Dawn of the Cretaceous Fossil Beds NM

Utah is justifiably famous for its many Upper Jurassic dinosaur sites in the Morrison Formation (Foster, 2021, Kirkland et al., 2020), with the Carnegie Quarry at Dinosaur National Monument and the Cleveland-Lloyd Quarry at Jurassic National Monument considered its crown jewels. Research over the past 30 years has established that Utah has the most complete and best dated dinosaur fossil record in the world (Kirkland et al., 2024). The Utah Geological Survey (UGS) is tasked with documenting these many discoveries through the UGS's Paleontological Locality Database (Fig. 1). These discoveries have led to a gold rush of sorts, with more than half of all excavation permits on public lands being issued for sites in Utah as informally reported to UGS by the Bureau of Land Management (BLM)'s national lead, Dr. Scott Foss in 2000.

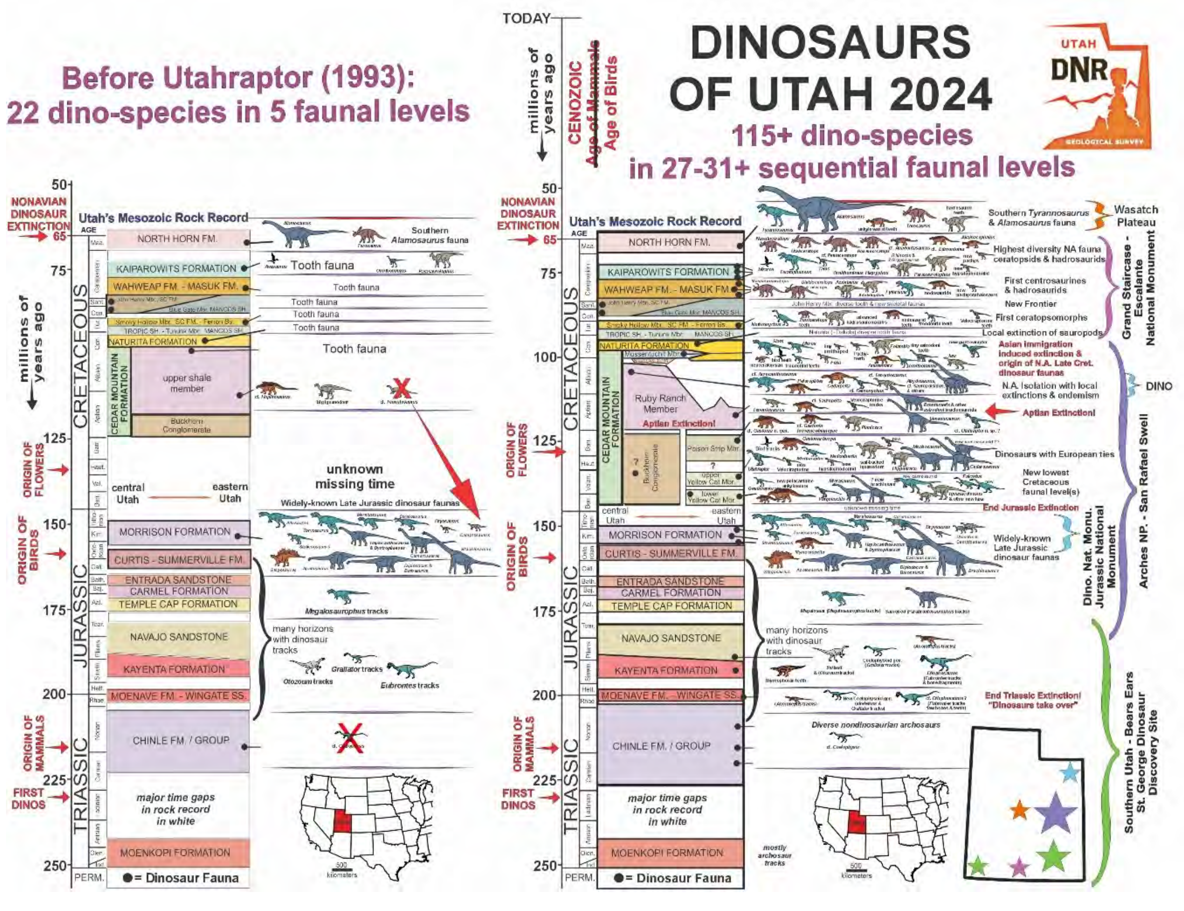


Figure 1. Dramatic explosion of new dinosaur discoveries in Utah over the past three decades as modified from Hunt-Foster et al. (2023).

In particular Utah's Cretaceous dinosaur record is extraordinary (Fig.2) and while the Upper Cretaceous, is well-managed at Grand Staircase – Escalante National Monument (GSENM). This work vastly increased the known vertebrate fossil diversity from every substage of the Upper Cretaceous (Eaton and Kirkland, 2003; Gates et al., 2010). These initial Upper Cretaceous fossil discoveries in the Kaiparowits Basin were noted in the presidential proclamation establishing Grand Staircase–Escalante National Monument (Clinton, 1996). Initial funding under this banner led to an extraordinary wave of significant fossil discoveries by several institutions (e.g., Titus and Loewen, 2013; Titus et al., 2016). The UGS' Paleontological Locality documents that with the establishment of GSENM known vertebrate fossil localities increased from 86 to 4449 bone sites and from 13 to 159 track sites, for a total of a 468% increase is known vertebrate paleontology localities in 28 years. A remarkable wealth of discovery by any standard!

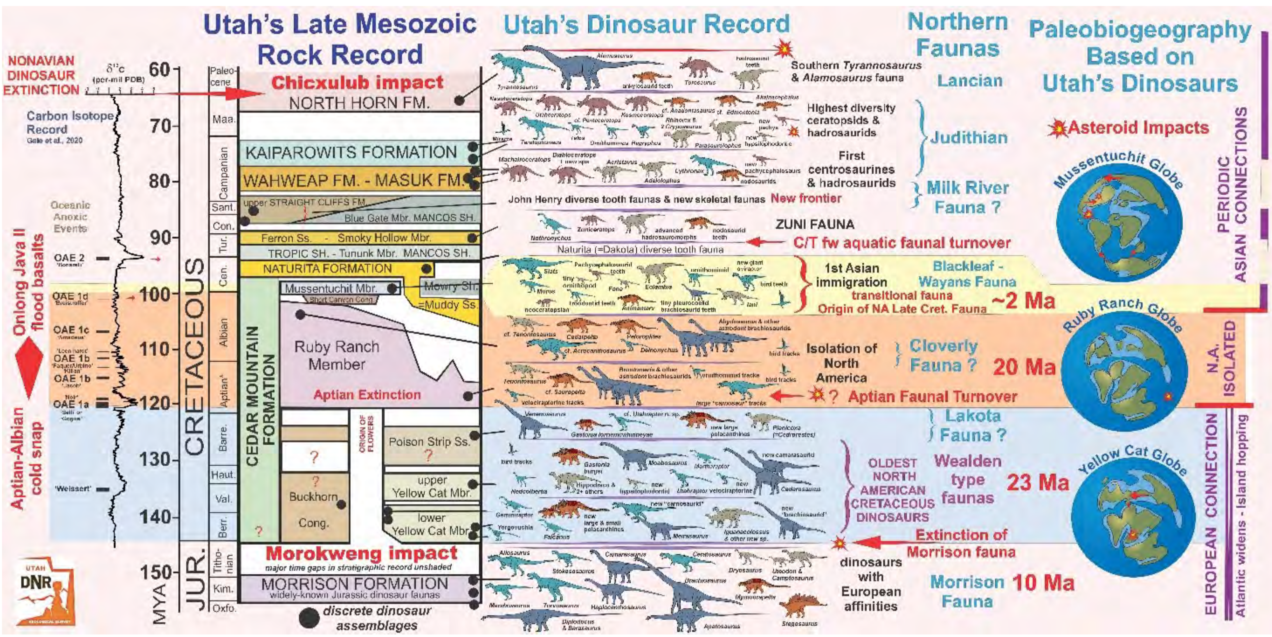


Figure 2. Late Mesozoic Dinosaurs of Utah. Note that data is plotted against a linear time scale. (updated after Kirkland et al., 2016).

Generally, the basal Cretaceous across the northern hemisphere is marked by an erosional gap in the terrestrial rock record marking an interval of tectonic quiescence and low sea-levels. Research on microfossils (ostracodes, charophytes, and palynomorphs), chemostratigraphy, and radiometric dating of paleosols in the Lower Cretaceous Yellow Cat Member of the Cedar Mountain Formation in the Paradox Basin of eastern Utah indicate that deposition in this region began much earlier than previously proposed, possibly near the beginning of the Cretaceous in the Berriasian stage (Joeckel et al., 2019, 2023). We have proposed that salt tectonics during the Early Cretaceous resulted in local subsidence and deposition of the fossiliferous Yellow Cat Member across the northern Paradox Basin in eastern Utah (Kirkland, 2017; Kirkland et al., 2023). Wealden-type assemblages characterize the entire Yellow Cat Member and overlying Poison Strip Member of the Cedar Mountain Formation (Kirkland et al., 2016) through 5-7 discrete and non-overlapping faunal levels (Kirkland et al., 2016, 2024). The Yellow Cat Member in the Paradox Basin of eastern Utah is now divided into an upper and lower sequence based on distinct dinosaur faunas separated by a prominent calcrete or caprock (Figs. 2, 3) marking the lowest occurrence of carbonate in Cedar Mountain paleosols (Kirkland et al., 2016).

These dinosaur occurrences document the strong palaeogeographic ties between Europe and North America during the Late Jurassic and that similar Upper Jurassic dinosaur faunas spanned the last 10 million years of the Jurassic. The basal Cretaceous of eastern Utah preserves a succession of Wealden-type dinosaur assemblages dominated by styracosternid iguanodontians, polacanthine ankylosaurs, turiosaur sauropods, possibly Europe-derived brachiosaurid sauropods (both groups characterized by broad, spatulate teeth), large dromaeosaurines, and possible carcharodontosaurid allosauroids (Kirkland et al., 2016; Royo-Torres et al., 2017). This dinosaur fauna strongly contrasts with those of the Upper Jurassic, indicating a significant turnover among dinosaurs in North America and Europe across the J/K boundary (Mannion, 2024). The precise timing and causes of this faunal turnover interval are not yet known, but the Morokweng impact crater in northern South Africa and the flood basalts of the Shansky Rise in the western Pacific are worthy of investigation (Kirkland et al 2024; Kirkland and DeBlieux, 2024).

The age of the upper Yellow Cat Member is further constrained by the identification of the Valanginian Weissert Oceanic Anoxic Event (Fig. 2) calibrated to detrital zircon ages from paleosols within the interval (Joeckel et al., 2023). However, the age of the overlying Poison Strip Member is poorly constrained, and this largely fluvial unit may have been deposited anytime from the Hauterivian through the Barremian. The dinosaurs from the Poison Strip, while represented by unique species, are broadly similar to those of the underlying Yellow Cat and thus, Wealden-type dinosaur assemblages characterize 20–25 million years of time spanning the lower half of the Early Cretaceous. (Kirkland et al., 2016; 2024).

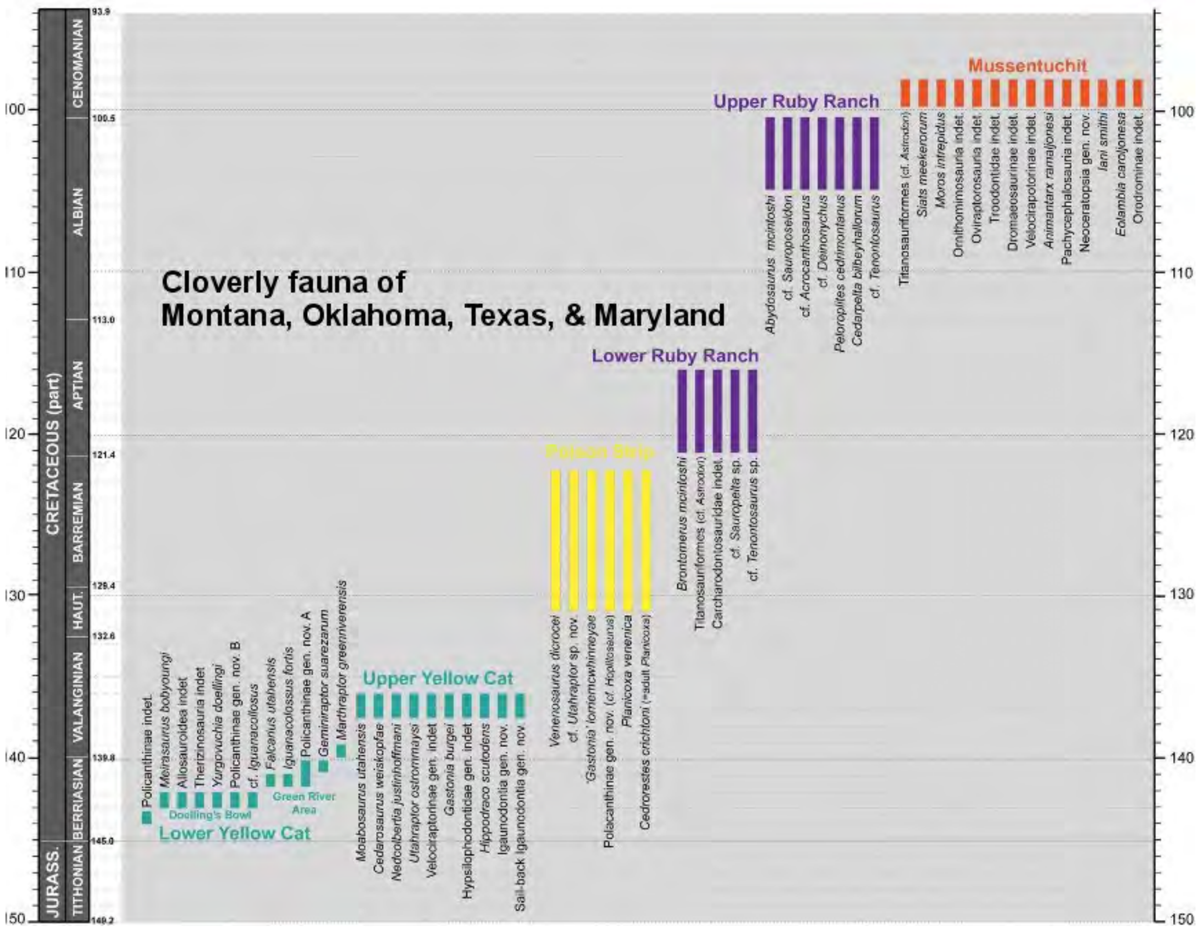


Figure 3. Temporal distribution of dinosaur taxa from the Cedar Mountain Formation, organized by approximate position within each member. Long bars do not represent stratigraphic ranges of each taxon but the range in possible age for these dinosaur faunas. Linear vertical scale in millions of years. Note The Early Albian Cloverly fauna has yet to be recognized in Utah, although rocks representing that time interval are certainly represented. Modified after Kirkland et al. (2024)

Another significant local faunal turnover occurs near the base of the overlying Ruby Ranch Member of the Cedar Mountain Formation, indicated by the absence of styracosternid iguanodontians, polacanthine ankylosaurs, sauropods with broad, spatulate teeth, and large dromaeosaurines. Few Ruby Ranch Member dinosaur sites have been excavated in eastern Utah, as carbonate nodule debris makes the identification of sites difficult, and pedogenic carbonate may encrust bones making excavation and preparation of bones challenging. The lowest skeletal remains in the Ruby Ranch in the Paradox Basin are about 10 meters above the base of the section south of Green River, Utah. These fossils consist of a large nodosaurine ankylosaur and fragments of *Tenontosaurus*-like, basal iguanodontian taxa replacing the more derived styracosternid iguanodontians. Elsewhere in eastern Utah, sauropod remains in the Ruby Ranch are restricted to narrow-toothed titanosauriform sauropods, while theropod remains are rare (Kirkland et al., 2016).

