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AN INVENTORY OF CENOZOIC FOSSIL VERTEBRATE TRACKS AND BURROWS IN NATIONAL PARK SERVICE AREAS

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Abstract—Paleontological resource inventory and monitoring activities have documented the occurrence of Cenozoic vertebrate tracks, burrows and other traces in 16 National Park Service areas since 1998. These traces include a diversity of avian and mammalian tracks, claw marks, swim traces, burrows and dens that provide information about extinct vertebrates and their behavior. The vertebrate ichnofossils are preserved in a variety of paleoenvironmental settings, including terrestrial, fluvial, lacustrine, desert playa, coastal, cave, and volcanic. This agency-wide compilation highlights the scope, significance, and distribution of Cenozoic vertebrate ichnofossils throughout the National Park System and the importance of supporting their *in situ* management and protection.

CENOZOIC TRACKSITES

Introduction

Cenozoic vertebrate ichnofossils are rarer and less studied compared to vertebrate ichnofossils documented from Mesozoic strata. McDonald et al. (2007) published a comprehensive indexed bibliography of Cenozoic vertebrate tracks that reflects a relatively more limited worldwide scientific literature than currently exists for Mesozoic vertebrate tracks. Santucci et al. (1998) initially reported on Cenozoic vertebrate ichnofossils from seven National Park Service areas: Badlands National Park (South Dakota); Death Valley National Park (California and Nevada); John Day Fossil Beds National Monument (Oregon); Mojave National Preserve (California); Montezuma Castle National Monument (Arizona); Scotts Bluff National Monument (Nebraska); and Zion National Park (Utah). Seven additional parks with Cenozoic vertebrate trace fossils have since been identified: Agate Fossil Beds National Monument (Nebraska); Chickamauga and Chattanooga National Military Park (Georgia and Tennessee); Golden Gate National Recreation Area (California); Hawaii Volcanoes National Park (Hawaii); Lake Mead National Recreation Area (Arizona and Nevada); Oregon Caves National Monument (Oregon); and White Sands National Monument (New Mexico) (Santucci et al., 2006). Additionally, Florissant Fossil Beds National Monument (Colorado) and Fossil Butte National Monument (Wyoming) currently or previously exhibited Cenozoic vertebrate tracks that were collected from localities outside of their respective monument boundaries. Thus, Cenozoic vertebrate ichnofossils, including footprints, tracks, trails, traces and burrows, are associated with 16 units of the National Park System (Fig.1). Hunt et al. (2012) reported on vertebrate coprolites from National Park Service areas, and those records are not included in this discussion. Likewise, Tweet et al. (2012) reported on packrat middens from National Park Service areas, and they are not presented in this publication.

Agate Fossil Beds National Monument, Nebraska

Fossil vertebrate tracks, dens and burrows are well documented from the Early Miocene (Arikareean [Tedford et al., 2004]) Anderson Ranch Formation and Harrison Formation at Agate Fossil Beds National Monument (AGFO), Nebraska. Medium-size rhinocerotid-like tracks are on display in the monument's visitor center (Fig. 2). A number of tracks are visible *in situ* in vertical profile at Carnegie Hill, University Hill and at the *Stenomylus* Quarry (Hunt, 1992; M. Hertig, personal communication, 2002). An interpretive wayside exhibit panel along the Fossil Hill Trail suggests these tracks may have been made by entelodonts (Hunt,1990).

Spiral burrows known as *Daemonelix* or "devil's corkscrews" were first reported from the Agate Fossil Beds area by Barbour in 1892 (Fig. 3). These spiral structures have been the focus of considerable research and debate relative to their origin (Barbour, 1892; Kenyon, 1895; Peterson, 1905; Lugn, 1941). Complete skeletons of the extinct rodent *Paleocastor* have been discovered in several of the "corkscrews" (Fig. 4), showing the structures to be vertebrate burrows. The *Daemonelix* burrows are up to 10 in (25 cm) in diameter and are composed mainly of hard, cemented sand and silt infilling the burrow voids. Silicified plant cells and microscopic plant roots are found in association with the burrows (Lugn, 1941).

Concentrations of mammalian carnivore dens were first investigated at Agate Fossil Beds National Monument in 1981 by field crews from the University of Nebraska (Hunt and Skolnick, 1983; Hunt, 1992, 1999, 2011; Hunt et al., 1996). Excavation of the carnivore dens from a locality named Beardog Hill yielded the remains of early Miocene (19.2 Ma) carnivores, including beardogs, canids and mustelids. In addition to six species of mammalian carnivores, the fragmentary remains of juvenile camels, oreodonts and rhinos were also recovered from within the fine volcaniclastic silt and sand that filled the carnivore dens. The ungulate remains discovered in the dens are believed to be the remains of prey.

Another, older den complex (22 Ma) was discovered at the monument in 1991. These dens represented the largest vertebrate burrows known from the fossil record at the time of discovery (Hunt et al., 1996). They consist of 5 or 6 large cylindrical burrows up to 32 ft (10 m) in length and 3-6 ft (1-2 m) in diameter. The fossilized remains of a wolf-size beardog, a smaller canid and a rodent were excavated from this burrow complex (Hunt et al., 1996).

