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Crossing park boundaries in the study of ancient ecosystems

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Introduction

National park units have at times been referred to as “ecological islands.” More recently, such units have begun to be viewed as ecological mosaics rather than separate island units as managers of publicly owned, federally managed lands have increasingly gained an appreciation for park boundaries and their relationships to particular biological issues. It is often apparent to these managers that individual park boundaries may not fully encompass appropriate habitat areas for managing biological resources. As a result, partnerships have been sought within and between land management agencies to best accommodate the needs of these biological resources.

In order to understand the natural world of today, one must examine the past. Studies such as those discussed below show that fossils are more than oddities of the rock record; they represent the record of life that has evolved on this planet. They are the means to test the scale and robustness of ecological principles observed in the modern world. Given the human proclivity for habitat manipulation, understanding ecological principles in geologic time can only be insightful.

Linking national park units is ideal for providing insights into ancient ecosystems because such units contain some of the most productive fossil-bearing rocks in North America. Traditionally, geologic—and by extension paleontologic—resources have been treated as isolated phenomena. For example, Fossil Butte National Monument contains a remarkably rich sequence of rocks containing some of the most spectacular fossil fish from the Eocene (58 to 36 million years ago) found anywhere in the world. However, this resource is often viewed as unique without regard to how the large fossil lake containing these fish relates to the contemporary environment of its time.

A notable exception is the Morrison Formation ecosystem project, a multi-year ancient ecosystem study sponsored by the National Park Service (NPS), that focused on the Late Jurassic Morrison Formation ecosystem. We briefly summarize basic results from one component of this study focused on the dominant group of vertebrates from the terrestrial ecosystem, the sauropod dinosaurs. This summary of data on sauropods illustrates the advantages of examining fossil resources in context beyond individual park boundaries. Lastly, we suggest an even larger-scale project that would minimally tie together NPS units from near the Arctic Circle (Denali National Park and Preserve and Yukon-Charley Rivers National Preserve) all the way to the Rio Grande Valley (Big Bend National Park). This suggested project is an extension of a crossing boundaries approach to studying ancient ecosystems and illustrates the nearly limitless nature of such an approach.

The Morrison Formation ecosystem project

The Upper Jurassic Morrison Formation of the western USA records a highly unusual time in earth history. At least six different genera of sauropods are recorded from this formation, and more than one taxon is represented at many localities (Dod-

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son et al. 1980). The most spectacular locality is the Carnegie Quarry at Dinosaur National Monument, which at one time was recognized as the single most important Jurassic vertebrate fossil site in the world. Sauropods were long-necked, long-tailed animals with adult weights estimated to range from 5 to 80 metric tons (Anderson et al. 1985; Colbert 1962: Colbert 1993) and these animals coincide closely with the popular view of a dinosaur. The most common of these taxa, and the ones most often found in association, are *Camarasaurus*, *Diplodocus*, and *Apatosaurus*. At Carnegie Quarry, it has been shown that this co-occurrence of sauropod taxa probably represents ecological coexistence rather than the mixing of different faunal assemblages as a result of stream depositional processes (Fiorillo 1994). Nowhere today do so many large-bodied animals co-exist in a terrestrial ecosystem.

Partitioning of food resources has been demonstrated for the two most common sympatric sauropod dinosaurs, *Camarasaurus* and *Diplodocus* (Fiorillo 1998). The patterns of occurrence of pits, coarse scratches, and fine scratches on the surfaces of teeth of these taxa show that, in general, *Camarasaurus* ate coarser foods than did *Diplodocus*. In contrast with the majority of *Camarasaurus* teeth belonging to adults, which show evidence of ingestion of coarser foods, the teeth of juveniles show a pattern of wear similar to that observed on *Diplodocus*. This suggests that there was dietary overlap between the young of *Camarasaurus* and adults of *Diplodocus*, and that dietary divergence occurred when individuals of *Camarasaurus* achieved adult size.

During the Jurassic, at the time these two sauropod taxa roamed western North America, there existed an enormous hypersaline, alkaline lake (>150,000 sq km) called Lake T'oo'dichi (Owen et al. 1989; Turner and Fishman 1991). The presence of this environmentally sensitive, large-scale feature provides a unique opportunity to examine the role of climate in the ecology of extinct vertebrates from the Mesozoic. The sites that produced these teeth are of varying distance from ancient Lake T'oo'dichi and extend along an 800-km transect. The site closest to the lake is Dinosaur National Monument and continues northeastward and includes sites extending into eastern Wyoming (Figure 63.1). There appears to be no variability on the wear patterns of these teeth regardless of the locality. This implies that the diets of these large dinosaurs remained unchanged due to the climatic influence that produced the alkaline lake (Fiorillo 1996). The elephant and the giraffe are often used as modern analogues for sauropods, the former because of its body size and the latter because of its long neck (e.g. Colbert 1993). Given comparisons with these modern-day large herbivores, sauropod feeding behavior is more similar to that of giraffes than to elephants because giraffes do not vary their diet due to climatic variance (Owen-Smith 1988).

