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AH-SHI-SLE-PAH WILDERNESS STUDY AREA (SAN JUAN BASIN, NEW MEXICO): A PALEONTOLOGICAL (AND HISTORICAL) TREASURE AND RESOURCE

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Abstract—The Ah-shi-sle-pah Wilderness Study Area ranks as one of the most important regions in the San Juan Basin for Late Cretaceous vertebrates from both a scientific and historical viewpoint. The venerable field paleontologist Charles H. Sternberg collected the holotype skull (PMU.R200) of *Pentaceratops fenestratus* and a postcranial skeleton with lower jaws (PMU.R268) from the south branch of Ah-shi-sle-pah Wash (formerly Meyers Creek). These and numerous other fossil vertebrates collected by C. H. Sternberg were sold to the University of Uppsala, Sweden in the early1920's. More recently, this region has been intensively collected by field crews of the State Museum of Pennsylvania, which have recovered 280 specimens of fossil vertebrates (fishes, turtles, crocodilians and dinosaurs), along with invertebrate and plant specimens, from numerous sites (many of them new) in the upper Fruitland (Fossil Forest Member) and lower Kirtland (Hunter Wash Member). The fossil vertebrates from these strata comprise the Hunter Wash local fauna, which are characteristic of early Kirtlandian time.

INTRODUCTION

The Ah-shi-sle-pah Wilderness Study Area (WSA), San Juan Basin, New Mexico (Fig. 1) is located about 80 kilometers south of Farmington, New Mexico and 3.2 kilometers north of Chaco Culture National Historic Park. It takes its name from the principal drainage, Ah-shi-sle-pah Wash (formerly Meyers [Meyer's] Creek), which drains to the southwest where it becomes confluent with the Chaco River. The Ah-shi-sle-pah WSA consists of 6563 acres of public land, which was initially set aside for wilderness consideration in November 1979 and has since been deemed as non-suitable for Wilderness designation. The Navajo Nation has selected approximately 3094 acres of the Ah-shi-sle-pah WSA as part of an exchange for lands relinquished in the Navajo-Hopi relocation settlement. The final disposition of the land has not been acted upon by Congress. The lands that have been selected by the Navajo Nation contain some of the most important paleontological sites in the San Juan Basin, both from a scientific and historical perspective.

The Ah-shi-sle-pah WSA was first collected by Charles H. Sternberg in early 1921, and specimens from this area form a significant part of the fossil vertebrate collection at the Museum of Evolution, University of Uppsala, Sweden (PMU). The WSA has been intermittently collected between 1924 and 1995, with a brief surge in 1977 as the result of a paleontological survey for the BLM (Kues et al., 1977). This survey documented the paleontological importance of the region, assessing it as an area "where substantial mitigation is essential." It has since been collected by field crews from the New Mexico Museum of Natural History and Science (NMMNH) and The State Museum of Pennsylvania (SMP) over the last 20 years. Intensive collecting has been accomplished by the latter institution over the last decade. To date, 280 specimens of fossil vertebrates from Ah-shi-sle-pah WSA have been collected and catalogued into the collections of the State Museum of Pennsylvania. Many of these specimens are significant and are presently being studied.

The purpose of this paper is to: (1) discuss the historical significance of the Ah-shi-sle-pah WSA in the annals of American vertebrate paleontology; (2) record the current collecting and research being conducted by the State Museum of Pennsylvania (Harrisburg); and (3) discuss the scientific importance of this paleontological resource.

