Discovery, preservation, and protection of notable paleontological resources from Dinosaur National Monument, Utah and Colorado

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ABSTRACT

Dinosaur National Monument was established in 1915 to protect and preserve the globally significant paleontological resources of the Carnegie Dinosaur Quarry. The park was expanded in 1938 and now protects 210,844.02 acres in northeastern Utah and northwestern Colorado. Extensive inventory, monitoring, excavation, and research work has taken place in the monument, mostly focusing on the Late Jurassic-age Morrison Formation over the past 113 years since the Carnegie Quarry's discovery in 1909. This work has helped to increase not only our knowledge of the dinosaur fauna, but also of the less well-known reptiles, amphibians, mammals, invertebrates, and plant communities that lived alongside these Jurassic giants. To protect and preserve these notable fossil discoveries, Dinosaur National Monument has explored several approaches. Public tours of the Carnegie Quarry have taken place since its discovery in 1909. In the early 1950s the monument erected a temporary building over a portion of the remaining Carnegie Quarry to protect and display *in situ* fossils, with the more extensive permanent construction of the Quarry Visitor Center completed in 1958, including a fossil preparation laboratory and museum collections space. Over time this structure was affected by the constant movement of the bedrock, requiring its overhaul in the early 2000s, resulting in today's Quarry Exhibit Hall. The park's museum collections were recently relocated to a facility at the Utah Field House of Natural History State Park Museum, where new facilities and a preparation laboratory are available to accommodate these extensive fossil collections. Other *in situ* fossil resources in the park have been made accessible along the Fossil Discovery Trail, or through tours to active quarries. Most of the fossil resources in the park are not suited for *in situ* display and require traditional excavation and curation practices.

INTRODUCTION

Dinosaur National Monument (DINO) was the first national monument designated specifically to protect dinosaur fossils. As of 2023, 285 National Park Service (NPS) units have been found to contain fossils, with only 18 of these being specifically designated to protect fossils. Only 27 parks are known to protect and preserve dinosaur fossils (Tweet 2018). DINO is situated on the border of northeastern Utah and northwestern Colorado, protecting 210,844.02 acres of public land, spanning 24 geologic units and roughly 1 billion years of geologic time, from the Precambrian Uinta Mountain Group (up to about 1,000 million years ago) to the Miocene Browns Park Formation (about 25 to 10 million years ago).

The original park designation was made on October 24, 1915, by President Woodrow Wilson, who used his powers under the Antiquities Act to proclaim the Carnegie Quarry (sometimes also referred to as the Douglass Quarry or the Dinosaur Quarry) and the surrounding 80 acres as Dinosaur National Monument, stating that "there is located [in Utah] an extraordinary deposit of Dinosaurian and other gigantic reptilian remains of the Juratrias period, which

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are of great scientific interest and value, and it appears that the public interest would be promoted by reserving these deposits as a National Monument…" (Wilson 1915).

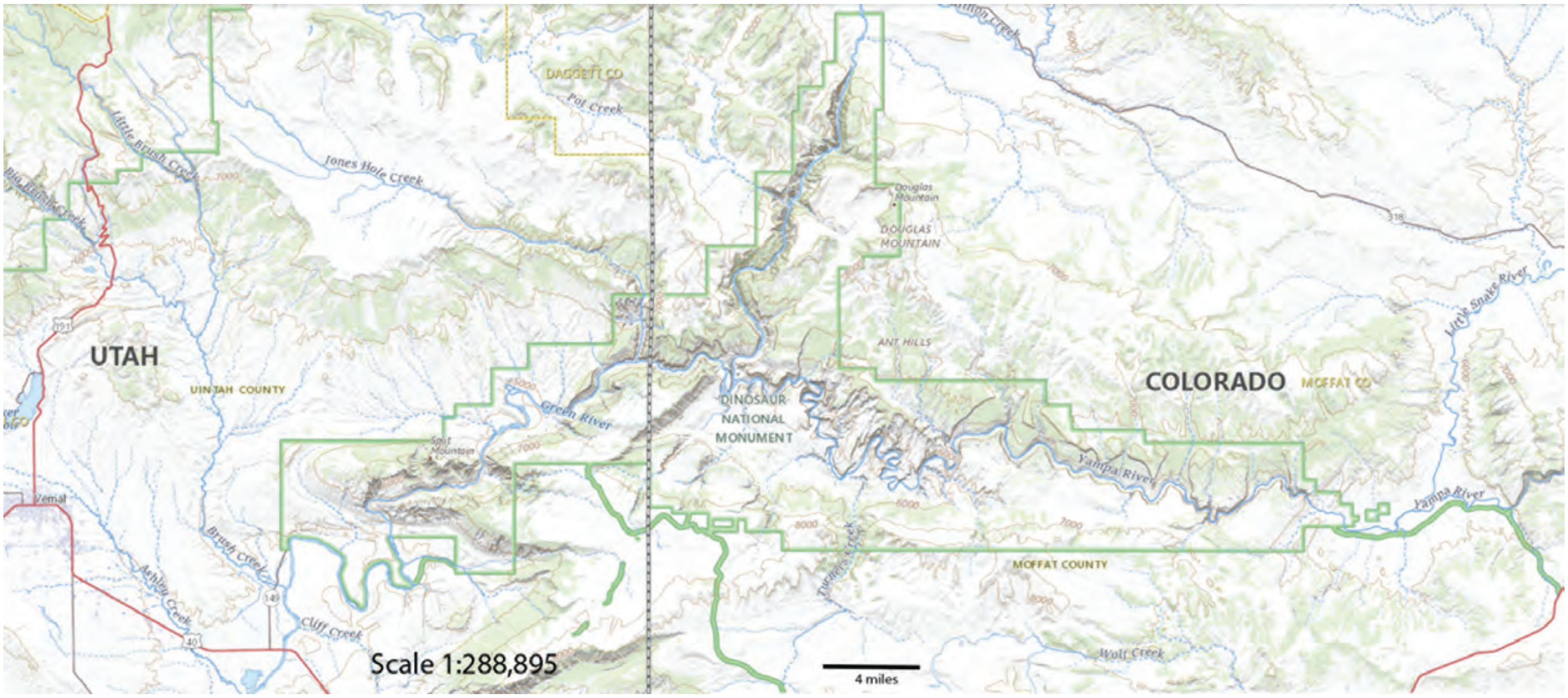
DINO would later be increased by another 200,000 acres by President Franklin Roosevelt on July 14, 1938, to protect the Green and Yampa river drainages (Figure 1). The monument has produced holotype (name-bearing) specimens for 16 scientifically accepted fossil vertebrate species (six dinosaurs, one crocodile, three lizards, two turtles, one salamander, one frog, and two mammals; Table 1).