The early Aptian faunal turnover among dinosaurs was more significant in North America than in other Northern Hemisphere localities. While polacanthine ankylosaurs are replaced by nodosaurine nodosaurids in North America, and by struthiosaurine nodosaurids in

Europe, styracosternid iguanodontians continue to dominate the ornithischian herbivore component of assemblages in Europe (Kirkland et al., 2016; 2024). At this time, the extensive Ontong-Java flood basalts were erupting in the southeastern Pacific basin, correlative with hothouse conditions in the early Aptian followed by an intense late Aptian cooling event. It has been suggested that this massive volcanic center was triggered by an asteroid impact blowing through the thin ocean crust in this area. The base of the Aptian also marks the last evidence of faunal interchange with Europe, with North America largely isolated until the end of the Early Cretaceous (Kirkland et al., 2016, 2024; Kirkland, 2018).

While this portion of the Early Cretaceous is well developed in the Paradox Basin of Grand County Utah, the younger Lower Cretaceous is only preserved along the western side of the San Rafael due to subsidence at the front of central Utah's rising Sevier Mountains in Emery County, Utah (Fig. 4). In fact, it is remarkable how different the rock record is in these two areas but combined together they represent 45 million years of geological and biological history that is largely unique to eastern Utah.

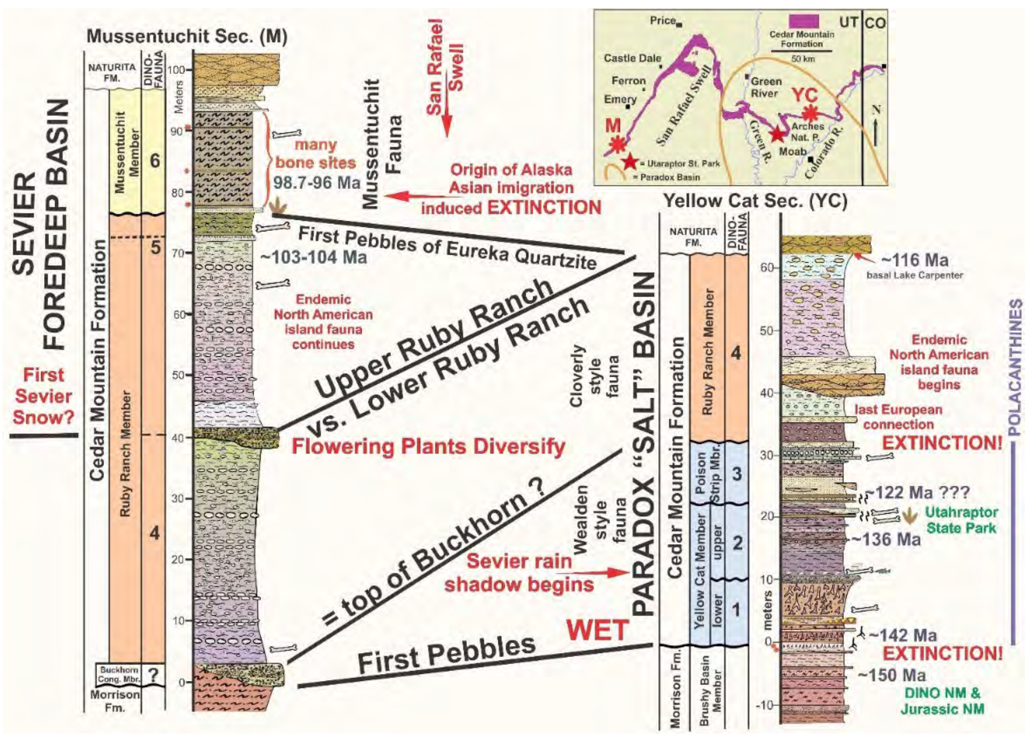


Figure 4. Contrasting Lower Cretaceous record preserved in the Paradox Basin of Grand County and west of the San Rafael Swell in the Sevier foredeep Basin of Emery County, Utah.

Strata dated to near the end of the Early Cretaceous at the top of the Ruby Ranch Member preserve a similar Cloverly style dinosaur fauna with a number of distinct species including the giant nodosauroid ankylosaurs *Peloroplites* and *Cedarpelta*, huge sauropods similar to *Sauropoisiden*, and giant carnosaurs like *Acrocanthosaurus*. Very extensive bonebeds preserving these dinosaurs occur southeast of Price Utah near the north end of the San Rafael Swell.

The Mussentuchit Member preserves one of the most diverse vertebrate assemblages in North America based largely on microvertebrate faunas extracted through wet screen washing (Cifelli et al., 1997; Kirkland et al., 2016), with approximately 100 taxa currently identified including 22 mammalian taxa (Eaton and Cifelli, 2001; Cifelli et al., 2016). Although diverse dinosaur teeth are present in abundance, dinosaur skeletal remains are still being excavated and described (Figure 5). By far the most abundant dinosaur is the hadrosauriform *Eolambia caroljonesa* (McDonald et al., 2012). A close relation to Asia's *Probactrosaurus*, it was derived from interchange with Asia (Kirkland et al., 2016). Other dinosaur remains include a mix of taxa similar to those in the Cloverly style assemblage: the giant carcharodontosaurid theropod *Siats*, large caenegnathid oviraptorosaurs, the basal iguanodontian *Iano*, slender-toothed titanosauriform sauropods, the nodosaurid *Animantrax*, and basal ceratopsids (Kirkland et al., 2016, 2023). In addition to *Eolambia*, dinosaurs possibly immigrating from Asia include the tyrannosauroid theropod *Moros* and possibly pachycephalosaurs marking the first Asian to North American immigration event (Cifelli et al., 1997; Kirkland et al., 2016). Highly resolved U-Pb ages, together with refined stratigraphic intervals for dinosaur taxa within the Mussentuchit Member, indicate that the immigration-induced extinction of North America's endemic Aptian-Albian dinosaur faunas are preserved through this 2-million-year long sequence such that Utah dinosaurs calibrate the origins of Alaska. This 2000 talk recorded on YouTube provides a fairly up-to-date review on the still ongoing research on Utah's Lower Cretaceous dinosaurs. https://www.youtube.com/watch?v=Thhb6Jy-Acw

Dawn of the Cretaceous Fossil Beds National Monument

While Utah's Upper Cretaceous dinosaur record has been both promoted and protected by the establishment of GSENM, Utah's unique and much more extensive Lower Cretaceous Dinosaur record has begun to receive much deserved attention both locally, and globally (Sadler, 2025), have not been especially protected. The Grand County area east of Arches National Park is nearly completely unprotected as activity in the Moab region is more than enough to fully occupy the attention of federal and state land managers. Utah's highly fossiliferous lower Cretaceous paleontological record is without question the most complete in the world and collaterally makes the Cedar Mountain Formation the most dinosaur rich formation on the planet! In addition, to its dinosaurs the Cedar Mountain Formation provides a 45 million year record of the complete terrestrial faunal and floral record together with an outstanding record of Utah's paleoclimatic and geological history that had been thought to be missing.

It is proposed that a National Park Service paleontology park be established along similar lines to the John Day Fossil Beds National Monument (JODA to protect, interpret, and provide a framework for ongoing research. John Day has been a model paleontology park developed within a framework of separate park units (Fig. 5) that together incorporate an outstanding and nearly complete record of the age of mammals in eastern Oregon (Beckham with Lentz, 2000) (https://npshistory.com/publications/joda/index.htm).

As with JODA, separate highly fossiliferous areas would be assigned as specific park units organized under coordinated management plan. For Dawn of the Cretaceous Fossil Beds four potential paleontological "honey holes" have been identified as potential management units that would essential encompass a virtually complete 45-million-year record of the Lower Cretaceous in eastern Utah. Such a paleontological park linked to eastern Utah's rural communities would also provide an economic tourism boon for the region, while maintaining open lands for future economic development. It is also envisioned that the Prehistoric Museum at Utah State University Eastern in Price, Utah would serve as the scientific hub for the park as it is already a recognized federal repository for both archaeological and paleontological antiquities and is a primary NPS repository for fossil specimens from Some of Utah's National Parks. Making the Prehistoric Museum the scientific hub would provide opportunities for students to get involved in the research as training to be future scientists and land managers.

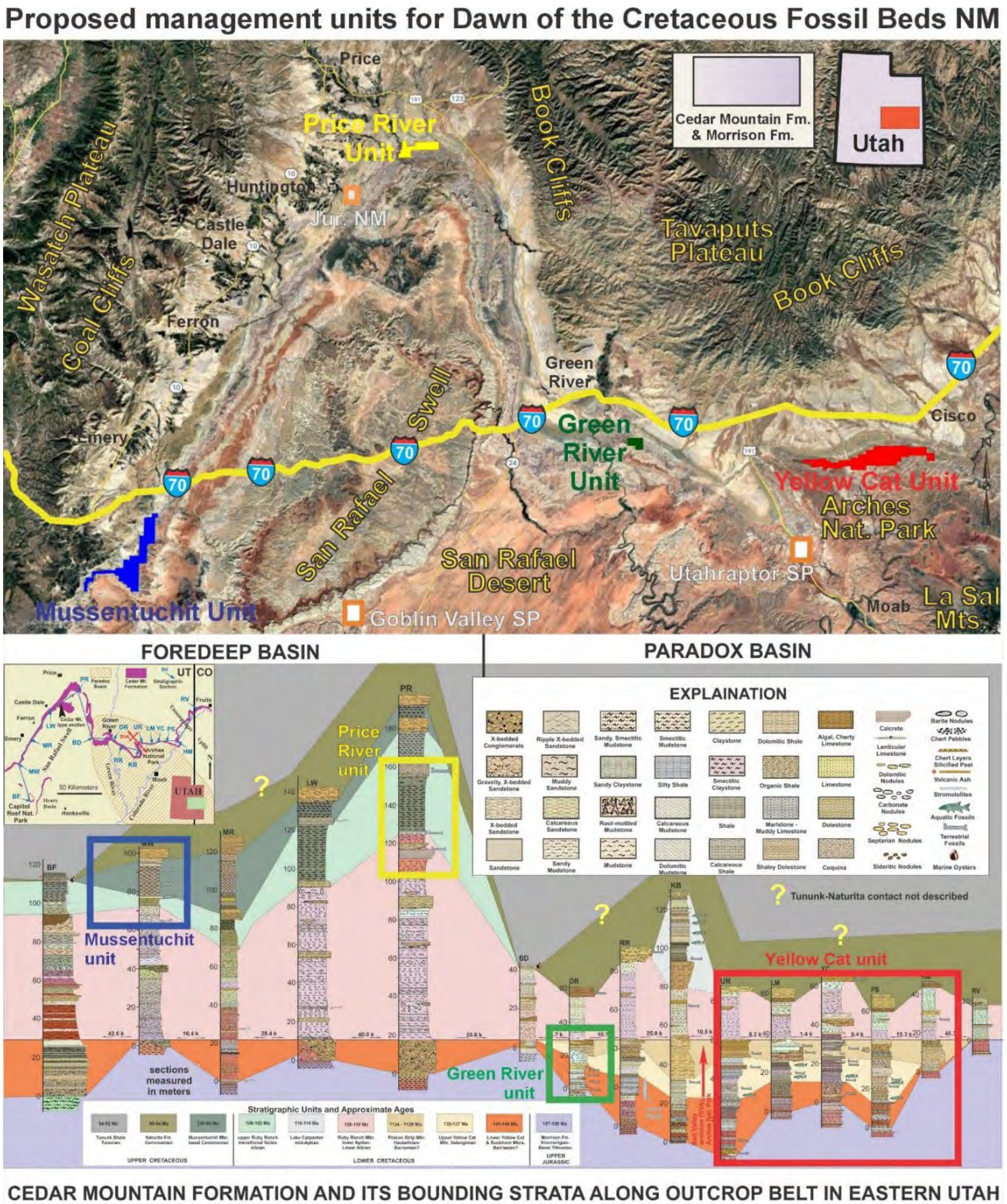


Figure 5. The aerial and stratigraphic limits of the four proposed management units. Red = Yellow Cat unit. Green = Green River unit. Yellow = Price River unit. Blue = Mussentuchit Unit.

The aerial extent of the four management units has been defined by the township and range system to the nearest quarter, quarter, section to encompass the majority of the most critical paleontological resources. It is clear that important paleontological sites will be discovered in the future outside of these proposed boundaries. Additionally. other geographic and historic features outside of these boundaries may be deemed worthy of inclusion. Furthermore, it may be considered more practical to define certain boundaries on geographic features more readily identified within the landscape. Thus, for this proposal it is acknowledged that if the concept of this proposal is accepted there will likely be considerable negotiation as to the final boundaries of these proposed management units.

