FISH, BIOTIC COMMUNITIES, AND ENVIRONMENTS OF THE BARSTOVIAN SUCKER CREEK FORMATION, SW IDAHO AND SE OREGON

Nathan E. Carpenter: Orma J. Smith Museum of Natural History, College of Idaho, Caldwell, Idaho 83605 <nate@paleopubs.com>
Gerald R. Smith: Museum of Paleontology, University of Michigan, Ann Arbor, MI 48109<grsmith@umich.edu.>

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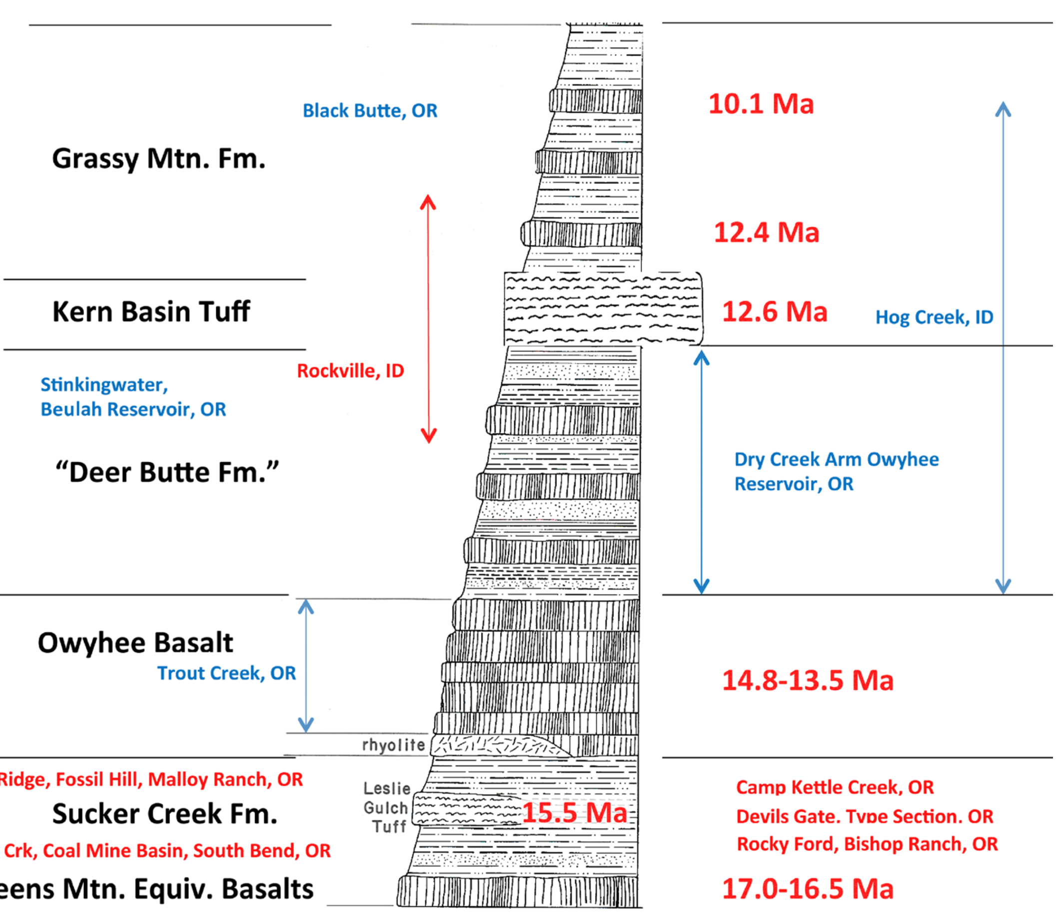
ABSTRACT

The 15-12 Ma Sucker Creek Formation, SE Oregon and SW Idaho, has one of the world's best-known Miocene floras. Over 100 species, including bald cyprus, sequoias, oaks, elm, hickory, sycamore, and other hardwoods and conifers are found in a 50X10 km strip of finely laminated, indurated volcaniclastic silt deposits along the Oregon-Idaho border. Over 50 species of mammals--perissodactyls, artiodactyls, carnivores, rodents, and bats occupied the forests and surrounding areas. We have identified seven kinds of fishes associated with thousands of leaf specimens in the Museum of Natural History at the College of Idaho. In order of abundance, two species of sunfishes, three species of minnows, one muskellunge, and one catfish from the Sucker Creek Formation comprise the earliest known "diverse" Neogene freshwater fish assemblage in the U.S. The fish community suggests warm winters, lowland basins isolated by barriers to dispersal, and high extinction rates. Extensive planar siltstone with associated arkosic sandstone channels, and abundance of diverse fossil leaves and sunfish (*Archoplites* and *Plioplarchus*) suggest a shallow flooded forest. Small minnows (*Lavinia* and *?Mylopharodon*) are often in partially digested masses, indicating bird pellets disgorged in shallow water with slack current. Large predatory fishes are rare, but isolated bones of 70 cm muskellunge (*Esox*) and 20 cm Pikeminnows (*Ptychocheilus*) have been found in coarser sedimentary environments marginal to the leaf-bearing siltstone.