BEGINNINGS OF PALEONTOLOGICAL STUDIES IN DINO

In 1908 mammal paleontologist Earl Douglass of the Carnegie Museum of Natural History was sent to the Uinta Basin of northeastern Utah in search of dinosaur fossils. During the time, the Uinta Basin was much more well known for its geologically younger mammal fossils, which Douglass had previously collected here. The Carnegie group had been collecting fossils in the Late Jurassic of Wyoming for the then-fledgling museum. Reports of Jurassic-aged fossils were provided by the American Museum of Natural History's O.E. Peterson, who had made the observations a number of years earlier. An initial discovery by Douglass of a *Diplodocus* femur appeared promising, and plans were made to return to the Uinta Basin in 1909 to collect the rest of the fossils at this locality. Unfortunately, upon the return of Douglass and his group in August 1909, they found that someone had beaten them back to the site, collecting the best of the fossils. After a week of additional prospecting, a new site was located north of the town of Jensen, Utah, situated just north of a bend in the Green River (Figure 2). Douglass exclaimed in his field notes: "At last, in the top of the ledge where the softer overlying beds form a divide, a kind of saddle, I saw eight of the tail bones of *Brontosaurus* [*Apatosaurus*] in exact position. It was a beautiful sight…. It is by far the best looking Dinosaur prospect I have ever found" (Earl Douglass, August 17, 1909).

Douglass reported the findings back to his supervisor, W.J. Holland, and promptly moved his wife and son to Utah, along with a crew, to begin excavating the site. Within a week of the discovery visitors were flocking to the site to view the fossil discoveries being made, requiring signs requesting that guests not "molest" the fossils as visitation soared. Over the course of the next 14 years the museum proceeded to ship 317 metric tons of fossil material and rocks from this site in Utah to Pittsburgh (Carpenter 2018).

FIGURE 1. Current boundaries of Dinosaur National Monument, located in northeastern Utah and northwestern Colorado.



	Citation	Specimen number
DINOSAURS		
Abydosaurus mcintoshi	Chure et al. 2010	DINO 16488
Allosaurus jimmadseni	Chure 2000, 2006, 2020	DINO 11541
Apatosaurus louisae	Holland 1916	CM 3018
Camptosaurus aphanoecetes	Carpenter and Wilson 2008	CM 11337
Dryosaurus elderae	Carpenter and Galton 2018	CM 3392
Koparion douglassi	Chure 1994	DINO 3353
CROCODILIANS		
Hoplosuchus kayi	Gilmore 1926	CM 11361
LIZARDS		
Schillerosaurus utahensis	Evans and Chure 1999	DINO 14720
Eoscincus ornatus	Brownstein et al. 2022	DINO 14864
Helioscopos dickersonae	Meyers et al. 2023	DINO 15914
TURTLES		
Dinochelys whitei	Gaffney 1979	DINO 986-991
Glyptops utahensis	Gilmore 1916	CM 3412
FROGS		
Rhadinosteus parvus	Henrici 1998a	DINO 14693
SALAMANDERS		
Iridotriton hechti	Evans et al. 2005	DINO 16453
MAMMALS		
Glirodon grandis	Engelmann and Callison 1999	DINO 10822
Triconolestes curvicuspis	Engelmann and Callison 1998	DINO 10780

TABLE 1. Holotype fossils of Dinosaur National Monument.

FIGURE 2. The original fossil discovery on August 17, 1909, with George Albert Goodrich standing to the left of the exposed vertebrae of what ultimately becomes the holotype of *Apatosaurus louisae*.