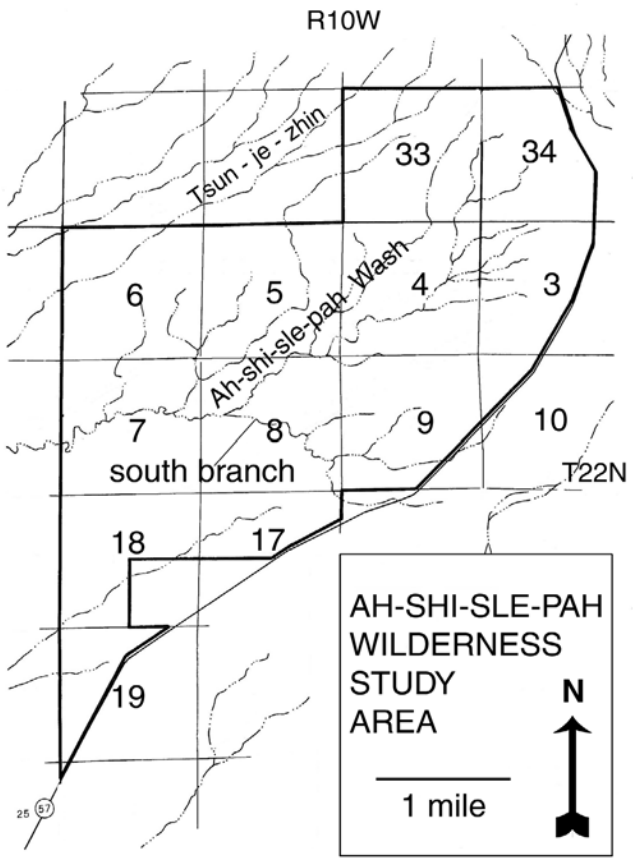

FIGURE 1. Map of Ah-shi-sle-pah Wilderness Study Area, San Juan Basin, New Mexico.

Geology

Strata within the Ah-shi-sle-pah WSA include most of the upper Fruitland Formation (Fossil Forest Member) and lower part of the Kirtland Formation (Hunter Wash Member). As such, the area is one of the few places in the San Juan Basin where the contact between the two forma-

tions is visible. The contact is placed at the base of the Bisti Bed (Lucas et. al., 2006), a persistent sandstone complex that crops out locally (Fig. 4A-B). The strata are dominated by mudstones and intermittent sandstones and occasional resistant channel sandstones.

The Sternberg Years (1921-1924)

The well-known fossil collector and field paleontologist Charles H. Sternberg (Fig. 2) collected fossil vertebrates from the Fruitland, Kirtland and Ojo Alamo formations beginning in the summer of 1921 and ending in 1924. Among his important discoveries during this period were three nearly complete skulls, an incomplete frill and postcranial skeleton of *Pentaceratops* from various localities within the San Juan Basin.

In 1921, Sternberg collected the holotype of *Pentaceratops fenestratus* (PMU.R200) and the postcranial skeleton (PMU.R268), and both were sold to the University of Uppsala. In 1922, Sternberg collected the holotype of *P. sternbergii* (AMNH 6325), presumably from what is now referred to as the Fossil Forest (Hunt, 1991). In early June of 1923, Sternberg discovered another skull (AMNH 1624), subsequently referred to as *P. sternbergii*. A fourth specimen, AMNH 1625 (nearly complete frill, consisting of the posterior part of the parietal and right squamosal) was discovered later that same month. Unfortunately, the provenance of both AMNH 1624 and AMNH 1625 is not known.

Sternberg (1932) reported that he discovered the crushed skull of *Pentaceratops fenestratus* (PMU.R200) "in a bit of badlands" 1 mile south of Mr. Tyler's (at Kimbeto Wash). Wiman (1930) and Lull (1933) recorded the locality of this specimen as "1 mile south of Kimbetoh Wash, on the south branch of Meyers Creek…" Rowe et al. (1981, p. 32) re-assessed the locality data based on Wiman's and Lull's papers and concluded that the holotype *P. fenestratus* was collected from the Kirtland Formation "one mile (1.6 km) *north* of Kimbeto Wash, on the south branch of Ah-shi-sle-pah Wash (Meyers), Wash." This would probably have been from either sections 8 or 9 (T22N, R10W) as this area is known to produce fossils, near the site of Sternberg's last camp of 1921 (on the south branch of Meyers Creek) and other collecting localities. Mateer (1981) reported that the postcranial skeleton of *Pentaceratops* (PMU.R268) was recovered from T22N, R11W. However, based on his autobiographical account (Sternberg, 1932), it is all but certain that the postcranial skeleton came from near Sternberg's "hoodoo locality" described below. Consequently, this places the site of PMU.R268 (Fig. 2) in the same township and range, also on the south branch of Ah-shi-sle-pah Wash. Indeed, a survey of the fossils collected by Sternberg and sold to the University of Uppsala show that many of the specimens were collected in this area.