Yellow Cat unit

The Yellow Cat unit is the largest proposed management unit and includes the most paleontological sites spanning the greatest interval of time. As currently proposed, it encompassed 24.25[2] miles or 15,520 acres (Fig. 6). The extraordinary sites preserved here is why the proposal was first conceived. This extraordinary paleontological resource (Figs 6-17) would certainly be a national park in most parts of the world.

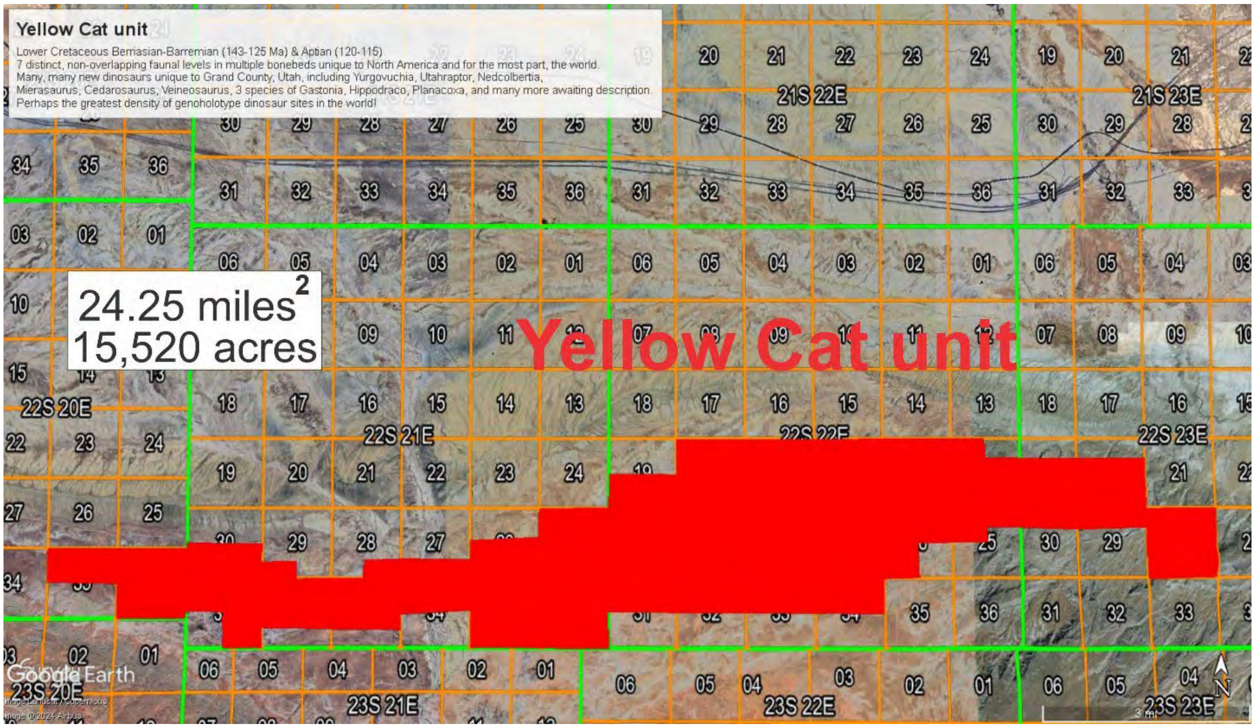


Figure 6). Geographic area of the Yellow Cat unit superimposed onto Townships and Ranges.

Figure 7. Spectacular exposures of the Upper Jurassic Morrison Formation underlies the Cedar Mountain Formation along the south side of the Yellow Cat unit. This is the Mollies Hogans area.

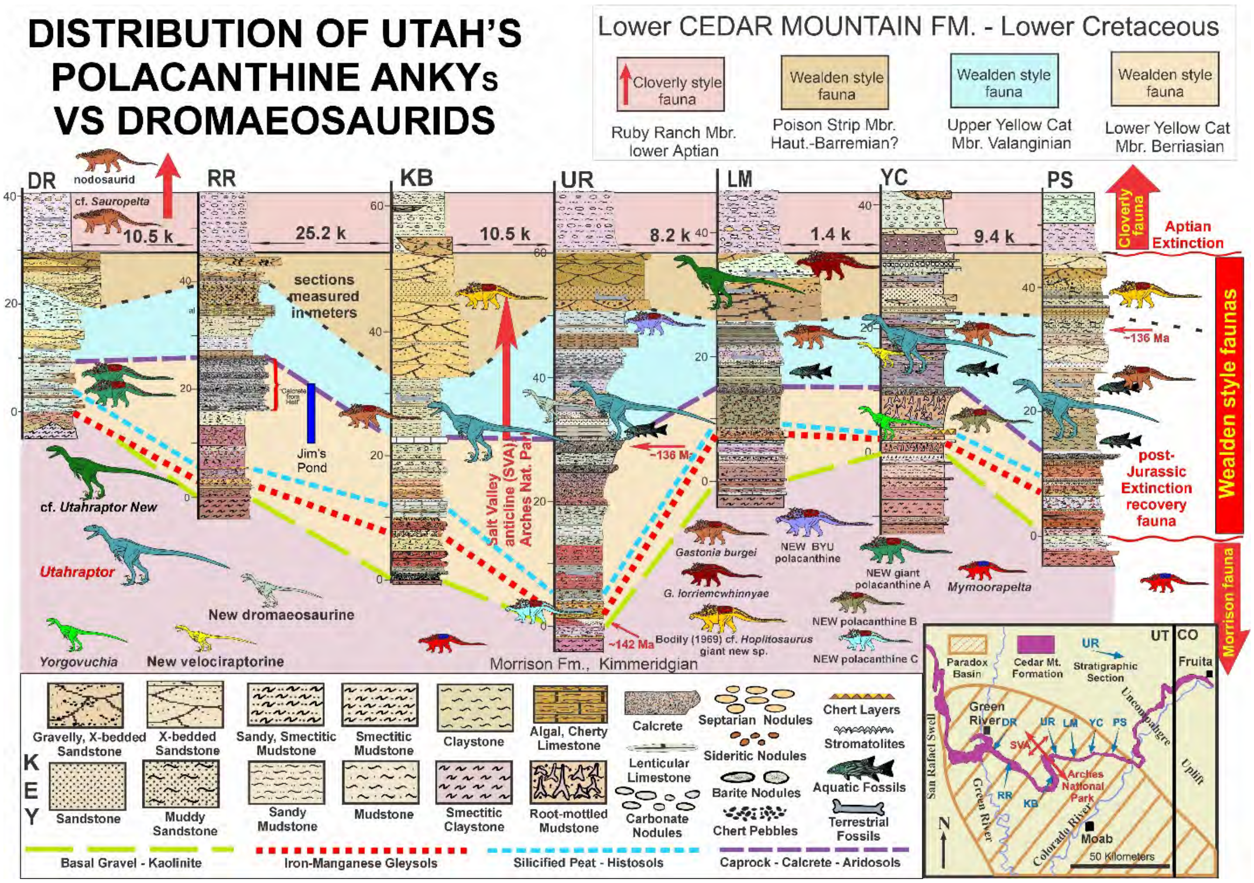


Figure 8. The fossil record being uncovered in the Yellow Cat unit is truly extraordinary. This shows the distribution of only two of the dinosaur groups, the dromaeosaurs (raptors) and the ankylosaurs. Ony new just discovered species of ankylosaur discovered by BYU is not even on this chart yet. The lines indicating the horizons of paleosols (fossil soils) indicates that the beginning of the Cretaceous was temporarily very wet in Utah, perhaps the result of an asteroid impact or intense volcanic activity.

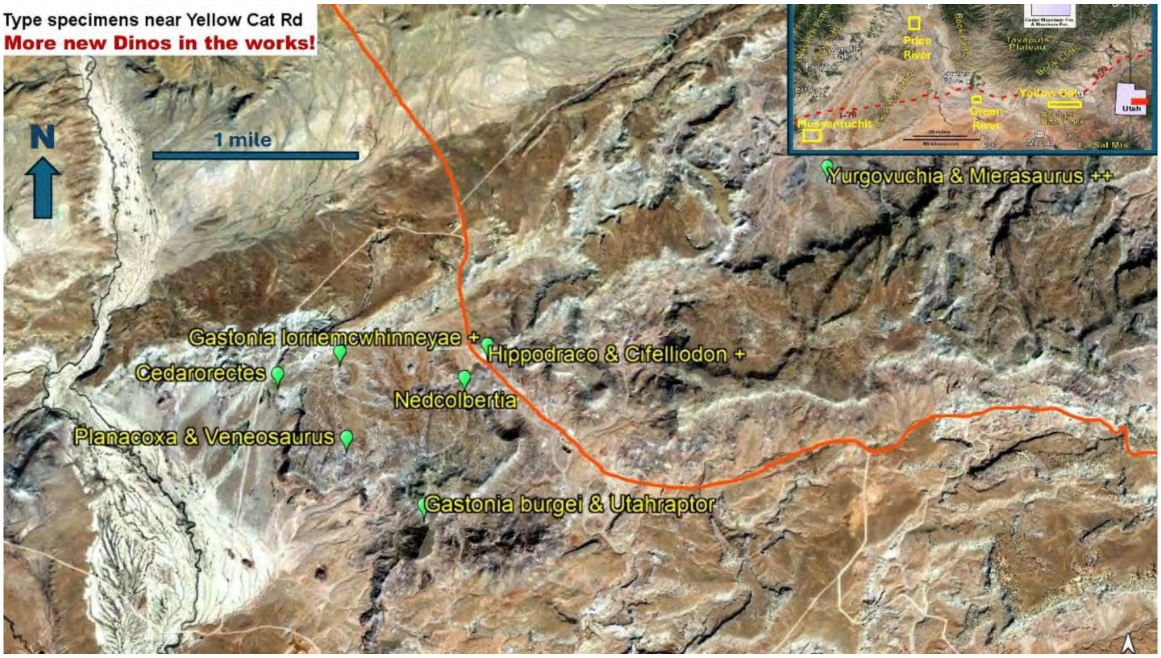


Figure 9. In a five-mile stretch crossing the Yellow Cat Road there are at present 10 genoholotype dinosaur sites distributed in four laterally extensive multigeneric bonebeds. There are numerous other new species from this area in Utah Paleontolocal labs still waiting to be described as indicated by + symbols.

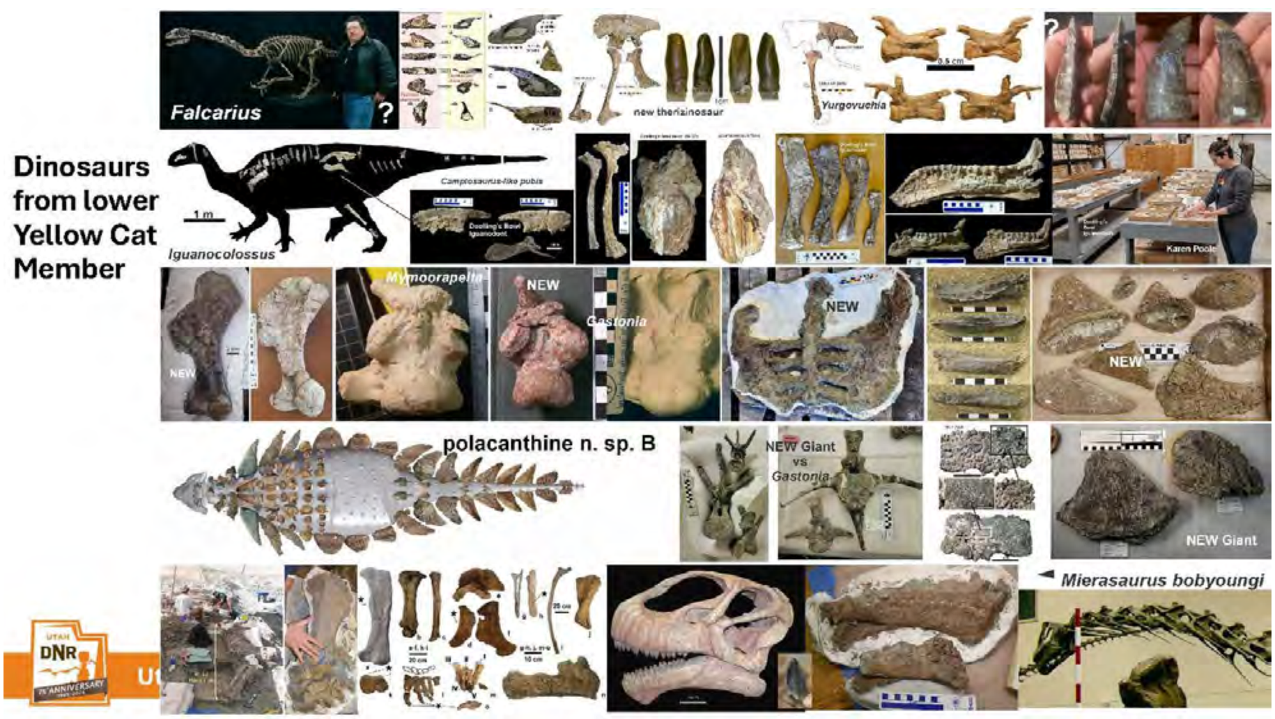


Figure 10. The lower Yellow Cat represents a stack of fossil soils and associated bonebeds representing at least 4 sequential nonoverlapping dinosaur faunas from the Yellow Cat and Green River management units.