From May to August of 1923 the Smithsonian Institution's United States National Museum (now the National Museum of Natural History) continued to excavate the site, followed by the University of Utah in November 1923. DINO was then one of 10 national monuments in the National Park System without an on-site custodian due to a lack of funding from Congress, leaving protection of its fossils to rely on the park's remoteness, the difficulty of excavating them (they are embedded in hard sandstone), and what proved to be ineffective warning signs (Carpenter 2018). That same year, Douglass wrote: "I hope that the Government, for the benefit of science and the people, will uncover a large area, leave the bones and skeletons in relief and house them in. It would make one of the most astounding and instructive sights imaginable." His plea would not be realized until 1958.

That delay is emblematic of what has turned out to be a long, fitful process by which DINO has slowly developed the facilities and staff necessary for proper care of the park's *in situ* fossils and an expanding museum collection. The rest of this paper will describe what happened.

THE QUARRY VISITOR CENTER: ICONIC, BUT PROBLEMATIC

Excavation paused at the Carnegie Quarry in 1924, as plans for developing the then-new Dinosaur National Monument were explored. The pause would last a decade. From 1934 to 1938, work took place under the New Deal program to remove the overburden covering the lower positions of the Carnegie Quarry at the suggestion of American Museum of Natural History curator Barnum Brown, who served as a consultant on the site for NPS in 1933 (Brown 1933; Elder 1999). Men were temporarily hired through the Civil Works Administration, the Transient Relief Service, and later the Works Progress Administration (WPA) to continue the overburden removal, but the work was suspended in 1938 (Elder 1999; Carpenter 2018; DINO Archives; Hunt-Foster 2021).

In 1951 the first structure, affectionately referred to as the "Tin Shed," was erected over a small portion of the Carnegie Quarry. This allowed for work to take place during the winter as well, to investigate if a more extensive building was warranted (Carpenter 2018). More intensive work on the quarry face resumed in September 1953, removing up to 3.7 m (12 ft) of bentonitic clay from the face of the quarry sandstone layer (White 1958; Hunt-Foster 2021).

Finally, in 1958, a permanent building at the quarry opened: the Quarry Visitor Center (QVC). (Carpenter 2018). The striking glass, steel, and concrete Mission 66 architectural-style structure was praised for its innovation and was immediately recognized as being architecturally significant, as it was literally built over the site, covering 585 m^2 (6,300 ft^2) of the quarry. The building was placed on the National Register of Historic Places in 1986. But it also immediately began to face trouble, as the bentonitic clays of the Morrison Formation's Brushy Basin Member were constantly shrinking and swelling with the variations in weather and moisture. As the years went by, steel beams were bending and shearing in place, concrete was ripping apart, windows would pop out of their frames, and floors tilted so much that doors would not close. Finally, in 2006 the QVC was deemed unsafe and condemned. The main steel and glass structure was retained and rehabilitated, while the rotunda, museum collections space, fossil preparation laboratory, and offices were demolished. In 2011 the rehabilitated structure was reopened for visitation as the Quarry Exhibit Hall (QEH), and it has since been designated a national historic landmark, with a new visitor center located at the Utah entrance of the park.

DEVELOPING A PROFESSIONAL PALEONTOLOGY STAFF

The decades leading up to the opening of the QVC in 1958 also saw the first steps toward the development of DINO's professional staff. Because of budget constraints, paleontology staff have often filled more than one role in the park and are often the museum curators for the park as well. The first park custodian was geologist Albert C. Boyle Jr. (Figure 3A), who also opened the first museum at DINO in 1936, located west of the Carnegie Quarry, as overburden removal was

FIGURE 3. Past DINO paleontology and museum staff and years served in role. TOP ROW, L–R (A) Albert C. Boyle, Jr. (1933–1938); (B) Theodore White (1953–1974); (C) Jim Adams (1953–1984); (D) Floyd "Tobe" Wilkins (1953–1988); (E) Frank McKnight (1964–1979). BOTTOM ROW, L–R (F) Sue Ann Bilbey (1969–1972); (G) Russ King (1975–1978); (H) Dan Chure (1979–2016); (I) Ann Schaffer Elder (1984–2008); (J) Scott Madsen (1988–2008); (K) ReBecca Hunt-Foster (2018–present).

taking place at the quarry during this time. He oversaw and trained the temporary work crews about the geology and paleontology of the area and hosted many groups of visitors and led talks at the museum, where visitors could view fossils and other artifacts from the park.

Dr. Theodore White, formerly of the Smithsonian Institution and Harvard University, was hired in 1953 as DINO's first paleontologist; like Boyle, he also was assigned all museum curatorial responsibilities (Figure 3B). White was a trained zooarchaeologist and easily transitioned to the role of paleontologist. He also took over the research and led public education responsibilities for the park, writing general papers on geology and paleontology, most notably describing the first *Camarasaurus* braincase, from a park specimen (DINO 28; White 1958, 1964, 1967). Former miner and DINO road crew member Jim Adams was hired by White in 1953 to assist with the excavation of the fossils on the Carnegie Quarry wall, and he conducted many of the daily curatorial duties until his retirement in 1984 (Figure 3C). Floyd "Tobe" Wilkins (Figure 3D), also a former miner, worked alongside Adams on fossil relief of the Carnegie Quarry cliff face for 32 years, along with Frank McKnight (Figure 3E), who worked on the relief of fossils on the quarry wall in the 1960–1970s (Figure 3C). Sue Ann Bilbey was hired in 1969 by the Dinosaur Nature Association to work at the QEH and worked from 1970–1972 as a naturalist for the park, assisting White in many curatorial and paleontological needs, and completing her Master's degree work in 1973 on the park's Morrison Formation (Figure 3F). White retired in 1973 (Santucci and Kirkland 2003; Lyman 2016).