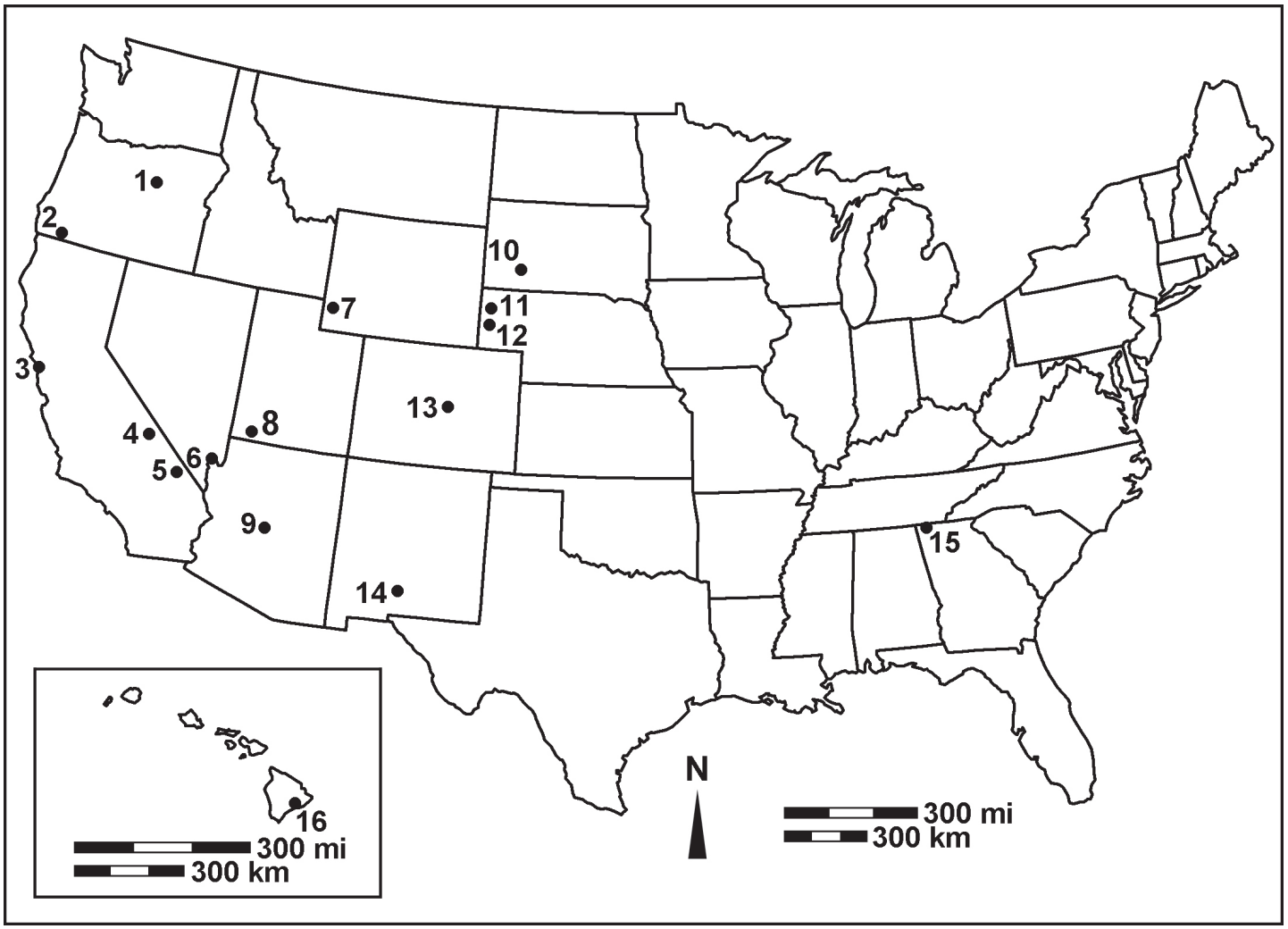


FIGURE 1. Map of National Park Service areas that have documented Cenozoic vertebrate tracks and burrows. 1, John Day Fossil Beds National Monument, Oregon; 2, Oregon Caves National Monument, Oregon; 3, Golden Gate National Recreation Area, California; 4, Death Valley National Park, California; 5, Mojave National Preserve, California; 6, Lake Mead National Recreation Area, Nevada; 7, Fossil Butte National Monument, Wyoming; 8, Zion National Park, Utah; 9, Montezuma Castle National Monument, Arizona; 10, Badlands National Park, South Dakota; 11, Agate Fossil Beds National Monument, Nebraska; 12, Scotts Bluff National Monument, Nebraska; 13, Florissant Fossil Beds National Monument, Colorado; 14, White Sands National Monument, New Mexico; 15, Chickamauga and Chattanooga National Military Park, Tennessee; 16, Hawaii Volcanoes National Park, Hawaii.



FIGURE 2. Early Miocene rhinocerotid-like track from the Harrison Formation on display at the Agate Fossil Beds National Monument Visitor Center.



FIGURE 3. *Daemonelix* or “Devil’s Corkscrew” burrow exposed *in situ* at Agate Fossil Beds National Monument, Nebraska.



FIGURE 4. *Daemonelix* or "Devil's Corkscrew" burrow from Agate Fossil Beds National Monument, Nebraska on exhibit at the Smithsonian National Museum of Natural History in Washington, D.C.

Badlands National Park, South Dakota

A fossil trackway consisting of four camelid tracks was reported from the Late Oligocene (Whitneyan [Tedford et al., 2004]) Poleslide Member of the Brule Formation within the south unit of Badlands National Park (BADL), South Dakota (Lemley, 1971; Bjork, 1976). Two poorly preserved carnivore tracks were also found in association with the camelid tracks. The carnivore tracks preserve claw marks. These tracks were preserved in a fluvial sandstone unit above the *Leptauchenia* clays. The tracks have been curated into the collections of the Museum of Geology, South Dakota School of Mines and Technology in Rapid City, South Dakota (Fig. 5).

Chickamauga and Chattanooga National Military Park, Georgia and Tennessee

Vertebrate trace fossils are documented from within a cave at Chickamauga and Chattanooga National Military Park (CHCH), Tennessee (Santucci et al., 2001). Kitty City Cave is a solution cave within the Cumberland Plateau Cave System. This cave has a large pit in which large felid paw prints are preserved on the cave floor and claw marks are impressed into the cave wall. A second cave within the park, named 27 Spider Cave, includes a pit that contains the skull and vertebral column of a large cat partially exposed in cave sediments and felid canines exposed in the cave wall. Although these fossils remain *in situ* and have not been studied, the evidence suggests that the cats apparently fell into the pits, survived the initial fall, and attempted to climb out (D. Curry, personal communication, 2001).

Death Valley National Park, California and Nevada

Cenozoic vertebrate ichnofossils are documented from four localities in Death Valley National Park (DEVA), California (Scrivner, 1984; Scrivner and Bottjer,1986; Nyborg and Santucci, 1999). The tracks consist of mammalian and bird traces preserved within fine-grained fluvial-lacustrine sediments. These track-bearing sediments are associated with Cenozoic tectonics that downdropped the present day Death Valley and uplifted the Black and Funeral mountains.

The earliest report of fossil vertebrate tracks from Death Valley was published by Donald Curry (Curry, 1939, 1941). Curry recognized the importance and rarity of the fossil tracks in Copper Canyon. He collected a number of track specimens and assigned names to specific sites (e.g., Carnivore Ridge, Barnyard). During the 1950s and early 1960s, Raymond Alf collected fossil cat, camel and bird tracks from unknown locations in Death Valley (Alf, 1959).

The most abundant and diverse vertebrate ichnofossil locality in the park is within Copper Canyon, where lakeshore deposits preserve 12 bird ichnospecies (*Avipeda*), five cat ichnospecies (*Felipeda*) (Fig. 6), five artiodactyl ichnospecies (*Ovipeda*), three horse ichnospecies (*Hippipeda*) (Fig. 7), two undescribed tridactyl tracks (cf. ?*Tapirpeda* n. sp.), and one proboscidean (*Proboscipeda*) trackway (Santucci et al., 2011). The new tridactyl tracks potentially represent at least one new ichnotaxon from the Copper Canyon tracksite (Fig. 9). The proboscidean trackway in Copper Canyon represents one of the earliest known proboscidean ichnofossils in North America. The lacustrine sequence includes over 9,842 feet (3,000 meters) of lake-basin sediments with interbedded volcanic flows that date to between 6 and 3 Ma. The track-bearing units were deposited between approximately 5 and 4 Ma (Nyborg and Buchheim, 2005a, b).

Unnamed sediments near Cow Creek preserve very large avian tracks (*Avipeda*), a panel with three carnivore tracks (*Felipeda*), and two types of artiodactyl tracks (*Ovipeda*). The tracks are preserved along several bedding planes representing intermittent fine-grained lacustrine sediments within an overall medium-grained sandstone unit (Nyborg and Santucci, 1999). Although the age of this track locality has not been determined, it appears to be approximately contemporaneous with the Copper Canyon track locality due to its similar track fauna.

