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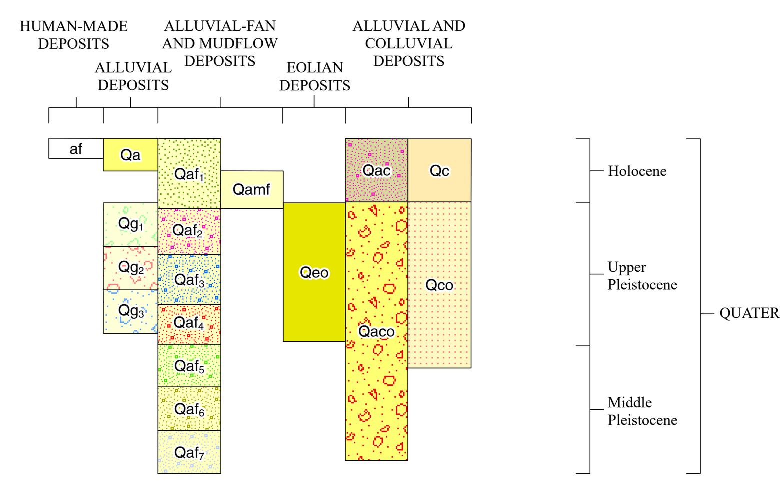
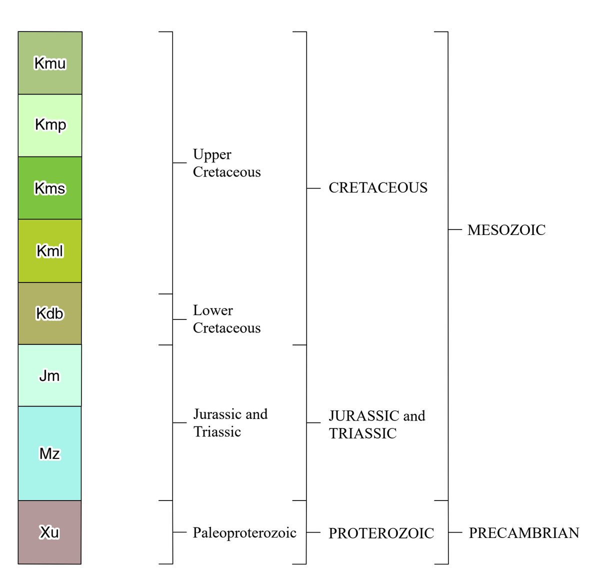
CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS



BEDROCK UNITS



3-D OBLIQUE

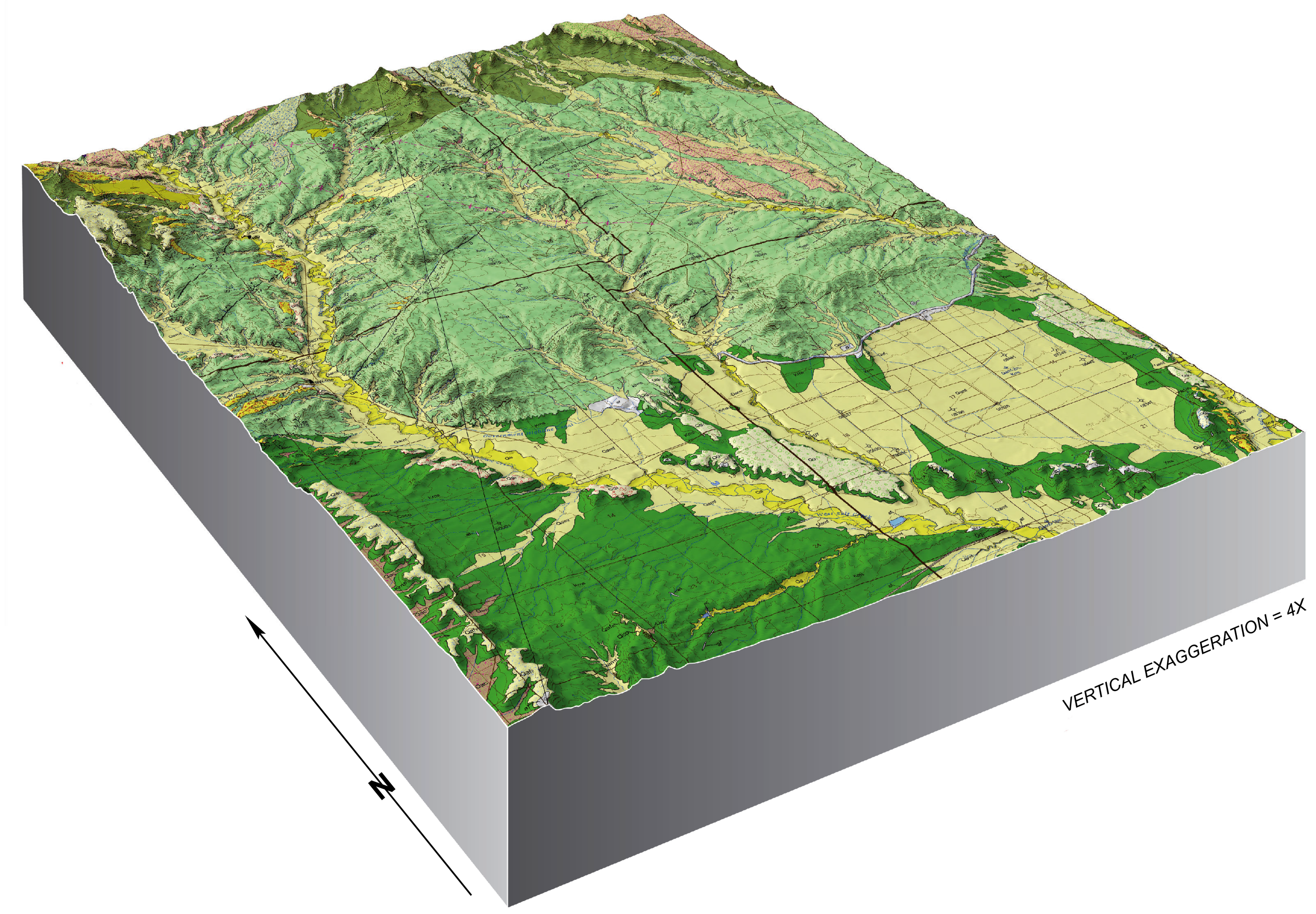
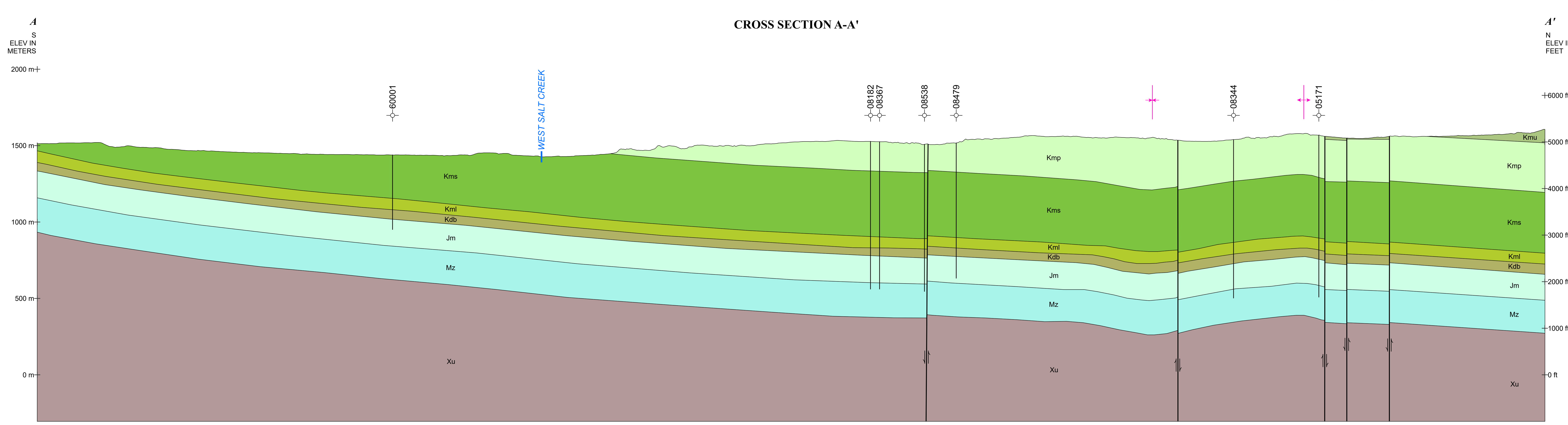