In April 1975, the monument hired paleontologist Dr. Russ King to replace White, with King assuming curatorial responsibility for the paleontology collection (Figure 3G). Adams continued to perform day-to-day curatorial duties. King was instrumental in the direction of the excavation and preparation oversight for a juvenile *Stegosaurus* specimen during his time in the park. Tragically, he died in a fishing accident on the Green River in 1978 (Elder 1999; Bayless et al. 2002).

Dan Chure succeeded King in 1979 and assumed research and curatorial duties for all museum collections in the park (Figure 3H). During his tenure, Chure published on many of the holotypes known from DINO. In 1984, Ann

Elder (then Ann Schaffer) replaced the retiring Jim Adams (Figure 3I). Scott Madsen was hired to replace the retiring Tobe Wilkins in 1988 (Figure 3J; Elder 1999). Both Elder and Madsen worked on a host of projects around the park, most notably excavating and preparing the holotypes of *Allosaurus jimmadseni* and *Abydosaurus mcintoshi*. Madsen's innovative preparation techniques led to the excavation of the Late Jurassic Rainbow Park microvertebrate quarries (among others), with thousands of tiny fossils discovered and prepared under his supervision. Elder assumed all duties that had been assigned to Adams, including care of the museum collections. The holotype of *Dryosaurus elderae* was named after Elder in 2018 for her contributions to the paleontology of the park (Carpenter and Galton 2018).

In the 1990s the museum's collections began to increase rapidly with additional fossil, biological, and archaeological collecting taking place by staff and associated researchers. Recognizing that the museum collection had grown to the point where more staff were necessary, the park established a full-time museum curator position in 2000. This position was filled by Ann Elder. Sporadic archival surveys and collections inventories followed over the next few years, culminating in annual inventories being conducted starting in 2020.

In 2018, DINO hired a new paleontologist, the author, who was also assigned the collateral duty of museum curator (Figure 3K). Hunt-Foster initiated the recent museum collections inventories and oversaw the move of the museum collections, described next.

A FREQUENT CHALLENGE: MUSEUM COLLECTIONS

While the condemnation and rehabilitation of the QVC was necessary, it also exacerbated a longstanding problem in the park: a lack of professional facilities to prepare and curate large amounts of fossil specimens.

As noted earlier, the museum collection space was part of the QVC (Figure 4A) when it opened in 1958. As the problems with the overall building became too glaring to ignore, DINO's General Management Plan (1986) identified the need for a new collection building and upgraded lab facilities under the preferred alternative. A series of plans was proposed between 1986–1997 to carry this out, but none were funded.

There has been no central archive or collections storage facility in the park since the original QVC was condemned in 2006. A replacement for the QVC's collections facility, which was already very full, was omitted from the plans for the QEH, and no plans were made for housing the material at DINO long-term. Instead, the park entered a partnership with the Utah Field House of Natural History

FIGURE 4. **(A) Original location of the collections in the Quarry Visitor Center, ca. 2004. (B) Collections located in headquarters basement from ca. 2006 to 2020. (C) Collections now housed at the Utah Field House of Natural History State Park Museum, located in Vernal, Utah.**

State Park Museum, and local Bureau of Land Management (BLM) and US Forest Service offices to construct and operate a joint curation/research facility that was slated for construction in 2005—but this too never materialized.

By August 2018 the park's museum collections were being stored in no fewer than 11 locations—some of which were truly substandard, including a garage, the "Tin Sheds" near QEH, and a semi-trailer parked in a maintenance yard. Although the number of locations has since been drastically decreased, some larger fossil specimens are still at risk of being lost because of problems such as water infiltration, pest infestations, and extreme temperature fluctuations in the remaining storage facility within the park. In addition, some fossils are radioactive and release a high level (9+ pCi/L) of dangerous radon gas. Some fossils in the collection that had been collected (under permit) from BLM lands north of the Monument were permanently transferred, at BLM's request, from DINO's official collections to the collections at the Utah Field House of Natural History State Park Museum.

In July 2020 the park followed suit, beginning the process of moving geology, paleontology, osteology, archaeology, history, and art collections to the Department of the Interior-accredited Utah Field House of Natural History State Park Museum (also a facility that is a federal repository) (Figure 4C). Rehousing of the art, paleontology, and geology collections was completed by 2022, with plans for rehousing the archaeology and history collections by 2024. The new location of these collections has aided in the accessibility of the collections to researchers and visitors and has allowed for an increased use of the collections, as well as condition stabilization.

Collections remaining in the park include limited larger fossil specimens, archives and parts of the research library, and the herbarium (which was recently 100% digitized and made available online).

This rather disjointed history is a challenge because the museum collections were identified as a "Fundamental Resource" in the 2015 Dinosaur National Monument Foundation Document, which calls them "extremely significant, documenting cultural and natural resource management activities from the early 1900s, preserving original land records upon which the Monument was established, and retaining scientific data from studies conducted on Monument resources" (p. 10). Despite this, the 2015 foundation document went on to observe: "Museum collections are also being improperly prepared and stored, including over 400,000 prehistoric and historic objects, artifacts, works of art, archival documents, and natural history specimens.… Under these conditions many of the applicable NPS standards (NPS Museum Handbook (2004) and Director's Order 24: NPS Museum Collections Management) are not being met" (p. 38).