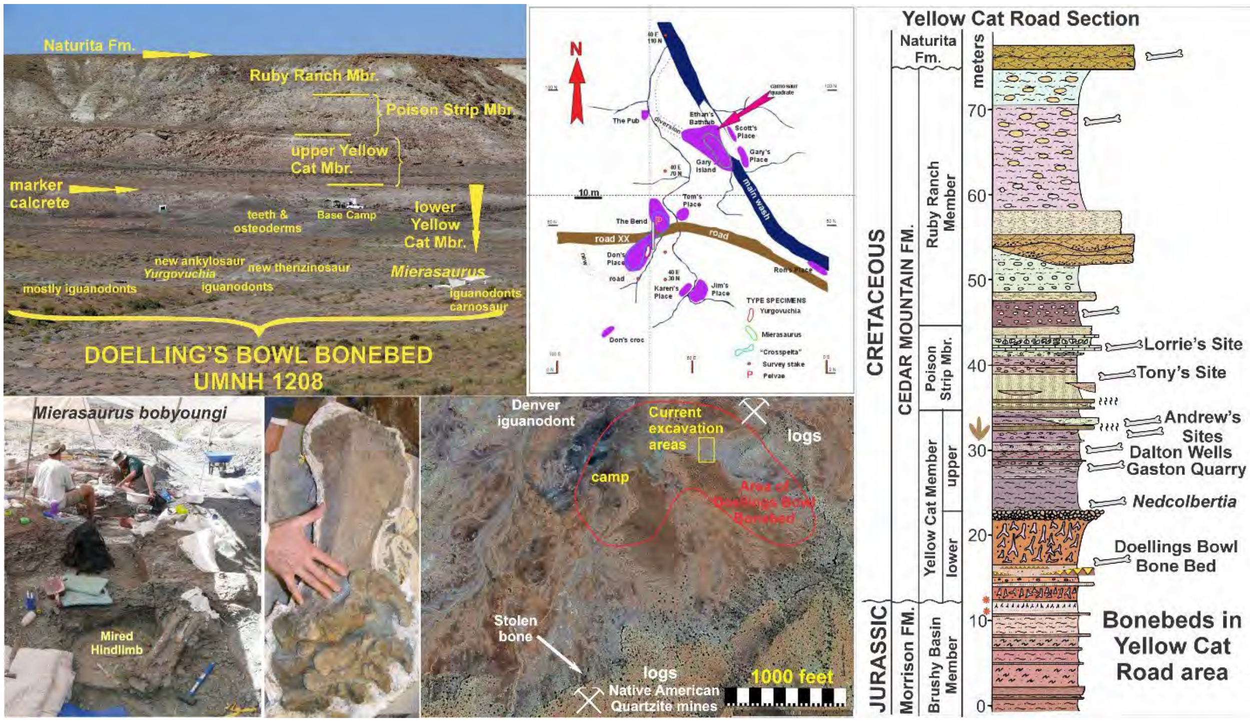


Figure 12. The Doellings Bowl Bonebed is the oldest the oldest Cretaceous multigeneric dinosaur bonebed in North America and possibly the oldest in the world. This extensive shallowly buried dinosaur site records the recovery from the dinosaur mass extinction at the end the Jurassic.

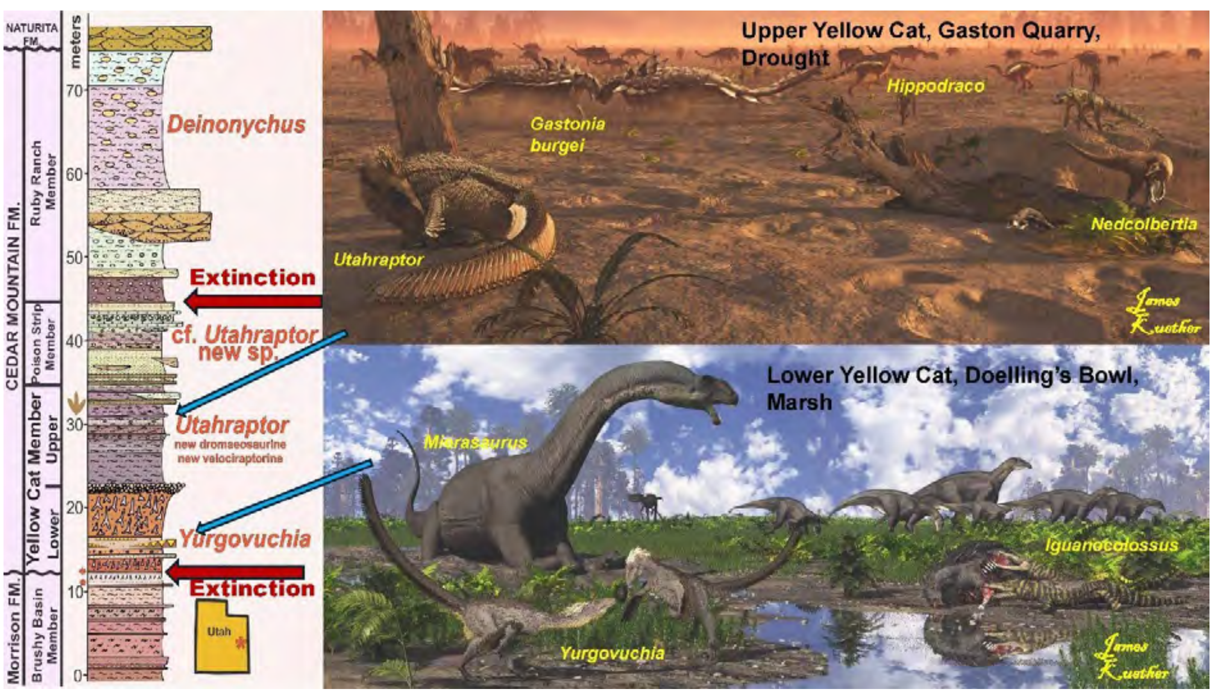


Figure 13. Although similar dinosaur lines are represented in the lower and upper Yellow Cat Member, different faunal levels are represented by different species. From Sadler (2025).

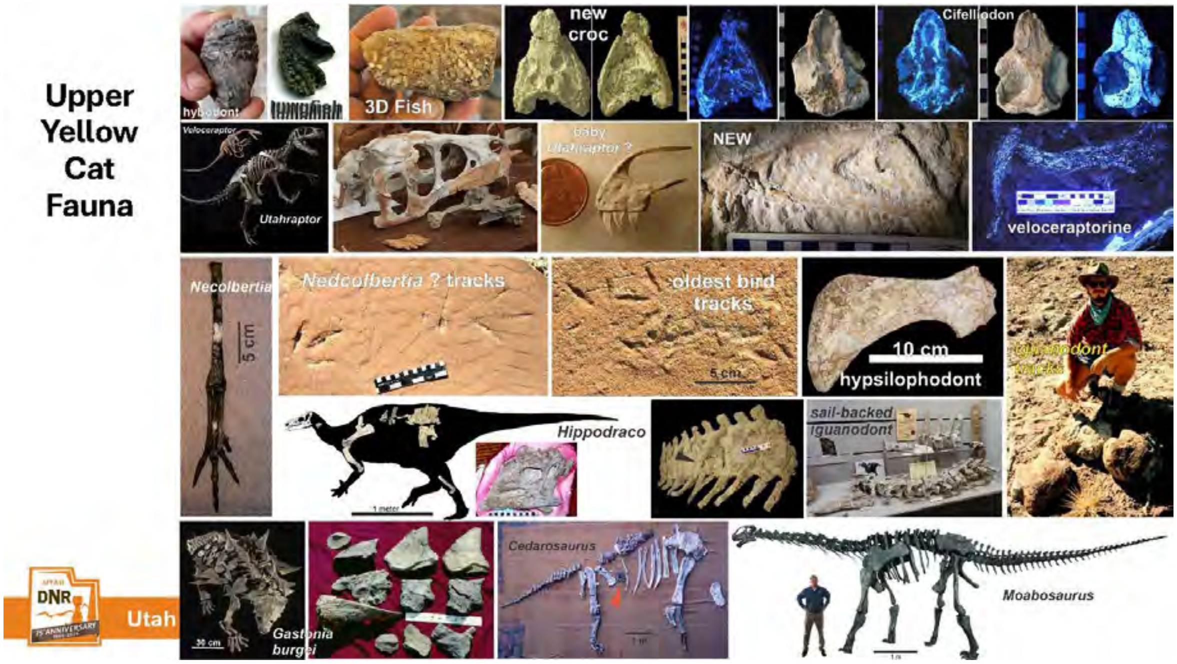


Figure 14. Some of the diverse fossils recovered from the various bonebeds in the upper Yellow Cat Member. Although "only" representing two dinosaur faunas, extraordinary bonebeds with distinct ecological signature are found across the length the Yellow Cat management unit. These well-dated faunas promise to reveal the complete ecosystem living in eastern Utah 136-134 million years ago.

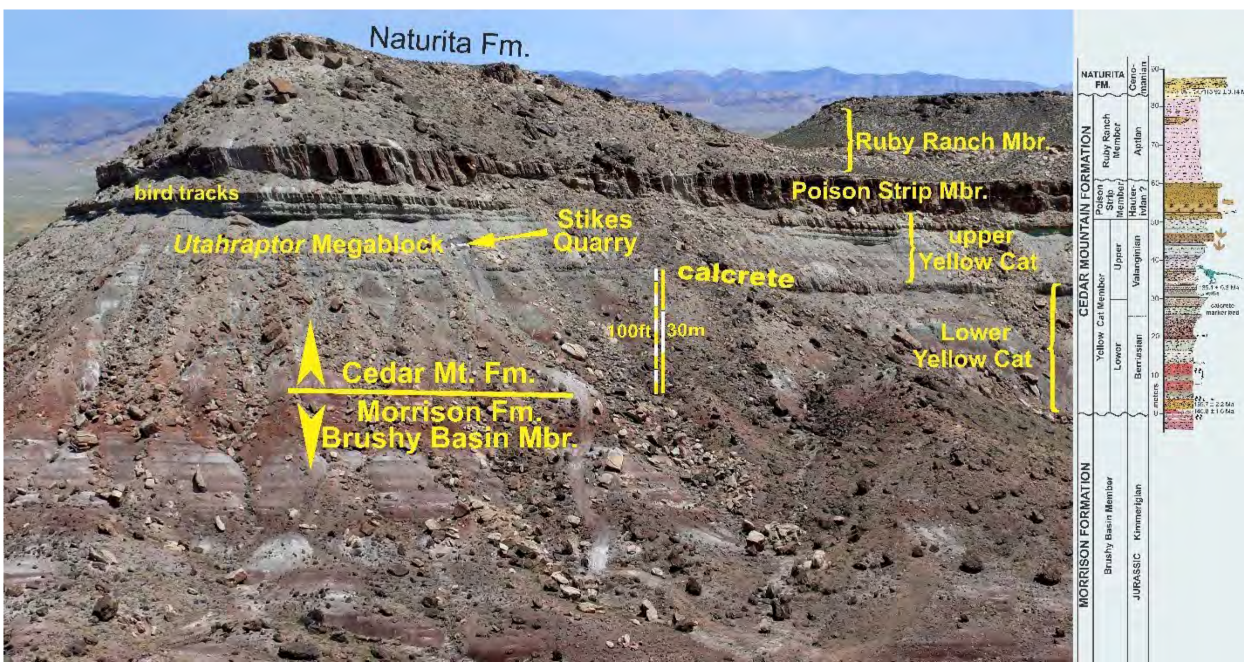


Figure 15. Looking north toward Utahraptor Ridge on the east end of the Yellow Cat Unit in addition to the spectacular Utahraptor block, the overlying bird tracks may be the oldest bird tracks in the world. Additionally, at the bird track level about a quarter mile to the west, Brigham Young University has recently discovered a major new multigeneric bonebed that extends for more than 100 meters laterally with at least two new dinosaur species so far, that has the potential to be a major interpretive site.

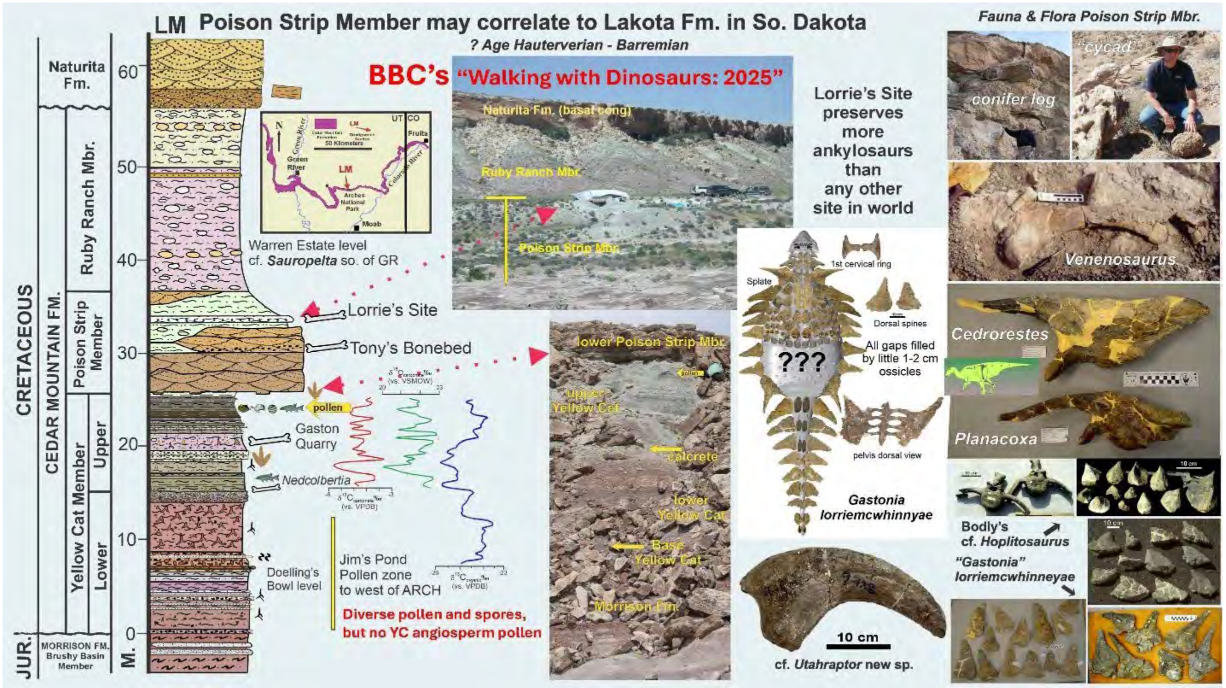


Figure 16. The overlying Poison Strip Member reflects an interval of time with extensive river systems it also includes many extensive bonebeds. Lorrie's Site extends for 150 meters and is the greatest accumulation of armored dinosaurs in the world. Exploration of these beds is only just beginning, but hold great promise as suggested by new discoveries to the east.