FIGURE 2. Charles Sternberg collecting the *Pentaceratops* skeleton (PMU.R268) in Ah-shi-sle-pah Wash (Meyer's Creek) in 1921. The photograph was taken by Wesley Bradfield, a photographer from the American School of Research of Santa Fe. He spent part of the day with C. H. Sternberg documenting his collecting in Ah-shi-sle-pah Wash. The photograph was originally published in Sternberg (1932).

VERTEBRATE FOSSIL LOCALITIES

To date, 19 regional fossil localities have been identified within the Ah-shi-sle-pah WSA by the State Museum of Pennsylvania. These localities vary in size, and each has been given name and assigned a locality number with their respective borders outlined on a master 7.5 minute USGS topographic map (Pueblo Bonito NW). At the end of each field season a duplicate map is made plotting each specimen (by hand for specimens collected prior to 2000; GSP coordinates [UTMs] for specimens collected from 2001 and beyond). Below is a brief list by locality of some of the more important specimens that have been recovered from within the Ah-shi-sle-pah WSA.

Fruitland Formation (Fossil Forest Member)

Bob's Bloody Bluff and Bob's Bloody Bluff (North Side) (SMP Localities 396 and 401)

Bob's Bloody Bluff (Fig. 3A) is prominent mesa capped by the Bisti Bed of the Hunter Wash Member (Kirtland Formation). The underlying stratum is the upper Fruitland Formation (Fossil Forest Member). On the west side of the bluff are the sites of Eagle's Nest and Eagle's Nest Flat; and to the north are Bob's Bloody Bluff (north side) (locality 401) and to the east Bob's Microsite (locality 409). Some of the more significant fossils collected from Bob's Bloody Bluff (locality 396) include: SMP VP-1592, nearly complete right maxilla with teeth (cf. *Kritosaurus navajovius*); VP-1623, a nearly complete (indeterminate) hadrosaurid femur; and VP-1685, incomplete xiphilastron (*Plastomenus* sp.). From Bob's Bloody Bluff (north side) (locality 401): SMP VP-1619, incomplete right humerus (cf. *Parasaurolophus crytocristatus*); and VP- 1621, incomplete osteoderm (Ankylosauridae indet.).

Eagle's Nest/Eagle's Nest Flat (SMP localities 397 and 398)

Eagle's Nest was named for the abandoned eagle's nest resting atop a pinnacle on the west side of Bob'Bloody Bluff (Fig. 3B). The nest sits on the capping Bisti Bed. The site of Eagle's Nest is immediately to the east of the base of the pinnacle, in a cul-de-sac of the bluff. Numerous weathered skeletal elements were visible, but only diagnostic specimens were collected. Eagle's Nest Flat is a vast flat surface that extends out from the west side of the bluff and Eagle's Nest (Fig. 4b). The flat is largely a lag deposit.

From Eagle's Nest (locality 397): SMP VP-1658, two isolated tyrannosaurid teeth (cf. *Daspletosaurus* sp.).

From Eagle's Nest Flat (locality 398): SMP VP-1669, incomplete crocodylian scutes and frags; VP-1593 (Fig. 3C), nearly complete pes phalanx (cf. *Daspletosaurus* sp.); VP-1596, skull fragments, including the distal end of a quadrate, partial ?jugal, fragments of epoccipitals (cf. *Pentaceratops sternbergii*); VP-1598 and 1605, isolated teeth of *Myledaphus bipartitus*.; VP- 1610, carapace of cf. *Denazinemys nodosa*; VP-1662, upper margin of right maxilla (cf. *Kritosaurus navajovius*); VP-1664, distal end of a metatarsal (cf. Ornithomimidae indet.); VP-1667, incomplete nuchal, right and left xiphiplastra and associated fragments (*Plastomenus robustus*); and VP-1668, nearly complete plastron, carapace fragments (*Denazinemys nodosa*).