Table 1. OSL analysis for Quaternary deposits in the Badger Wash quadrangle. Analysis by Geoluminescence Dating Research Laboratory, Dept. of Geosciences, Baylor University, Waco, TX, USA

Field Number	Depth (m)	Lab Number	Grain Size (µm)	Equivalent Dose (De) (Gy)[b]	Over-dispersion (%)[c]	U (ppm)[d]	Th (ppm)[d]	K_2O (%)[d]	Rb (ppm)	H_2O (%)	Cosmic Dose Rate (mGray/yr)[e]	Dose Rate (mGray/yr)	SAR-OSL age (yr)[f]
BW-189	6.71	5436	150-250	21.39 ± 0.85	43 ± 6	1.63 ± 0.01	5.17 ± 0.01	1.42 ± 0.01	55.2 ± 0.01	20 ± 3	0.138 ± 0.014	1.68 ± 0.04	12755 ± 615
BW-044	6.71	5435	150-250	>154	NA	2.18 ± 0.01	6.40 ± 0.01	1.30 ± 0.01	50.0 ± 0.01	20 ± 3	0.137 ± 0.014	1.77 ± 0.05	>87000

[a] Aliquots measured and used to define De population by Central Age or Minimum Age Model (Galbraith and Roberts, 2012)
[b] Equivalent dose calculated on a pure quartz fraction with ultra-small aliquots with 20-80 grains/aliquot and analyzed under blue-light excitation (470 ± 20 nm) by Single Aliquot Regeneration protocols (SAR; Murray and Wintle, 2003; Wintle and Murray, 2006). Equivalent dose (De) was calculated by the Central Age assuming a normal data distribution (Galbraith and Roberts, 2012; Liang and Forman, 2019). Prefix "TT-" means the use of Thermal Transfer approaches as outlined in Forman et al. (2022).
[c] Overdispersion values reflects precision beyond instrumental errors; values of ≤ 20% (at 1 sigma limit) indicate low dispersion in equivalent dose values and defines a unimodal distribution. Values > 20% are associated with mixed equivalent dose signature reflecting multiple grain populations or partial solar resetting.
[d] U, Th, Rb and K content analyzed by inductively coupled plasma-mass spectrometry by ALS Laboratories, Reno, NV.
[e] Includes a cosmic dose rate calculated from parameters in Prescott and Hutton (1994) and includes soft components (Liang and Forman, 2019).
[f] Systematic and random errors calculated in a quadrature at one standard deviation by the Luminescence Dating and Age Calculator (LDAC) at https://www.baylor.edu/geosciences/index.php?id=962356 (Liang and Forman, 2019) Datum year is AD 2010.

CROSS SECTION A-A'



PHYSIOGRAPHIC SETTING

The Badger Wash quadrangle lies in Mesa and Garfield counties, Colorado, approximately 24 km northwest of the town of Fruita and 4.4 km east of the Utah border. The quadrangle lies at the northwestern edge of the Grand Valley where agricultural lands are irrigated by the Government Highline Canal. The Grand Valley is a topographically low area of subdued hills and badlands that lie between the Uncompahgre Plateau and the Book Cliffs. Access to the quadrangle map area is best from Old Highway 6 & 50 to Garfield County Road 201 (Baxter Pass Road) that follows the West Salt Creek valley into the Book Cliffs. The topography in the southern part of the map area consists of wide and subdued flats, low hills, and low (<50-m high) mesas, The small mesas are capped with Pleistocene alluvial-fan and stream-terrace gravel, which are now topographically inverted. North of the flat irrigated lands and the canal in the map area, the underlying Mancos Shale bedrock is more sandy and more resistant to weathering and erosion. Shallow dendritic drainage patterns are developed in low hills and ridgelines that rise from 70 to 90 m above the irrigated lands. The major creeks are intermittent or ephemeral. They included Badger Wash and Prairie Canyon creeks that are tributaries of West Salt Creek. The confluence of West Salt and East Salt creeks occurs 1.7 km below the southern map boundary where the Salt Creek thalweg extends an additional 5 km to its confluence with the Colorado River in Ruby Canyon. The highest elevation of the Badger Wash quadrangle is 1,632.5 m above mean sea level (AMSL) at the north-central map boundary on a high narrow mesa capped by rocky and resistant Pleistocene alluvial-fan deposits. The lowest elevation is 1,376.3 m AMSL at the southern map boundary where East Salt Creek flows though the southeastern corner of the map area. The climate is arid and vegetation outside of irrigated areas is sparse. The landscape is comprised in part of adobe-type badlands that are common in the Colorado (Grand), Gunnison, and the Uncompahgre river valleys of west-central Colorado where the Mancos Shale bedrock is exposed. The annual precipitation ranges from 20 to 30 cm (National Centers for Environmental Information).

