NPRES	

TABLE 6. NPS units with Ordovician paleontological resources.

Ordovician overall		
Bering Land Bridge NPRES	Gates of the Arctic NP&PRES	Noatak NPRES
Big Bend NP	Grand Teton NP	Ozark NSR
Bighorn Canyon NRA	Great Basin NP	Pictured Rocks NL
Buffalo NR	Great Smoky Mountains NP	Roosevelt-Vanderbilt NHS
Camp Nelson Heritage NM	Hot Springs NP	Saint Croix NSR
Chesapeake and Ohio Canal NHP	Ice Age National Scientific Reserve‡	Saratoga NHP
Chickasaw NRA	Katahdin Woods and Waters NM	Stones River NB
Death Valley NP	Kobuk Valley NP	Wind Cave NP
Delaware Water Gap NRA	Mississippi NRRA	Yellowstone NP
Denali NP&PRES	Natchez Trace PKWY	Yukon-Charley Rivers NPRES
Effigy Mounds NM		

TABLE 7. NPS records by division of the Ordovician.

Early Ordovician	Middle Ordovician	Late Ordovician	Undivided Ordovician
Buffalo NR Chesapeake and Ohio Canal NHP Death Valley NP Denali NP&PRES Effigy Mounds NM Great Basin NP Great Smoky Mountains NP Ice Age National Scientific Reserve‡? Kobuk Valley NP Mississippi NRRA Ozark NSR Pictured Rocks NL Saint Croix NSR Wind Cave NP Yukon-Charley Rivers NPRES	Buffalo NR Chesapeake and Ohio Canal NHP Chickasaw NRA? Death Valley NP Denali NP&PRES Great Basin NP Kobuk Valley NP Mississippi NRRA Noatak NPRES Saratoga NHP Yukon-Charley Rivers NPRES	Big Bend NP Bighorn Canyon NRA Buffalo NR Camp Nelson Heritage NM Chesapeake and Ohio Canal NHP Chickasaw NRA Death Valley NP Delaware Water Gap NRA Denali NP&PRES? Effigy Mounds NM Grand Teton NP Great Basin NP Hot Springs NP Ice Age National Scientific Reserve‡ Katahdin Woods and Waters NM Mississippi NRRA Natchez Trace PKWY Pictured Rocks NL Saint Croix NSR Saratoga NHP Stones River NB Yellowstone NP Yukon-Charley Rivers NPRES	Bering Land Bridge NPRES Denali NP&PRES Gates of the Arctic NP&PRES* Great Basin NP Ice Age National Scientific Reserve‡* Kobuk Valley NP Roosevelt-Vanderbilt NHS Yukon-Charley Rivers NPRES

TABLE 8. NPS units with Silurian paleontological resources.

Silurian Overall		
Appalachian NST Bering Land Bridge NPRES Buffalo NR Chesapeake and Ohio Canal NHP Chickasaw NRA Death Valley NP	Delaware Water Gap NRA Denali NP&PRES Gates of the Arctic NP&PRES Glacier Bay NP&PRES Great Basin NP Ice Age National Scientific Reserve‡*	Katahdin Woods and Waters NM Kobuk Valley NP Noatak NPRES Potomac Heritage NST Yukon-Charley Rivers NPRES

TABLE 9. NPS records by division of the Silurian.

Early Silurian	Middle Silurian	Late Silurian	Undivided Silurian
Appalachian NST	Appalachian NST	Chesapeake and Ohio Canal NHP	Appalachian NST
Buffalo NR	Chesapeake and Ohio Canal NHP	Chickasaw NRA	Bering Land Bridge NPRES
Chickasaw NRA	Chickasaw NRA	Death Valley NP	Buffalo NR
Death Valley NP	Death Valley NP	Delaware Water Gap NRA	Death Valley NP
Delaware Water Gap NRA	Delaware Water Gap NRA	Glacier Bay NP&PRES	Denali NP&PRES
Denali NP&PRES	Denali NP&PRES	Great Basin NP	Gates of the Arctic NP&PRES
Great Basin NP	Great Basin NP	Katahdin Woods and Waters NM	Ice Age National Scientific Reserve‡*
Ice Age National Scientific Reserve‡*	Ice Age National Scientific Reserve‡*	Potomac Heritage NST	Katahdin Woods and Waters NM*?
Katahdin Woods and Waters NM	Katahdin Woods and Waters NM	Yukon-Charley Rivers NPRES	Kobuk Valley NP
Yukon-Charley Rivers NPRES	Yukon-Charley Rivers NPRES		Noatak NPRES
			Potomac Heritage NST
			Yukon-Charley Rivers NPRES

TABLE 10. NPS units with Devonian paleontological resources.

Devonian Overall		
Allegheny Portage Railroad NHS?	Dinosaur NM	Lewis and Clark NHT
Bering Land Bridge NPRES	Gates of the Arctic NP&PRES	Mojave NPRES
Bighorn Canyon NRA	Glacier Bay NP&PRES	Natchez Trace PKWY
Cape Cod NS*	Grand Canyon NP	Noatak NPRES
Cape Krusenstern NM	Grand Teton NP	Parashant NM?
Chesapeake and Ohio Canal NHP	Great Basin NP	Upper Delaware SRR
Chickasaw NRA	Ice Age National Scientific Reserve‡*	Whiskeytown NRA?
Cuyahoga Valley NP	Katahdin Woods and Waters NM	Wind Cave NP
Death Valley NP	Kobuk Valley NP	Wrangell-St. Elias NP&PRES
Delaware Water Gap NRA	Lake Mead NRA	Yellowstone NP
Denali NP&PRES		Yukon-Charley Rivers NPRES

TABLE 11. NPS records by division of the Devonian.

Early Devonian	Middle Devonian	Late Devonian	Undivided Devonian
Cape Cod NS*	Cape Krusenstern NM	Allegheny Portage Railroad NHS?	Bering Land Bridge NPRES
Chesapeake and Ohio Canal NHP	Death Valley NP	Bighorn Canyon NRA	Denali NP&PRES
Chickasaw NRA	Delaware Water Gap NRA	Chesapeake and Ohio Canal NHP	Gates of the Arctic NP&PRES
Death Valley NP	Denali NP&PRES	Chickasaw NRA	Ice Age National Scientific Reserve‡*
Delaware Water Gap NRA	Gates of the Arctic NP&PRES	Cuyahoga Valley NP	Noatak NPRES
Denali NP&PRES	Glacier Bay NP&PRES	Death Valley NP	Wrangell-St. Elias NP&PRES
Glacier Bay NP&PRES	Grand Canyon NP	Delaware Water Gap NRA	Yukon-Charley Rivers NPRES
Great Basin NP	Great Basin NP	Denali NP&PRES	
Katahdin Woods and Waters NM	Kobuk Valley NP	Dinosaur NM	
Kobuk Valley NP	Lake Mead NRA	Gates of the Arctic NP&PRES	
Noatak NPRES	Mojave NPRES	Glacier Bay NP&PRES?	
Yukon-Charley Rivers NPRES	Noatak NPRES	Grand Canyon NP	
	Parashant NM?	Grand Teton NP	
	Yukon-Charley Rivers NPRES	Great Basin NP	
		Kobuk Valley NP	
		Lake Mead NRA	
		Lewis and Clark NHT	
		Mojave NPRES	
		Natchez Trace PKWY	
		Noatak NPRES	
		Parashant NM?	
		Upper Delaware SRR	
		Whiskeytown NRA?	
		Wind Cave NP	
		Yellowstone NP	
		Yukon-Charley Rivers NPRES	

TABLE 12. NPS units with Mississippian paleontological resources.

