Penistaja
New Mexico State Soil

Photo Soil Monolith: Chip Clark/Smithsonian Institution

Soil Science Society of America

Introduction

Many states have a designated state bird, flower, fish, tree, rock, etc. And, many states also have a state soil – one that has significance or is important to the state. The Penistaja is the official state soil of New Mexico. Let's explore how the Penistaja is important to New Mexico.

History

The Penistaja series was established in Sante Fe County, NM in 1970. The soil was named after a small farming and stock raising community in northwest New Mexico. "Penistaja" is a Navajo word that means "forced to sit". This soil is found in the Southwest landscape of sandstone mesas, snow-capped mountains and desert grasslands.

What is Penistaja Soil?

The Penistaja soils are found on *mesas*, *plateaus*, hills, *cuestas*, and *bajadas*. They are formed in *alluvium* (deposited by water) and *eolian* (wind-driven) *materials* derived from sandstone and shales. Penistaja soils are aridisols, or desert soils, that formed in arid or semi-arid climates. These soils typically support grassland sites. Every soil can be separated into three separate size fractions called *sand*, *silt*, and *clay*, which makes up the *soil texture*. They are present in all soils in different proportions and say a lot about the character of the soil. Penistaja (**Figure 1**) has a shallow sandy loam *topsoil*, or A horizon. The *subsoil* then has an accumulation of clays (*argillic or Bt horizon*) where water from rain has moved the clay particles to this part of the soil. The texture in this horizon is typically a clay loam. Below this horizon, where rainwater does not often seep, is an area with an accumulation of calcium carbonate that will effervesce, or fizz, when acid is added to the soil.

Fig. 1 Soil profile of a Penistaja soil. Credit: Aaron Miller, Soil Scientist

Fig. 2. Soil pit of Penistaja soil – location is close to La Bajada Mesa where the El Camino Real brought mnay of the early Spanish settlers into Santa Fe. In the early days of settlement (late 1500's through 1600's it would take almost a day to summit this obstacle with wagons! Credit: Aaron Miller, Soil Scientist.

Fig. 3 Location of the Penistaja soil in New Mexico. Credit: Smithsonian Institution's Forces of Change.

Where to dig Penistaja

Yes, you can dig a soil (**Figure 2**). It is called a soil pit and it shows you the *soil profile*. The different horizontal layers of the soil are called *soil horizons*. This does not mean that other types of soil cannot be found there but that the Penistaja is the most common. Penistaja soils can be found in central and northwest New Mexico and northeastern Arizona. Penistaja covers more than 1,000,000 acres of land in New Mexico (**Figure 3**). In all, there are a total of 1,331 named soils (series) in New Mexico.

Importance

What makes the Penistaja soil so important is its use and prevalence in the State. They are very productive rangeland soils and are excellent for livestock grazing, wildlife habitat, and recreation. Penistaja soils provide habitat for Pronghorn antelope along with other wildlife. The Pronghorn (**Figure 4**) is America's only antelope. The Pronghorn is sometimes called a "speedgoat" due to its similar appearance to a goat and high running speed of 55 miles per hour. It is often cited as the second-fastest land animal, second only to the cheetah.

Uses

In general, soils can be used for agriculture (growing foods, raising animals, stables); engineering (roads, buildings, tunnels); ecology (wildlife habitat, wetlands), recreation (ball fields, playground, camp areas) and more. Major uses for the Penistaja soil are livestock grazing and wildlife habitat. Almost all ranching operations in New Mexico are family business, and they are the socio-economic baseline for many communities in the state. There are approximately 6,800 beef and sheep producers in New Mexico. In almost 25 percent of New Mexico counties, beef cattle production is the largest economic output of all private industries. In some counties, the beef industry alone provides 40 per-

Fig. 4. Pronghorn antelope. Adobe Stock.

Fig. 5. Wind erosion on rangeland in New Mexico. Credit: USDA-NRCS.

Fig. 6 A range rider moves cattle along a fenceline within the Valles Caldera National Preserve. Credit: National Park Service.

cent of the total economic output. Ranching has been a relatively stable economic and cultural foundation for the majority of New Mexico communities.

Limitations

When a soil cannot be used for one or more of the described functions, it is referred to as a limitation. Soil experts, called *Soil Scientists*, studied Penistaja soil and identified that it has moderate limitation. Penistaja soils are well suited to rangeland uses like grazing and wildlife habitat. The hazard of soil wind erosion for this soil is severe therefore grazing management should ensure a proper amount of ground cover is maintained on this soil.