An isolated outcrop, also within unnamed sediments, in the Central Death Valley Playa near Salt Creek preserves avian, artiodactyl, perissodactyl and possible proboscidean tracks (D. Curry, personal communication, 1998). The track-bearing unit is contained within fluvial-lacustrine deposits in an overall conglomerate unit.

Two poorly preserved artiodactyl tracks within lacustrine sediments believed to be associated with the Pliocene-age (4 to 3 Ma [Knott et al., 2008]) Furnace Creek Formation were collected from Twenty Mule Canyon track locality in the 1980s. No additional tracks have been found in this region, but this discovery reveals the potential of the region, which is dominated by fluvial-lacustrine deposits.



FIGURE 5. Camelid tracks from the Poleslide Member of the Brule Formation, Badlands National Park, South Dakota, on display at the Museum of Geology, South Dakota School of Mines & Technology. Photo courtesy of Rachel Benton.



FIGURE 6. Small felid print from lacustrine deposits of Copper Canyon at Death Valley National Park, California.



FIGURE 7. Hundreds of horse tracks preserved at the "Barnyard" locality in Copper Canyon at Death Valley National Park, California.

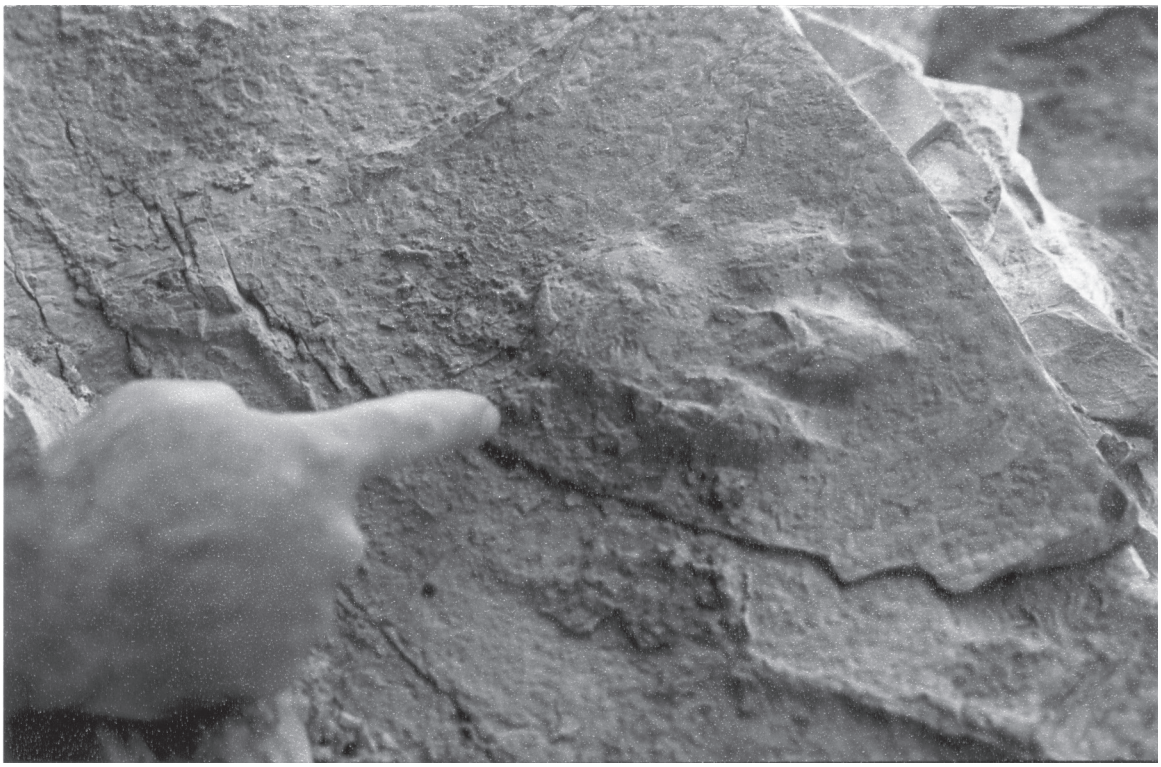


FIGURE 8. A rare tridactyl track preserved in lacustrine deposits of Copper Canyon at Death Valley National Park, California.

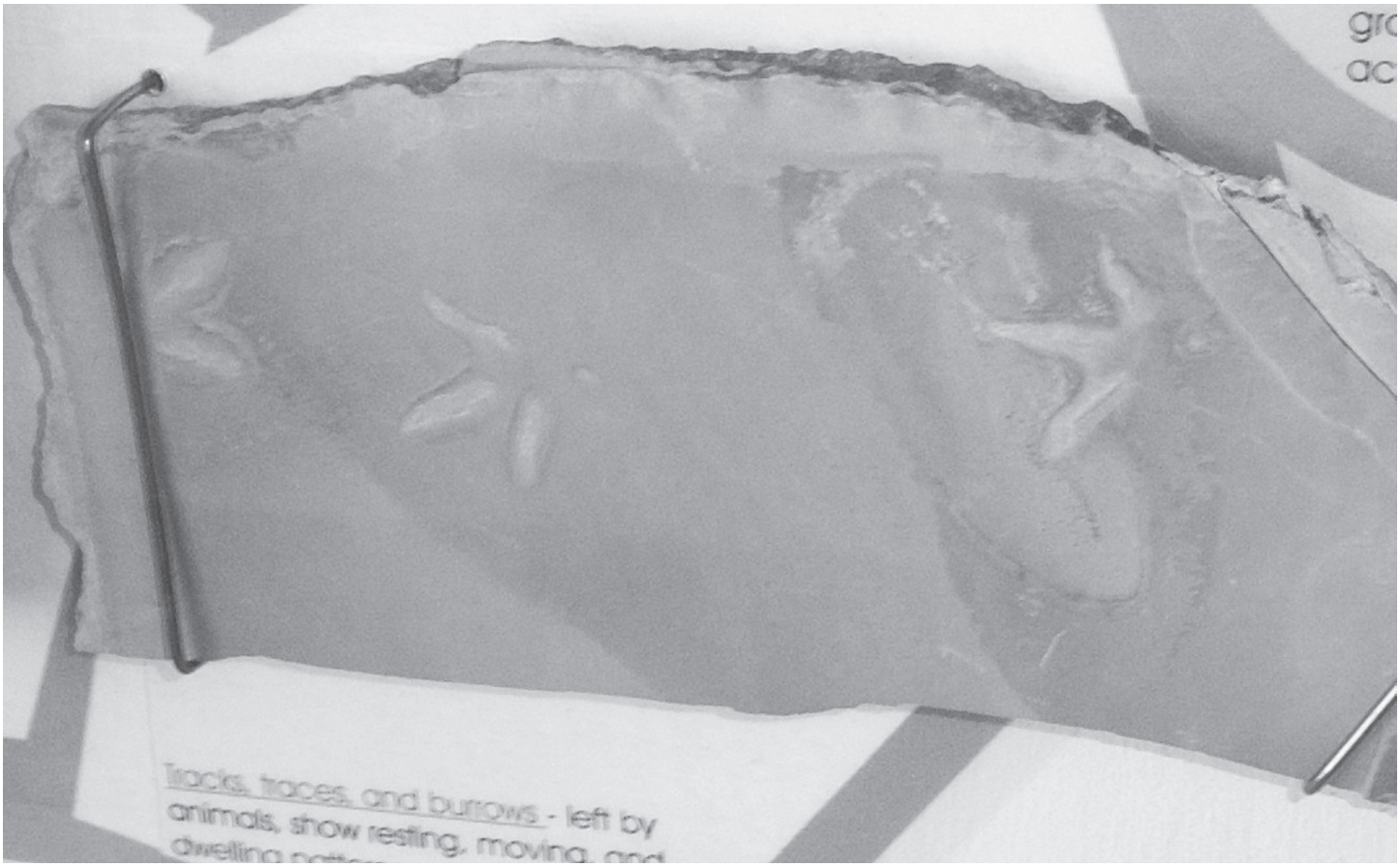


FIGURE 9. Fossil bird tracks from a locality outside of the boundary of Florissant Fossil Beds National Monument.