Mississippian Overall		
Abraham Lincoln Birthplace NHP	Dinosaur NM	New River Gorge NP&PRES
Arches NP*?	Fort Donelson NB	Noatak NPRES
Big South Fork NRRA	Gates of the Arctic NP&PRES	Parashant NM
Bighorn Canyon NRA	Gateway Arch NP	Pea Ridge NMP
Buffalo NR	Grand Canyon NP	Russell Cave NM
Cape Krusenstern NM	Grand Teton NP	Timpanogos Cave NM
Chickamauga and Chattanooga NMP?	Jewel Cave NM	Ulysses S Grant NHS
Chickasaw NRA	Kobuk Valley NP	Whiskeytown NRA
Craters of the Moon NM&PRES	Lake Mead NRA	Wilson's Creek NB
Cumberland Gap NHP	Mammoth Cave NP	Wind Cave NP
Cuyahoga Valley NP	Mill Springs Battlefield NM	Wrangell-St. Elias NP&PRES
Death Valley NP	Mojave NPRES	Yellowstone NP
Denali NP&PRES	Natchez Trace PKWY	Yukon-Charley Rivers NPRES

TABLE 13. NPS records by division of the Mississippian.

Early Mississippian	Middle Mississippian	Late Mississippian	Undivided Mississippian
Abraham Lincoln Birthplace NHP	Abraham Lincoln Birthplace NHP	Big South Fork NRRA	Arches NP*?
Bighorn Canyon NRA	Bighorn Canyon NRA	Bighorn Canyon NRA	Cape Krusenstern NM
Buffalo NR	Buffalo NR	Buffalo NR	Craters of the Moon NM&PRES
Cape Krusenstern NM	Chickamauga and Chattanooga NMP?	Chickamauga and Chattanooga NMP?	Cumberland Gap NHP?
Chickasaw NRA	Chickasaw NRA	Chickasaw NRA	Denali NP&PRES
Cuyahoga Valley NP	Cumberland Gap NHP	Cumberland Gap NHP	Gates of the Arctic NP&PRES
Death Valley NP	Death Valley NP	Death Valley NP	Kobuk Valley NP
Dinosaur NM	Dinosaur NM	Dinosaur NM	Lake Mead NRA*
Gates of the Arctic NP&PRES	Fort Donelson NB	Gates of the Arctic NP&PRES	Natchez Trace PKWY?
Grand Canyon NP	Gateway Arch NP	Grand Canyon NP	Noatak NPRES
Grand Teton NP	Grand Canyon NP	Grand Teton NP	Whiskeytown NRA
Jewel Cave NM	Grand Teton NP	Lake Mead NRA	Wrangell-St. Elias NP&PRES
Kobuk Valley NP	Lake Mead NRA	Mammoth Cave NP	
Lake Mead NRA	Mammoth Cave NP	New River Gorge NP&PRES	
Mill Springs Battlefield NM?	Mill Springs Battlefield NM?	Parashant NM	
Mojave NPRES	Mojave NPRES	Russell Cave NM	
Natchez Trace PKWY	Natchez Trace PKWY	Wrangell-St. Elias NP&PRES	
Noatak NPRES	Parashant NM	Yellowstone NP	
Parashant NM	Pea Ridge NMP	Yukon-Charley Rivers NPRES	
Timpanogos Cave NM	Russell Cave NM		
Wilson's Creek NB	Timpanogos Cave NM		
Wind Cave NP	Ulysses S Grant NHS		
Yellowstone NP	Yellowstone NP		
Yukon-Charley Rivers NPRES	Yukon-Charley Rivers NPRES		

TABLE 14. NPS units with Pennsylvanian paleontological resources.

Pennsylvanian Overall		
Allegheny Portage Railroad NHS	Dinosaur NM	Little River Canyon NPRES
Arches NP	Flight 93 NMEM	Mojave NPRES
Big South Fork NRRA	Fort Bowie NHS	New River Gorge NP&PRES
Bighorn Canyon NRA	Fort Necessity NB	Noatak NPRES Obed WSR
Buffalo NR	Gates of the Arctic NP&PRES	Parashant NM
Canyonlands NP	Gauley River NRA	Pecos NHP
Capitol Reef NP*	Glen Canyon NRA	Potomac Heritage NST
Chickasaw NRA	Golden Spike NHS	Russell Cave NM
Chiricahua NM	Grand Canyon NP	Santa Fe NHT
Coronado NMEM?	Grand Teton NP	Wind Cave NP
Cumberland Gap NHP	Great Sand Dunes NP&PRES	Wrangell-St. Elias NP&PRES
Death Valley NP	Jewel Cave NM	Yellowstone NP
Denali NP&PRES	Lake Mead NRA	Yukon-Charley Rivers NPRES

TABLE 15. NPS records by division of the Pennsylvanian.

Early Pennsylvanian	Middle Pennsylvanian	Late Pennsylvanian	Undivided Pennsylvanian
Big South Fork NRRA	Arches NP	Arches NP	Allegheny Portage Railroad NHS
Bighorn Canyon NRA	Big South Fork NRRA	Bighorn Canyon NRA	Big South Fork NRRA
Buffalo NR	Bighorn Canyon NRA	Canyonlands NP	Capitol Reef NP*
Capitol Reef NP*	Canyonlands NP	Chiricahua NM	Denali NP&PRES
Cumberland Gap NHP	Capitol Reef NP*	Coronado NMEM?	Gates of the Arctic NP&PRES
Death Valley NP	Chickasaw NRA	Death Valley NP	Golden Spike NHS
Denali NP&PRES	Cumberland Gap NHP	Dinosaur NM	Jewel Cave NM
Dinosaur NM	Death Valley NP	Flight 93 NMEM	Noatak NPRES
Gates of the Arctic NP&PRES	Dinosaur NM	Fort Bowie NHS	Potomac Heritage NST
Grand Canyon NP	Flight 93 NMEM	Fort Necessity NB	Santa Fe NHT
Grand Teton NP	Gauley River NRA	Glen Canyon NRA	Wind Cave NP
Lake Mead NRA	Glen Canyon NRA	Grand Canyon NP	Wrangell-St. Elias NP&PRES
Little River Canyon NPRES	Grand Canyon NP	Grand Teton NP	Yukon-Charley Rivers NPRES
Mojave NPRES	Grand Teton NP	Lake Mead NRA	
New River Gorge NP&PRES	Great Sand Dunes NP&PRES	Mojave NPRES	
Noatak NPRES	Lake Mead NRA	Parashant NM	
Obed WSR	Mojave NPRES	Pecos NHP	
Parashant NM	New River Gorge NP&PRES	Wrangell-St. Elias NP&PRES	
Russell Cave NM	Obed WSR		
Wrangell-St. Elias NP&PRES	Parashant NM		
Yellowstone NP	Pecos NHP		
	Wrangell-St. Elias NP&PRES		
	Yellowstone NP		

TABLE 16. NPS units with Permian paleontological resources.