Bob's Mircosite (SMP locality 409)

Bob's Microsite is a rich microsite that has yielded fish (scales and teeth), turtle, crocodylian (osteoderms and teeth) and dinosaur remains. It is located northeast of Bob's Bloody Bluff. Some of the more

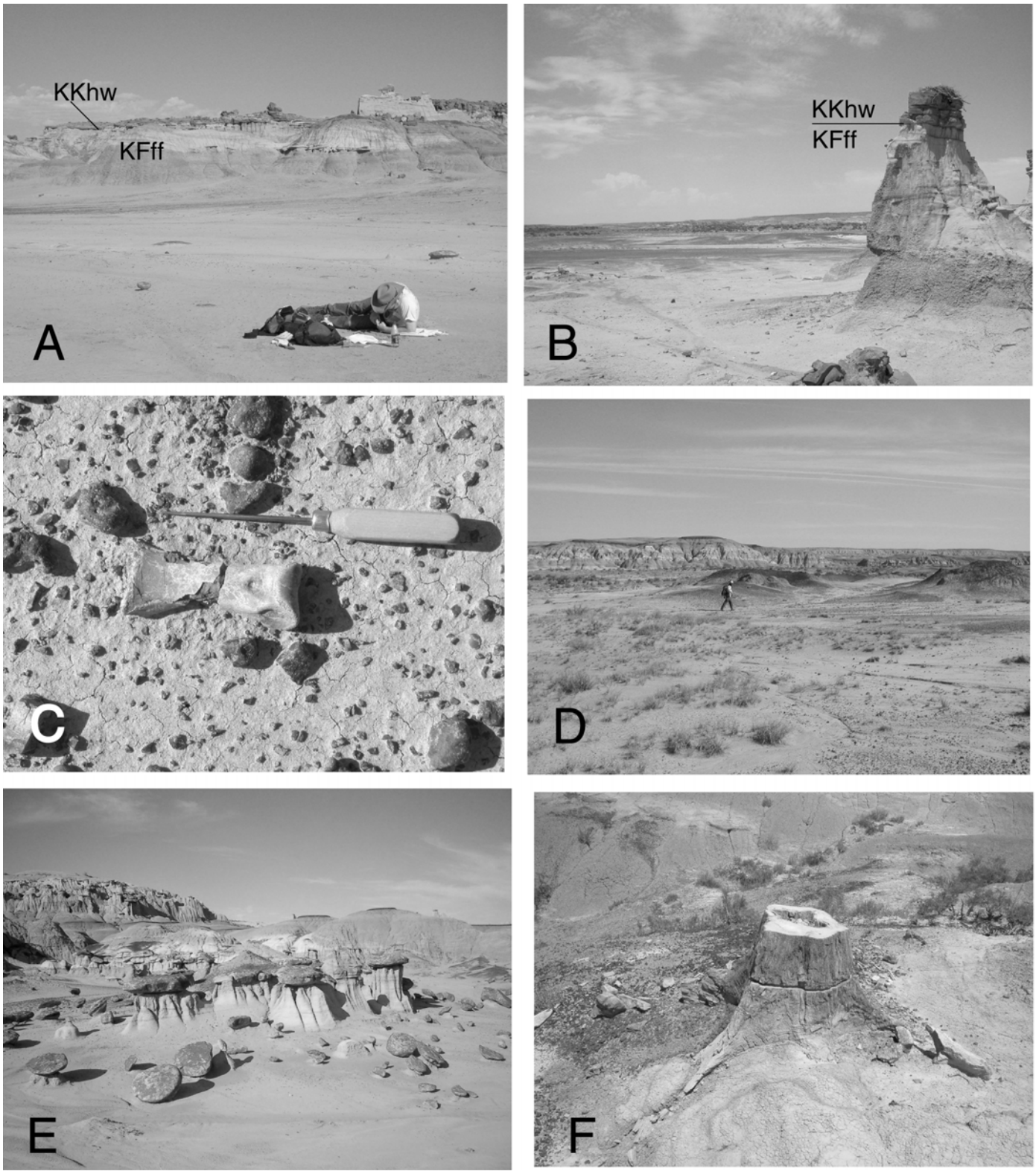

FIGURE 3. Localities and fossils in the Ah-shi-sle-pah Wilderness Study Area. **A**, Bob's Bloody Bluff (background), exposures of the upper Fruitland Formation (Fossil Forest Member), darker cap rock is the Bisti bed of the Kirtland Formation (Hunter Wash Member); **B**, Eagle's Nest and Eagle's Nest Flat, looking west across the lag surface of Eagle's Nest Flat (upper Fruitland Formation). The abandoned eagle's nest is visible atop the pinnacle (right); the locality of Eagle's Nest is located further to the right, out of view; **C**, nearly complete pes phalanx (SMP VP-1593) of cf. *Daspeltosaurus* sp. found at Eagle's Nest Flat; **D**, Denver's Blowout, low-lying exposures of the Kirtland Formation (Hunter Wash Member from center to right of photo; **E**, channel sandstones forming "toadstools" are numerous along the south branch of Ah-shi-sle-pah Wash (west); and **F**, fossil tree stump *in situ*, one of many such stumps in the Kirtland and Fruitland formations of Ah-shi-sle-pah WSA. Abbreviations: KFff = Fruitland Formation, Fossil Forest Member; KKhw = Kirtland Formation, Hunter Wash Member.

important specimens recovered from this site include: SMP VP-1668, scute fragments (*Denazinosuchus kirtlandicus*); VP-1686, very small and incomplete frontal (Crocodylidae indet.); and VP-1704, incomplete and weathered carapace and plastron (? *Denazinemys nodosa*).

Turtle Terrace (SMP locality 400)

"Turtle Terrace" was named for the many turtle fragments that were found weathering out of the formation. Among the more significant fossils recovered are: SMP VP-1615 and 1616, two large coprolites; VP-1680, nearly complete radius (Hadrosauridae indet); and VP-1698, large humerus (Testudines indet.).

KIRTLAND FORMATION (HUNTER WASH MEMBER)

Denver's Blowout (SMP locality 281)