Localities in red have Sucker Creek Fm fishes. Blue indicates related localities. Sequence is based on superposition, Ar/Ar dates, paleomagnetism, lithology, and petrology, with diatomite, plants, and vertebrates. The Sucker Creek Fm rests on Silver City Range Rhyolites; older rhyolites and basalts of Bishop Ranch show normal magnetic polarity, suggesting deposition ca16.3 Ma.
Subsidence of a structural high, dipping toward the north-northeast, formed the basin. Broadleaved hardwoods lived on lowlands; evergreens occupied uplands. Fish lived in shallow ponds and flooded forest.
Caldera formation in the southwest, 15.5-15.1 Ma, produced maar tuffs that aggraded into the north-trending ancestral Sucker Creek, with standing water progressing to stream channels, then paleosols. Nearshore sediments contain fossil mammals. Aquatic conditions fluctuated before being inundated by Owyhee Basalts and pyroclastics 14.8-14.6 Ma. (See references).

DEVELOPMENT OF STRATIGRAPHIC CONCEPTS OF THE SUCKER CREEK FORMATION

Lindgren (1898-1900; Lindgren and Drake 1904) expanded Eldridge's (1895) concept of the Payette beds to include the type section at Horseshoe Bend, ID, south to the Succor Creek drainage in southeastern OR and southwestern ID.

Buwalda (1920s) discovered a mammal fauna near Succor Creek, below the Jump Creek rhyolite near Rockville, ID, in the Oregon-Idaho Graben (OIG).

Sharf (1935) named the "Sucker Creek Beds" and noted similarity between mammals at Succor Creek and Buwalda's mammals from Rockville, ID, but he misidentified the type locality.

Kittleman (1962) designated Cal Tech localities in Succor Creek gorge as the type section of the Sucker Creek Fm, and defined the top at the upper Owyhee Basalts, with Leslie Gulch Ash-Flow Tuff (15.5 Ma) near the middle of the formation.

Axelrod (1964) suggested that the Sucker Creek plant-bearing beds might be a fine-grained facies of the Payette Formation.

Shah (1968-1974) assigned fine sediments at Coal Mine Basin to the Sucker Creek Fm, and coarse sediments nearby to the Payette Fm.

Ekren et al. (1981-84) showed the Sucker Creek Fm resting conformably on basalts and rhyolites of the Owyhee/Silver City Mountains.

Lawrence (1988) mapped the Sucker Creek Fm from its base on massive basalts (16.5 Ma) at Bishop's Ranch up to the rhyolite dome complex below the Jump Creek rhyolite (11.4 Ma).

Ferns et al. (1993) mapped the OIG but abandoned formation names. They defined units based on superposition, lithology, petrology, geochemistry, radiogenic dates, and depositional environments, in the context of geology of the OIG (Cummings et al. 2000). We follow that paper but use formation nomenclature.

SUCKER CREEK FISH – ANNOTATED LIST

Ictaluridae—North American Catfish, now eastern USA to Mexico.
***Ameiurus* sp.**—Bullhead Catfish (benthic, length to 11 cm, locally)
Western bullheads are first found at Rockville, ID. In the Later Miocene and Pliocene, spines are abundant in WA, OR, ID, UT, and NV.

Cyprinidae—Minnows, the most diverse family of NA freshwater fishes.
***Ptychocheilus* sp.**—Pike Minnow (length to 20 cm, locally)
Pikeminnows are the largest cyprinid predators. They first appear in WA & ORabout 16 Ma, now widespread in western North America.

***Lavinia* sp.**—Hitch (length to 8 cm, locally)
Lavinia is western genus, first found in the Sucker Creek Fm, where two *Lavinia*-like pharyngeal forms are found (see next). Now they live in CA.

