United States Department of Agriculture

Natural Resources Conservation Service

EXPLORING SOIL COLORS

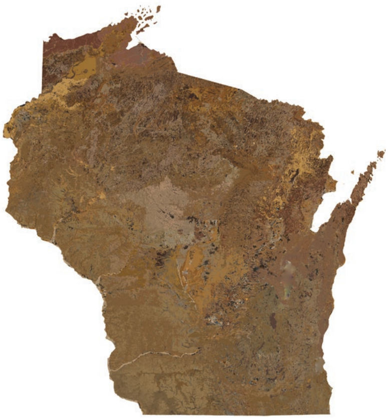
Highlighting Wisconsin State Parks & Forests

NCSS
National Cooperative Soil Survey




WHAT DOES THE COLOR OF SOIL TELL US?

Soil color can help us predict mineral content, chemical composition, physical properties, and other important soil characteristics. The first impression we have when looking at bare earth, or soil, is the color. Vivid colors and striking differences in the soil can catch our eye. The stories that soil colors tell us vary with the ecosystems and other factors. Soils come in many different shades, most commonly in shades of black, brown, red, gray, and white.



Wisconsin soil color at 50 cm depth.

Soil color and other properties, including texture, structure, and consistency, are used to identify soil horizons (layers in the soil). These properties are also used to classify soils according to the official USDA system, which is named “Soil Taxonomy.” Development and distribution of color within a soil are affected by weathering. As rocks containing iron or manganese weather, the elements oxidize. Iron forms small yellow or red crystals, and manganese forms black mineral deposits. Organic matter decomposes into black humus. Color is also affected by the amount of oxygen in the soil. Soils that contain lots of oxygen are called “aerobic” and can produce sweeping vistas of uniform or subtly changing color. Soils that contain little oxygen are called “anaerobic” and can disrupt the color flow with complex, often intriguing patterns and points of accent. Wet environments are commonly anaerobic. As we look deeper below the surface, soil colors usually become lighter and yellower or redder.

TYPES OF SOIL COLOR

White Soil

Some soils are white because they are influenced by calcium carbonate, magnesium carbonate, gypsum, or other more soluble salts. Commonly, a white layer from which pigments were removed occurs between organic matter and the soil surface. This layer consists mostly of quartz. An example of a soil with such a layer is Antigo silt loam, which is the Wisconsin State Soil.

Brown Soil

Some soils are brown because of decaying plant material. Darker colors often indicate higher levels of the decomposed organic matter known as humus. Soil contains living organisms and dead organic matter, which decompose into black humus. In grassland (prairie) soils, the dark color permeates through the surface layers, bringing nutrients and high fertility to deeper layers.

Deeper in the soil, organic material coats the soil particles, making them darker on the outside than the inside. The coloring caused by humus decreases with depth, and the coloring caused by iron increases.

Yellow or Red Soil

Yellow or red soil indicates the presence of ferric iron oxides. The red color may be mainly due to thin coatings of ferric oxides on the soil particles. Where the iron oxide is hematite or hydrous ferric oxide, the color is red. Where the iron oxide is in the hydrate form (limonite), the soil appears more yellow.

Grey Soil

Grey soil commonly indicates water in the soil for extended periods. Organic matter also plays an indirect, but crucial, role in the removal of iron and manganese pigments in wet soils. All bacteria, including those that remove iron and manganese coloring, must have a food source. Bacteria thrive in concentrations of organic matter, particularly in dead roots. Where bacteria that remove color from the soil thrive, gray colors develop.

WHY DO SOIL SCIENTISTS DESCRIBE SOIL COLOR?

Soil color is an indicator of wetness, mineral composition, and chemical properties. Soil scientists measure depth to wetness or a water table by understanding how patterns of soil color and types of mineral vary in wet conditions. Soil color can indicate the composition of the soil and give clues to the conditions of the soil. Horizontal bands of color in the soil often identify a specific soil horizon. The development and distribution of color in soil occurs in a predictable manner from chemical and biological weathering. An especially important form of weathering is named “redox” (reduction-oxidation).

Color is one of the physical properties that is most commonly used to describe and classify soil horizons. Color allows us to determine some of the most important soil characteristics, such as mineral composition, age, and extent of soil processes (for example, chemical alteration, carbonate accumulation, and accumulation of humified organic matter).