Denver's Blowout (Fig. 3D) was discovered by Denver Fowler in the Summer of 2002. The site consists of low-lying exposures of the lower Kirtland Formation (Hunter Wash Member) and at the time of its discovery it was the richest site found in the Ah-shi-sle-pah WSA. A number of important specimens have been recovered from Denver's Blowout, including: SMP VP-1445 proximal end of left ulna and two ?radius fragments (Theropoda: ?Ornithomimidae or Dromaeosauridae); VP-1485, incomplete skull and lower jaws of *Melvius chauliodous* (the most complete known); VP-1488, portion of jugal with orbital rim of *Pentaceratops sternbergii*; VP-1500, nearly complete parietal, incomplete squamosals, jugal and epoccipital of *Pentaceratops sternbergii*; and VP-1522, carapace and plastron fragments (*Basilemys nobilis*).

Ah-shi-sle-pah Wash (west) (SMP locality 228) (includes Sternberg's hoodoo site)

This locality covers 1295 square kilometers and there are numerous collecting sites within its boundaries. It is from this general area that Sternberg collected his postcranial skeleton of *Pentaceratops sternbergii* (PMU.R268) in the fall of 1921 and a number of turtles.

Noteworthy specimens from Ah-shi-sle-pah Wash (west) include: SMP VP-742, plastron fragments (*Aspideretes* sp.); VP-1508, two complete dorsal vertebrate and lower half of a centrum of another (*Pentaceratops sternbergii*); VP- 1712, left jugal and quadratojugal (*Pentaceratops sternbergii*); and VP- 1789, complete left femur (*Ornithomimus* sp.).

The hoodoo site, which is located within SMP locality 228, was collected by C. H. Sternberg and his Navajo assistants Dan Padilla and Ned Shouver in 1921. A photograph of them at this site was published by Sternberg (1932) and is reproduced here (Fig. 4). We recognized this site in 2003 and published a note briefly describing the site as Sternberg's hoodoo, not a Palmetto, as indicated by Sternberg (Lucas and Sullivan, 2003).

In the manifest of specimens collected and sold to the University of Uppsala, Sternberg lists a turtle (no. 107) identified by him as "*Adocus*. This fine turtle, injured in taking it up under a high pilar. I could not get behind it without tumbling over the pilar."