***Mylopharodon*? sp.** – Hardhead (length to 14 cm, locally)
Dentaries (but not pharyngeals) like this fish are in the Sucker Creek Fm., but these might belong with one of the forms of *Lavinia*-like pharyngeals.

Esocidae—Pikes, from Paleogene of W NA to Recent E NA.
Esox* cf. *E. masquinongy—Muskellunge (predator, length to 70 cm)
First reported from Quartz Basin; later at Rockville ID, and Miocene & Pliocene in OR & WA. Now they live in the Ohio R, Great Lakes, & St Lawrence drainages.

Centrarchidae—Sunfish and bass, an E NA endemic family.
***Plioplarchus* sp.**—Cope's Sunfish (omnivore, length to 20 cm)
It has distinctive pre-dorsal bones; known from Miocene of the Great Plains west to Trout Creek, Danforth, and Mascall fms. Now extinct.

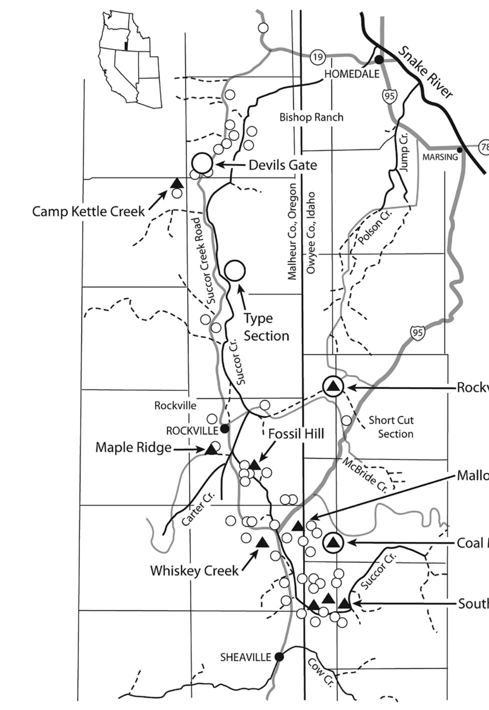
***Archoplites* sp.**—Western Sunfish (omnivore, length to 12 cm)
This small sunfish genus is endemic to western NA. It is first found in the Sucker Creek Fm then dispersed to OR, WA, NV, & UT. Now in CA.

Photos of diagnostic bone shapes. Row 1--dentaries; 2--frontal, preopercles, opercle, cleithra; 3--pharyngeal arches; 4--opercles, frontals, skull, basioccipital; 5--frontal & opercle, hyomandibula, caudals, preopercle & vomer, 6--scale, hyomandibula, opercles, vomer, dentaries, predorsals. Scale bars indicate millimeters.