Florissant Fossil Beds National Monument, Colorado

The visitor center at Florissant Fossil Beds National Monument (FLFO), Colorado, formerly exhibited a slab with several fossil bird footprints discovered in a quarry located just outside of the monument (Fig. 9). Presumably the specimen was collected from either a shallow water or near lakeshore unit of the Eocene Florissant Formation. This specimen was on loan and exhibited at the monument's visitor center for a short time. It is now in the collections of the Denver Museum of Nature and Science (H. Meyer, personal communication, 2006).

Fossil Butte National Monument, Wyoming

Fish trace fossils are documented from the Fossil Butte Member of the Green River Formation in southwestern Wyoming. The ichnofossils are fish swim marks and feeding traces assigned to the ichnogenus *Undichna* and represent the first occurrence of fish swim traces from between the Mesozoic and the Quaternary (Loewen and Gibert, 1999). Martin et al. (2010) interpret the feeding and swim traces as produced by the Eocene teleost *Notogoneus osculus*, which is also preserved as body fossils in the contemporaneous lake deposits. Several specimens of Green River Formation fish swim traces are on exhibit at the Fossil Butte National Monument (FOBU) Visitor Center (Fig. 10).

Golden Gate National Recreation Area, California

Fossil mammal tracks are reported from the Late Pliocene to Early Pleistocene Merced Formation at Golden Gate National Recreation Area (GOGA), California (Hall, 1965, 1966; Hunter et al., 1984; Clifton and Hunter, 1999). The rare vertebrate ichnofossils are preserved in terrestrial strata representing a backshore facies of the Merced Formation. The trace fossils range in degree of preservation from penecontemporaneous deformation structures to track impressions with well-defined morphology. The bioturbated water-saturated sediments are intensively trampled, and some surfaces exhibit trace patterns interpreted as trackways. Vertebrate traces include prints produced by canids, didactyl artiodactyls and proboscideans (Fig. 11). A few of the canid tracks are extremely well preserved and have associated claw impressions (Hunter et al., 1984).

Hawaii Volcanoes National Park, Hawaii

Several thousand modern human footprints are embedded in a muddy ash at Hawaii Volcanoes National Park (HAVO), Hawaii (Moniz-Nakamura, 2003; Meldrum, 2004). The footprint-bearing ash dates to approximately 1780 A.D. The tracks are concentrated in an elongate passage between Kilauea and Mauna Loa apparently used by humans to traverse through this saddle (Figs. 12-14). The tracks are continuously covered and uncovered by drifting sand.

Based upon preliminary morphometric analysis, most of the footprints appear to have been made by adult women. There are also smaller tracks that are interpreted as those of children, and a few very large footprints thought to have been made by adult males. It is unclear whether some of the people who made the tracks were killed in a contemporaneous eruption associated with the muddy ash (Don Swanson, personal communication, 2013)

John Day Fossil Beds National Monument, Oregon

Two blocks containing small fossil bird tracks have been discovered in the Middle Eocene Clarno Formation within the bound-

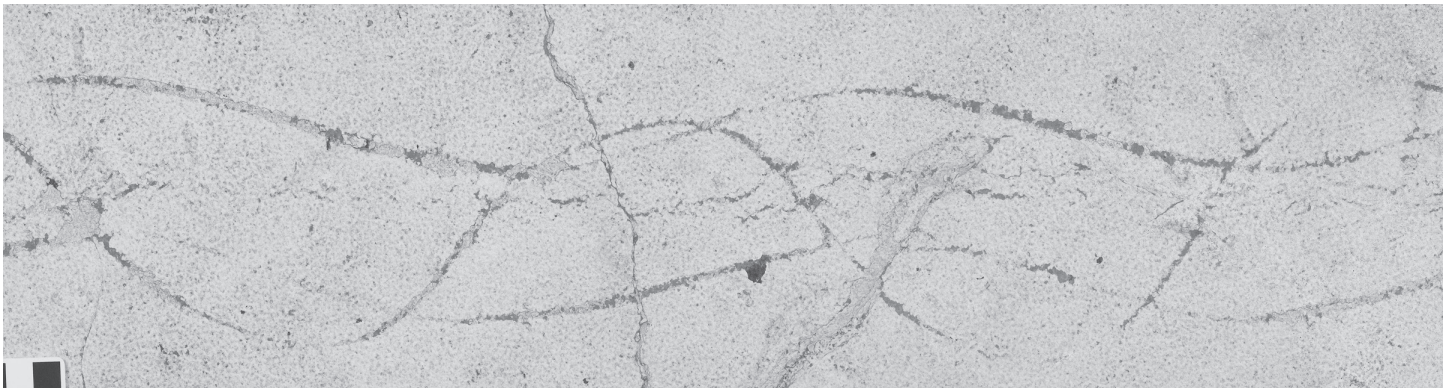


FIGURE 10. Fossil fish swim traces (*Undichnia*) from the Eocene Green River Formation on exhibit at the Fossil Butte National Monument Visitor Center, Wyoming.

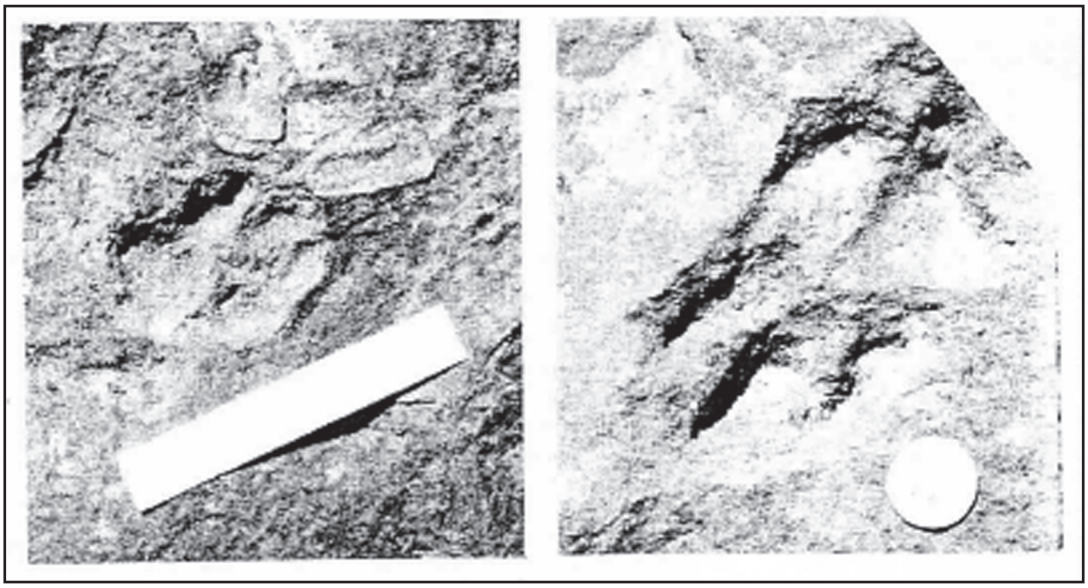


FIGURE 11. Fossil carnivore (left) and artiodactyl (right) tracks from the Plio-Pleistocene Merced Formation at Golden Gate National Recreation Area, California. Photo courtesy of Ralph Hunter.