This is all the more worrisome because some specimens in the museum collection are "type specimens," which are unique to the park and of great scientific importance (see Table 1). Even though much of the collections has been moved off-site, DINO has a responsibility for collections from the park no matter where they are stored. The ultimate plan is that DINO will move forward with the Intermountain Region Park Museum Collection Storage Plan (2007), which calls for a multi-park repository to be constructed in DINO.

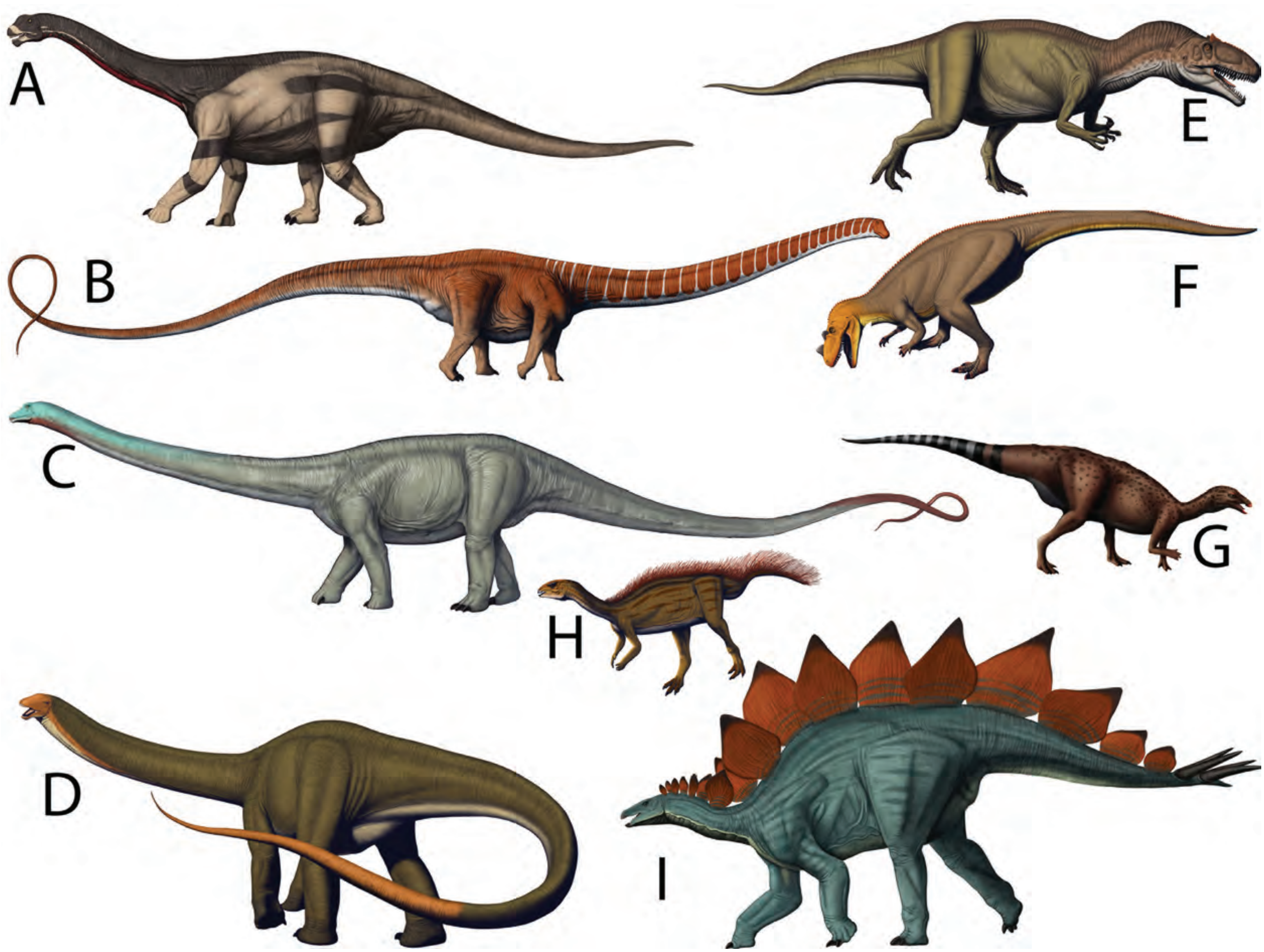
NOTABLE DISCOVERIES

The importance of getting DINO's collections properly settled once and for all is underlined by several notable discoveries that have been made over the years.