Color, or lack of color, can also tell us how commonly a soil is wet. In many soils, the water table rises in the rainy season. When a soil has a high water table or water settles above a waterproof layer in the soil, the amount of oxygen in the soil goes down. When this happens, the bacteria that need oxygen (aerobic bacteria) go dormant and the bacteria that don’t need oxygen (anaerobic bacteria) thrive. Some anaerobic bacteria convert ferric iron (Fe^{3+}), which is red, to ferrous iron (Fe^{2+}), which is colorless. The colorless iron is water-soluble and returns to the soil. Other anaerobic bacteria convert manganese Mn^{4+} to colorless, water-soluble manganese Mn^{2+}. The loss of pigment leaves the soil material gray. If water stays for long periods, the entire zone turns gray.

HOW DO SOIL SCIENTISTS DESCRIBE SOIL COLOR?

The Munsell System classifies colors based on three factors: hue (the specific color), value (lightness and darkness), and chroma (color intensity). These factors are arranged in books of color chips. The system allows for direct comparison of soils anywhere in the world. Soil is held next to the color chips to find a visual match, and the corresponding Munsell notation is noted. For example, a soil that matched the chip for hue of 10YR, value of 5, and chroma of 3 would be noted as “brown (10YR 5/3).” For a detailed explanation of the Munsell System, visit www.munsell.com. Using a soil-color book, students can learn to read and record soil colors scientifically. They can visually connect soil colors with natural environments. Munsell color notations also have other uses. For example, they can be used to define an archaeological site or to make comparisons in a criminal investigation. Even carpet manufacturers use Munsell soil colors. They match carpet colors to local soils so that the carpet will not show the dirt (soil) tracked into a house.

Munsell notation is one of many standard methods used to describe soils for soil survey. Another way soil scientists measure soil color is spectroscopically, either in the field or from photographs. Optical sensors are used to determine the soil’s ability to reflect light in different parts of the electromagnetic spectrum.

Field-based optical sensors are fundamentally the same as aerial or satellite systems. One advantage of close range sensors is that they can be applied both at the surface and below ground. In soil survey, optical reflectance is used in point-data documentation and can be used for on-the-go measurements. In addition, both near- and mid-infrared diffuse reflectance spectroscopy are used in the laboratory for rapid determination of soil properties. Optical sensing systems cover the ultraviolet (100–400 nm), visible (400–750 nm), near infrared (750–2,500 nm), or mid-infrared (2,500–25,000 nm) wavelengths individually or in combination. Typically, optical sensors used for soil measurements supply their own light source (e.g., a light bulb or light-emitting diode). Photodiodes or array detectors are used to estimate the intensity of reflected light. This measurement is related to the light reflected from a given set of standards. Both source light and reflected light can be transmitted through the air, via fiber optics, or, when feasible, through a contact window fabricated from highly resistive material, such as sapphire or quartz. These soil sensors allow rapid and inexpensive collection of precise, quantitative, high-resolution data, which can be used to better understand soil.

LANDSCAPES

Landscape can dictate soil color by influencing the weathering of minerals in the soil. A stable landscape allows soil weathering processes to act longer, developing different soil colors than an unstable landscape. Consequently, we can use color intensity to judge land-surface age and to make assumptions about landscape stability and past climates. Generally speaking, wet and warm climates create different soil colors than hot and dry climates.

INTERPRETING SOIL COLOR

Color can be a clue to the mineral content of a soil. Iron minerals provide, by far, the most and the greatest variety of pigments in earth and soil.