Sternberg (1932) mentions that the hoodoo site was a locality where his two Navajo assistant discovered and collected a number of turtles. The base of the hoodoo bears a scar that is consistent with a small quarry site, the size of a common fossil turtle (~ 40 cm). The photograph, taken by Wesley Bradfield in 1921, clearly shows the chiseled base of the hoodoo and rock debris strewn across the surface, to the left of the base, suggesting that it was an excavation site.

Ah-shi-sle-pah Wash (east) (SMP locality 365)

SMP VP-1086, centrum (*Melvius chauliodous*); VP-1090, incomplete skull of a juvenile *Parasaurolophus* sp. (this specimen was published by Sullivan and Bennett, [2000] as coming from the Fruitland Formation but has since been determined to be the Kirtland Formation); VP-1440, distal end of a right femur (Hadrosauridae indet.); VP-1144, axis vertebra (?*Pentaceratops sternbergii*); VP-1145, a large unidentified ?skull element (dubbed the "mystery bone") possibly pertaining to an ankylosaurid; VP-1146, terminal phalanx (Trionychidae indet.); VP-1473, skull and scute fragment (Crocodylidae indet.); and part of the edge of a carapace (*Basilemys nobilis*).

FIGURE 4. Sternberg's hoodoo site in 1921 (top) and 2003 (bottom). Note the excavation scar and debris at the based of the hoodoo in the 1921 photo. This is probably the site of specimen (no. 107) sold to the University of Uppsala. Today, the scar of Sternberg's collecting is still evident (below).

FOSSIL INVERTEBRATE LOCALITIES

To date only one invertebrate fossil specimen (SMP IP-8335), an incomplete internal mold of a large bivalve (presumably *Unio* sp.), has been recovered from Ah-shi-sle-pah WSA. The specimen was found in association with the numerous fossil vertebrates from Denver's Blowout (locality 281).

FOSSIL PLANT LOCALITIES

During the course of our fieldwork, we have, on occasion, come across sites that are of paleobotanical interest. These sites produce petrified wood (stumps and logs), leaves and palynomorphs (from lignites). Overall, fossil plants have received little attention. Knowlton (1916) was the first to study the flora from the Fruitland and Kirtland formations of the San Juan Basin, but none of the material he reported on came from Ah-shi-sle-pah WSA. Later, a summary of the Cretaceous and

Tertiary floras of the San Juan Basin was presented by Tidwell et al. (1981). In recent years there has been a renewed interest in the macrofloras and trees of the Fruitland and Kirtland formations (Boucher and Wing, 1997; Boucher et al, 1997; Boucher, 2000; Vollum-Davies et al., 2000).

WOOD

Petrified wood is common throughout most of the Ah-shi-sle-pah WSA . Wood is known from both the Fruitland and the Kirtland formations and occurs mostly as broken material. However, there are a few areas where large logs and stumps are preserved. There is also a significant stump field along the western edge of the Ah-shi-sle-pah WSA. *In situ* stumps occur in both formations.

Two specimens of petrified wood have been collected. SMP PB-1009 and PB-4602 are from localities 386 and 228, respectively, and both are from the Hunter Wash Member (Kirtland Formation). The taxonomic identity of these specimens has not been determined.

LEAVES

Two incomplete and unidentified specimens of fossil leaves have been recovered from Ah-shi-sle-pah WSA. SMP PB-4601 is a small incomplete leaf impression from locality 396 (Fruitland Formation, Fossil Forest Member). SMP PB-4432 is an incomplete leaf impression from locality 406 (Kirtland Formation, Hunter Wash Member).

PALYNOMORPHS

Lignites are encountered in the upper part of the Fruitland and lower Kirtland formations. One lignite sample, SMP PB-1042 (locality 365), from the Kirtland Formation (Hunter Wash Member) was processed and yielded palynomorphs of *Baculatisporites* sp., *Cicatricosisporites* sp., *Cyathidites minor, Cycadopites fragilis, C.* sp., *Ephedrites* sp., *Faveotriletes* sp., *Frauxinoipollenites constrictus, Gleichneiidiites delicatus, Klukisporites* sp., *Liliacidites* sp., *Pityosporites constrictus, Proteacidites retusus, P. thalmanni, Pseudoplicapollis newmanii, Retitriletes* sp., *Taxodiaceaepollenites hiatus, Tricolpites hians, T.* sp. and *Varirugosisporites* sp.