Permian Overall		
Alibates Flint Quarries NM	Fort Bowie NHS?	Parashant NM
Bryce Canyon NP*	Gates of the Arctic NP&PRES	Pecos NHP
Canyon de Chelly NM	Glacier Bay NP&PRES	Petrified Forest NP*
Canyonlands NP	Glen Canyon NRA	Salinas Pueblo Missions NM
Cape Krusenstern NM	Grand Canyon NP	Santa Fe NHT
Capitol Reef NP	Grand Teton NP	Tallgrass Prairie NPRES
Carlsbad Caverns NP	Guadalupe Mountains NP	Walnut Canyon NM
Chiricahua NM	Jewel Cave NM	Wind Cave NP
Coronado NMEM?	Kenai Fjords NP	Wrangell-St. Elias NP&PRES
Death Valley NP	Lake Mead NRA	Wupatki NM
Denali NP&PRES	Mojave NPRES	Yellowstone NP
Dinosaur NM	Natural Bridges NM	Yukon-Charley Rivers NPRES
El Malpais NM	Noatak NPRES	Zion NP

TABLE 17. NPS records by division of the Permian.

Early Permian	Early Permian (cont.)	Middle Permian	Undivided Permian
Canyon de Chelly NM	Lake Mead NRA	Carlsbad Caverns NP	
Canyonlands NP	Mojave NPRES	Chiricahua NM	
Capitol Reef NP	Natural Bridges NM	Coronado NMEM?	Bryce Canyon NP*
Chiricahua NM	Noatak NPRES	Death Valley NP	Cape Krusenstern NM
Coronado NMEM?	Parashant NM	Denali NP&PRES	Capitol Reef NP*
Death Valley NP	Pecos NHP	Dinosaur NM	Denali NP&PRES
Denali NP&PRES	Petrified Forest NP*	El Malpais NM	Gates of the Arctic NP&PRES
Dinosaur NM	Salinas Pueblo Missions NM	Grand Teton NP	Guadalupe Mountains NP
El Malpais NM	Tallgrass Prairie NPRES	Guadalupe Mountains NP	Kenai Fjords NP
Fort Bowie NHS?	Walnut Canyon NM	Salinas Pueblo Missions NM	Noatak NPRES
Gates of the Arctic NP&PRES	Wind Cave NP	Yellowstone NP	Santa Fe NHT
Glacier Bay NP&PRES	Wrangell-St. Elias NP&PRES	Yukon-Charley Rivers NPRES	Wrangell-St. Elias NP&PRES
Glen Canyon NRA	Wupatki NM	**Late Permian**	Yukon-Charley Rivers NPRES
Grand Canyon NP	Yellowstone NP	Alibates Flint Quarries NM?	
Grand Teton NP	Yukon-Charley Rivers NPRES		
Guadalupe Mountains NP	Zion NP		
Jewel Cave NM			

TABLE 18. NPS units with Triassic paleontological resources.

Triassic Overall		
Arches NP	Grand Teton NP	
Canyon de Chelly NM	Katmai NP&PRES?	Petrified Forest NP
Canyonlands NP	Lake Clark NP&PRES	Petroglyph NM*
Capitol Reef NP	Lake Mead NRA	Pipe Spring NM*
Chesapeake and Ohio Canal NHP	Lake Meredith NRA	Sequoia-Kings Canyon NP
Colorado NM	Manassas NBP	Wrangell-St. Elias NP&PRES
Denali NP&PRES	Mojave NPRES	Wupatki NM
Dinosaur NM	Natural Bridges NM*	Yellowstone NP
Gates of the Arctic NP&PRES	Noatak NPRES	Yukon-Charley Rivers NPRES
Glen Canyon NRA	North Cascades NP Complex	Zion NP
Grand Canyon NP	Pecos NHP*	

TABLE 19. NPS records by division of the Triassic.

Early Triassic	Late Triassic	Late Triassic (cont.)
Arches NP	Arches NP	
Canyonlands NP	Canyon de Chelly NM	
Capitol Reef NP	Canyonlands NP	
Denali NP&PRES	Capitol Reef NP	Wupatki NM
Dinosaur NM	Chesapeake and Ohio Canal NHP	Yellowstone NP
Glen Canyon NRA	Colorado NM	Yukon-Charley Rivers NPRES
Grand Teton NP	Denali NP&PRES	Zion NP
Lake Mead NRA	Dinosaur NM	
Mojave NPRES	Gates of the Arctic NP&PRES	
Yellowstone NP	Glen Canyon NRA	
Zion NP	Grand Canyon NP	
Middle Triassic	Katmai NP&PRES?	**Undivided Triassic**
Arches NP	Lake Clark NP&PRES	
Canyonlands NP	Lake Mead NRA	
Capitol Reef NP	Lake Meredith NRA	
Dinosaur NM	Manassas NBP	
Gates of the Arctic NP&PRES	Natural Bridges NM*	Denali NP&PRES
Glen Canyon NRA	Noatak NPRES	Noatak NPRES
Grand Canyon NP	North Cascades NP Complex	Petroglyph NM*
Lake Mead NRA	Pecos NHP*	
Wrangell-St. Elias NP&PRES	Petrified Forest NP	
Wupatki NM	Pipe Spring NM*	
Yukon-Charley Rivers NPRES	Sequoia-Kings Canyon NP	
Zion NP	Wrangell-St. Elias NP&PRES	

TABLE 20. NPS units with Jurassic paleontological resources.

Jurassic Overall		
Aniakchak NM&PRES	Dinosaur NM	Pipe Spring NM
Arches NP	Gates of the Arctic NP&PRES	Rainbow Bridge NM
Bighorn Canyon NRA	Glen Canyon NRA	Redwood NP
Black Canyon of the Gunnison NP	Golden Gate NRA	Santa Monica Mountains NRA?
Canyonlands NP	Grand Teton NP	Sequoia-Kings Canyon NP
Cape Hatteras NS†	John D. Rockefeller, Jr. MEM PKWY	Springfield Armory NHS (historical association)
Cape Krusenstern NM	Katmai NP&PRES	Wind Cave NP
Capitol Reef NP	Lake Clark NP&PRES	Wrangell-St. Elias NP&PRES
Colorado NM	Lake Mead NRA	Yellowstone NP
Curecanti NRA	Noatak NPRES	Yukon-Charley Rivers NPRES
Death Valley NP	Old Spanish NHT (historical association)	Zion NP
Denali NP&PRES		
Devils Tower NM		

TABLE 21. NPS records by division of the Jurassic.

