

HANGING GARDENS OF THE COLORADO PLATEAU

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Hanging gardens of the Colorado Plateau are plant communities situated in areas where water seeps out of cracks, joints, or bedding planes in sedimentary rocks. The term is unique to the plateau, which probably has the largest concentration of these communities in North America, and perhaps the world. In this article, we would like to discuss why hanging gardens are interesting, how they form and where they are found, and what is known about the plants that occur in them.

The classic hanging garden develops in a recessed alcove along a canyon. Water seeps out of joints, trickling down over a vertical or sloping rock face termed the backwall. This specialized habitat supports a variety of plants not generally found in arid regions, including ferns, sedges, lilies, primroses, and orchids. Often a pool is found at the base of backwalls, with stands of rushes and cattails. Over time, as a result of weathering processes, debris begins to accumulate, gradually burying the backwall. An interesting variety of woody, grass and forb species can be found on these slopes. Some hanging gardens consist of a backwall only, or in the simplest situations of a patch of maidenhair fern (Adiantum capillus-veneris) in a crack. Another kind of garden develops as a series of wet terraces on the sides of canyons, often in exposed settings. These are especially common along the Colorado River through the Grand Canyon. Because of the wide variety of rock types, topography, and water quantities and qualities, it is difficult to strictly define hanging gardens. A diversity of

spring or seep-supported vegetation occurs on the Colorado Plateau, including typical springs derived from ground water along drainages, marshes, tinajas, and classic alcove gardens. We will define hanging gardens as isolated wet sites in certain topographic settings, including alcoves, cliffs, and terraces, which are generally perched above drainages with their associated ground water and surface flows.

Hanging gardens are most commonly associated with certain sedimentary strata, especially massive sandstones, through which water can percolate. The best formations in the northern and eastern parts of the plateau include the Cedar Mesa, Entrada, Kayenta, and especially the Navajo formations. The largest concentrations of classic alcove gardens occur in Arches, Canyonlands, and Zion National parks, Natural Bridges National Monument, and especially Glen Canyon National Recreation Area.

Hanging gardens support one of the most remarkable groups of plants on the Colorado Plateau. Species typical of the Great Plains, Rocky Mountain meadows, Mexican mountains and forests, and nearby arid lands can be found growing intermixed, along with regional and garden endemics. A high concentration of relicts (species which persist following climate or community change) occur in gardens. One interesting group of relicts include prairie grasses, such as little bluestem (Andropogon gerardii). Another common grass in gardens is Jones reedgrass (Calamagrostis scopulorum), which is generally found in the subalpine and alpine zones of the Rocky Mountains. Several species appear to be very ancient relicts. These include a variety of woody species, such as Knowlton Hornbeam (Ostrya knowltonii), Hackberry (Celtis reticulata), New Mexico raspberry (Rubus neomexicanus), and Western Redbud (Cercis occidentalis), which have relatives from, or currently grow in, the mixed hardwood forests of Mexico and the southeastern U.S. Many of these plants have fossil relatives known from the

Intermountain West region as early as the late Eocene or early Oligocene (40-50 million years ago). A large group of plateau endemics occur in hanging gardens, including the spectacular Rydberg's thistle (Cirsium rydbergii), cave primrose (Primula specuicola), alcove columbine (Aquilegia micrantha), alcove bog-orchid (Habenaria zothecina), Eastwood monkeyflower (Mimulus eastwoodiae), and alcove death camas (Zigadenus vaginatus). Many of these are backwall specialists, where they can be found growing with scarlet monkeyflower (Mimulus cardinalis), scarlet lobelia (Lobelia cardinalis), helleborine orchid (Epipactus gigantea), and maidenhair fern. Many of these herbaceous species have closest relatives, or currently grow in, the southeastern U.S. or Mexican mountains. For example, it is thought that the alcove death camas is most closely related to a species found on the volcanoes of Mexico and central America. This remarkable conjunction of species with widely differing origins and distributions makes the flora of hanging gardens one of the most exciting and fruitful areas for biogeographic and systematic research on the plateau.

Several current research programs are being conducted on hanging gardens. A research group from the University of Wyoming is investigating the community structure, biogeography, and systematics of mammals and invertebrates in hanging gardens, groups about which very little is known. Other work includes determining the age of water in gardens, and analysing the structure of the vegetation and the regional distributions of the plants. A recent event in which a garden in Glen Canyon National Recreation Area was burned has provided researchers the opportunity to study the recovery of garden communities from fire. It is hoped that these investigations will provide data that can be used to formulate guidelines for effectively managing and protecting gardens. Many interesting questions related to the origins, structure and dynamics of these remarkable communities remain to be pursued. Some of these include, 1) the origin and

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movement of the water that travels to the gardens through rock strata, 2) the sensitivity of gardens to climate change, and 3) the historical ecology of gardens. Finally, because of their probable sensitivity to water flows, we feel that hanging gardens could provide valuable sites to monitor potential climate changes, such as would result from global warming.