Management

Grazing management to achieve desired vegetation is the most common management on Penistaja soils. Techniques to and best management practices for this include rest-rotations, adjusting stocking levels, and potentially range riding among many others. A rest-rotation system is a multi-pasture system where one pasture per year does not get grazed and grazing is rotated around the remaining pastures. This grazing system can be especially beneficial when using sensitive grass that requires time for rest and regrowth. This grazing system can be especially beneficial when using sensitive grass that requires time for rest and regrowth. Stocking rate is the number of animal units per acre for a specified amount of time. Several years of stocking rate, animal performance, and precipitation records can be used to identify levels of stocking beyond which undesirable plant or animal responses begin to occur. Range riding involves actively pursuing and pushing livestock to get better utilization across the pasture and to protect sensitive areas (**Figure 6**).

Penistaja Formation

Before there was soil there were rocks and in between, CLORPT. Without CLORPT, there will be no soil. So, what is CLORPT? It is the five major factors that are responsible for forming a soil like the Downer series. It stands for **CL**imate, **O**rganisms, **R**elief, **P**arent material and **T**ime. CLORPT is responsible for the development of soil profiles and chemical properties that differentiate soils. So, the characteristics of **Penistaja** (and all other soils) are determined by the influence of ClORPT. Weathering takes place when environmental processes such as rainfall, freezing and thawing act on rocks causing them to dissolve or fracture and break into pieces. CLORPT then acts on rock pieces, marine sediments and vegetative materials to form soils.

Climate – Temperature and precipitation influence the rate at which parent materials weather and dead plants and animals decompose. They affect the chemical, physical and biological relationships in the soil. Penistaja soils are formed in a desert climate with a mean annual precipitation of 10 to 14 inches and a mean annual air temperature of 49 to 57 degrees F. The frost-free period in these soils is 115 to 180 days per year.

Organisms – This refers to plants and animal life. In the soil, plant roots spread, animals burrow in, and bacteria break down plant and animal tissue. These and other soil organisms speed up the breakdown of large soil particles into smaller ones. Plants and animals also influence the formation and differentiation of soil horizons. Plants determine the kinds and amounts of *organic matter* that are added to a soil under normal conditions. Animals breakdown complex compounds into small ones and in so doing add organic matter to soil. Organisms that play a key role in the formation of Penistaja soils are grasses and ground dwelling rodents. Grasses incorporate organic matter into the soils through root growth and turnover.

Relief – Landform position or relief describes the shape of the land (hills and valleys), and the direction it faces which makes a difference in how much sunlight the soil gets and how much water it keeps. Deeper soils form at the bottom of the hill rather than at the top because gravity and water move soil particles downhill. Penistaja soils are found between 4,700 to 7,100 feet elevation (**Figure 7**).

Parent material (C horizon) – Just like people inherit characteristics from their parents, every soil inherits some traits from the material from which it forms. Some parent materials are transported and deposited by glaciers, wind, water, or gravity. Penistaja soils are formed from water and wind born