Common Pigmenting Agents in the Soil

Properties of Minerals

MINERAL	FORMULA	SIZE	MUNSELL	COLOR
goethite	FeOOH	(1-2mm)	10YR 8/6	yellow
goethite	FeOOH	(~0.2mm)	7.5YR 5/6	strong brown
hematite	Fe_2O_3	(~0.4mm)	5R 3/6	red
hematite	Fe_2O_3	(~0.1mm)	10R 4/8	red
lepidocrocite	FeOOH	(~0.5mm)	5YR 6/8	reddish-yellow
lepidocrocite	FeOOH	(~0.1mm)	2.5YR 4/6	red
ferrihydrite	$Fe\ (OH)_3$		2.5YR 3/6	dark red
glauconite	$K(Fe\ (OH)_3Si_xAl_{4x})$ $(Al,Fe,Mg)O_{10}(OH)_2$		5Y 5/1	dark gray
iron sulfide	FeS		10YR 2/1	black
pyrite	FeS_2		10YR 2/1	black (metallic)
jarosite	$K\ Fe_3\ (OH)_6\ (SO_4)_2$		5Y 6/4	pale yellow
todorokite	MnO_4		10YR 2/1	black
humus			10YR 2/1	black
calcite	$CaCO_3$		10YR 8/2	white
dolomite	$CaMg\ (CO_3)_2$		10YR 8/2	white
gypsum	$CaSO_{4x}\ 2H_2O$		10YR 8/3	very pale brown
quartz	SiO_2		10YR 6/1	light gray

HIGHLIGHTING STATE PARKS & FOREST LOCATIONS

Wisconsin State parks and forests highlight a variety of landscapes across the State. Featured in the next section are selected State parks and forests that illustrate various soil colors and profiles. Enjoy pictures of highlighted locations, soil-color samples you can compare to your local soils, and soil profile samples while reading more about the diverse landscapes across Wisconsin.

Highlighted Locations:

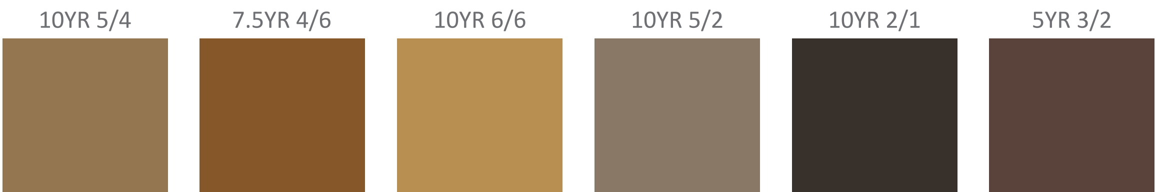
1. Buckhorn State Park
2. Chippewa Moraine State Park
3. Copper Falls State Park
4. Devil's Lake State Park
5. Kettle Moraine State Forest
6. Rock Island State Park
7. Wyalusing State Park

BUCKHORN STATE PARK

Buckhorn State Park and Soil Colors

By Mike England, Soil Scientist USDA-NRCS Onalaska Soil Science Office

The area now known as Buckhorn State Park was called the “unbroken wilderness” by the Ho Chunk Native Americans, who previously inhabited the area. This area is unique in an otherwise relatively flat landscape. The landforms in the park were created from outwash deposits and lake basins from glacial advancements. The park is located at the convergence of the Wisconsin River and the Yellow River in central Wisconsin. The rivers created a peninsula by isolating sandy soil deposits with water bodies that where the once part of a relict glacial-lake basin. Although the soils across this now-drained lake plain are relatively similar in texture, they formed in drastically different material and thus have drastically different mineralogy. The soils in the park formed in sandy outwash that was not directly derived from sandy residuum. They contrast with the soils west of the Yellow River, which formed in nearly homogeneous quartz pediment from Cambrian Age Sandstone. In many respects, these sandy soils are relatively alike in color. Most of them have a brown to reddish hue. This coloring can be attributed to the past glacial-lake basins, the post-glaciation vegetation, and the relatively high ground water table. The vegetation in the area is dominated by an overstory of conifers and hardwoods. Many other areas have been described as “once sand barrens.” In the areas that have trees, the needles and leaf litter directly contribute to the acidity of the soil. There is very little soil development due to the limited soil minerals and high water table. Because the soil has few fine-textured particles, nutrient availability is very poor and the soil is extremely droughty where the water table is not near the surface. Where the fluctuating water table recedes, exposed soil gains rust colors due to oxidation.