aries of John Day Fossil Beds National Monument (JODA), Oregon. Two additional blocks with canid tracks were discovered by Bruce Hansen from within a tuff unit in the Turtle Cove Member (Late Oligocene–Early Miocene) of the John Day Formation (Josh Samuels, personal communication, 2013). One of the canid track blocks is on display at the Thomas Condon Paleontology Center at the monument (Fig. 15).

Lake Mead National Recreation Area, Arizona and Nevada

Vertebrate ichnofossils are documented in the Miocene Horse Spring Formation exposed within Lake Mead National Recreation Area (LAKE), Nevada. Fossil footprints identified as camelid, canid, felid and avian are preserved in the Thumb Member of the Horse Spring Formation (Kissel et al., 1995; Kissel, 1998; Jones, 2002; Kissel and Rowland, 2003). The track-bearing unit occurs in the Calville Wash area of the recreation area and extends outside the boundary of LAKE (Figs. 16-17).

Mojave National Preserve, California

Mammal tracks are known from the Pliocene Tecopa Formation in Mojave National Preserve (MOJA), California. Collections of camelid and carnivore footprints from this unit in MOJA are on display at the Raymond Alf Museum. Lockley and Hunt (1995) reported on a locality in the Tecopa Formation named "Standing Camel Basin" in which fossil camel limbs were discovered preserved in an upright position.

Montezuma Castle National Monument, Arizona

An assemblage of rare fossil mammalian tracks is preserved within the Miocene–Pliocene Verde Formation at Montezuma Castle National Monument (MOCA), Arizona. The first published report of a fossil mammal track from within the MOCA area was written by H. H. Nininger in October 1941. According to Nininger, two large distinct cat footprints were found in a limestone slab located in a "ditch leading from the big spring known as Montezuma's Well" (Nininger, 1941).

The fossil track locality, referred to as "Elephant Hill," is the best known and documented paleontological locality at MOCA (Farmer, 1956; Danson, 1960; Nations et al., 1981; McGregor and Schur, 1994; Hunt et al., 2005). The fossil mammal tracks of "Elephant Hill" were first reported by National Park Service Ranger Myron Sutton in 1953 when this area was administered by the Coconino National Forest (Sutton, written communication, 1953). In 1958, paleontologists from the Museum of Northern Arizona evaluated this fossil site and gave it the name "Elephant Hill" (Brady and Seff ,1959, 1960). "Elephant Hill" has been the focus of other scientific and resource management attention, including: Twenter's 1962 survey of Verde Formation fossil sites; the 1994 Southwest

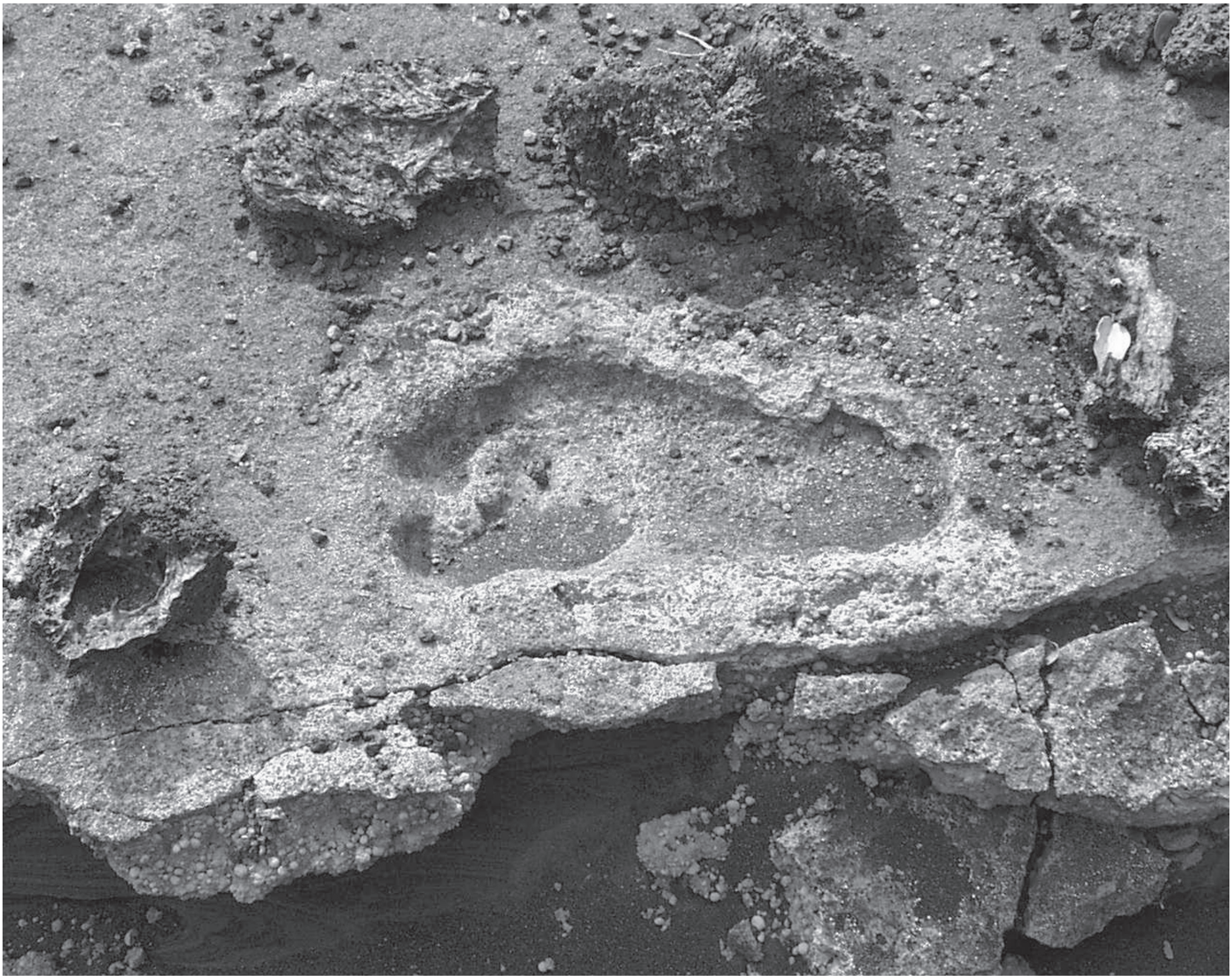


FIGURE 12. Right human footprint preserved in a muddy ash layer at Hawaii Volcanoes National Park, Hawaii. Photo courtesy of Jadelyn Moniz-Nakamura.