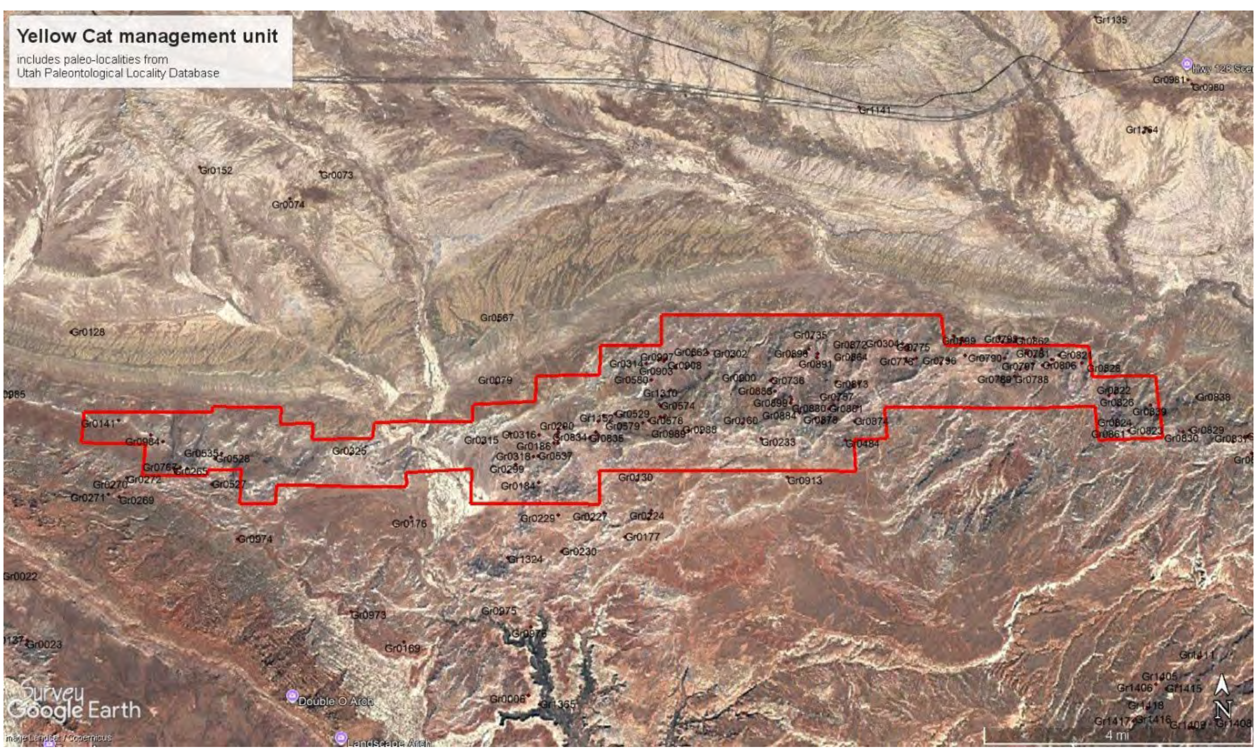


Figure 17. Geographic area of the proposed Yellow Cat unit with paleontological sites from UGS paleo-locality database superimposed.

The Yellow Cat unit represents an extraordinary opportunity to learn about the recovery of North America's dinosaur following the catastrophic extinction of Utah's beloved Morrison Dinosaur fauna. Interpretative opportunities abound within this unit and in nearby areas. The Yellow Cat Mining district to the south presents opportunities to interpret Utah Uranium mining boom years of the 1950s and 1960s. All mines have been closed in recent years for safety reasons, but care has been taken to leave the surface mine features intact as cultural artifacts. From the south side of the Yellow Cat unit, a well-developed BLM road extends south past natural arches to the north rim of Professor Valley with spectacular views of the Colorado River Canyon and the La Sal Mountains further to the south. Camping and off-road exploration opportunities abound. It is amazing to those in the know, that the extent of this beautiful landscape is completely unrealized by motorists travelling along I-70 to the north (Fig. 15).

In addition to exhibits of dinosaurs from this area at the Prehistoric Museum in Price, Utah, which already houses many of the dinosaur type specimens unique to this management unit, the John Wesley Powell River History Museum in Green River would provide a site for further interpretation. In situ exhibits, interpretive trails, and camping opportunities would provide reasons for the public to pay a fee to visit the area. A stand-alone visitors center on an abandoned well pad on the east side of the Yellow Cat Road overlooking the escarpment above the Morrison Formation would connect potential interpretive trails to sites in the immediate vicinity.

Figure 18. View south to the La Sal Mountains from the Poison Strip escarpment on the Yellow Cat Road.

Green River unit

The Green River unit is the smallest of the proposed management units and it was tempting to extend the Yellow Cat unit west across US 191 to encompass the unique sites present here. However, extensive oil and gas infrastructure development between these areas provides greater reason to separate these areas. The Green River Unit encompasses 2.5^2 miles or 1600 acres (Fig. 19) on the western side of the Paradox Basin, where the Yellow Cat strata thins as it onlaps the eastern San Rafael Swell. Several unique and extensive localities are present in the lower Yellow Cat Member (Fig. 20, 21) that are interpreted to represent somewhat younger dinosaur faunal levels younger than that at Doellings Bowl (Fig. 2), but still clearly older that those in the upper Yellow Cat and it has be hypothesized that with these sites included, it is proposed that the northern Paradox Basin of Grand County preserves the six oldest Cretaceous dinosaur faunas in North America and such hallmark dinosaurs as *Utahraptor*, *Gastonia*, *Falcarius*, *Iguanocolossus*, and *Moabosaurus* will never be found anywhere else. When discovered, it was noted that most of these sites had undergone extensive illegal excavation.

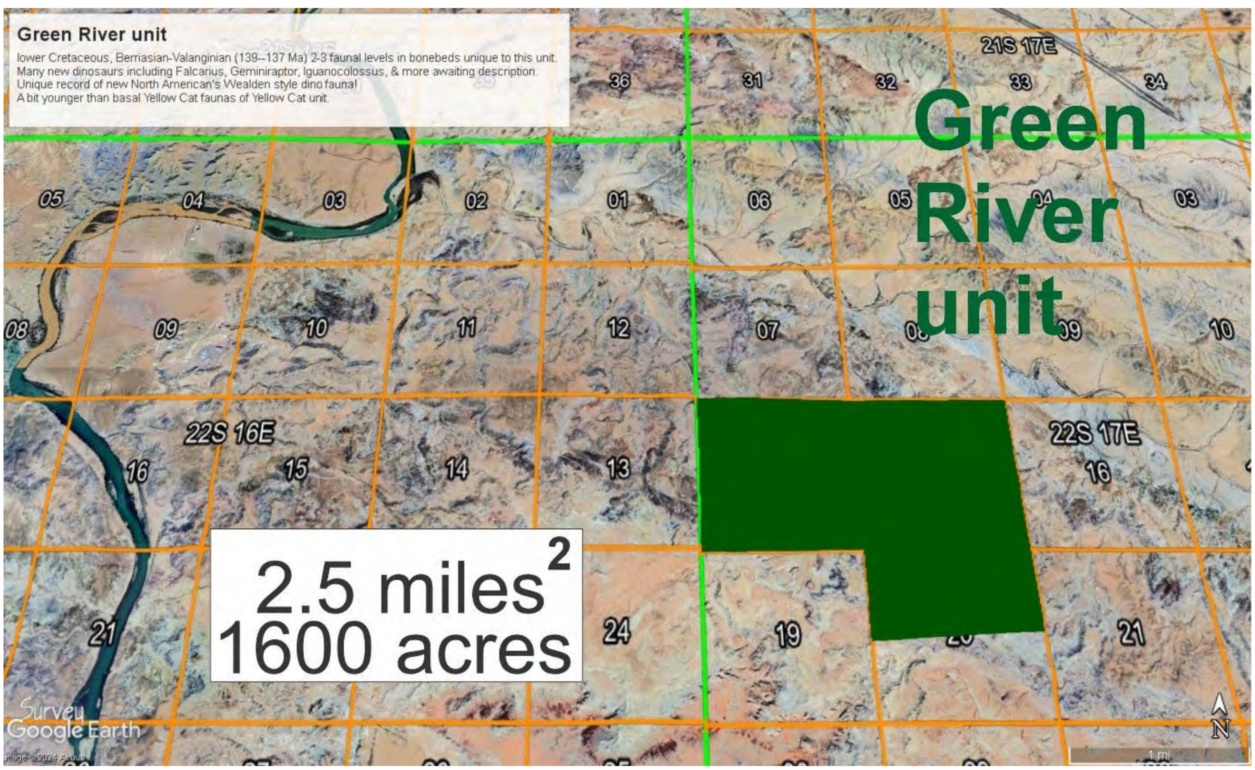


Figure 19. Geographic area of the Green River unit superimposed onto Townships and Ranges.

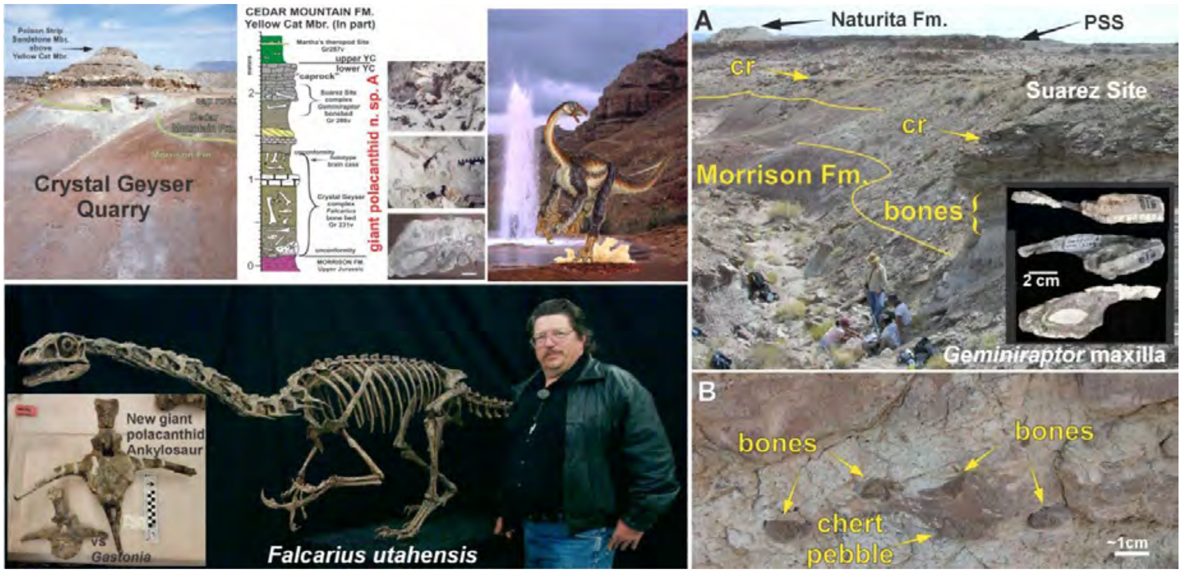


Figure 20. Major sites in the easter half of the Green River unit. In a half mile stretch there are 3 genera of the plant-eating raptor group, therizinosaurids described; from oldest to youngest, Falcarius, Geminiraptor, *and* Martharaptor. *Both the Crystal Geyser and the Suarez sites, are bonebeds with tens of thousands of bones that are still being actively excavated. The Science Channel did a fine documentary on the Crystal Geyser* Falcarius *discovery in 2007, https://www.youtube.com/watch?v=uJ918JXmzts .*

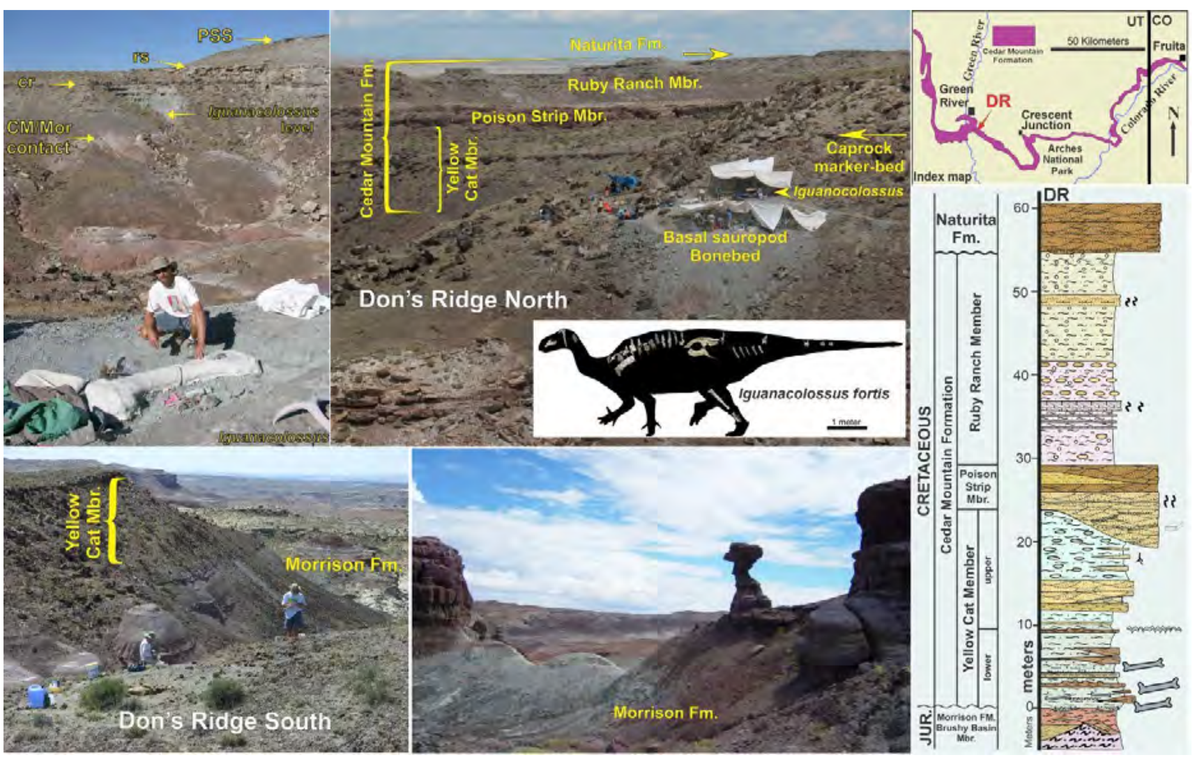


Figure 21, Don's Ridge was found close to 2 miles to the west of the Crystal Geser Quarry, initially 11 individual sites were found around the margin of the ridge. The base of the Cretaceous is marked by a cobble conglomerate filled with broken and complete sauropod bones that extends from one side of the ridge to the other. A few meters higher much more complete dinosaurs are found of which only Iguanocolossus *has been described. These sites have not been developed nearly to their potential. These sites are surrounded by spectacular, colorful Morrison Badlands.*

The dinosaur sites in the Green River unit (Fig. 22) represent a distinct faunal level known nowhere else. When first reported, Grand County investigated the possibility of putting a road into the locality as an interpretive site. Later, a trail bike track was put in right across the east side of the unexcavated Crystal Geyser bonebed. Nearby interpretive opportunities include Crystal Geyser, which is a popular tourist attraction and a put-in site for river trips on the Green River desperately in need of a vault toilet. West of the Green River, the Bureau of Land Management has developed an interpretive site at the heavily vandalized Fossil Point Morrison bonebed with the encouragement of the City of Green River and the support of the UGS. Off-roading opportunities are plentiful, and all can coexist with oil and gas development opportunities in the area.