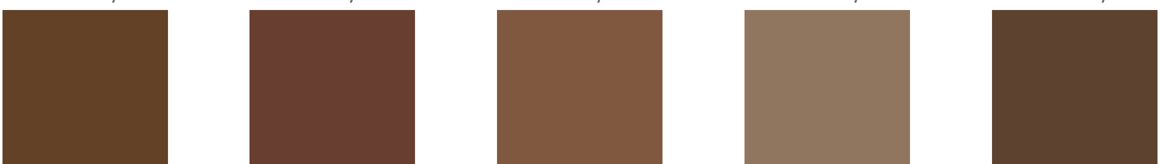

CHIPPEWA MORAINE STATE PARK

Chippewa Moraine State Park and Soil Colors

By Alexander Gajdosik, Soil Scientist USDA-NRCS Rhinelander Soil Science Office

Chippewa Moraine State Recreation Area gets its name from the same features that gave this area its soil colors: Glaciers! The last glacial advance into this region was the Laurentide ice sheet, which originated in eastern Canada. Within the Laurentide were two smaller ice sheets that affected Wisconsin: the Keewatin and the Labrador. Chippewa Moraine State park is within the range of the Chippewa lobe. The physical and chemical characteristics (i.e., red and sandy) of the materials laid down by this glacial advance are primarily responsible for the colors of the soils. The post-glaciation vegetation also plays an important role in the development of the colors. Prairie grasses currently share this area with mixed forests. The influx of organic material from the grasses helps to enrich the soil with organic carbon, adding darker material to the top. The coniferous vegetation and the needles that fall from it contain organic acids. These acids work to make metal ions (predominantly iron) soluble in water. Once soluble, the metals can move downward through the soil. After the water is gone and oxygen returns to the soil, the iron becomes immobile and stays in the soil. The iron creates a rust-like appearance that is similar to rust found on industrialized iron products.

7.5YR 3/4 5YR 3/4 5YR 4/4 7.5YR 5/3 7.5YR 3/3



COPPER FALLS STATE PARK

Copper Falls State Park and Soil Colors

By Alexander Gajdosik, Soil Scientist USDA-NRCS Rhinelander Soil Science Office

The geologic past of Copper Falls State Park, and the landforms that it created, can be directly related to the soils of the park. Although the soils across this beautiful landscape can be drastically different in many respects (texture, parent material, chemical composition, etc.), the colors of the soils are relatively similar—most have a red hue. This coloring can be attributed to the ice of the last glacial advance (>12,000 years ago), the post-glacial vegetation, and the adequate rainfall that the area receives. The predominantly coniferous vegetation in the area deposits needles onto the soil. These needles release organic acids, which are then carried downward into the soil. Along with the needles, other types of organic matter aid in the “chelation” of certain metals in the soil, mostly iron. Chelation is the chemical binding of metals to organic matter. It allows the iron to dissolve in water and be carried downward into the soil. The soils get their red colors from this movement of organic acids and iron and from the nature of the material in which the soils formed.

5YR 4/4	5YR 4/6	2.5YR 4/4	2.5YR 4/6	5YR 3/4

DEVIL'S LAKE STATE PARK

Devil's Lake State Park and Soil Colors

By Mike England, Soil Scientist USDA-NRCS Onalaska Soil Science Office

The history of the name Devil's Lake State Park is interesting. The area was called "Spirit Lake" by the Ho Chunk Native Americans, who previously inhabited the region. Through errors in translation, the area was eventually deemed Devil's Lake.

This area is unique to the State in that it consists of steeply elevated Precambrian Quartzite bluffs. It is locally named the Baraboo Hills because of its high relief and topography. This landform was created through erosion by the Wisconsin River where the 360-acre lake now resides. In the last gasp of the most recent Wisconsin Age glaciation, both ends of the quartzite gorge created by the river were blocked. The blockage created the lake and changed the course of the Wisconsin River.

The eastern half of the park has been glaciated, the western half has not. The soils are in the western area, therefore, have had longer to form. The soils on the bluffs formed in wind-blown silts, called loess. The valley bottoms formed in a mix of material carried away from glaciers by meltwater, material deposited by flowing streams, and material that accumulated at the foot of the adjacent high reliefs. The warm, humid summers, the cold winters, and the fairly uniform precipitation made ideal growing conditions for temperate forests, grasslands, and woodlands. Most of the soils in the area formed in a forested ecosystem that was deciduous, co-niferous, or a mixture of both. The soils formed in materials that tend to have brown hues, but significant color differences come from the Quartzite bedrock. The bedrock is a significantly hardened, metamorphic version of sandstone. It radiates red and pink hues across the landform and is clearly visible along road cuts, lake shores, and steep backslopes of rock outcrops. It also is a limiting factor for many soil uses.