Carnegie Quarry

Nine dinosaur genera have been discovered within the Carnegie Quarry (Late Jurassic, Brushy Basin Member of the Morrison Formation, 150 million years in age) making this one of the richest multitaxic bonebeds in the Morrison Formation (a minimum of 124 individuals are currently among the over 1,500 fossils preserved in the *in situ* remains on the quarry wall; Figure 5). The genera are: the sauropods *Apatosaurus*, *Diplodocus*, *Barosaurus*, and *Camarasaurus*; the theropods *Allosaurus* and *Ceratosaurus*; and the ornithischians *Stegosaurus*, *Camptosaurus,* and *Dryosaurus*. Notable finds include three dinosaur holotypes found in the Carnegie Quarry: *Apatosaurus louisae* (CM 3018, Holland 1916); *Camptosaurus aphanoecetes* (CM 11337, Carpenter and Wilson 2008); and *Dryosaurus elderae* (CM 3392, Carpenter and Galton 2018). This is in addition to the best preserved and most complete sauropod skeleton ever found, a juvenile *Camarasaurus* (CM 11338, Gilmore 1925); all four were collected by the Carnegie Museum of Natural History. Six skulls and three nearly complete skeletons of *Camarasaurus* have been discovered at the Carnegie Quarry, making it not only the most well-represented animal in the quarry itself, but also from the Morrison Formation across North America (McIntosh 1981; Foster 2020). A *Barosaurus* specimen (ROM 3670) collected by the Carnegie Museum and later traded to the Royal Ontario Museum also preserves a patch of skin impression of an area near the front leg. Two turtles (*Dinochelys whitei,* DINO 986-991, Gaffney 1979; and *Glyptops utahensis*, CM 3412, Gilmore 1916) and a crocodylomorph (*Hoplosuchus kayi,* CM 11361, Gilmore 1926) are also holotypes noted from this site, with

FIGURE 5. The dinosaurs of Carnegie Quarry at Dinosaur National Monument. Sauropods: (A) *Camarasaurus;* (B) *Barosaurus;* (C) *Diplodocus;* and (D) *Apatosaurus.* Theropods: (E) *Allosaurus;* (F) *Ceratosaurus.* Ornithischians: (G) *Camptosaurus;* (H) *Dryosaurus;* (I) *Stegosaurus.* Art by Bob Walters and Tess Kissinger.



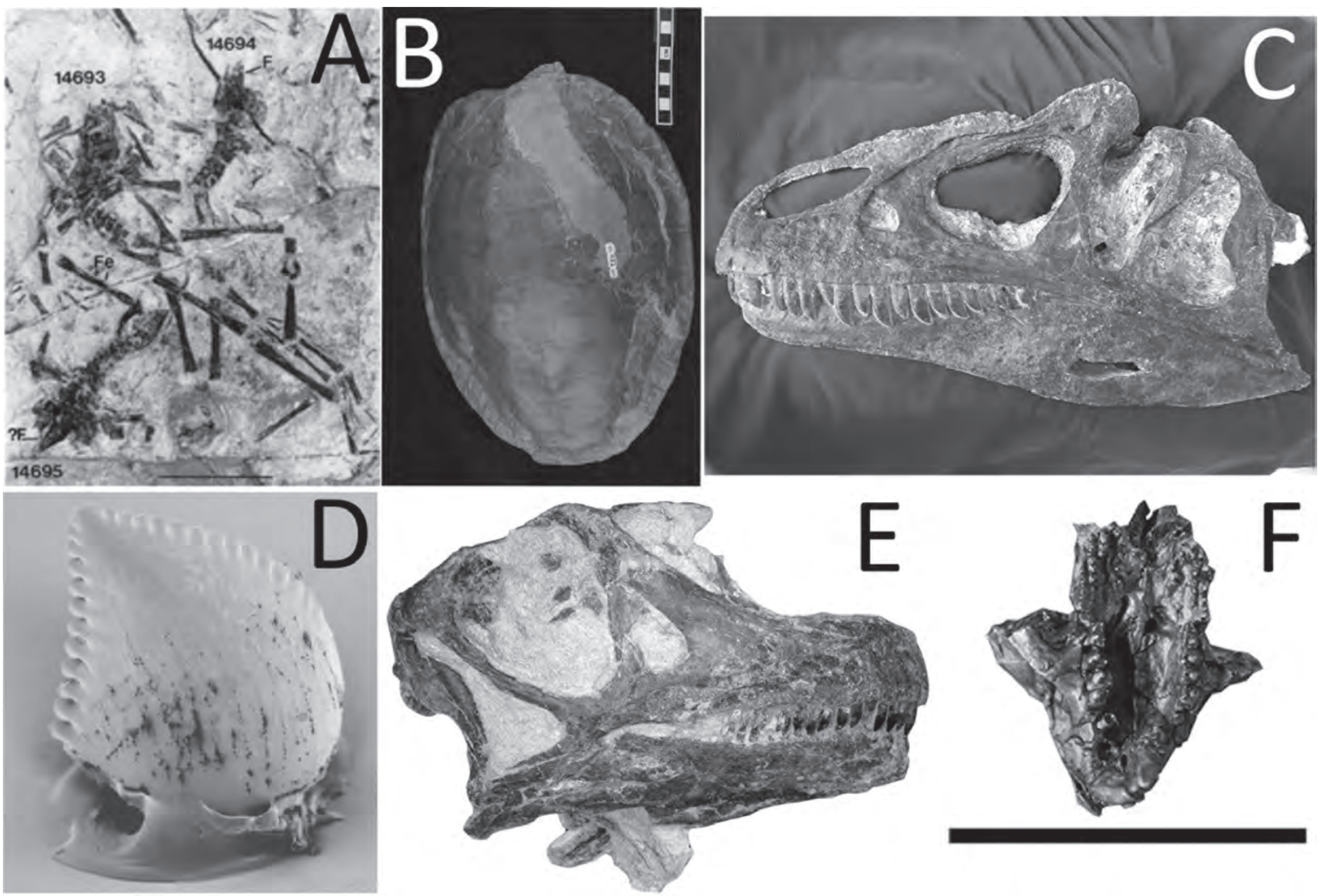
this also being the only known occurrence of *Hoplosuchus*. The most abundant fossils at the quarry are those of unionid clams, which are the indicator fossil that helped scientists to understand the drought-related assemblage that forms the quarry bonebeds. A mold of the jaw of the lizard-like reptile *Opisthias* and isolated remains of the crocodylomorph *Amphicotylus* have also been reported from the quarry wall.