In addition to exhibits of dinosaurs from this area at the Prehistoric Museum in Price, the John Wesley Powell River History Museum in Green River would provide a site for further interpretation of this nearby paleontological area.

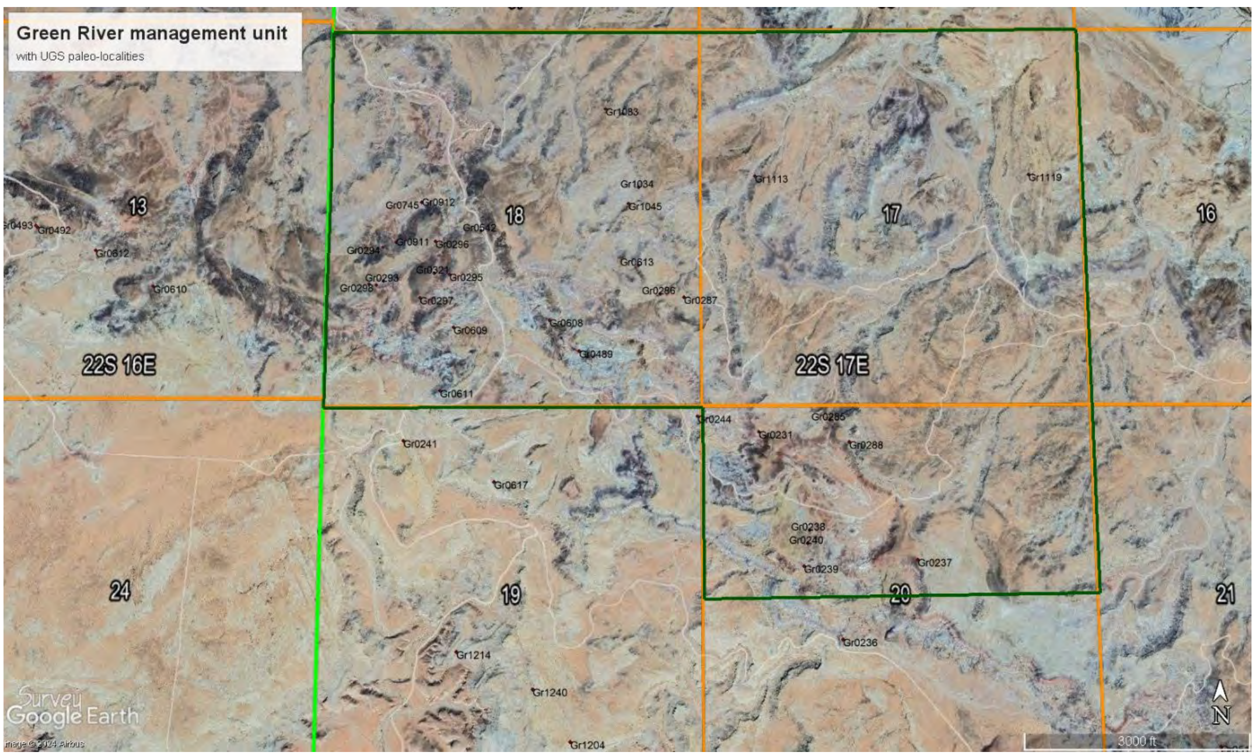


Figure 22. Geographic area of the proposed Green River unit with paleontological sites from UGS paleo-locality database superimposed.

Price River unit

The Price River unit is also of limited aerial extent (5.5² miles, 3520 acres) and is largely set up to preserve a unique series of fossil in the upper Ruby Ranch Member of the Cedar Mountain Formation roughly dated as upper Albian at ~105 to 102 million years ago. These localities are at the near the top of formation on the north end of the San Rafael Swell (Fig. 23-

26). The similar but better Cloverly faunal sites of Montana, Oklahoma, Texas, and Maryland are older, approximately at 112 to 107 Ma (lower Albian). The huge ankylosaurs from the sites in the Price River unit are well-characterized and are distinct from the large ankylosaur *Sauropelta* from the Cloverly Formation of Montana. In fact, the only known examples of the ankylosaurs Peloroplites and Cedarpelta in the worl hail from these sites and are currently held in the Prehistoric Museum in Price. Large sauropods similar to *Sauropoisiden* from Oklahoma and the huge carnosaur *Acrocanthosaurus* are present but are not likely the same species as dinosaur species have been shown to turn over at least every couple of million years when well-dated. Careful comparative taxonomic studies still need to be carried out to see if it is possible that these lineages are exceptions to this tentative "rule." A single new locality at Dinosaur National Monument is similar in age, otherwise this huge complex of sites is also unique in North America in that it records the end of the early Cretaceous.

Several localities (e.g. PR-2, PR2-3, CEM sites) have been found on either side of a large east to west drainage extending to the Price River and are now thought to be part of an extensive bonebed stretching over one-half mile. Other more isolated dinosaur sites appear to be present at this level throughout this area. A partial skeleton of primitive, bipedal animal *Tenontosaurus* at the PR-1 Site is from an overlying sandstone bed near the Price River and was the first discovery leading to more focused explorations in the area. Recent flooding has taken out the road into the major bonebed and heavy equipment will be required to gain access to these sites in the future.

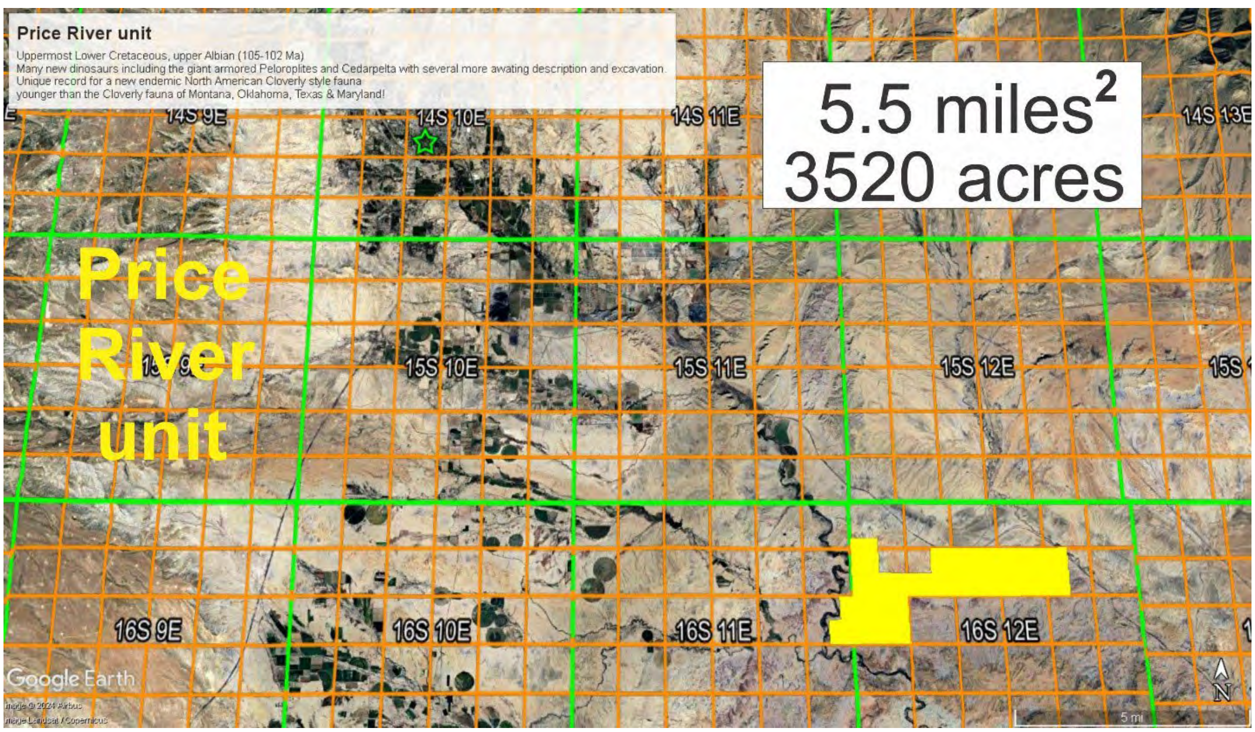


Figure 23. Geographic area of the Price River unit superimposed onto Townships and Ranges. Green star marks location of the USU Eastern's Prehistoric Museum.

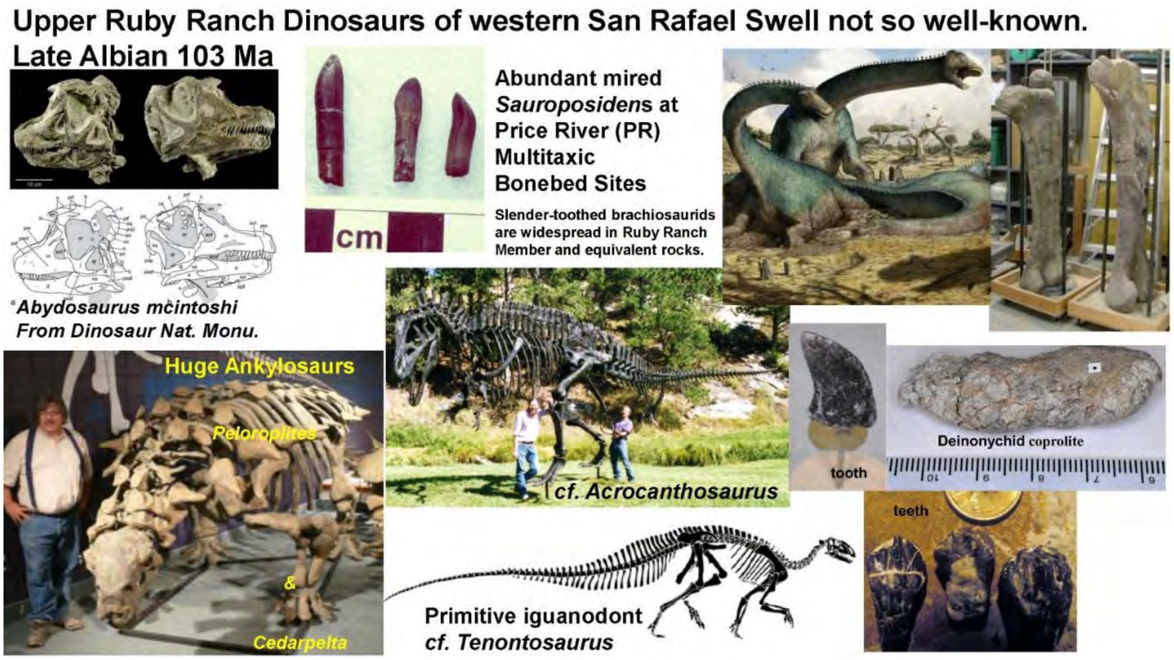


Figure 24. Some of the dinosaur remains characteristic of the upper Ruby Ranch Member.

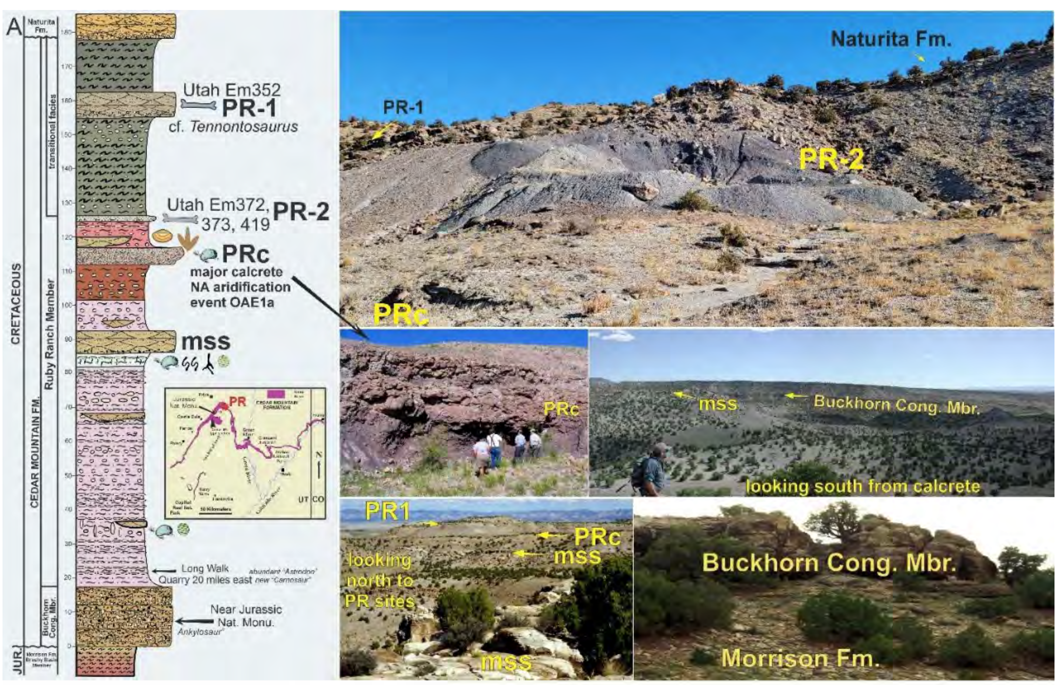


Figure 25. The Cedar Mountain Formation as exposed in the Price River area on the north end of the San Rafael Swell. This particularly thick section of these Lower Cretaceous has been the subject of a number of importand geological and stable isotope, geochemistry studies examining the paleoclimate and testing the posiblities correlating shifts in paleoatmospheric stable carbon isotopes ratios as a tool to correlate rocks in this time interval globally (e.g. Ludvigson et al., 2010, 2015).