FIGURE 13. Toe impressions from a right human footprint preserved in a muddy ash layer at Hawaii Volcanoes National Park, Hawaii. Photo courtesy of Jadelyn Moniz-Nakamura.

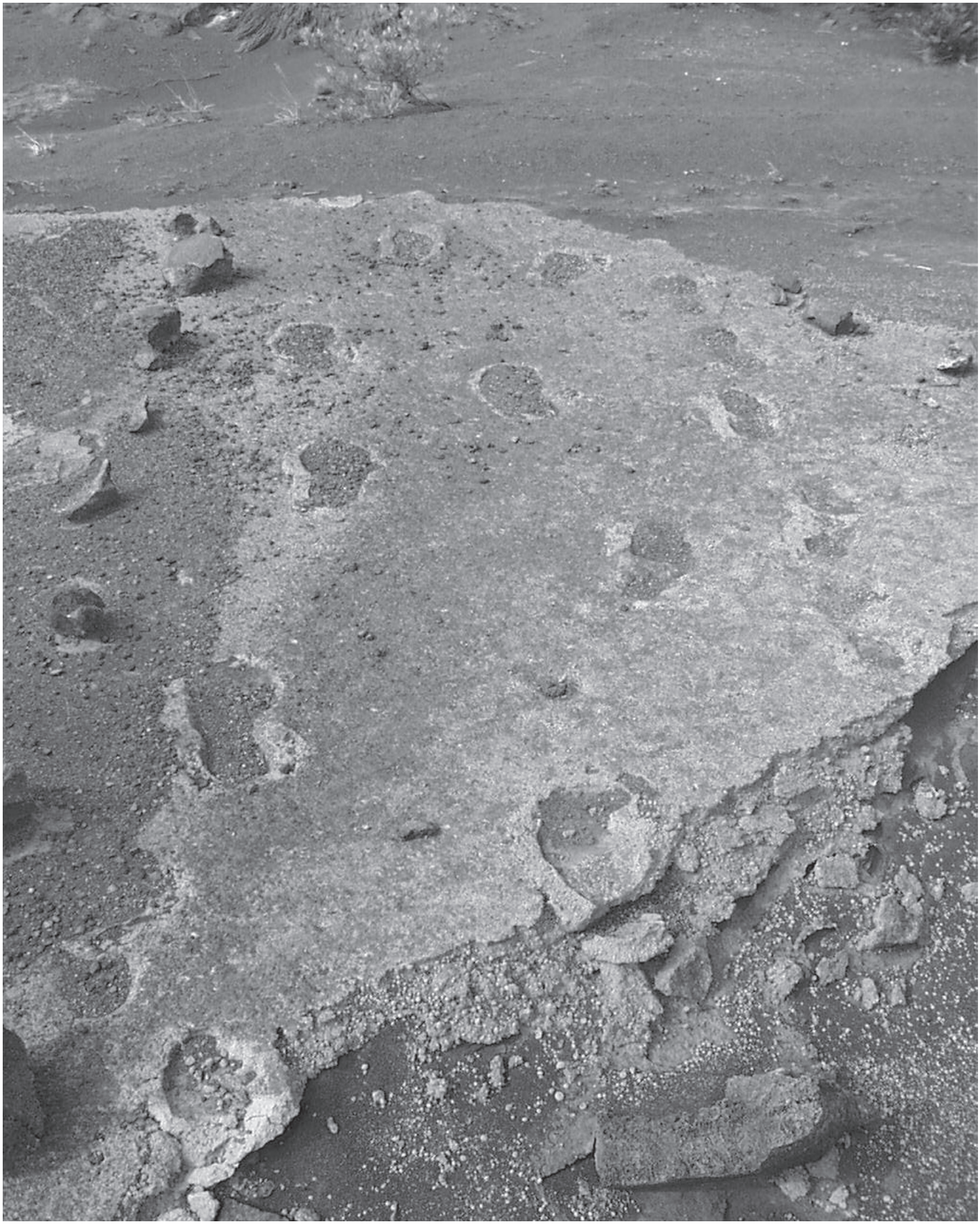


FIGURE 14. Several human trackways preserved in a muddy ash layer at Hawaii Volcanoes National Park, Hawaii. Photo courtesy of Jadelyn Moniz-Nakamura.



FIGURE 15. Canid tracks from the Turtle Cove Member of the John Day Formation on display at the Thomas Condon Paleontology Center at John Day Fossil Beds National Monument, Oregon.



FIGURE 16. Fossil mammal tracks from the Miocene Horse Spring Formation at Lake Mead National Recreation Area, Nevada.

Paleontological Society inventory of fossil tracks at MOCA; and the most recent investigation of the "Elephant Hill" tracksite, undertaken by Nicholas Czaplewski, a paleontologist with the Oklahoma Museum of Natural History (Czaplewski, 1990). The land that includes the "Elephant Hill" fossil locality was transferred to the National Park Service at MOCA in November 1978.

Fossil tracks from "Elephant Hill" include footprints associated with proboscideans, camelids, small antelope-like artiodactyls, tapirids, and other unidentified animals (Figs. 18-19). The site includes individual isolated footprints as well as trackways consisting of several footprints. The characteristics of the track-bearing strata and the track impressions limit the ability to successfully excavate and remove these resources without damaging the resource. Therefore, the management strategy in the past has been to maintain the tracks *in situ* and the tracks have typically been reburied with soil and sediment by monument staff following observation or study.

A few fossil mammal tracks from the Montezuma Castle area are in the collections of the American Museum of Natural History.

Oregon Caves National Monument, Oregon

Santucci et al. (2001) were the first to report on vertebrate trace fossils preserved at Oregon Caves National Monument (ORCA),

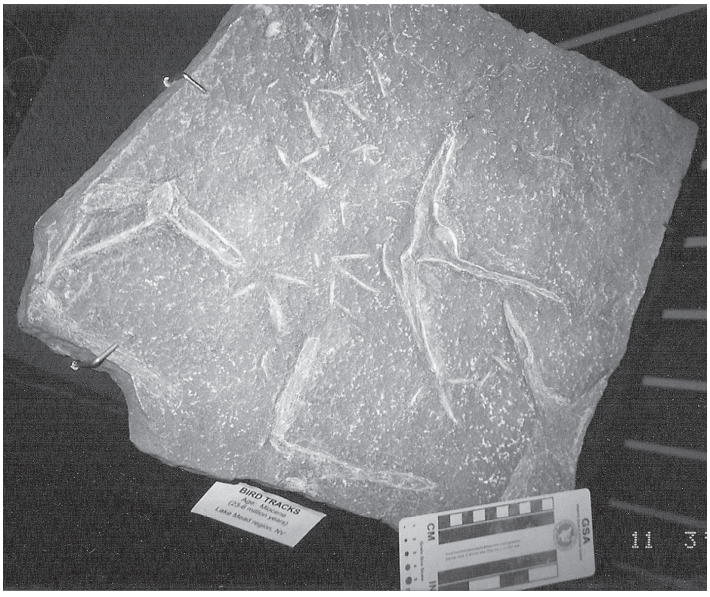


FIGURE 17. Fossil bird tracks from the Miocene Horse Spring Formation at Lake Mead National Recreation Area, Nevada.