Other Late Jurassic specimens of interest

Stratigraphically lower, in the older Salt Wash Member of the Late Jurassic Morrison Formation, the holotype fossil of *Allosaurus jimmadseni* was found by Dr. George Engelmann (University of Nebraska, Omaha) in July 1990 (Hubert and Chure 1992) during a paleontological inventory of the formation in the park (DINO 11541, Chure and Loewen 2020). Currently this is the only specimen that has been described from the Salt Wash Member in DINO.

Many of the richer fossil sites in DINO are found in concentrated microvertebrate quarries. The only other dinosaur holotype from the upper Brushy Basin Member of the Morrison Formation outside of the Carnegie Quarry in the park is that of *Koparion douglassi* (DINO 3353, Chure 1994) and is from one of these sites (Figure 6). This species is known from a single, nearly complete maxillary tooth crown, and is thought to represent the oldest member of the troodontid family. Additional holotype specimens collected from this area slightly higher in the Morrison Formation section represent the frog *Rhadinosteus parvus* (DINO 14693, Henrici 1992, 1993, 1998), the salamander *Iridotriton*

FIGURE 6. Examples of holotypes from Dinosaur National Monument: (A) *Rhadinosteus parvus* (DINO 14693); (B) *Dinochelys whitei* (DINO 986-991, scale bar = 6 inches); (C) *Allosaurus jimmadseni* (DINO 11541); (D) *Koparion douglassi* (DINO 3353); (E) *Abydosaurus mcintoshi* (DINO 16488); (F) *Glirodon grandis* (DINO 10822, scale bar = 1 inch).



hechti (DINO 16453, Evans et al. 2005), the multituberculate mammal *Glirodon grandis* (DINO 10822, Engelmann and Callison 1999), and the triconodont mammal *Triconolestes curvicuspis* (DINO 10780, Engelmann and Callison 1998). A separate microvertebrate locality in the Bushy Basin Member of the Morrison Formation within the park has produced the holotype partial skeleton of the lizard *Schillerosaurus utahensis* (formerly *Schilleria utahensis*; DINO 14720, Evans and Chure 1999; Nydam et al. 2013). Other new holotypes from additional microvertebrate quarries include one of the oldest known lizards, *Eoscincus ornatus* (DINO 14864, Brownstein et al. 2022) and the oldest known gecko-like lizard, *Helioscopos dickersonae* (DINO 15914, Meyers et al. 2023). Many other microvertebrate fossils from the Brushy Basin Member of the Morrison Formation around DINO are also awaiting study and description.

Additional Notable Specimens

Abydosaurus mcintoshi was originally discovered in the late 1970s but was not excavated until the late 1990s (DINO 16488, Chure et. al 2010). This brachiosaurid sauropod was found in the Mussentuchit Member of the Cedar Mountain Formation (roughly 105 million years in age) and is known from a minimum of four individuals found at this single site in the park. These specimens also represent the first sauropod skull material known from the Cedar Mountain Formation in North America. *A. mcintoshi* is currently known only from DINO. The fragmentary remains of a small deinonychid dinosaur discovered in the late 1970s are currently under study (Britt et al. 2021), but it is already clear that the fossil is not a juvenile *Utahraptor*.

Some of the oldest holotypes from DINO come from the Paleozoic rocks found along the river corridors. These invertebrate fossils include the horn coral *Amplexus zaphrentiformis* (White 1876), from the Pennsylvanian Morgan Formation, and the foraminiferan *Millerella circuli* (Thompson 1945), from the Pennsylvanian Round Valley Formation. Additional new work is currently taking place on fossils from the Middle Cambrian Lodore Formation and the recently identified Upper Devonian Parting Formation (Myrow et al. 2023a, 2023b).

INTERPRETING DINO'S PALEONTOLOGICAL RICHES: THE FOSSIL DISCOVERY TRAIL

This paper has largely focused on internal management challenges, but throughout its history DINO has paid close attention to interpreting the park's paleontological resources to visitors. The early tours of the Carnegie Quarry have already been mentioned, and a key element in the original QVC design was to provide a place where visitors could watch professionals interact with fossils *in situ*. Today, a major interpretive focus in DINO is the Fossil Discovery Trail (FDT).

The FDT is the most popular trail within DINO, a 1.2-mile hike (one way) which passes through nearly 80,000,000 years of Earth history and provides visitors with the opportunity to see dinosaur bones and other fossils in the field. The tilted nature of the geology here allows visitors to explore the Jurassic- and Cretaceous-age rocks exposed along the trail, including the Stump, Morrison, Cedar Mountain, Muddy, Mowry, and Frontier Sandstone Formations. Year-round use occurs as both ranger-led and self-guided hiking.