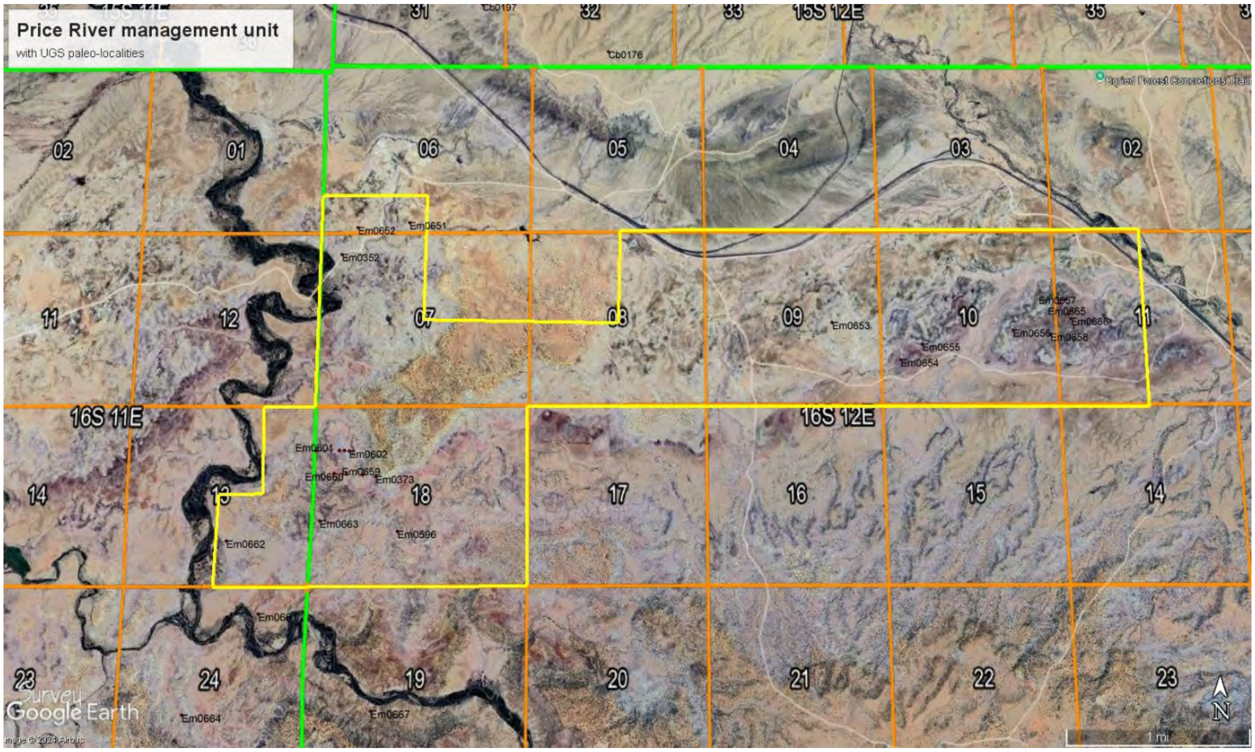


Figure 26. Geographic area of the proposed Price River unit with paleontological sites from UGS paleo-locality database superimposed.

The Prehistoric Museum in Price has been the sole repository for all material from the Price River localities. Their close proximity to Price, means that most museum personnel could commute from home to excavate at these sites. The Prehistoric Museum also ran numerous digs with volunteers from the public on these important sites. The continued interpretation of these dinosaur sites and the utilization of these extraordinary resources in education at Utah State University Eastern is a logical part of this management unit when established.

Mussentuchit unit

The fossils of the Mussentuchit Member of the Cedar Mountain Formation are spectacular in their extraordinary diversity and in their pristine preservation. The Mussentuchit preserves the complete fauna and flora at the very base of the Upper Cretaceous though an interval of immigration inducted extinction with opening of a land bridge to Asia following the small continental collision forming Alaska at the Cretaceous north pole (Kirkland et al, 2016). Making a conservative estimate of the most critical badlands to include in this management unit results in a proposal to include 19.9375^2 miles, or 12,400 acres (Fig. 27, 28). Numerous volcanic ashes within this unit permit it to be accurately dated as only spanning a couple of million years from approximately 99.5-97.5 Ma. About 30 years ago these rocks would have been considered as being latest Early Cretaceous, but biostratigraphic correlations with the Cretaceous type areas in Europe have revealed that these rocks of this age represent the beginning of the Late Cretaceous. This determination has only recently been widely accepted, but works out nicely as numerous animals, whose first North American occurrences are in the Mussentuchit, reflect many of the lineages that will characterize the Late Cretaceous of North America up to the terminal extinction event (Cifelli et al. 1997).

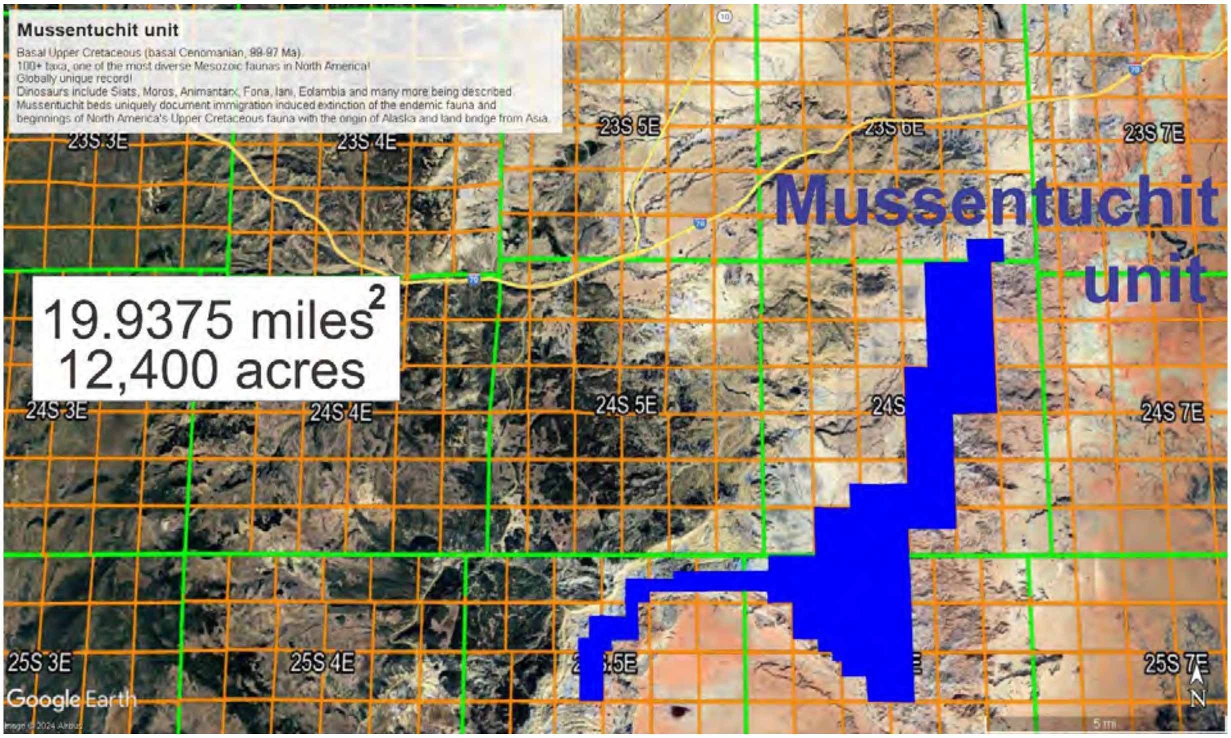


Figure 27. Geographic area of the Mussentuchit unit superimposed onto Townships and Ranges.

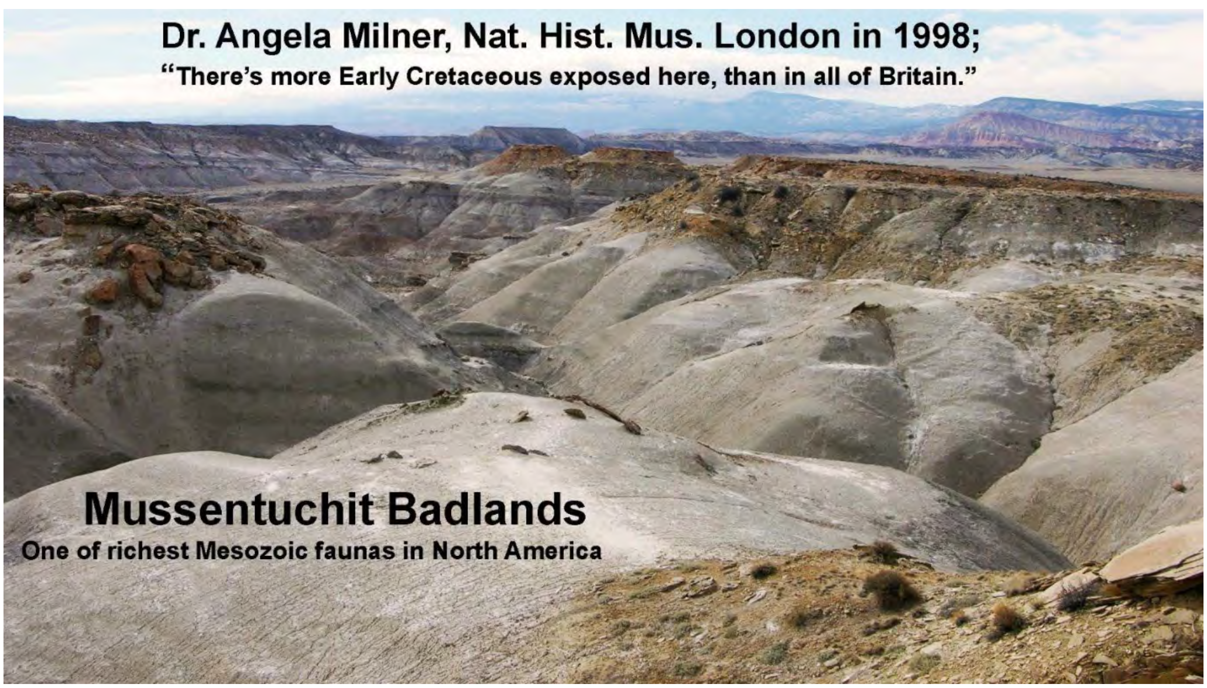


Figure 28. The Mussentuchit Badland are so rugged that there is essentially no sign of off-roaders venturing into this

area and paleontologist hike in and out of the area from the rim much as they do at the much later Dinosaur Provincial Park in Alberta.

The initial paleontological research into the Mussentuchit Badlands was by Rich Cifelli of the Oklahoma Museum of Natural History (OMNH) in the quest for Cretaceous mammals by wet screenwashing fossiliferous rocks for microvertebrates. As much as 100 tons of rock went through their screen boxes producing a wealth of teeth and jaws of tiny vertebrates. A great diversity of dinosaurs, birds, mammals, lizards, snakes, salamanders, frogs, freshwater sharks, and bony fish were recovered in this way with 22 mammal species described among the bounty (Fig. 29, 30). For the most part the beautifully preserved dinosaur remains were avoided by (OMNH).

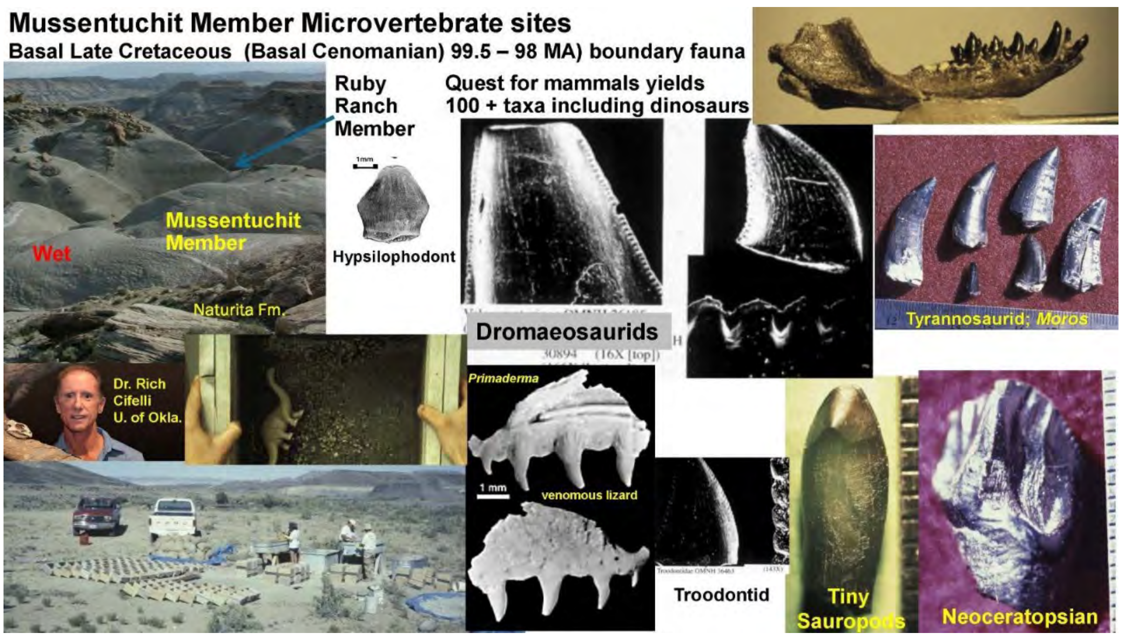


Figure 29. A few examples of the early results from the Oklahoma Museum of Natural History's extensive screenwashing operation in the Mussentuchit Badlands during the 1990s.