Oregon. At least 20 distinct claw scratch marks and a single 4.5 in (11 cm) paw print are preserved in cave sediments at the monument. The claw scratch marks and paw print are believed to have been produced by a bear or bears. One trace is exceptionally well preserved, showing five claw points pushed into the mud (Fig. 20).

Scotts Bluff National Monument, Nebraska

Putative fossil vertebrate tracks have been reported from the Late Oligocene (early Arikareean [Tedford et al., 2004]) Gering Formation at Scotts Bluff National Monument (SCBL), Nebraska (Loope, 1986; Swinehart and Loope, 1987). They are located along the Saddle Rock Trail in horizontally stratified fine-grained volcaniclastic sand and ash deposits. The tracks appear in cross-section as concave-up deformation structures. The size and bilobed morphology of some of these structures suggest that the trackmakers were possibly large ungulates such as entelodonts.

White Sands National Monument, New Mexico

Fossil vertebrate footprints were first reported from the Tularosa Basin in 1932. However, at that time these traces were proposed to be the tracks of giant humans. It was not until 1981 that a more focused evaluation of fossil tracks from the White Sands area reinterpreted the tracks as having been produced by proboscideans and camelids (Lucas et al., 2002; Morgan and Lucas, 2002; Allen et al., 2006).

In 2006, researchers documented extensive mammoth trackways in Pleistocene lake margin sediments in White Sands National Monument (WHSA). Many of the tracks were preserved in convex relief. Erosion of the soft gypsum matrix causes rapid deterioration of the tracks. The circular proboscidean tracks from the Tularosa Basin were assigned by Lucas et al. (2009) to the ichnotaxon *Proboscipeda panfamilia*.

Beginning in 2011, a systematic field documentation of vertebrate tracks was initiated at White Sands National Monument. Hundreds of proboscidean tracks and extensive trackways were discovered and photogrametrically documented on the southern shore of Lake Lucero in the monument (Fig. 21). Additionally, a few artiodactyl and large carnivore tracks were also photogrametrically documented during field inventories (Fig. 22).



FIGURE 18. Fossil proboscidean track from the Mio-Pliocene Verde Formation at Montezuma Castle National Monument, Arizona.

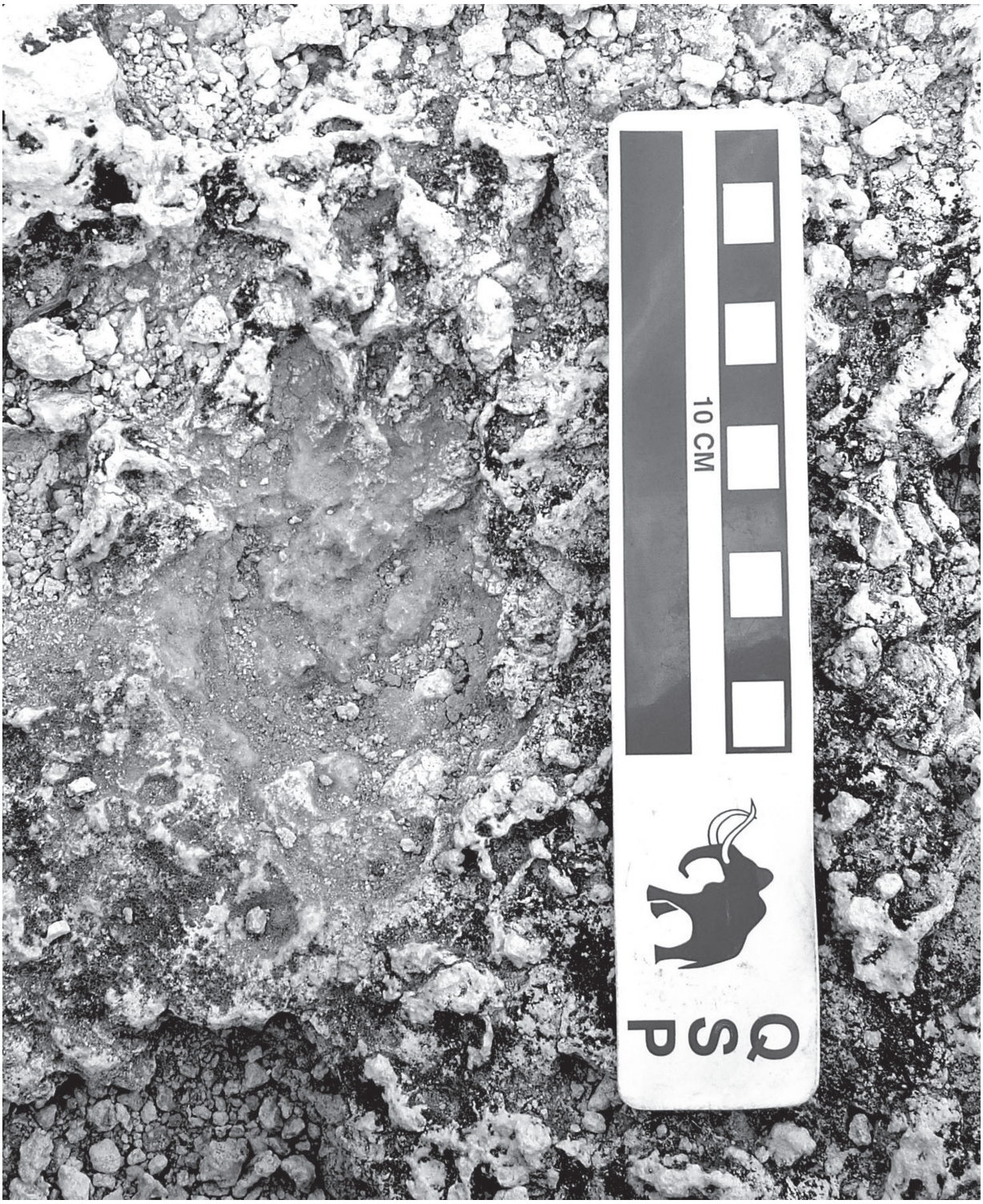


FIGURE 19. Fossil artiodactyl track from the Mio-Pliocene Verde Formation at Montezuma Castle National Monument, Arizona.



FIGURE 20. Fossil bear claw marks preserved in cave wall at Oregon Caves National Monument, Oregon.



FIGURE 21. Fossil proboscidean trackway in Pleistocene sediments at White Sands National Monument, New Mexico.



FIGURE 22. Large fossil cat track in Pleistocene sediments at White Sands National Monument, New Mexico.