Originally this area was a series of unofficial trails through the drainage known as the upper part of Nielsen Gulch that runs east of the QEH, which visitors would sometimes use when hiking back from visiting the quarry. The FDT was originally designed as a primitive path that was used primarily for ranger-led walks to view the unique geology surrounding the original QVC. In 2004, park managers approved minimal development along the trail to better delineate the route to provide an alternative visitor experience in anticipation of the closure and rehabilitation of the QVC. As noted earlier, in 2006 NPS permanently closed the QVC due to the danger of imminent collapse. During the QVC closure, the FDT became the main attraction for visitors who wanted to see fossils. The trail has become a major focus for interpretive activities and is used by most visitors to the quarry area. Staff also have discovered four sticks of dynamite from 1922, various tools, and other relics left over from the time of the Carnegie excavation along the FDT. At the time the original QVC was closed one instance of illegal collecting of fossils occurred along the trail and a rock art panel along the trail was vandalized. Funding was provided by NPS to better delineate the approved trail, improve informational and interpretive signs, and improve access for visitors, as well as initiate repeat photography and increased inventory and monitoring of sites along the FDT. While initial documentation of the FDT Morrison Spur Wall took place in the early 2010s, an in-depth survey and status report had not taken place since 2015. In the summer of 2023, this program was expanded to include these baseline data by mapping exposed fossils in the sandstone along this section. These data have been made available to DINO interpretation and law enforcement staff for use when fossils at this site are suspected of having been damaged, vandalized, or stolen. This work has also proactively provided the opportunity to directly discuss the fossil resources and their protection with visitors, allowing for an increase in public awareness about the significance of paleontological resources. Additional new signage and waysides are planned to be installed along the FDT in 2025.

CONCLUSION

The Late Jurassic collection from DINO is one of the most important Jurassic vertebrate collections in the world, and certainly in the Morrison Formation, between the dinosaur and especially the microvertebrate holotypes, and things continue to move forward in DINO. The park continues to move ahead to find a permanent solution to housing the museum collections. Efforts are being made to digitize museum collections as well to make them more accessible. The herbarium collection is already fully digitized and available online, with plans to begin on the holotype and other significant fossils within the paleontology collections in 2024. Plans are also underway to digitize the entirety of the Carnegie Quarry Wall through LiDAR and photogrammetry. The research library and paleontology archives have begun to be digitized, with collaborative efforts with the Carnegie Museum to digitize their historic correspondence and quarry activity documents from their time working at the Carnegie Quarry. Specimen loans that have been overdue, for decades in some instances, are beginning to be returned. The physical museum collections also have been rehoused, updating storage conditions from boxes and field jackets to cavity mounts and bedding jackets, where appropriate. Through these organizational efforts we have been able to identify specimens in need of stabilization, as well as those ideal for research projects, and have invited researchers to work on these collections. The museum program at DINO is on its way back to an organized and accessible state, with three new holotypes being published in the past three years, and several other specimens actively being worked on.

Outside of the museum collections, education and outreach efforts have been improved. Yearly STEAM (Science, Technology, Engineering, Arts, and Mathematics) camps are being offered to youth, several science-based internships are available yearly, and seasonal staff positions have been re-established. Work is also underway to hire a full-time museum curator who also will assist with the originally envisioned multi-park repository needs. The DINO interpretive staff has been working directly with resource staff to update all public-facing media information to give the public the most up-to-date information possible. New exhibits are also planned to be installed in the QEH in 2025, to better interpret the park's rich fossil history.

New inventory and monitoring efforts are underway in the 90% of DINO that has not been surveyed for fossil resources, with focus being given to areas outside the traditional studied exposures within the park. A GIS database has been constructed for all localities, including digitizing and organizing past documents and media, and to help with resource management and fire hazard needs. There also has been an increase in law enforcement training and multi-agency collaboration to protect federal fossil resources in the past several years. In short, DINO is continuing to move forward, onward, and upward to make our paleontology and other science in the park accessible, successful, and sustainable using scientific principles and expertise.

ACKNOWLEDGMENTS

Dinosaur National Monument is on the traditional lands of the Ute Indian Tribe, Southern Ute Indian Tribes, and the Ute Mountain Ute Tribe, along with 36 additional associated Tribes in northeastern Utah and northwestern Colorado, and we recognize their care of these lands. Special thanks to Ken Carpenter for his work and many discussions about the park since my arrival here; John Foster for his encyclopedic knowledge of the Morrison Formation and patience; Arvid Aase (Fossil Butte National Monument) and Matthew Smith (Petrified Forest National Park) have been an asset with the museum collections and inventory efforts; and Jim Kirkland, Ben Burger and Doug Sprinkle for their assistance with the stratigraphy of the region. The staff of the Western Archeological and Conservation Center, notably Tef Rodeffer, Kim Beckwith, Rachael Campbell, Brenda McLain, Khaleel Saba and Betsy Burr, have been instrumental in the assistance in providing needed guidance to stabilize and improve the museum collections and archives at DINO, along with the assistance of Lisa Baldwin, Bob Schelly, Paul Scolari, and Mark Foust. Much of the work at DINO would not have been possible without the fossil technicians, seasonal employees, staff, and interns over the years, who deserve more credit than they often receive. This manuscript was greatly improved with reviews from an anonymous reviewer, Justin Tweet, and Vince Santucci.

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