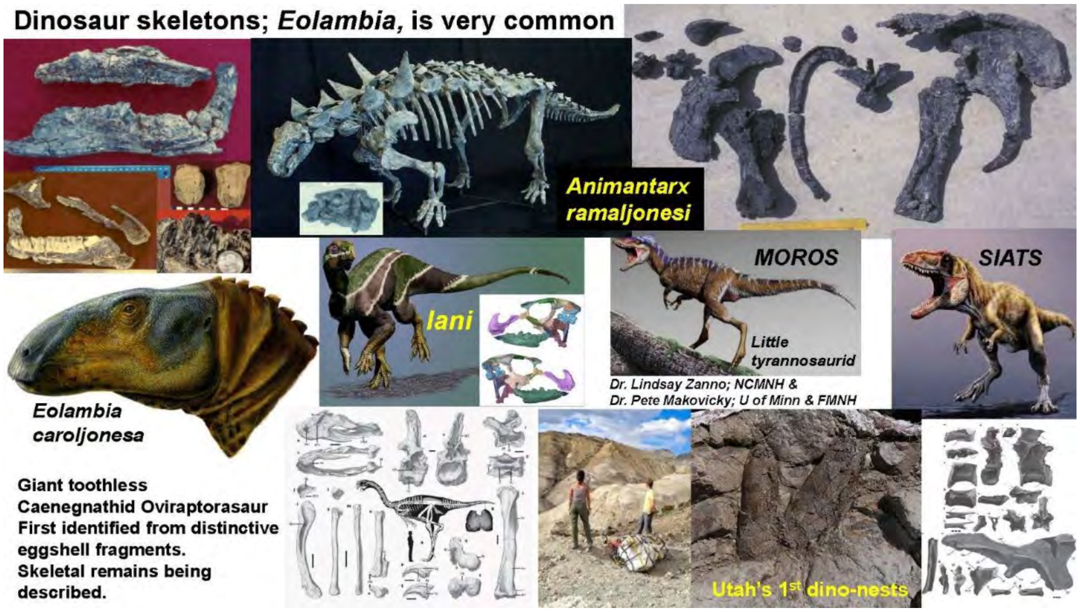


Figure 30. Some examples of dinosaur discoveries in the Mussentuchit Member of the Cedar Mountain Formation on the western side of the San Rafael Swell.

The Prehistoric Museum collected many juvenile *Eolambia* specimens from a single mass mortality site in the Mussentuchit Badlands during the late 1990s. Over the last 20 years Pete Makovicky of the Chicago's Field Museum and Lindsay Zanno of the North Carolina Museum of Natural Sciences have been leading teams into the Mussentuchit Badlands each season with extraordinary results (Fig. 31). The Zanno team has air lifted out the first large dinosaur nests from the Cedar Mountain, although eggshell fragments are fairly common throughout the entire formation. Early tyrannosaurs, the last giant carnosaurs, and early horned dinosaurs are among their groundbreaking discoveries.

The outstanding opportunities for hiking trails, and the amazing badlands are obvious additional draws to the area. The north rim of Cathedral Valley is formed by the Last Chance anticline providing extraordinary views to the south. The Last Chance Road is the gateway to the north end of the Capitol Reef National Park and where it cuts down through the anticline proves a striking cross-section of the south end Jurassic seaway. This road could make an obvious southern extension of SR-10 southward through the Mussentuchit management unit and through Cathedral Valley to SR-24. The development of the Mussentuchit would provide an impetus to develop the I-70 - SR-10 interchange as the southern gateway up into Castle Valley. Development of this interchange could provide needed infrastructure that does not exist between Green River and Salina (the longest stretch of interstate in the lower 48 states) and additional jobs for the nearby communities of Emery and Moore.

The Museum of the San Rafael in Castle Dale, Utah would provide an essential site for interpretation of the importance of this unique paleontological area. Eventually a visitors' center on the north rim of the Mussentuchit Badlands would provide an essential site to provide an overview of the area and provide a reason to charge an entry fee to visitors to this specific area.

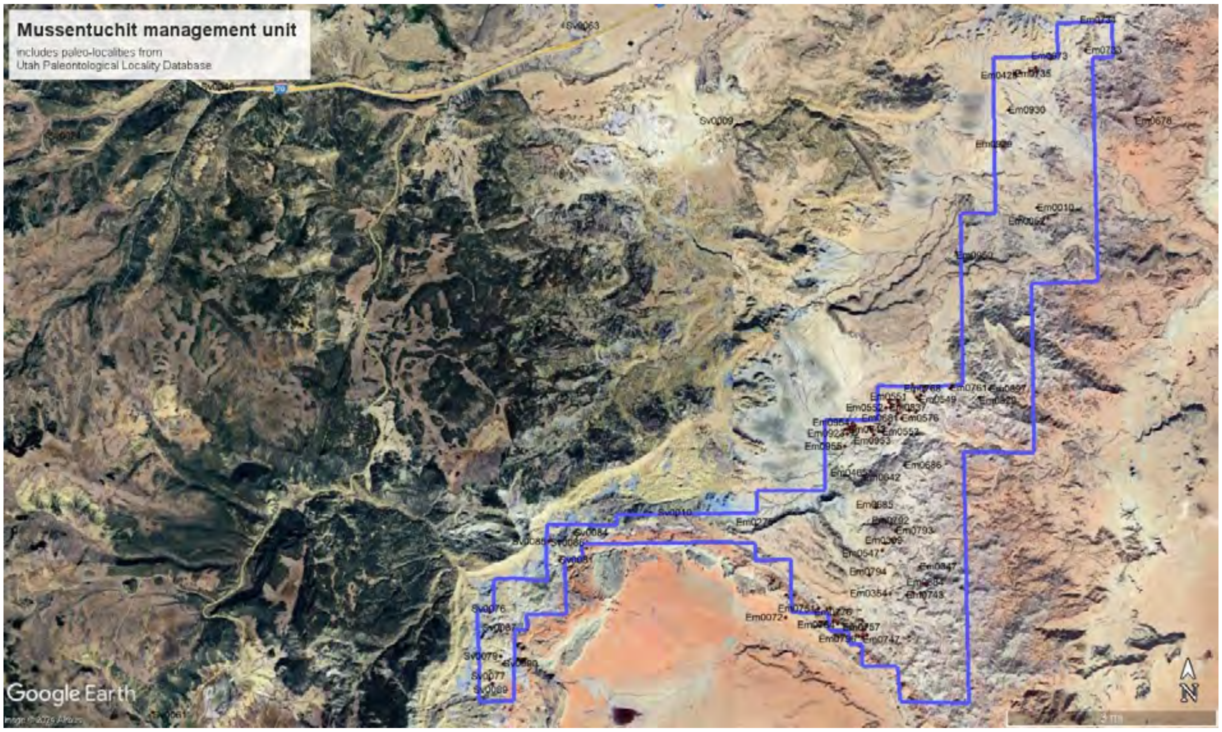


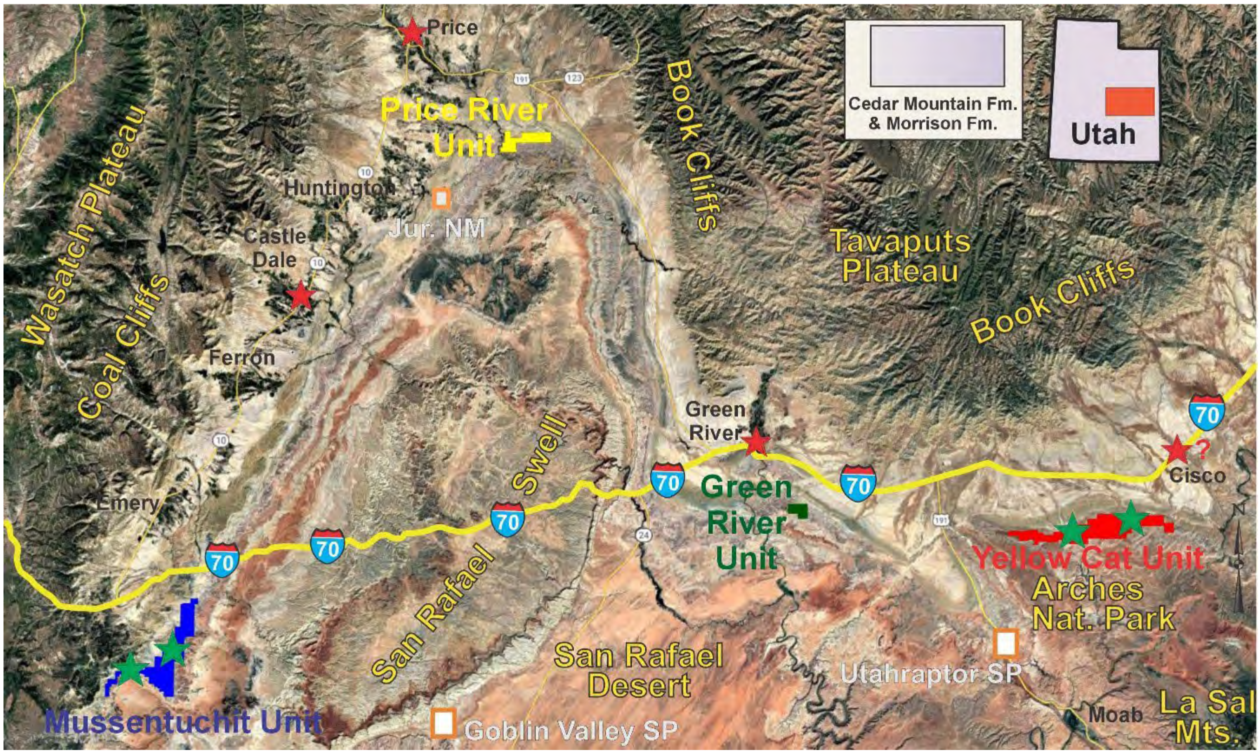
Figure 31. Geographic area of the proposed Mussentuchit unit with paleontological sites from UGS paleo-locality database superimposed.

Conclusions

Emery and Grand Counties in eastern Utah have been shown to preserve the most complete record of Lower Cretaceous dinosaurs in the world. These fossil sites provide outstanding and unique opportunities for interpretation and tourism in this region that has the potential to provide long term benefit to our rural communities. The establishment of an extended Dawn of the Cretaceous Fossil Beds National Monument modeled after John Day Fossil Beds Nat. Mon., Oregon provides the best opportunity to provide a long-term mechanism to protect resources, support ongoing research, interpret this globally significant resource and promote recreation and development in these regions of rural eastern Utah. It is for this reason that making these areas a National Park Service fossil park for which including “Fossil Beds” as part of its name is essential!

To ensure a strong linkage of this proposed NPS fossil park to our communities in Grand and Emery Counties, formally designating the Prehistoric Museum at USU Eastern as the research hub would provide an important educational focal point, with interpretive sites at Yellow Cat, ?Cisco, Green River, Price, Castle Dale, and Mussentuchit would provide a network through our rural communities in eastern Utah that would provide additional benefits for all! Expanding and modernizing the repository facilities at the Prehistoric Museum is an essential facet to the success of this proposal. USU Eastern serves rural communities in eastern and central Utah as one of the few residential campuses of Utah State University. The interdisciplinary nature of paleontology allows a new repository/learning facility to support a diverse array of programs already at USU, including geosciences, anthropology, computer sciences, nursing and pre-medicine tracks, welding, etc.

Simple designation of Dawn of the Cretaceous Fossil Beds is not enough; initial funding for organization and infrastructure is essential. To be viable over the long-term, monies coming in must equal monies going out. As such, creating a park that brings in funding is essential, thus the development of campgrounds, interpretive trails, and visitor centers at the larger management units at Yellow Cat and Mussentuchit will be essential for justifying entrance fees. Thinking out of the box, while difficult, is critical to make Dawn of the Cretaceous Fossil Beds a long-term success for all our citizens.



The aerial limits of the four proposed management units with suggested sites for visitor center, camping, hiking trail hubs designated by green stars and community interpretive sites designated by red stars. Red = Yellow Cat unit. Green = Green River unit. Yellow = Price River unit. Blue = Mussentuchit Unit.

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Appendix. Formal Geographic Definitions

Yellow Cat management unit

BLM land
20.875 miles^2
13,360 acres

Utah TLA land
3.375 miles^2
2160 acres

Township 22 south, Range 20 east
northern ½, section 35
section 36 **Utah TLA**
Township 22 south, Range 21 east
section 25
southern ½, section 26
southern ¼, section 27
southern ½, southwest ¼, section 28
southern ½, southeast ¼, section 29
southern ½, section 30
northern ½, and southwest ¼, section 31
northern ¾ and southern ½, southwest ¼ section 32 **Utah TLA**
northern ¾, section 33
northern ½, section 34
section 35
section 36 **Utah TLA**
Township 22 south, Range 22 east
southern ½, section 19
section 20
section 21
section 22
section 23
western ½ and southeast ¼ and south ½, nortk1/4, section 24
northwest ¼ and northern ½, northeast ¼, section 25
western ½ and southwest ¼, section 26
section 27
section 28
section 29
section 30
northern ½, section 31
northern ½, section 32 **Utah TLA**
northern ½, section 33
northern ½, section 34
Township 22 south, Range 23 east

southern ¾, section 19
southern ¾, section 20
section 28
northern 1/4, section 29
northern 1/4, section 30

Green River management unit.

BLM land

2.5 $miles^2$
1600 acres

Utah TLA land

0

Township 22 south, Range 17 east
section 17
section 18
northern ½, section 20

Price River management unit.

BLM land

5.25
3360 acres

Utah TLA land

0.25 $miles^2$
160 acres

Township 19 south, Range 11 east
eastern ½, northeast ¼ and southeast ¼, section 13
Township 19 south, Range 12 east
southern ½, southwest ¼, section 6
southern ½ and northwest ¼, section 7
southern ½ and northeast ¼, section 8
section 9
section 10
west ½, section 11
northwest ¼, section 16 **Utah TLA**
northern ½, section 17
section 18

Mussentuchit management unit.

BLM land
16.5625 $miles^2$
10,240 acres

Utah TLA land
3.375 $miles^2$
2160 acres

Township 23 south, Range 6 east
southeast ¼, section 35
western ½, southwest ¼, section 36 **Utah TLA**
Township 24 south, Range 6 east
section 2 **Utah TLA**
eastern ½, section 3
eastern ½, section 10
section 11
section 14
section 15
section 22
section 27
southern ½, section 28
eastern ½, southeastern ¼, section 29
section 32 **Utah TLA**
section 33
northern ½, section 34
Township 25 south, Range 5 east
southern ½, northwest ¼; southern ½, northeast ¼; southern ½, northwest ¼; and northern ½, southeast ¼, section 1
northern ½, southeast ¼; southern ½, northwest ¼; and northern ½, southeast ¼, section 2
southwest ¼, section 3
southern ½, northwest ¼; western ½, northeast ¼; northern ½ and southwest ¼, southwest ¼; and northwest ¼ southeast ¼, section 10
southeast ¼, northeast ¼, and southwest ¼ and eastern ½, southeast ¼, section 9
eastern ½, section 16 **Utah TLA**
Township 25 south, Range 6 east
western ½, section 3
section 4
section 5
northern ½, northwest ¼; northern ½, southwest ¼; and eastern ½, section 6
northern ½; northern ½, southwest ¼; and southeast ¼, section 8
section 9
western ½, section 10
western ½, section 15
northern ½ and southeastern ¼, section 16 **Utah TLA**