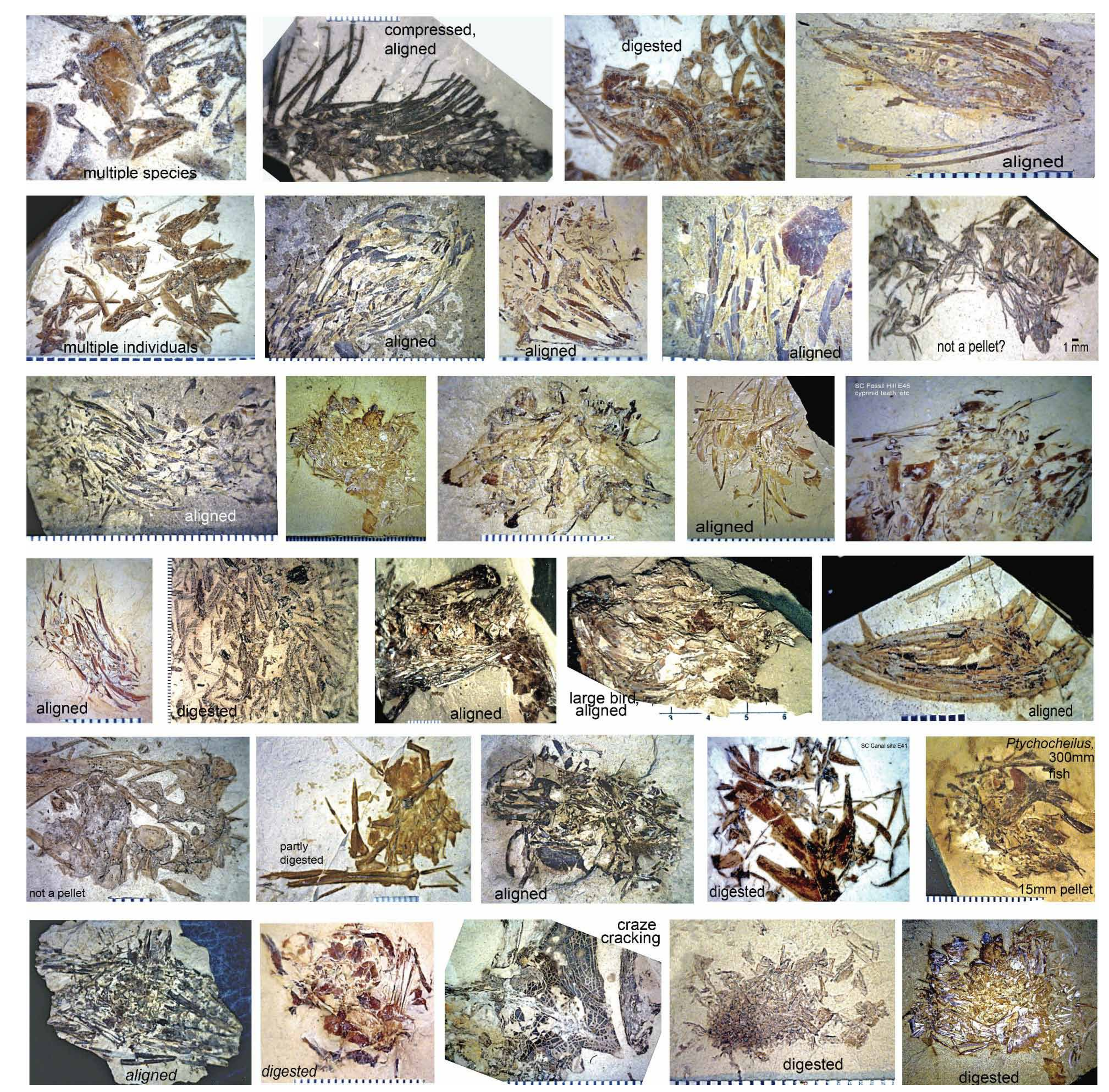
Species			Age	Ex	Am	Or	Pt	Mp	Mc	Ac	La	Gi	Ri	Si	Rh	De	Ch	Ca	Pa	Pr	Sv	On	Pli	Ar	Co	Mx	Kc	Ga	Fu	Tot
Locality	State	LMA	base																											
Glenns Ferry	ID-OR	BL	4.5		XX	X	X	X	X	X	XX	X	X		X	X	X	X	X	X		XX		X	X	XXX	XXXX			28
Ringold	WA	BL	4.9	X	X		X		X	X	X	X					X	X				X		X						11
Mono Lake	CA	HHBL					X							X			X	X												4
Junction Hills	UT	HH	6		X		X		X	X		X					X								X					7
Cache Valley	ID	HH	8						X	X	X	X																		4
Chalk Hills	IDOR	HH	8.1		X	X	X	X	X	X	X					X	X	X		X	X	XXX		X	X					17
Rome	OR	HH	8.1		X		X				X							X						X						5
Danforth	OR	HH	8.5		X		X																X	X						4
Drewsey	OR	HH	8.8	X	X	X	X	X		X	X			X		X	X	X	X					X						13
Poison Creek	IDOR	HH	8.9		X		X	X	X	X								X			X			X						9
Truckee	NV	CL	10		X									X								X						X	X	5
Granger Clay	WA	CLHH	10.5		X				X						X									X						4
Esmeralda	NV	CL	12					X				X		X								X								4
Juntura	OR	CL	12.5		X		X		X		X				X				X		X									7
Stewart Valley	NV	BACL	15					X	X												X	X								4
Trout Creek	OR	BA	15.4																				X	X						2
Clarkia	ID	BA	15.9																		X			X						2
Sucker Creek	IDOR	BA	16	X	X		X	?			XX												X	X						7
Quartz Basin	OR	BA	15.9	X																										1
Mascall	OR	BA	15.9																				X							1
Barstow	CA	BA	15.9																										X	1
Siebert Tuff	NV	BA	17																										X	1
Bullfrog Mine	NV	HM	23																										X	1