Early Jurassic	Middle Jurassic	Late Jurassic	Undivided Jurassic
Arches NP	Bighorn Canyon NRA	Aniakchak NM&PRES	Cape Krusenstern NM
Canyonlands NP	Black Canyon of the Gunnison NP	Arches NP	Denali NP&PRES
Capitol Reef NP	Capitol Reef NP	Bighorn Canyon NRA	Katmai NP&PRES
Colorado NM	Colorado NM	Black Canyon of the Gunnison NP	Noatak NPRES
Death Valley NP	Devils Tower NM	Cape Hatteras NS†	Yukon-Charley Rivers NPRES
Denali NP&PRES	Dinosaur NM	Capitol Reef NP	
Dinosaur NM	Gates of the Arctic NP&PRES	Colorado NM	
Gates of the Arctic NP&PRES	Glen Canyon NRA	Curecanti NRA	
Glen Canyon NRA	Golden Gate NRA	Denali NP&PRES	
Golden Gate NRA	Grand Teton NP	Devils Tower NM	
Lake Clark NP&PRES	John D. Rockefeller, Jr. MEM PKWY	Dinosaur NM	
Lake Mead NRA	Katmai NP&PRES?	Glen Canyon NRA	
Noatak NPRES	Lake Clark NP&PRES	Golden Gate NRA	
Pipe Spring NM	Noatak NPRES	Grand Teton NP	
Rainbow Bridge NM	Wind Cave NP	John D. Rockefeller, Jr. MEM PKWY	
Sequoia-Kings Canyon NP	Wrangell-St. Elias NP&PRES	Katmai NP&PRES	
Springfield Armory NHS (historical association)	Yellowstone NP	Lake Clark NP&PRES	
Wrangell-St. Elias NP&PRES	Zion NP	Old Spanish NHT (historical association)	
Zion NP		Redwood NP	
		Santa Monica Mountains NRA?	
		Wind Cave NP	
		Wrangell-St. Elias NP&PRES	
		Yellowstone NP	

TABLE 22. NPS units with Cretaceous paleontological resources.

Cretaceous Overall		
Amistad NRA	El Camino Real de los Tejas NHT	Lewis & Clark NHT (historical association)
Aniakchak NM&PRES	El Malpais NM	Little Bighorn Battlefield NM
Arches NP	Fire Island NS†	Mesa Verde NP
Badlands NP	Fort Foote Park	Mississippi NRRA*
Baltimore-Washington PKWY	Fort McHenry NM and Historic Shrine†	Missouri NRR
Bent's Old Fort NHS	Fort Sumter and Fort Moultrie NHP†	Natchez Trace PKWY
Big Bend NP	Fort Washington Park	New Jersey Pinelands NRES‡†
Bighorn Canyon NRA	Gates of the Arctic NP&PRES	Noatak NPRES
Black Canyon of the Gunnison NP	Gateway NRA†	Old Spanish NHT
Brices Cross Roads NBS	George Washington Birthplace NM†	Oxon Run PKWY
Bryce Canyon NP	Glacier NP	President's Park (White House)†
Buck Island Reef NM	Glen Canyon NRA	Prince William Forest Park
Cabrillo NM	Golden Gate NRA	Redwood NP
Cape Hatteras NS†	Grand Teton NP	Richmond NBP
Cape Krusenstern NM	Greenbelt Park	Rio Grande WSR
Capitol Reef NP	Gulf Islands NS*	Rock Creek Park
Chaco Culture NHP	John D. Rockefeller, Jr. MEM PKWY	Salt River Bay NHP and Ecological Preserve
Channel Islands NP	John Day Fossil Beds NM	Santa Fe NHT
Chiricahua NM	Katmai NP&PRES	Santa Monica Mountains NRA
Colonial NHP†	Kobuk Valley NP	Virgin Islands NP
Colorado NM	Lake Clark NP&PRES	Wind Cave NP
Congaree NP†	Lake Meredith NRA*	Wrangell-St. Elias NP&PRES
Curecanti NRA		Yellowstone NP
Denali NP&PRES		Yucca House NM
Devils Tower NM*?		Yukon-Charley Rivers NPRES
Dinosaur NM		Zion NP

TABLE 23. NPS records by division of the Cretaceous.

Early Cretaceous	Late Cretaceous	Late Cretaceous (cont.)
Amistad NRA	Amistad NRA	Little Bighorn Battlefield NM
Arches NP	Aniakchak NM&PRES	Mesa Verde NP
Baltimore-Washington PKWY	Arches NP	Mississippi NRRA*
Big Bend NP	Badlands NP	Missouri NRR
Bighorn Canyon NRA	Baltimore-Washington PKWY	Natchez Trace PKWY
Black Canyon of the Gunnison NP	Bent's Old Fort NHS	New Jersey Pinelands NRES‡†
Cape Hatteras NS†	Big Bend NP	Old Spanish NHT
Cape Krusenstern NM	Bighorn Canyon NRA?	Oxon Run PKWY
Capitol Reef NP	Black Canyon of the Gunnison NP	Prince William Forest Park
Chiricahua NM	Brices Cross Roads NBS	Redwood NP
Colorado NM	Bryce Canyon NP	Rio Grande WSR
Curecanti NRA	Buck Island Reef NM	Rock Creek Park
Denali NP&PRES	Cabrillo NM	Salt River Bay NHP and Ecological Preserve
Devils Tower NM*?	Cape Hatteras NS†	Santa Fe NHT
Dinosaur NM	Capitol Reef NP	Santa Monica Mountains NRA
El Malpais NM	Chaco Culture NHP	Virgin Islands NP
Fort Foote Park	Channel Islands NP	Wrangell-St. Elias NP&PRES
Fort McHenry NM and Historic Shrine†	Colorado NM	Yellowstone NP
Fort Washington Park	Congaree NP†	Yucca House NM
Gates of the Arctic NP&PRES	Curecanti NRA	Yukon-Charley Rivers NPRES
Glacier NP	Denali NP&PRES	Zion NP
Golden Gate NRA	Dinosaur NM	**Undivided Cretaceous**
Greenbelt Park	El Camino Real de los Tejas NHT	
John D. Rockefeller, Jr. MEM PKWY	El Malpais NM	
John Day Fossil Beds NM	Fire Island NS†	
Katmai NP&PRES	Fort Foote Park	
Kobuk Valley NP	Fort Sumter and Fort Moultrie NHP†	
Missouri NRR	Fort Washington Park	
Noatak NPRES	Gateway NRA†	
Oxon Run PKWY	George Washington Birthplace NM†	Colonial NHP†
President's Park (White House)†	Glacier NP	Golden Gate NRA
Prince William Forest Park	Glen Canyon NRA	Gulf Islands NS*
Richmond NBP	Golden Gate NRA	Lake Meredith NRA*
Rio Grande WSR?	Grand Teton NP	Redwood NP
Rock Creek Park	Greenbelt Park	
Santa Fe NHT	John D. Rockefeller, Jr. MEM PKWY	
Virgin Islands NP	Katmai NP&PRES	
Wind Cave NP	Lake Clark NP&PRES	
Wrangell-St. Elias NP&PRES	Lewis & Clark NHT (historical association)	
Yellowstone NP		
Yukon-Charley Rivers NPRES		
Zion NP		

TABLE 24. NPS units with Paleocene paleontological resources.

Paleocene Overall		
Big Bend NP	Fort Washington Park	Petersburg NB
Bryce Canyon NP	George Washington Birthplace NM†	Piscataway Park
Cedar Breaks NM	Golden Gate NRA	Santa Monica Mountains NRA
Channel Islands NP	Gulf Islands NS*	Suitland PKWY
Colonial NHP†	Katmai NP&PRES	Theodore Roosevelt NP
Denali NP&PRES	Lake Clark NP&PRES	Wrangell-St. Elias NP&PRES
Fort Pulaski NM†	Natchez Trace PKWY	Zion NP*
Fort Union Trading Post NHS*	New Jersey Pinelands NRES‡†	

TABLE 25. NPS records by division of the Paleocene.