10R 6/3 | 10YR 5/4 | 10YR 4/4 | 10YR 5/6 | 10YR 4/3 | 10YR 4/2

KETTLE MORAINE STATE FOREST

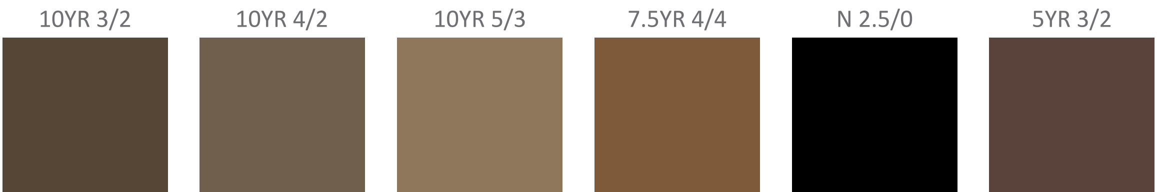
Kettle Moraine State Forest and Soil Colors

By Natalie Irizarry, Soil Scientist, USDA-NRCS Juneau Soil Science Office

A moraine is an accumulation of rock and sediment deposited by a glacier. Kettle Moraine State Park occupies a large and unique moraine in Wisconsin. It is about 30,000 acres. The moraine starts in Walworth County (south) and ends in Kewaunee County (north). It is sometimes referred to as the Kettle Interlobate Moraine. The moraine was formed when the Green Lake Lobe of the Laurentide Ice Sheet collided with the Lake Michigan Lobe, depositing sediments. The colliding ice changed the shape of the land, resulting in different glacial landforms. Examples include parallel, steep-sided ridges, conical hills, and flat outwash plains. Most of the park is underlain by limestone.

Most of the soils on kames (conical hills) and eskers (undulating, level toped and narrow ridges) are well drained to excessively well drained, have a subsoil that is mainly silty or sandy and contains a large amounts of rock fragments, and are commonly underlain by stratified gravel and sandy outwash. The permeability of these soils is moderate to very rapid, and available water capacity is low. Colors range from brown to reddish.

The flat outwash plains became pitted due to the melting of buried ice masses. Soils on this landform are very poorly drained, and muck is common. Permeability is moderately rapid, and available water capacity is high. These soils are dark and have muted colors. The vegetation varies. The highlands are forested with hardwood (maples, cherry, ash, and basswood). Swampy or low areas support softwoods. Conifers (white and red pine) and spruce are also part of the flora of the park.



ROCK ISLAND STATE PARK

Rock Island State Park and Soil Colors

By Jason Nemecek, Soil Scientist USDA-NRCS State Office

The geologic origin of the majority of Rock Island State Park is the Liberty Grove Member of the Holy Hill Formation. This formation consists of material (glacial till) deposited by ice of the Green Bay Lobe. The soils in the park formed from glacial deposits during the Late Wisconsin Glaciation. Much of the landscape is an undulating, bedrock-controlled, glacial till plain. It has “karst” topography; that is, the underlying Silurian dolomite bedrock has been eroded by surface water or groundwater, resulting in ridges, sinkholes, and other characteristic landforms.

The soils in the area formed in brown to reddish-brown, calcareous, sandy loam to clay till. They have surface textures that include loam and silt loam. These soils are generally moderately well drained, but they range from well drained to somewhat poorly drained. They typically have a perched water table. They have moderate to slow permeability and moderate to high available water capacity.

Along the shoreline of the island, landforms were caused by deposition. The landforms include beaches, beach ridges, terraces, fans, dunes, and swamps. The soils in these areas are sandy or silty, are excessively drained to poorly drained, and typically have a water table. They have rapid to slow permeability and low to very high available water capacity. Wetlands are scattered throughout the island. The soils of the wetlands are very poorly drained or poorly drained and formed in non-acidic muck, loamy till, or sandy to silty lake deposits. The plant community on the island includes northern hardwood forest; northern wet-to-moderately-moist forest; forested seeps; and shaded cliff communities. The interior plateau of Rock Island contains a mature, moderately moist hardwood forest dominated by beech and sugar maple. Canopy associates include basswood and red oak.