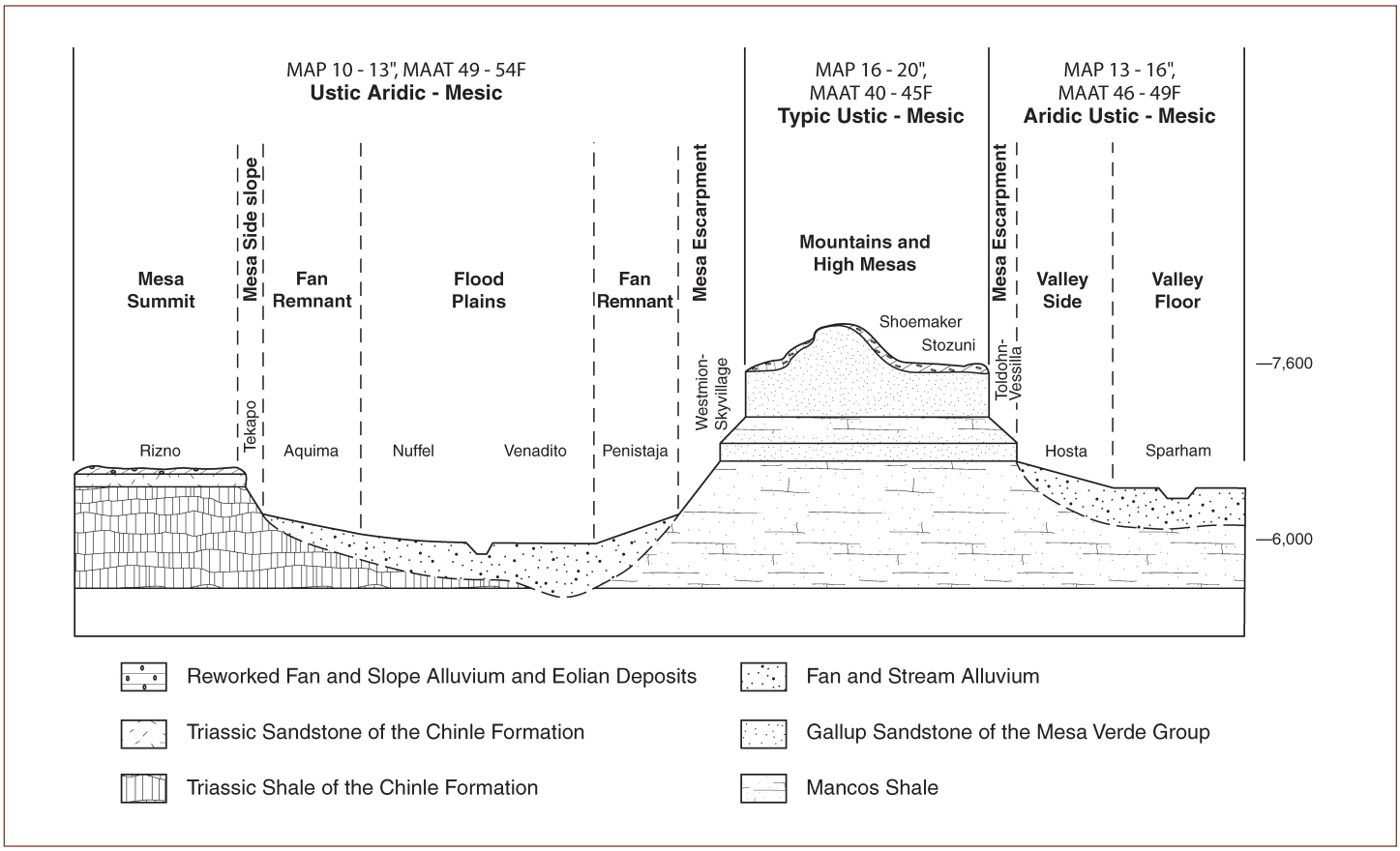

Fig. 7. Idealized cross section illustrating soil-geomorphic-geologic relationships of soils (including Penistaja) on the Zuni Indian Reservation. Credit: Soil Survey of McKinley County, New Mexico.

sediments of sandstones and shales from the Colorado Plateau. The soil textures of sandy loams are directly related to the sandy rock formations.

Time – All the factors act together over a very long period of time to produce soils. As a result, soils vary in age. The length of time that soil material has been exposed to the soil-forming processes makes older soils different from younger soils. Generally, older soils have better defined horizons than younger soils. Less time is needed for a soil profile to develop in a humid and warm area with dense vegetative cover than in a cold dry area with sparse plant cover. More time is required for the formation of a well-defined soil profile in soils with fine textured material than in soils with coarse-textured soil material. The Colorado Plateau Province, which occupies parts of New Mexico, Arizona, Utah, and Colorado, has been a relatively stable block in the Earth's crust for at least 600 million years. North to northeast-trending normal faulting associated with the development of the Rio Grande rift, an extensional feature that roughly parallels the course of the Rio Grande between central Colorado and west Texas, affected the area starting about 26 million years ago. The sandstones and shales at the surface in the region where Penistaja is found were formed during the Triassic to Cretaceous periods spanning approximately 130 million years. The youngest of these rocks are estimated to be about 100 million years old. Penistaja soils are formed from water and wind born sediments of these sandstones and shales.

Ecoregions, Soils and Land Use in New Mexico

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of patterns of *biotic* and *abiotic* phenomena, including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The Penistaja soils is primarily found in three of the ecoregions in New Mexico: Colorado Plateau, Arizona/New Mexico Plateau, and Arizona/New Mexico Mountains (**Figure 8**).

The Colorado Plateau is an uplifted, eroded, and deeply dissected tableland. Its benches, mesas, buttes, salt valleys, cliffs, and canyons are formed in and underlain by thick layers of sedimentary rock. Precipitous side-walls mark abrupt changes in local relief, often of 1000 to 2000 feet or more. The region contains a greater extent of pinyon-juniper and Gambel oak woodlands than the Wyoming Basin to the north. There are also large low lying areas containing saltbrush-greasewood (typical of hotter, drier areas), which are generally not found in the higher Arizona/New Mexico Plateau to the south where grasslands were typically more common. Summer moisture from thunderstorms supports warm season grasses not found in the Central Basin and Range to the west. Several national parks are located in this ecoregion and attract many visitors to view their arches, spires, and canyons.