Early Paleocene	**Late Paleocene**	**Undivided Paleocene**
Big Bend NP	Big Bend NP	Bryce Canyon NP
New Jersey Pinelands NRES‡†	Channel Islands NP	Cedar Breaks NM
Middle Paleocene	Colonial NHP†	Denali NP&PRES
Big Bend NP	Fort Union Trading Post NHS*	Fort Pulaski NM†
Channel Islands NP	Fort Washington Park	George Washington Birthplace NM†
New Jersey Pinelands NRES‡†	Lake Clark NP&PRES	Golden Gate NRA
Santa Monica Mountains NRA	Natchez Trace PKWY	Gulf Islands NS*
Theodore Roosevelt NP	New Jersey Pinelands NRES‡†	Katmai NP&PRES
	Petersburg NB	Santa Monica Mountains NRA
	Piscataway Park	Wrangell-St. Elias NP&PRES
	Santa Monica Mountains NRA	Zion NP*
	Suitland PKWY	
	Theodore Roosevelt NP	

TABLE 26. NPS units with Eocene paleontological resources.

Eocene Overall		
Aniakchak NM&PRES	El Camino Real de los Tejas NHT	Mount Rainier NP
Arches NP*	Florissant Fossil Beds NM	Natchez Trace PKWY?
Badlands NP	Fort Monroe NM†	New Jersey Pinelands NRES‡†
Big Bend NP	Fort Pulaski NM†	North Cascades NP Complex
Bryce Canyon NP	Fossil Butte NM	Olympic NP
Cape Cod NS*	Gateway NRA*?	Point Reyes NS
Cape Hatteras NS†	George Washington Birthplace NM†	Santa Monica Mountains NRA
Cedar Breaks NM	Glacier NP	Theodore Roosevelt NP
Channel Islands NP	John Day Fossil Beds NM	Wrangell-St. Elias NP&PRES
Colonial NHP†	Katmai NP&PRES	Yellowstone NP
Death Valley NP	Lake Clark NP&PRES	Yukon-Charley Rivers NPRES
Denali NP&PRES	Lewis and Clark NHP	Zion NP*

TABLE 27. NPS records by division of the Eocene.

Early Eocene	Middle Eocene	Late Eocene	Undivided Eocene
Big Bend NP	Big Bend NP	Aniakchak NM&PRES	Arches NP*
Bryce Canyon NP	Bryce Canyon NP	Badlands NP	Cape Cod NS*
Cape Hatteras NS†	Cape Hatteras NS†	Big Bend NP	Denali NP&PRES
Cedar Breaks NM	Cedar Breaks NM	Channel Islands NP	Fort Monroe NM†
Channel Islands NP	Channel Islands NP	Colonial NHP†	Gateway NRA*?
Colonial NHP†	Colonial NHP†	Death Valley NP	Glacier NP
Fort Pulaski NM†	El Camino Real de los Tejas NHT	Florissant Fossil Beds NM	Katmai NP&PRES
Fossil Butte NM	Fort Pulaski NM†	Fort Monroe NM†	New Jersey Pinelands NRES‡R†
George Washington Birthplace NM†	John Day Fossil Beds NM	Fort Pulaski NM†	North Cascades NP Complex
John Day Fossil Beds NM	Lewis and Clark NHP	John Day Fossil Beds NM	Yukon-Charley Rivers NPRES
Katmai NP&PRES	New Jersey Pinelands NRES‡†	Mount Rainier NP	
Lake Clark NP&PRES	Olympic NP	Natchez Trace PKWY?	
Lewis and Clark NHP	Santa Monica Mountains NRA	New Jersey Pinelands NRES‡†	
New Jersey Pinelands NRES‡†	Yellowstone NP	Olympic NP	
Olympic NP	Zion NP*	Santa Monica Mountains NRA	
Point Reyes NS		Wrangell-St. Elias NP&PRES	
Santa Monica Mountains NRA		Yellowstone NP*	
Theodore Roosevelt NP			
Wrangell-St. Elias NP&PRES			
Yellowstone NP			
Yukon-Charley Rivers NPRES			
Zion NP*			

TABLE 28. NPS units with Oligocene paleontological resources.

Oligocene Overall		
Aniakchak NM&PRES	Everglades NP†?	Mount Rainier NP
Badlands NP	Fort Pulaski NM†	New Jersey Pinelands NRES‡†
Big Bend NP	Glacier Bay NP&PRES	Olympic NP
Cape Hatteras NS†	Glacier NP	Parashant NM
Channel Islands NP	John Day Fossil Beds NM	Santa Monica Mountains NRA
Chimney Rock NHS‡	Katmai NP&PRES	Scotts Bluff NM
Colonial NHP†	Lake Clark NP&PRES	Vicksburg NMP
Cumberland Island NS†	Lake Mead NRA	Wind Cave NP
Death Valley NP	Lewis and Clark NHP	Wrangell-St. Elias NP&PRES
Denali NP&PRES		

TABLE 29. NPS records by division of the Oligocene.

Early Oligocene	Late Oligocene	Undivided Oligocene
Aniakchak NM&PRES	Badlands NP	
Badlands NP	Cumberland Island NS†	
Big Bend NP	Denali NP&PRES?	
Chimney Rock NHS‡	Everglades NP†?	Cape Hatteras NS†
Cumberland Island NS†	Fort Pulaski NM†	Channel Islands NP
Death Valley NP	Glacier Bay NP&PRES	Colonial NHP†
Everglades NP†?	John Day Fossil Beds NM	Denali NP&PRES
Glacier Bay NP&PRES	Katmai NP&PRES	Glacier NP
John Day Fossil Beds NM	Lake Mead NRA	Lake Clark NP&PRES
Mount Rainier NP	Lewis and Clark NHP	New Jersey Pinelands NRES‡†
New Jersey Pinelands NRES‡†	Mount Rainier NP	Olympic NP
Santa Monica Mountains NRA	New Jersey Pinelands NRES‡†	Wrangell-St. Elias NP&PRES
Scotts Bluff NM	Parashant NM	
Vicksburg NMP	Santa Monica Mountains NRA	
Wind Cave NP	Scotts Bluff NM	

TABLE 30. NPS units with Miocene paleontological resources.

Miocene Overall		
Agate Fossil Beds NM	George Washington Birthplace NM	Nez Perce NHP
Alibates Flint Quarries NM	Glacier Bay NP&PRES	Niobrara NSR
Bering Land Bridge NPRES	Golden Gate NRA	Olympic NP
Big Bend NP	Grand Teton NP	Oxon Cove Park & Oxon Hill Farm*
Big Thicket NPRES?	Harriet Tubman Underground Railroad NHP†	Parashant NM
Cape Hatteras NS†	John Day Fossil Beds NM	Petrified Forest NP
Cape Lookout NS†	Joshua Tree NP	Pinnacles NP
Channel Islands NP	Lake Clark NP&PRES	Point Reyes NS
Colonial NHP	Lake Mead NRA	Redwood NP
Cumberland Island NS*†	Lake Meredith NRA	Salt River Bay NHP and Ecological Preserve
Death Valley NP	Lewis and Clark NHP	Santa Monica Mountains NRA
Denali NP&PRES	Mojave NPRES	Scotts Bluff NM
Everglades NP†?	Montezuma Castle NM	Suitland PKWY
Fort Dupont Park*	Mount Rainier NP	Tuzigoot NM
Fort Monroe NM†	New Jersey Pinelands NRES‡	Wrangell-St. Elias NP&PRES
Fort Pulaski NM†		

TABLE 31. NPS records by division of the Miocene.