7.5YR 6/4 7.5YR 4/4 7.5YR 5/4 10YR 5/3 10YR 6/4 10YR 5/4

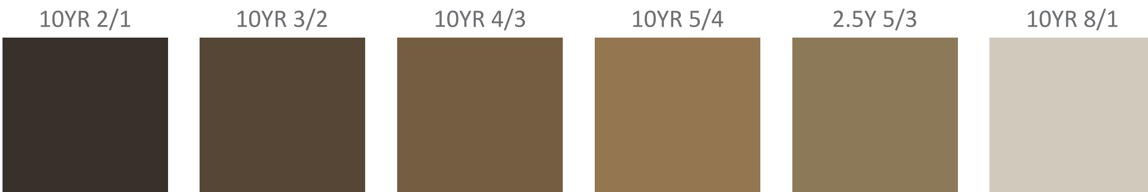
WYALUSING STATE PARK

Wyalusing State Park and Soil Colors

By Mike England, Soil Scientist USDA-NRCS Onalaska Soil Science Office

Wyalusing State Park is high above two major converging rivers along ancient, bedrock-controlled uplands. The Mississippi River makes up most of the western political boundary of Wisconsin. The Wisconsin River bisects the State from the north, drastically turns west two-thirds of the way down the State, and forms the northern boundary of the park. The high-relief soils in the area formed in wind-blown silts with combinations of material weathered from rock, material deposited at the foot of steep slopes, or material left by flowing streams.

The history of the area starts around 600 million years ago. After the crystalline formation of Precambrian igneous rocks, dramatic earth movements caused a succession of shallow to deep seas to spread over North America. Over long years, the seas receded and advanced. They deposited sediments of various origins that “sandwiched” themselves to eventually become sedimentary bedrock of immense depths. The bedrock-controlled, upland landscape was eroded by rivers after the seas levels finally diminished. The erosion created a pristine erosional landscape, which we now know as the “Driftless Area.” Many of the soils that formed around the park are eroded remnants of the various types of dolomite, shale, and sand-stone bedrocks. Most of the soils in the area originated from deciduous, coniferous, or mixed forested ecosystems. The soils tend to be brown to yellow as influenced directly from the mineral composition of the bedrock. Bedrock exposures can be seen across the park as road cuts in the steep backslopes. They contribute to the factors that limit land use.



WISCONSIN STATE PARKS & FOREST SOIL PROFILES

Buckhorn State Park

Chippewa Moraine State Park

Copper Falls State Park

WISCONSIN STATE PARKS & FOREST SOIL PROFILES

Devil's Lake State Park

Kettle Moraine State Forest

Rock Island State Park

Wyalusing State Park

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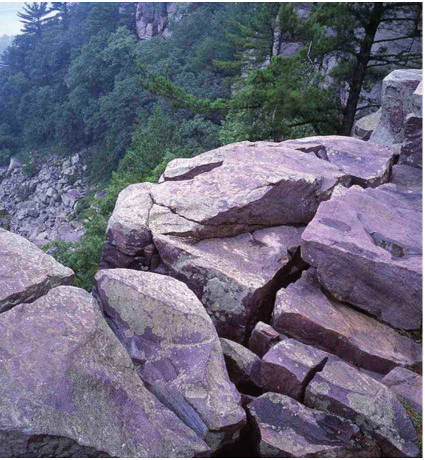
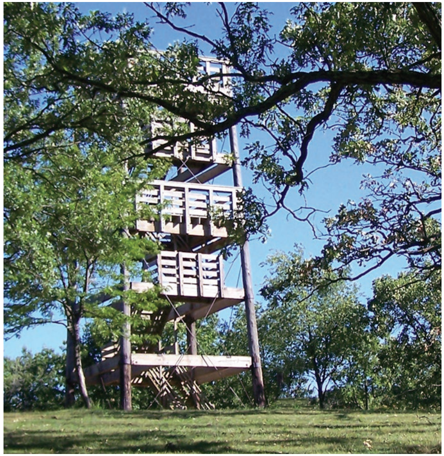
Wyalusing State Park Soil Profile: Photo provided courtesy of Alfred Hartemink, PhD.

MORE INFORMATION

For more information about the NRCS Wisconsin Soils Program or soil colors, visit our website at **www.wi.nrcs.usda.gov**, or contact the Wisconsin State Soil Scientist, **Jason Nemecek**, at **Jason.Nemecek@wi.usda.gov**, **(608) 662-4422**.





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