The above points highlight the value of looking beyond park boundaries for gathering life history data for ancient organisms. Specifically, food partitioning, which in modern ecosystems is a mechanism for co-existence by animals that are similar, was documented for the two most common and dominant animals of the ancient terrestrial ecosystem. Further, dietary change from juveniles to adults was also demonstrated (Fiorillo 1998). Lastly, with respect to environmental response, sauropods behave more similarly to giraffes than to elephants. By moving beyond the boundaries of one park, Dinosaur National Monument, the studies mentioned here illustrate that sauropods were animals living in a diverse and dynamic landscape.

A proposed Western Interior Seaway project

During various times during the Mesozoic Era a shallow seaway extended from the present Gulf of Mexico to the Arctic Ocean (Figure 63.2). Rocks laid down during this time have produced the vast majority of fossil vertebrates from the Mesozoic and include such famous dinosaurs as *Tyrannosaurus* and *Triceratops*, and other such famous fossil reptiles as the swimming mosasaurs and the flying pterosaurs. The Cretaceous is a vitally important time, for it is when many of the modern groups of mammals appear in the fossil record. By the end of this geologic period many organisms, including the reigning dominant terrestrial life forms, the dinosaurs, go extinct. With respect to terrestrial vertebrate biogeography along the Interior Seaway, many animals have a cosmopolitan distribution along its entire length (such as the duck-billed dinosaur, *Edmontosaurus*), while other animals have only localized distributions.

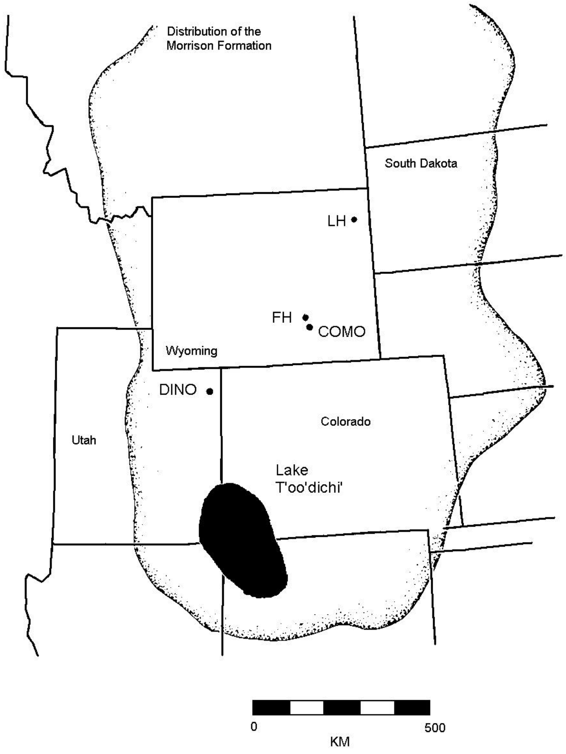

Figure 63.1. Map of the westernmost distribution of the Morrison Formation, also showing the general location of Lake T'oo'dichi and the four localities that yielded sauropod teeth examined in this study. The locality acronyms DINO, FH, COMO, and LH refer to Carnegie Quarry (Dinosaur National Monument), Freezeout Hills Quarry N-O, Quarry I (?) Como Bluff, and Little Houston Quarry, respectively.

As an example of the latter, the last surviving sauropod dinosaur in North America is *Alamosaurus*. The known distribution of *Alamosaurus* is limited to lower latitudes and has only been found as far north as Utah. These animals are perhaps best known from the Late Cretaceous Javelina Formation in Big Bend National Park in western Texas. While in the modern world one can appreciate the reasons why polar bears don't wander around Texas, the reasons for a restricted distribution for *Alamosaurus* are not as apparent.