Early Miocene	Middle Miocene	Late Miocene
Agate Fossil Beds NM	Alibates Flint Quarries NM	Alibates Flint Quarries NM
Big Bend NP	Big Thicket NPRES?	Big Bend NP
Big Thicket NPRES?	Cape Hatteras NS†	Cape Hatteras NS†
Cape Hatteras NS†	Cape Lookout NS†	Colonial NHP
Cape Lookout NS†	Channel Islands NP	Cumberland Island NS†
Channel Islands NP	Colonial NHP†	Death Valley NP
Colonial NHP†	Cumberland Island NS†	Fort Dupont Park*
Cumberland Island NS†	Death Valley NP	Fort Monroe NM†
Death Valley NP	Fort Monroe NM†	Fort Pulaski NM†
Denali NP&PRES?	Fort Pulaski NM†	Glacier Bay NP&PRES
Fort Monroe NM†	George Washington Birthplace NM	Golden Gate NRA
Fort Pulaski NM†	Glacier Bay NP&PRES	Grand Teton NP
George Washington Birthplace NM	Grand Teton NP	John Day Fossil Beds NM
Glacier Bay NP&PRES	Harriet Tubman Underground Railroad NHP†	Joshua Tree NP
Grand Teton NP	John Day Fossil Beds NM	Lake Mead NRA
Harriet Tubman Underground Railroad NHP†	Lake Clark NP&PRES	Lake Meredith NRA
John Day Fossil Beds NM	Lake Mead NRA	Montezuma Castle NM
Lake Clark NP&PRES	Lake Meredith NRA	New Jersey Pinelands NRES‡†
Lake Mead NRA	Lewis and Clark NHP	Niobrara NSR
Lewis and Clark NHP	Montezuma Castle NM	Oxon Cove Park & Oxon Hill Farm*
Mojave NPRES	New Jersey Pinelands NRES‡	Petrified Forest NP
Mount Rainier NP	Nez Perce NHP	Point Reyes NS
New Jersey Pinelands NRES‡†	Niobrara NSR	Redwood NP
Parashant NM	Point Reyes NS	Salt River Bay NHP and Ecological Preserve?
Santa Monica Mountains NRA	Salt River Bay NHP and Ecological Preserve?	Santa Monica Mountains NRA
Scotts Bluff NM	Santa Monica Mountains NRA	Tuzigoot NM
Suitland PKWY	Suitland PKWY	Wrangell-St. Elias NP&PRES
Wrangell-St. Elias NP&PRES	Tuzigoot NM	**Undivided Miocene**
	Wrangell-St. Elias NP&PRES	Bering Land Bridge NPRES
		Cape Lookout NS†?
		Cumberland Island NS*
		Denali NP&PRES
		Everglades NP†?
		Olympic NP
		Pinnacles NP

TABLE 32. NPS units with Pliocene paleontological resources.

Pliocene Overall		
Alibates Flint Quarries NM	Death Valley NP	Lake Meredith NRA
Bering Land Bridge NPRES	Denali NP&PRES	Montezuma Castle NM
Big Bend NP	Everglades NP†	Petersburg NB
Big Cypress NPRES	Fort Monroe NM†	Petrified Forest NP
Big Thicket NPRES	Glacier Bay NP&PRES	Point Reyes NS
Cape Cod NS*?	Golden Gate NRA	Redwood NP
Cape Lookout NS†	Gulf Islands NS†	Santa Monica Mountains NRA
Colonial NHP	Hagerman Fossil Beds NM	Tuzigoot NM
Cumberland Island NS†*	Lake Mead NRA	Wrangell-St. Elias NP&PRES

TABLE 33. NPS records by division of the Pliocene.

Early Pliocene	**Late Pliocene**	**Undivided Pliocene**
Alibates Flint Quarries NM	Big Cypress NPRES	Bering Land Bridge NPRES
Colonial NHP	Big Thicket NPRES	Big Bend NP
Death Valley NP	Colonial NHP	Cape Cod NS*?
Everglades NP†?	Cumberland Island NS†	Cape Hatteras NS†
Fort Monroe NM†	Death Valley NP	Cape Lookout NS†
Glacier Bay NP&PRES	Everglades NP†	Cumberland Island NS*
Hagerman Fossil Beds NM	Fort Monroe NM†	Denali NP&PRES
Lake Mead NRA	Golden Gate NRA	Golden Gate NRA
Lake Meredith NRA	Hagerman Fossil Beds NM	Gulf Islands NS†
Petersburg NB	Petersburg NB	Lake Mead NRA
Petrified Forest NP	Point Reyes NS	Montezuma Castle NM
Point Reyes NS	Redwood NP	Tuzigoot NM
Redwood NP	Santa Monica Mountains NRA	Wrangell-St. Elias NP&PRES

TABLE 34. NPS units with Pleistocene paleontological resources.

Pleistocene Overall		
Acadia NP	El Malpais NM	Natchez Trace PKWY
Aleutian World War II NHA‡	Everglades NP	National Mall and Memorial Parks
Arches NP	Fire Island NS†	Natural Bridges NM
Assateague Island NS†	Florissant Fossil Beds NM	New Jersey Pinelands NRES‡
Bent's Old Fort NHS	Fort Matanzas NM	Nez Perce NHP
Bering Land Bridge NPRES	Fort McHenry NM and Historic Shrine†?	Niobrara NSR
Big Bend NP	Fort Sumter and Fort Moultrie NHP	Noatak NPRES
Big Cypress NPRES	Gates of the Arctic NP&PRES	North Cascades NP Complex
Big Thicket NPRES	Gateway NRA	Olympic NP
Bighorn Canyon NRA	Glacier Bay NP&PRES	Oregon Caves NM&PRES
Biscayne NP	Glacier NP	Organ Pipe Cactus NM
Boston Harbor Islands NRA	Glen Canyon NRA	Ozark NSR
Buck Island Reef NM	Golden Gate NRA	Padre Island NS
Buffalo NR	Grand Canyon NP	Point Reyes NS
Cabrillo NM	Grand Teton NP	Potomac Heritage NST
Canaveral NS	Great Basin NP	Redwood NP
Canyon de Chelly NM	Great Sand Dunes NP&PRES	Russell Cave NM
Canyonlands NP	Guadalupe Mountains NP	Saguaro NP
Cape Cod NS	Hagerman Fossil Beds NM	Salinas Pueblo Missions NM
Cape Hatteras NS	Harriet Tubman Underground Railroad NHP†	San Juan Island NHP
Cape Krusenstern NM	Ice Age National Scientific Reserve‡	Santa Monica Mountains NRA
Cape Lookout NS	Joshua Tree NP	Shenandoah NP
Capitol Reef NP	Katmai NP&PRES	Theodore Roosevelt NP
Carlsbad Caverns NP	Kenai Fjords NP	Tule Springs Fossil Beds NM
Cedar Breaks NM	Kobuk Valley NP	Valles Caldera NPRES
Chaco Culture NHP	Lake Mead NRA	Valley Forge NHP
Channel Islands NP	Lake Meredith NRA	Vicksburg NMP
City of Rocks NRES	Lassen Volcanic NP	Waco Mammoth NM
Colonial NHP	Lava Beds NM	White Sands NP
Congaree NP	Lewis and Clark NHT	Wind Cave NP
Crater Lake NP	Mammoth Cave NP	Wupatki NM
Craters of the Moon NM&PRES	Mississippi NRRA	Yellowstone NP
Cumberland Island NS*	Missouri NRR	Yosemite NP
Death Valley NP	Mojave NPRES	Yukon-Charley Rivers NPRES
Denali NP&PRES	Montezuma Castle NM	Zion NP
Dry Tortugas NP		
Ebey's Landing NHRES		
El Camino Real de los Tejas NHT		

TABLE 35. NPS records by division of the Pleistocene.