GEOLOGIC SETTING

The oldest bedrock unit exposed in the map area is the Late Cretaceous Mancos Shale. The marine shale was deposited during the transgression of the Cretaceous Western Interior Seaway (WIS) (Franczyk and others, 1992). Regressive and transgressive sequences of the western shoreline of the WIS formed the sediments of the Iles and Williams Fork formations of the Mesaverde Group. These rocks are more resistant to weathering and form the Book Cliffs that are exposed north of the map area. South of the mapped area, faulting and monoclinal folding of the northeast front of the Uncompahgre Uplift exposes earlier Mesozoic rocks and Proterozoic basement rocks of the Uncompahgre Plateau in the Colorado National Monument (Scott and others, 2001) and the McInnis Canyons National Conservation Area south of the Colorado River (White and others, 2015). The exposed package of Triassic and Jurassic sedimentary rocks includes the basal Triassic Chinle Formation, which nonconformably overlies Proterozoic basement rocks. This type of unconformity indicates an earlier Pennsylvanian-Permian uplift of the Ancestral Uncompahgre Mountains. Earlier Paleozoic sedimentary rocks that were exposed in the ancestral uplift were subsequently eroded away over millions of years. The Triassic Period ground surface in the Mesozoic Era was beveled to a peneplain eroded down to crystalline Proterozoic basement rocks prior to the deposition of later Mesozoic and Cenozoic sedimentary rocks. These rocks were later uplifted during the Laramide Orogeny when the faulting and folding of the Uncompahgre Uplift occurred and formed the present-day Uncompahgre Plateau. The Grand Valley was formed by Late Neogene to Pleistocene erosion and long-term ground lowering by the Colorado River and its tributaries where the less resistant Mancos Shale was at ground surface (Aslan and others, 2019).

The structural geology of the Badger Wash quadrangle reflects the regional faulting along the general northwest to southeast trend of the Uncompahgre Uplift. The general dip of the strata is north to northeast towards the Unita and Piceance basins. Structural data within the Badger Wash quadrangle were difficult to obtain because of the weathering of the exposed shale bedrock. However, useful attitudes of the bedrock were gained from exposures of tabular sandy dolomite concretionary beds, very thin beds of bentonite, and thinly interbedded sandstone beds of the Prairie Canyon Member. The major structural features in the map area are several subparallel normal faults, shallow folds, and the termination of the Flume Creek monoclinal fold that is expressed in the dip of Mancos Shale near the southwest corner of the quadrangle near Old Highway 6 & 50. This monocline trend extends northwest from the Mack area and is likely fault cored at depth (White and others, 2015). Field work for this study identified surface faulting, shallow-displacement grabens, and paired anticlines and synclines. These southwest- to northeast-trending subparallel branch faults were first mapped by Krey (1962). These faults are also shown in the 1:250,000-scale (Cashion, 1973) and 1:100,000-scale (Ellis and Gabaldo, 1989) geologic maps; however, several other subparallel normal faults were identified during the mapping of the Badger Wash quadrangle. Significant structural variation was also noted in exposed bedrock strata within the faulted terrain, as well as localized deformation of strata near faults. Crystalline calcite filling that locally include casts of fault and shear zone slickensides were also observed. The faults trend approximately 70 to 80 degrees (north to northeast) from the general southeast to northwest trend of the folded front of the Uncompahgre Uplift at the Flume Creek monocline.