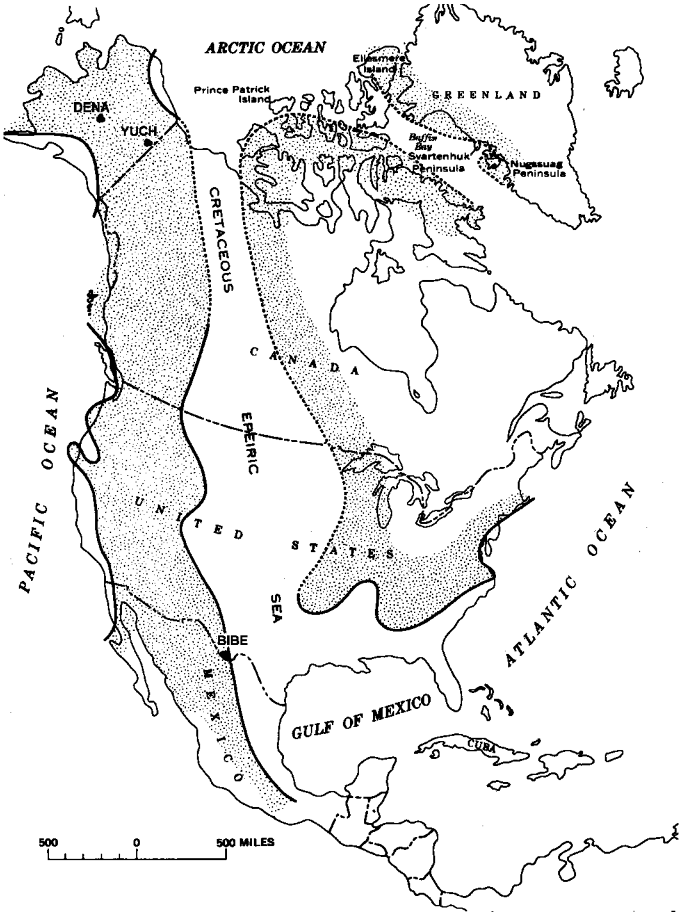

Figure 63.2. Schematic drawing of the Western Interior Seaway of North America during the Cretaceous. Denali National Park and Preserve, Yukon-Charley Rivers National Preserve, and Big Bend National Park are designated respectively by DENA, YUCH, and BIBE. These parks illustrate the range of NPS units that contain rocks deposited during the Cretaceous. Map modified from Gill and Cobban (1973).

By examining the rocks containing sauropods both in the Morrison and the Javelina formations, one can observe a pattern of ancient semi-aridity associated with sauropods (Engelmann et al., in press). Whereas this aridity is evident at the south end of the Interior Seaway, looking beyond the boundaries at Big Bend National Park to the north end of the seaway, the rocks indicate a much moister environment (Engelmann et al., in press). Therefore, one can tentatively attribute the restricted distribution of *Alamosaurus* to regions of aridity.

In still another example of ecological insights to be obtained by expanding beyond park boundaries, a recent study of the distribution of theropod dinosaurs along this seaway has provided insights into ecosystem dynamics for the Cretaceous. This recent study has shown that though many taxa are in common from north to south, there is slightly less diversity at the north end of the seaway compared with the south (Fiorillo and Gangloff 2000). This is a pattern consistent with the distribution of many animals in the modern world and is likely related to resource availability and diversity. In addition, although the theropod dinosaur *Troodon* dominates the northern assemblage, this genus is rare farther south. One characteristic that distinguishes this theropod is the presence of large orbits, a feature in modern animals attributed to an adaptation for low-light conditions. Low-angle light is the condition in high latitudes regardless of geologic time. Thus, it has been suggested that the dominance of *Troodon* is likely a faunal adaptation by this component of a cosmopolitan theropod fauna to low-light conditions at a high paleolatitude (Fiorillo and Gangloff 2000).

These are just two examples of the results that can be obtained from expanding beyond park boundaries in the study of ancient ecosystems. In addition to qualitatively outlining the Western Interior Seaway across North America, Figure 63.2 also shows the position of Big Bend National Park, Denali National Park and Preserve, and Yukon-Charley Rivers National Preserve. These parks all contain sedimentary fossil-bearing rocks of the same age, and serve as end points on a transect along this seaway. Many other national park units, also containing similar-aged rocks, are intermediate in position between these parks.

The above discussion has highlighted the potential for cross-boundary studies. A comprehensive investigation by a team of field, lab, and library researchers and geographic information systems (GIS) specialists investigating the expansive rock sequences of the Cretaceous Western Interior Seaway in these many parks can provide further details in an important ancient ecosystem. For example, it has been suggested that the fluctuations of the seaway exerted speciation pressures on organisms by expanding and contracting niche spaces (Weishampel 1987; Horner et al. 1992). Detailed paleontological investigation linking parks with similar-aged rocks can provide a valuable means for testing models for paleoecology, evolution, and the paleogeographic distribution of ancient taxa.

Summary

Fossils are the basis for understanding life in the past. They provide the means for determining long-term patterns of evolution. They also provide the means for examining how ancient organisms may have interacted among themselves within a community. NPS units contain some of the most important fossil-bearing rocks anywhere in North America. By linking parks with similar-aged rocks to other areas, either within the National Park System or elsewhere, important additional paleoecological insights on specific ecosystems can be obtained. Here we have briefly discussed one component of a successful effort to link similar land units to better understand an ancient ecosystem. Further, we have suggested an additional venue for application of the crossing boundaries approach to understanding ancient ecosystems. While these early efforts have proven valuable, additional large-scale projects are needed to compare ecosystems through time.

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