Early Pleistocene	Late Pleistocene	Late Pleistocene (cont.)	Undivided Pleistocene
Big Bend NP	Acadia NP	Great Basin NP	
Big Cypress NPRES	Arches NP	Guadalupe Mountains NP	
Big Thicket NPRES	Assateague Island NS†	Hagerman Fossil Beds NM	Aleutian World War II NHA‡
Channel Islands NP	Bering Land Bridge NPRES	Harriet Tubman Underground Railroad NHP†	Bent's Old Fort NHS
Death Valley NP	Big Bend NP	Ice Age National Scientific Reserve‡	Bering Land Bridge NPRES
Golden Gate NRA	Big Cypress NPRES	Joshua Tree NP	Buck Island Reef NM
Hagerman Fossil Beds NM	Bighorn Canyon NRA	Katmai NP&PRES	Buffalo NR
Mammoth Cave NP	Biscayne NP	Kenai Fjords NP	Cape Cod NS*
Potomac Heritage NST	Boston Harbor Islands NRA	Lake Mead NRA	Cape Hatteras NS
Santa Monica Mountains NRA	Cabrillo NM	Lassen Volcanic NP	Cedar Breaks NM
Valles Caldera NPRES	Canaveral NS	Lewis and Clark NHT	Channel Islands NP
Valley Forge NHP	Canyon de Chelly NM	Mammoth Cave NP	Cumberland Island NS*
Yellowstone NP	Canyonlands NP	Mississippi NRRA	Death Valley NP
Middle Pleistocene	Cape Cod NS	Missouri NRR	Denali NP&PRES
	Cape Hatteras NS	Mojave NPRES	Fort McHenry NM and Historic Shrine†?
	Cape Krusenstern NM	Montezuma Castle NM	Gates of the Arctic NP&PRES
	Cape Lookout NS	National Mall and Memorial Parks	Gateway NRA
	Capitol Reef NP	Natural Bridges NM	Golden Gate NRA
	Carlsbad Caverns NP	Nez Perce NHP	Great Sand Dunes NP&PRES
	Chaco Culture NHP	Niobrara NSR	Guadalupe Mountains NP
	Channel Islands NP	Noatak NPRES	Kobuk Valley NP
Arches NP	City of Rocks NRES	North Cascades NP Complex	Lake Mead NRA
Big Cypress NPRES	Colonial NHP	Olympic NP	Lake Meredith NRA
Biscayne NP	Congaree NP	Oregon Caves NM&PRES	Lava Beds NM
Canaveral NS	Crater Lake NP	Organ Pipe Cactus NM	Natchez Trace PKWY
Carlsbad Caverns NP	Craters of the Moon NM&PRES	Ozark NSR	New Jersey Pinelands NRES‡
Death Valley NP	Death Valley NP	Padre Island NS	Noatak NPRES
Dry Tortugas NP	Dry Tortugas NP	Point Reyes NS	Oregon Caves NM&PRES
Everglades NP	Ebey's Landing NHRES	Saguaro NP	Point Reyes NS
Fort Matanzas NM	El Camino Real de los Tejas NHT	San Juan Island NHP	Redwood NP
Mammoth Cave NP	El Malpais NM	Santa Monica Mountains NRA	Russell Cave NM
Mojave NPRES	Everglades NP	Shenandoah NP	Salinas Pueblo Missions NM
Potomac Heritage NST	Fire Island NS†	Theodore Roosevelt NP	Santa Monica Mountains NRA
Tule Springs Fossil Beds NM	Florissant Fossil Beds NM	Tule Springs Fossil Beds NM	Theodore Roosevelt NP
Valles Caldera NPRES	Fort Matanzas NM	Valles Caldera NPRES	Waco Mammoth NM†?
Valley Forge NHP	Fort Sumter and Fort Moultrie NHP	Vicksburg NMP	White Sands NP
Wind Cave NP	Gateway NRA*	Waco Mammoth NM	Wind Cave NP
Yellowstone NP	Glacier NP	White Sands NP	Yellowstone NP
	Glacier Bay NP&PRES	Wind Cave NP	Yukon-Charley Rivers NPRES
	Glen Canyon NRA	Wupatki NM	
	Golden Gate NRA	Yellowstone NP	
	Grand Canyon NP	Yosemite NP	
	Grand Teton NP	Zion NP	

TABLE 36. NPS units with Holocene paleontological resources.

Holocene		
Acadia NP	Fort Larned NHS	Mount Rainier NP
Apostle Islands NL	Fort Matanzas NM	Natural Bridges NM
Arches NP	Fort Pulaski NM	New Jersey Pinelands NRES‡†
Assateague Island NS	Fort Vancouver NHS	Nez Perce NHP
Bandelier NM	Gates of the Arctic NP&PRES	Noatak NPRES
Bering Land Bridge NPRES	Gateway NRA	North Cascades NP Complex
Big Bend NP	George Washington MEM PKWY	Ocmulgee NHP
Big Cypress NPRES?	George Washington Birthplace NM	Olympic NP
Bighorn Canyon NRA	Glacier Bay NP&PRES	Oregon Caves NM&PRES
Biscayne NP	Glacier NP	Organ Pipe Cactus NM
Boston Harbor Islands NRA	Glen Canyon NRA	Ozark NSR
Buck Island Reef NM	Golden Spike NHS	Padre Island NS
Canaveral NS	Grand Canyon NP	Palo Alto Battlefield NHP
Canyon de Chelly NM	Grand Teton NP	Parashant NM
Canyonlands NP	Great Basin NP	Pictured Rocks NL
Cape Cod NS	Great Sand Dunes NP&PRES	Point Reyes NS
Cape Hatteras NS	Great Smoky Mountains NP	Pu‘uhonua O Hōnaunau NHP
Cape Krusenstern NM	Guadalupe Mountains NP	Redwood NP
Capitol Reef NP	Gulf Islands NS	Rocky Mountain NP
Carlsbad Caverns NP	Haleakalā NP	Russell Cave NM
Cedar Breaks NM	Hawai‘i Volcanoes NP	Saint Croix NSR
Chaco Culture NHP	Ice Age National Scientific Reserve‡	Salt River Bay NHP and Ecological Preserve
Channel Islands NP	Indiana Dunes NP	San Juan Island NHP
City of Rocks NRES	Isle Royale NP	Santa Monica Mountains NRA
Colorado NM	John Day Fossil Beds NM	Sequoia-Kings Canyon NP
Colonial NHP	Joshua Tree NP	Shenandoah NP
Congaree NP	Katmai NP&PRES	Sitka NHP
Crater Lake NP	Kenai Fjords NP	Sleeping Bear Dunes NL
Craters of the Moon NM&PRES	Kobuk Valley NP	Tallgrass Prairie NPRES
Cumberland Island NS	Lake Mead NRA	Theodore Roosevelt NP
Curecanti NRA?	Lake Roosevelt NRA	Timpanogos Cave NM
Death Valley NP	Lassen Volcanic NP	Timucuan Ecological and Historic Preserve
Delaware Water Gap NRA	Lava Beds NM	Tule Springs Fossil Beds NM
Dinosaur NM	Mammoth Cave NP	Valles Caldera NPRES
Dry Tortugas NP	Marsh Billings Rockefeller NHP	Voyageurs NP
Ebey's Landing NHRES	Mesa Verde NP	Walnut Canyon NM
Effigy Mounds NM	Mississippi NRRA	Wind Cave NP
El Camino Real de los Tejas NHT	Missouri NRR	Wupatki NM
El Malpais NM	Mojave NPRES	Yellowstone NP
Everglades NP	Montezuma Castle NM	Yosemite NP
Fire Island NS		Zion NP
Fort Frederica NM		

TABLE 37. NPS units with paleontological resources of undivided Quaternary age.