Ex *Esox*, **Am** *Ameiurus*, **Or** *Orthodon*, **Pt** *Ptychocheilus*, **Mp** *Mylopharodon*, **Mc** *Mylocheilus*, **Ac** *Acrocheilus*, **La** *Lavinia*, **Gi** *Gila*, **Ri** *Richardsonius*, **Si** *Siphateles*, **Rh** *Rhinichthys*, **De** *Deltistes*, **Ch** *Chasmistes*, **Ca** *Catostomus*, **Pa** *Pantosteus*, **Pr** *Prosopium*, **Sv** *Salvelinus*, **On** *Oncorhynchus*, **Pli** *Plioplarchus*, **Ar** *Archoplites*, **Co** *Cottus*, **Mx** *Myoxocephalus*, **Kc** *Kerocottus*, **Ga** *Gasterosteus*, **Fu** *Fundulus*.

Map of the Sucker Creek Formation and Succor Creek Flora, Oregon and Idaho.



Open circles are fossil plant localities; larger circles are especially important to stratigraphy and are discussed in the text. Filled triangles are important fish localities.



Photos of fish bones in putative bird pellets. Scale bars indicate millimeters

SUCKER CREEK FISH TAPHONOMY and PALEOECOLOGY

Sucker Creek fish fossils usually consist of partly to wholly disarticulated bones in laminar, leaf-bearing, volcaniclastic shales or as isolated bones in unconsolidated basin-marginal silts.

Fossil fish bones in the leaf-bearing shales usually appear in clusters 20-80 mm in diameter. Most of these clusters are about 30-40mm across, with bones packed together, aligned, and eroded. These are interpreted as cast pellets of small fish-eating birds, disgorged into shallow, low-energy ponds in flooded forest, based on the lack of dispersion and semi-etched condition of the bones. Fecal material would show more etched surfaces. Deeper water would have produced more dispersion of the bones.

Grebes are known to disgorge pellets (Dudley 2010) and small grebes are reported among Miocene fossils in the west (Murray 1967). Disgorged pellets are distinguished from "normal" fish mortality and taphonomy by some of the following observations.

- Consistent size, approximately the dimensions expected from small grebes
- Alignment of ribs, spines, and other long bones in tightly packed clusters.
- Eroded bone edges and surfaces, including "craze cracking" indicative of limited acid etching or digestion, not complete digestion.
- Little evidence of scavenger disturbance; no crayfish.
- Larger and elliptical putative pellets, possibly from cormorants, herons, larger grebes, or mergansers are present, but rare. Long-necked birds such as herons disgorge larger, elongate pellets.
- Grebes ingest and disgorge feathers along with sharp fish parts (Dudley 2010); feathers are not seen in Sucker Creek pellets, perhaps because they float.

Presence of pellets from fish-eating birds suggest paleoecology of warm, shallow, oxygenated ponds sometimes in flooded forest, with food to support fish. Fossil insects and mollusks are generally absent, suggesting acidic water and predation. Pellets were intact, so not dropped from birds in flight (kingfishers or cormorants). Deep water would dissolve and disperse pellets. Cold, deep water would preserve articulated skeletons.

FISH AND STATIGRAPHY NEAR THE SUCKER CREEK FORMATION

PAYETTE FORMATION, ID & OR.—We have seen no fish bones from the Payette Fm., which overlies the Imnaha and Grande Ronde basalts of the CRBG (16.4 Ma). Axelrod (1964) noted plants, sediments, and basalts of the Payette Fm near Weiser similar to the Sucker Creek Fm, suggesting that the Sucker Creek Fm might be a fine-grained facies of the Payette Fm. Fitzgerald (1982) found chemically similar basalts in the Payette and Owyhee/Sucker Creek regions, confirmed by Lees (1994) with a date of 15.1 Ma for middle Weiser Basalts. Forester et al. (2004) reported the 14.9 Ma Obliterator Tuff, also in the Sucker Creek Fm, associated with plant fossils above this basalt flow.

QUARTZ BASIN, OR.—The *Esox* reported by Cavender et al. (1970) is the only fish known from here. The Quartz Basin Basalt is equivalent to the upper Owyhee Basalts (Ferns et al. 1993), above the Littlefield Rhyolite, which erupted during initial subsidence at the western edge of the Oregon-Idaho Graben (16-14.7 Ma).