WATER RESOURCES

Water resources of the Badger Wash quadrangle are minimal. Streams only flow intermittently during high precipitation events. The cobble-rich alluvial aquifer composed of lower Colorado River terrace gravels of the Grand Valley is not present in the map area. This buried, water-bearing cobbly deposit ends where the Colorado River has incised into Horsethief Canyon between Fruita and Mack (Butler and others, 1996). Government Highline Canal provides water to irrigate farmlands in the lower third of the quadrangle. Canal water empties into West Salt Creek, which marks the western end of irrigated farmlands in the Grand Valley of Colorado. The underlying Mancos Shale members are considered confining units and water production is poor, as is the water quality of older Mesozoic rocks at depth. High total dissolved solids (>2,000 mg/L) and high sulfate and selenium levels that exceed EPA maximum contaminant levels have been reported in water wells producing from the Mancos Shale in the Grand Valley area (Sebol and others (2017).

MINERAL RESOURCES

Oil and Gas resources are present in the quadrangle (Colorado Energy and Carbon Management Commission (ECMC)). Named oil and gas fields include portions of the Bar-X, Bidle, and Peachtree fields (ECMC). These fields were developed in the structural terrain mentioned above (Krey, 1962). For most of the oil and gas wells, the total depth was in the Entrada Sandstone and production predominantly occurred from the Dakota Sandstone and Burro Canyon Formation (Kdb) and the Entrada Sandstone (Je). These units are not exposed in the map area but are shown in the cross section. Within the Mancos Shale, the Niobrara Member may have oil and gas potential using horizontal well drilling and hydraulic fracturing (fracking) completion techniques. There are local gravel pits excavated in some of the mesa surfaces underlain by old gravels, but the gravel quality is poor, being low-durability, sandstone-rich gravel derived chiefly from Mesaverde Group rocks of the Book Cliffs and locally containing channels or layers composed of mud-flow and debris-flow deposits with a clay matrix.

GEOLOGIC HAZARDS

Potential geologic hazards in the map area are primarily the risks posed by stream flooding as well as mudflow and debris flow deposition. The floors of the intermittent stream show evidence of flooding, scour, and deposition of bouldery gravel. The Mancos Shale contains bentonite and other expansive clay minerals. Clayey surficial deposits (soils in geotechnical engineering terms) derived from the shale may be expansive (swelling soils) (Noe, 2007). Some silty to clayey sand deposits may also be low density and may be collapsible and settle upon wetting (hydrocompactive soils) (White and Greenman, 2008). Unimproved dirt road and 4WD tracks in the adobe badlands may become impassable when they are wet as the clay soils becomes increasingly slick, greasy, and adhere to tires and shoes. The marine shale may also be locally high in sulfates and may be corrosive to unprotected concrete and steel. High selenium levels and other dissolved solids have been reported in irrigation return waters in the Mancos Shale (Butler and other, 1996). Site-specific geotechnical investigations including bore holes and soil testing should be conducted for structures planned in the Mancos Shale or in clayey soils derived from the Mancos.

PREVIOUS GEOLOGIC MAPPING

The preparation of this map was aided by the review of previous geologic mapping conducted in the area. The geology of the Badger Wash quadrangle was previously mapped at 1:100,000 scale by Ellis and Gabaldo (1989) and at the 1:250,000 scale (1° by 2°) by Cashion (1973). Krey (1962) prepared a small-scale structural map of the area. On an adjacent 1:24,000-scale quadrangle at the southeast corner of the Badger Wash quadrangle, the geology of the Mack quadrangle was mapped by White and others (2015) as part of this multi-year mapping program in the Grand Valley by the Colorado Geological Survey. The 1:24,000-scale quadrangle adjacent to the Badger Wash quadrangle are shown in the index map on Plate 1.

ACKNOWLEDGMENTS

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GEOLOGIC MAP OF THE BADGER WASH QUADRANGLE, MESA AND GARFIELD COUNTIES, COLORADO
CORRELATION OF MAP UNIT, 3-D OBLIQUE, GEOLOGIC SETTING, AND CROSS SECTION

By Jonathan L. White and Emily A. Perman
2024