Quaternary Undivided		
Acadia NP	Chickamauga and Chattanooga NMP	Jewel Cave NM
Amistad NRA	Colorado NM	Montezuma Castle NM
Arches NP	Cumberland Gap NHP	New Jersey Pinelands NRES‡
Badlands NP	El Malpais NM	Parashant NM
Canyonlands NP	Fossil Butte NM	Sequoia-Kings Canyon NP
Cape Cod NS*	Gila Cliff Dwellings NM	Timpanogos Cave NM
Cape Hatteras NS	Great Basin NP	White Sands NP
Cape Lookout NS	Herbert Hoover NHS	Yellowstone NP
Carlsbad Caverns NP	Hopewell Culture NHP	Zion NP

TABLE 38. NPS units with Quaternary paleontological resources.

Quaternary Overall
Acadia NP
Aleutian World War II NHA‡
Amistad NRA
Apostle Islands NL
Arches NP
Assateague Island NS
Badlands NP
Bandelier NM
Bent's Old Fort NHS
Bering Land Bridge NPRES
Big Bend NP
Big Cypress NPRES
Big Thicket NPRES
Bighorn Canyon NRA
Biscayne NP
Boston Harbor Islands NRA
Buck Island Reef NM
Buffalo NR
Cabrillo NM
Canaveral NS
Canyon de Chelly NM
Canyonlands NP
Cape Cod NS
Cape Hatteras NS
Cape Krusenstern NM
Cape Lookout NS
Capitol Reef NP
Carlsbad Caverns NP
Cedar Breaks NM
Chaco Culture NHP
Channel Islands NP
Chickamauga and Chattanooga NMP
City of Rocks NRES
Colonial NHP
Colorado NM
Congaree NP
Crater Lake NP
Craters of the Moon NM&PRES
Cumberland Gap NHP
Cumberland Island NS
Curecanti NRA?
Death Valley NP
Delaware Water Gap NRA
Denali NP&PRES
Dinosaur NM
Dry Tortugas NP
Ebey's Landing NHRES
Effigy Mounds NM
El Camino Real de los Tejas NHT
El Malpais NM
Everglades NP
Fire Island NS
Florissant Fossil Beds NM
Fort Frederica NM
Fort Larned NHS Fort Matanzas NM
Fort McHenry NM and Historic Shrine†?
Fort Pulaski NM
Fort Sumter and Fort Moultrie NHP
Fort Vancouver NHS
Fossil Butte NM
Gates of the Arctic NP&PRES
Gateway NRA
George Washington Birthplace NM
George Washington MEM PKWY
Gila Cliff Dwellings NM
Glacier Bay NP&PRES
Glacier NP
Glen Canyon NRA
Golden Gate NRA
Golden Spike NHS
Grand Canyon NP
Grand Teton NP
Great Basin NP
Great Sand Dunes NP&PRES
Great Smoky Mountains NP
Guadalupe Mountains NP
Gulf Islands NS
Hagerman Fossil Beds NM
Haleakalā NP
Harriet Tubman Underground Railroad NHP†
Hawai‘i Volcanoes NP
Herbert Hoover NHS
Hopewell Culture NHP
Ice Age National Scientific Reserve‡
Indiana Dunes NP
Isle Royale NP
Jewel Cave NM
John Day Fossil Beds NM
Joshua Tree NP
Katmai NP&PRES
Kenai Fjords NP
Kobuk Valley NP
Lake Mead NRA
Lake Meredith NRA
Lake Roosevelt NRA
Lassen Volcanic NP
Lava Beds NM
Mammoth Cave NP
Marsh Billings Rockefeller NHP
Mesa Verde NP
Mississippi NRRA
Missouri NRR
Mojave NPRES
Montezuma Castle NM
Mount Rainier NP
Natchez Trace PKWY
National Mall and Memorial Parks
Natural Bridges NM
New Jersey Pinelands NRES‡†
Nez Perce NHP
Niobrara NSR
Noatak NPRES
North Cascades NP Complex
Ocmulgee NHP
Olympic NP
Oregon Caves NM&PRES
Organ Pipe Cactus NM
Ozark NSR
Padre Island NS
Palo Alto Battlefield NHP
Parashant NM
Pictured Rocks NL
Point Reyes NS
Potomac Heritage NST
Pu‘uhonua O Hōnaunau NHP
Redwood NP
Rocky Mountain NP
Russell Cave NM
Saguaro NP
Saint Croix NSR
Salinas Pueblo Missions NM
Salt River Bay NHP and Ecological Preserve
San Juan Island NHP
Santa Monica Mountains NRA
Sequoia-Kings Canyon NP
Shenandoah NP
Sitka NHP
Sleeping Bear Dunes NL
Tallgrass Prairie NPRES
Theodore Roosevelt NP
Timpanogos Cave NM
Timucuan Ecological and Historic Preserve
Tule Springs Fossil Beds NM
Valles Caldera NPRES
Valley Forge NHP
Vicksburg NMP
Voyageurs NP
Waco Mammoth NM
Walnut Canyon NM
White Sands NP
Wind Cave NP
Wupatki NM
Yellowstone NP
Yosemite NP
Yukon-Charley Rivers NPRES
Zion NP

TABLE 39. NPS units with paleontological resources of uncertain age.

Uncertain		
Aniakchak NM&PRES	Hovenweep NM	Padre Island NS*
Apostle Islands NL*	Ice Age NST	Perry's Victory & International Peace MEM*
Assateague Island NS*	Ice Age National Scientific Reserve‡*	Pictured Rocks NL*
Aztec Ruins NM*	Indiana Dunes NP*	Piscataway Park*?
Big Thicket NPRES	Isle Royale NP*	Santa Monica Mountains NRA*
Cape Cod NS*	Katmai NP&PRES	Sleeping Bear Dunes NL*
Cape Hatteras NS*	Lake Clark NP&PRES	Theodore Roosevelt NP
Chiricahua NM*	Lake Mead NRA	Thomas Edison NHP*?
Colonial NHP†	Lake Meredith NRA*	Tule Springs Fossil Beds NM*
Death Valley NP	Mojave NPRES*	War in the Pacific NHP
Devils Tower NM*	New Jersey Pinelands NRES‡*	Wind Cave NP
Fort Dupont Park*	Old Spanish NHT	Wrangell-St. Elias NP&PRES
Fort Stanwix NM*	Olympic NP	Yellowstone NP*
Fort Union Trading Post NHS*	Oregon Caves NM&PRES	Yosemite NP
Gates of the Arctic NP&PRES	Organ Pipe Cactus NM	Yukon-Charley Rivers NPRES
Great Smoky Mountains NP