DEER BUTTE FM., OR.—As defined by Kittleman et al. (1965), this name covered a range of sediments and fossils from early Barstovian to Blancan. We use the name for sediments above the upper Owyhee Basalts of Ferns et al. (1993) and below the Kern Basin Tuff at the base of the Grassy Mountain Basalt, roughly 14.7 -12.6 Ma.

STINKINGWATER, OR.—Fishes from this locality are similar but younger than those of the Sucker Creek Fm based on the presence of *Catostomus*. Beulah Reservoir beds, stratigraphically close to Stinkingwater, have small minnows of the Sucker Creek Fm. These are in the lower member of the Juntura Fm of Shotwell et al. (1963), which is below basalts of the Keeney Chemical Group (12.5 Ma, Camp et al 2003) and above Tims Peak Basalt (13.5 Ma, Cummings et al. 2000).

ROCKVILLE, ID.—Two fish from this site are muskellunge (*Esox*) and catfish (*Ameiurus*). The section is in the Oregon-Idaho Graben below the Jump Creek Rhyolite (11.4 Ma, Wood and Clemens 2002) and peripheral to the Sucker Creek Fm. Buwalda's (1924) large mammals from here are Barstovian and distinct from those above the Jump Creek Rhyolite, considered Clarendonian. Downing (1992) found the species of *Copemys* at Rockville, ID, to be intermediate between Barstovian and Clarendonian.

HOG CREEK, ID.—*Plioplarchus* and *Lavinia* from Hog Creek, are in lithology (with disgorged pellets) like the Sucker Creek Fm. Hog Creek was placed in the "Lower Idaho" or Poison Creek Fm. (Kirkham 1931), however, our work suggests they are between 13.5-11.5 Ma.

BLACK BUTTE, OR.— Contains *Pantosteus* and *Ameiurus* unlike those faunas found earlier. The fishes are in the upper member of the Juntura Fm of Shotwell et al. 1963 (11.5 Ma, Evernden and James 1964).

POISON CREEK FM., ID.—*Acrocheilus, Ptychocheilus, Mylocheilus, Mylopharodon, Catostomus, Ameiurus, Salvelinus,* and *Archoplites* (Smith and Cossel, 2002) are in sediments above the Jump Creek Rhyolite (11.4 Ma) and under the Teapot Volcanics (8.0 Ma, Wood and Clemens 2002).

BIOTIC ASSOCIATIONS IN THE SUCKER CREEK FLORA AND FAUNA

The Succor Creek Flora is one of the best-studied Miocene floras, with over 100 fossil-bearing sites, producing at least 150 species of plants (including 22 gymnosperms) (Fields 1996). *Cedrela* and *Oreopanax* indicate a temperate climate with frost-free days (Taggart & Cross 1980). The mammal fauna is relatively sparse compared to the flora, with roughly 50 species (Sharf 1935, Shotwell 1968, Downing 1992).

Wet to dry gradient:
• **Swamp & Flooded Forest:** Ponds and lakes with *Actinocyclus* (centric diatom indicating eutrophic, slightly alkaline water, Bradbury & Krebs 1995), seasonal wetlands, with high water table. Biotic associations: water lily, water chestnut, cattail, small fish, gastropods, turtles, and fish-eating bird pellets indicate shallow water.

• **Riparian:** Horse tail, ferns, Chinese swamp cyprus, swamp cypress, dawn redwood, beavers, hippomorph rhino, rabbit, *Martes*, and deer mice (Shotwell 1968, Fields 1996).

• **Floodplain:** Seasonally dry with grasses, forbs, sequoia, sycamore, oak, maples, elm, ginkgo, magnolia, and 21 species of shrubs; grazing horses, "deer", running rhino, and granivorous squirrels, rats, and mice (Shotwell 1968, Downing 1992, Fields 1996); "recovery" vegetation indicates disturbances by fires, volcanoes, and floods (Taggart & Cross 1980).

• **Savannah and Woodlands:** Mixed conifer-hardwood forest with oak, maple, ash, cypress, madrone, chestnut, sumac, alder, aspen, hackberry, basswood, hemlock, cedar, pine, spruce, fir; browsing horses, oreodont, forest rhino, *Martes*, beavers, flying squirrel, deer mice, mole and elephant (Shotwell 1968, Downing 1992, Fields 1996).

• **Uplands:** Conifer-rich plant fossils and pollen suggest an elevation gradient from lower and wetter in the north to higher, cooler, and drier, with pine and fir, in the south (Fields 1996). Clasts and wood fragments indicate current directions to the west and north (Cummings et al. 2002).

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