FUTURE WORK AND THE FATE OF THE AH-SHI-SLE-PAH WSA

All fossil vertebrates from Ah-shi-sle-pah WSA belong to the Hunter Wash local fauna, a vertebrate fauna known from the upper Fruitland and lower Kirtland Formation (Fossil Forest Member and Hunter Wash Member, respectively). The fauna is based mostly on lower vertebrates (fish, turtles, crocodylians and dinosaurs). While mammal teeth have been collected in Hunter Wash (Clemens, 1973) and the Fossil Forest (Rigby and Wolberg, 1987), none are known from Ah-shi-sle-pah WSA. A preliminary list of fossil vertebrates is presented in Table 1.

Our understanding of the paleontology, fauna and flora, of the Ah-shi-sle-pah WSA is presently in its infancy. Although it has been intensively collected for macrovertebrate fossils in recent years, more sites need to be discovered and collected. Presently, the majority of the fossils from this region are housed in the collections of the State Museum of Pennsylvania and the Museum of Evolution, University of Uppsala. Only a handful of specimens (12, mostly dinosaur) from Ah-shi-sle-pah WSA are catalogued in the collections of the New Mexico Museum of Natural History and Science.

In addition to collecting macrovertebrate fossil sites, the microvertebrate sites (many of them co-occur with the macrovertebrate sites) are numerous throughout the Ah-shi-sle-pah WSA and need to be intensively collected. These sites have yet to been screened *en masse*. To date, all microfossils from this area have been picked-up from the outcrop. Thus, an increase sample of both the micro and macrovertebrate faunas is highly desirable in order to properly assess the taxonomic diversity of the Hunter Wash local fauna in this and nearby areas.

TABLE 1. A preliminary list of fossil vertebrates from Ah-shi-sle-pah WSA based on collection data from NMMNH, PMU and SMP. **FF Mbr** = Fossil Forest Member; **HW Mbr** = Hunter Wash Member.

TAXON GROUP	SUBGROUP	GENUS/SPECIES	Fruitland (FF Mbr)	Kirtland (HW Mbr)
Chondrichthyes				
	Rhinobatidae			
		Myledaphus bipartitus	X	X
Actinopterygii				
	Amiidae			
		Melvius chauliodous		X
Testudines				
	Baenidae	*Denazinemys nodosa*	X	X
		Neurankylus sp.	X	X
		Thescelus hemispherica	X	X
	Dermatemydidae			
		Adocus sp.	X	X
	Nanhsiungchelyidae			
		Basilemys nobilis	X	X
	Trionychidae			
		Aspideretes sp.	X	X
		Plastomenus robustus	X	X
Crocodylia				
	"Mesosuchia"			
		Denazinosuchus kirtlandicus		X
	Crocodylidae			
		Deinosuchus rugosus	X	
		cf. *Leidyosuchus* sp.	X	X
Dinosauria				
	Tyrannosauridae			
		Daspletosaurus sp.	X	X
	Ornithomimidae			
		Ornithomimus sp.		X
	Dromaeosauridae			
		Dromaeosauridae indet.		X
	Hadrosauridae			
		cf. *Kritosaurus navajovius*	X	X
		Parasaurolophus sp.		X
	Ankylosauridae			
		Ankylosauridae indet.	?	X
	Ceratopsidae			
		Pentaceratops sternbergii	X	X

Little is known regarding the paleobotanical realm in this region. The stump field needs to be studied in detail. The *in situ* stumps need to be mapped, sampled and thin sectioned. Comparison of the plants with those from the Dinosaur Provincial Park (Oldman and Dinosaur Park formations) reported by Koppelhus (2005a,b) needs to be made in order to determine how, and if, these floras differ both latitudinally and biostratigraphically.

In summary, a thorough study of the fossil faunas (vertebrate and invertebrate) and floras from Ah-sli-sle-pah WSA is an essential part of the completing the paleontological picture for the early Kirtlandian age in North America. It is imperative that this region remain in the public domain in perpetuity because of its historical and paleontological importance.

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