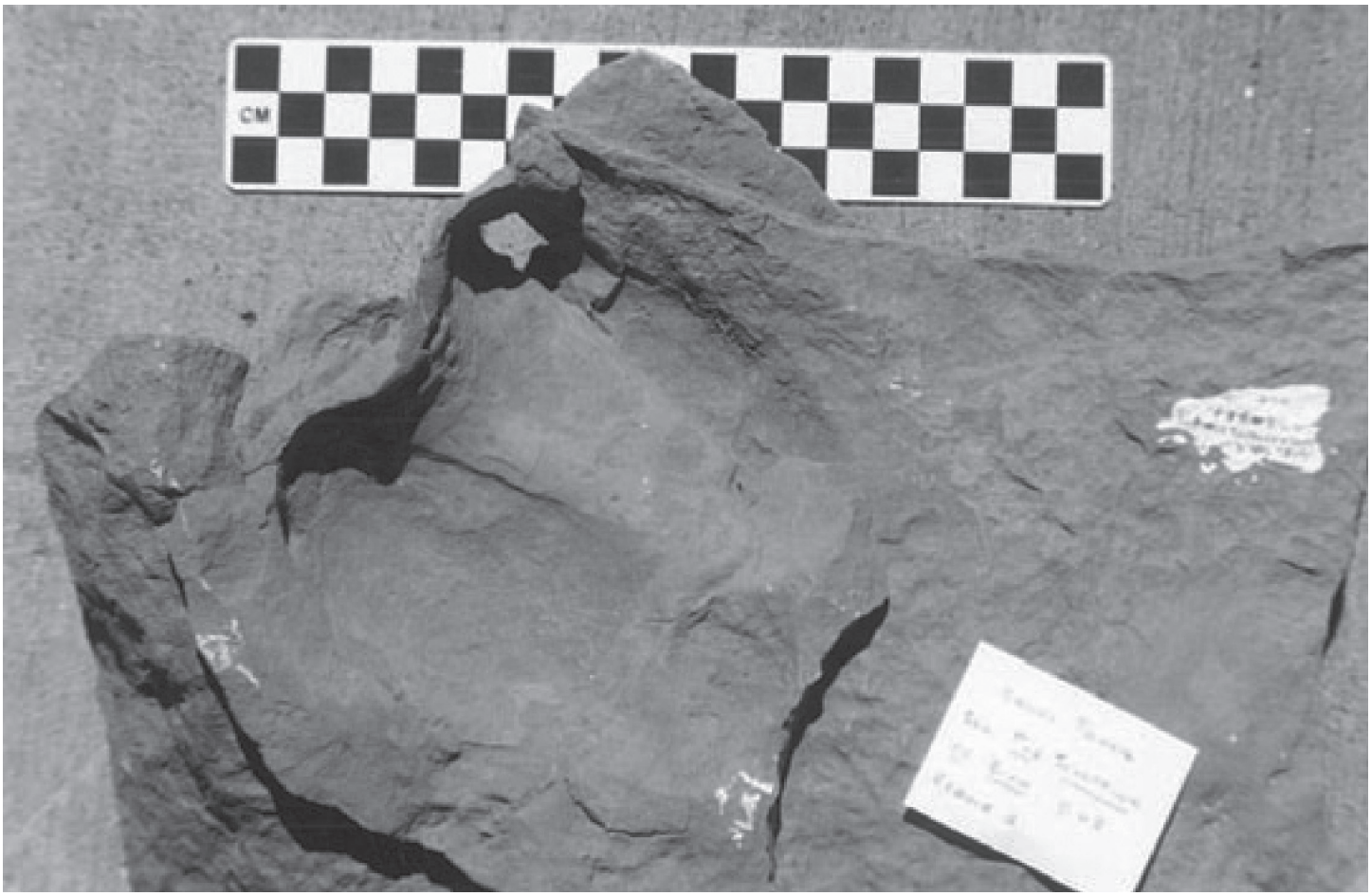


FIGURE 23. Large fossil artiodactyl track preserved in lacustrine sediments at Zion National Park, Utah.

Zion National Park, Utah

The first reports of vertebrate trace fossils from the Cenozoic of Zion National Park (ZION), Utah, were published in the late 1970s (Hamilton, 1979; Hevly, 1979). The finds consist of a single large unidentified bilobate artiodactyl track (Fig. 23) and a large bird track, found in an unnamed lacustrine mudstone referred to informally as the Coalpits Lake deposits. The lake existed around 125,000 years ago (Biek et al., 2010). The tracks are now curated into the ZION museum collection (Smith and Santucci, 1999; Santucci, 2000; DeBlieux et al., 2003, 2005).

VERTEBRATE TRACKSITE MANAGEMENT AND PROTECTION

Fossil vertebrate tracks and trackways are generally fragile resources; hence, they are difficult to excavate and are typically studied and maintained *in situ*. Natural conditions and processes, such as weathering, erosion, and freeze-thaw temperature changes, will act directly upon surficially exposed *in situ* vertebrate ichnofossils. Such conditions will contribute to the deterioration and eventual destruction of these surficial trace fossils. Growing scientific and public interest in fossil vertebrate tracksites is paralleled by the increasing incidence of their theft and vandalism (Santucci, 2002).

The management and protection of *in situ* fossil vertebrate tracksites has become challenging. During 2001, over two dozen incidents of either theft or vandalism of *in situ* fossil vertebrate tracks were documented (Santucci, 2002). These incidents range from damages resulting from poor or inappropriate casting techniques to the unauthorized collecting of vertebrate tracks. A well-known dinosaur tracksite at Red Fleet State Park, Utah, was vandalized by members of a Boy Scout group and received considerable national and local media attention. Fossil vertebrate tracks are commonly offered for sale on the commercial fossil market. Human impacts to vertebrate ichnofossils include incidents of damage or destruction through intentional vandalism, casual theft and systematic theft. Effective management and protection strategies employed for *in situ* fossil vertebrate tracksites include tracksite inventories, site mapping, photo documentation, track replication, specimen collection, site stabilization, burial, site closure, construction of maintenance barriers, fencing, and a variety of site monitoring strategies.

In 2000, an *in situ* fossil tracksite conservation plan was developed for the vertebrate ichnofossils at Death Valley National Park (Nyborg and Santucci, 2000). Subsequently, an initial strategy for the management of *in situ* paleontological resources, including vertebrate trace fossils, was developed for the National Park Service in 2003 (Santucci and Koch, 2003). A more detailed guidance for paleontological resource monitoring was developed to evaluate the stability and condition of *in situ* fossil localities (Santucci et al., 2006). During 2009, the National Park Service identified Glen Canyon National Recreation Area, Utah, as the prototype park for implementing a paleontological resource monitoring program for vertebrate ichnofossils. Detailed site evaluation, documentation and repeat photography of *in situ* vertebrate trace fossils enables a greater ability to monitor the stability and condition of these trac-

es through both quantitative and qualitative data (Kirkland et al., 2011). In turn, these data provide park management with scientific information to support park planning and decision making.

CONCLUSIONS

This summary presents the baseline of information currently available to the National Park Service to evaluate the scope, significance and distribution of Cenozoic vertebrate tracks and burrows on a servicewide basis on agency administered lands. The 16 parks and monuments that have been identified with vertebrate ichnofossils have the responsibility and ability to manage and protect *in situ* occurrences using scientific principles and techniques. Through the active monitoring and condition assessments of *in situ* vertebrate track localities, park managers will be able to utilize these data to support planning and decision making. Continued paleontological fieldwork and research in National Park Service areas will likely yield more occurrences of Cenozoic fossil vertebrate tracks in the future and increase our knowledge of these rare and important paleontological resources.

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