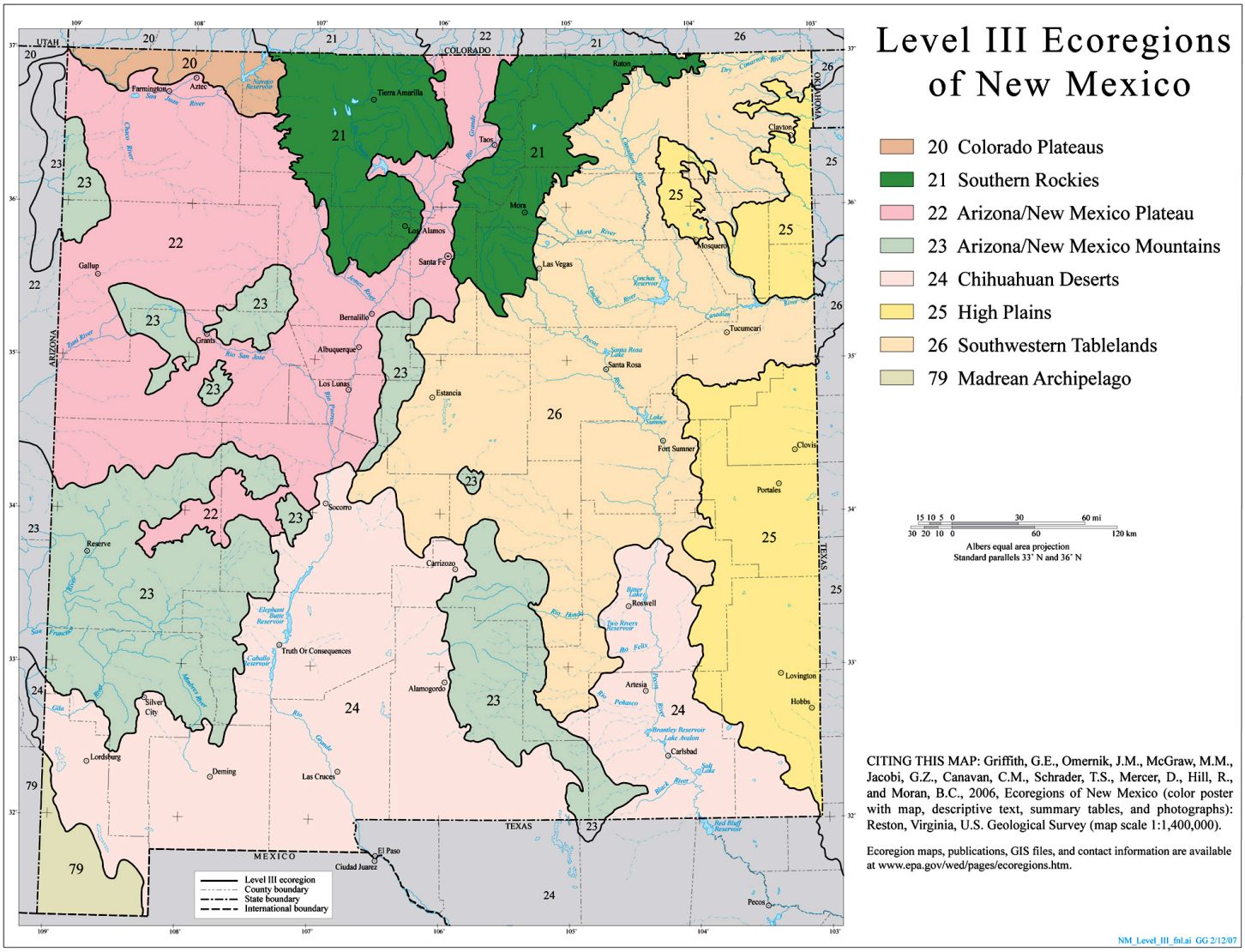

Fig. 8. Ecoregions of New Mexico, Credit: US-EPA.

The Arizona/New Mexico Plateau represents a large transitional region between the drier shrublands and wooded higher relief tablelands of the Colorado Plateaus in the north, the lower, hotter, less vegetated Mojave Basin and Range in the west, and the semiarid grasslands of the Southwestern Tablelands to the east. Higher, forest-covered mountainous ecoregions border the region on the northeast and south. Local relief in the region varies from a few feet on plains and mesa tops to well over 1000 feet along tableland side slopes. The region extends across northern Arizona, northwestern New Mexico, and into the San Luis Valley of Colorado. Gunnison prairie dogs are a keystone species in many of the sagebrush ecosystems and their burrows provide habitat for other wildlife including burrowing owls, weasels, badgers, and a variety of snakes.

The Arizona/New Mexico Mountains are distinguished from neighboring mountainous ecoregions by their lower elevations and an associated vegetation indicative of drier, warmer environments, which is also due in part to the region's more southerly location. Forests of spruce, fir, and Douglas fir, that are common in the Southern Rockies and the Uinta and Wasatch Mountains, are only found in a few high elevation parts of this region. Chaparral is common on the lower elevations, pinyon-juniper and oak woodlands are found on lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests.

Glossary

Abiotic: Non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems. (Wikipedia, abiotic components)

Argillic horizon: A sub-surface B soil horizon that is identified by the illuvial (see illuviation) accumulation of silicate clays.

Alluvium: Sediments deposited by running water of streams and rivers. It may occur on terraces well above present streams, on the present flood plains or deltas, or as a fan at the base of a slope.

Bajada: A broad slope of alluvial material at the foot of an escarpment or mountain.

Biotic: Biotics describe living or once living components of a community; for example organisms, such as animals and plants. (Wikipedia, biotics)

Clay: A soil particle that is less than 0.002 mm in diameter. Clay particles are so fine they have more surface area for reaction. They hold a lot of nutrients and water in the soil. A clay soil is a soil that has more than 40% clay, less than 45% sand and less than 40% silt.

Cuesta: A hill or ridge with a gentle slope on one side, and a steep slope on the other.

Ecoregion: Represents areas with similar biotic and abiotic characteristics which determine the resource potential and likely responses to natural and man-made disturbances. Characteristics such as climate, topography, geology, soils, and natural vegetation define an ecoregion. They determine the type of land cover that can exist and influence the range of land use practices that are possible.

Effervesce: Giving off bubbles; fizzy.

Eolian material: A deposit that forms as a result of the accumulation of wind-driven products of the weathering of solid bedrock or unconsolidated alluvial, lacustrine, marine, or other deposits.

Grazing: A method of feeding in which a herbivore feeds on plants such as grasses, or other multicellular organisms such as algae. In agriculture, grazing is one method used whereby domestic livestock are used to convert grass and other forage into meat, milk and other products.

Horizon: see Soil horizons

Illuviation: The process of deposition of soil material removed from one horizon to another in the soil; usually from an upper to a lower horizon in the soil profile.

Leaching: The removal of soluble material from soil or other material by percolating water.

Mesa: Tableland, an elevated area of land with a flat top and sides that are usually steep cliffs.

Organic matter: Material derived from the decay of plants and animals. Always contains compounds of carbon and hydrogen.

Plateau: A high plain or tableland, or an area of highland, usually consisting of relatively flat terrain that is raised significantly above the surrounding area, often with one or more sides with steep slopes.

Sand: A soil particle between 0.05 and 2.0 mm in diameter. Sand is also used to describe soil texture according to the soil textural triangle, for example, loamy sand.

Sandy Loam: Soil material that contains between 43-85% sand, 0-50% silt and 0-20% clay. It has less sand than loamy sand.

Silt: A soil particle between 0.002 and 0.05 mm diameter. It is also used to describe a soil textural class.

Soil Horizon: A layer of soil with properties that differ from the layers above or below it.

Soil Profile: The sequence of natural layers, or horizons, in a soil. It extends from the surface downward to unconsolidated material. Most soils have three major horizons, called the surface horizon, the subsoil, and the substratum.

Soil Scientist: A soil scientist studies the upper few meters of the Earth's crust in terms of its physical and chemical properties; distribution, genesis and morphology; and biological components. A soil scientist needs a strong background in the physical and biological sciences and mathematics.

Soil Texture: The relative proportion of sand, slit, and clay particles that make up a soil. Sand particles are the largest and clay particles the smallest. Learn more about soil texture at www.soils4teachers.org/physical-properties

Subsoil: (B horizon) The soil horizon rich in minerals that eluviated, or leached down, from the horizons above it. Not present in all soils.

Topsoil: (A horizon) The horizon that formed at the land surface. Mostly weathered minerals from parent material with a little organic matter added.

Additional Resources

Soil! Get the Inside Scoop. David Lindbo and others. Soil Science Society of America, Madison, WI.

Know Soil, Know Life. David L. Lindbo, Deb A. Kozlowski, and Clay Robinson, editors. Soil Science Society of America, Madison, WI.

Web Resources

Soils for Teachers—www.soils4teachers.org

Soils for Kids—http://www.soils4kids.org/

Have Questions? Ask a Soil Scientist—https://www.soils.org/ask

Soil Science Society of America—https://www.soils.org/

Smithsonian Soils Exhibit – http://forces.si.edu/soils/

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