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PURPLE-STEMMED CLIFFBRAKE

(*Pellaea atropurpurea*)



Purple-stemmed cliffbrake grows in masonry of the Eastern State Penitentiary just outside Center City. It is absent downtown.

Figure 18.1 Purple-stemmed cliffbrake growing in the north wall of Eastern State Penitentiary. Brown structures containing spores line the edges of the undersurface of the leaves.

In 1822 the Commonwealth of Pennsylvania began construction of Eastern State Penitentiary from locally quarried Wissahickon gneiss and schist. The construction of the outer walls took seven years to complete. These walls are 10 meters high, over 3 meters thick at ground level, and over 200 meters long on each of four sides, covering 4 hectares (10 acres). The prison closed in 1970 and in 1994 reopened as a historic site.¹



Figure 18.2 Eastern State Penitentiary, north wall, viewed looking east. At this distance, ferns growing in the wall are practically invisible.



Figure 18.3 Purple-stemmed cliffbrake on the north wall, viewed looking up through a telephoto lens.

The prison walls are habitat to purple-stemmed cliffbrake (*Pellaea atropurpurea*), a native fern that festoons the top of the wall and grows out of cracks between stone blocks. Accompanying it but less abundant is another fern: ebony spleenwort (*Asplenium platyneuron*). Unlike most ferns, purple-stemmed cliffbrake likely evolved in dry rocky habitats resembling a desert. The center of dispersal for its taxonomic group is the southwestern United States and adjacent Mexico. It is found on limestone ledges and cliffs from Guatemala to Vermont.²



Figure 18.4 Ebony spleenwort (*Asplenium platyneuron*) growing in the penitentiary's north wall.

Distribution outside Center City

Like common milkweed, purple-stemmed cliffbrake grows wild just outside Center City but not inside. Unlike milkweed, it requires little space and thrives on vertical surfaces. It tolerates heat, cold, and drought and flourishes in otherwise barren habitats inhospitable to most other plants. In addition to populating Eastern State Penitentiary, it grows in masonry retaining walls around the Fairmount Water Works. Just south of Center City, I found it thriving on the wall of a rundown brick industrial building, since demolished. Buildings downtown offer this fern seemingly infinite opportunities to colonize masonry walls, but paradoxically, it has failed to do so.

The plant has lived in the vicinity of Philadelphia for as long as records exist. In 1793 Henry Muhlenberg recorded it in Lancaster County,³ and in 1837 William Darlington reported it in Chester County.⁴ It was omitted in the first flora of Philadelphia, by William P. C. Barton in 1818,⁵ but included in one published in 1905.⁶ Its long tenure in the region would appear to have given the plant ample time to colonize buildings downtown.

Tolerance of dry habitat and desiccation

In 1911, William Nicholas Steil at the University of Wisconsin discovered that purple-stemmed cliffbrake produces spores asexually,⁷ a trait present in only 5 to 10 percent of ferns.⁸ The life cycle of ferns usually begins with spores germinating and producing minute plants, called prothallia (gametophytes), which produce male and female organs. Sperm swim to female organs containing eggs, which, when fertilized, develop into ferns (sporophytes) that make spores. Steil observed that prothallia of purple-stemmed cliffbrake did not produce sex organs; ferns developed directly from sexually undifferentiated prothallia. By bypassing sexual development and fertilization, purple-stemmed cliffbrake eliminates the need for water as a medium for sperm to swim to eggs. The plant can complete its life cycle on dry rock, like the wall of Eastern State Penitentiary.⁹

In 1931 Fermen Layton Pickett at Washington State University showed that purple-stemmed cliffbrake tolerates desiccation during active growth phases of its life cycle.¹⁰ This phenomenon is rare among vascular plants, which encompass all higher plants such as ferns, flowering plants, and gymnosperms (including conifers). Only 0.15 percent of all vascular plants tolerate desiccation outside of dormant stages such as seeds and spores.¹¹ Pickett showed that prothallia of purple-stemmed cliffbrake that had been air-dried in the laboratory for five years grew when rehydrated. He found that prothallia remained viable after repeated exposure to periods of air drying lasting three to four weeks. He discovered similar tolerance of desiccation for ebony spleenwort.¹² Pickett's findings suggest how these two species of fern survive heat and drought on penitentiary masonry high above ground.

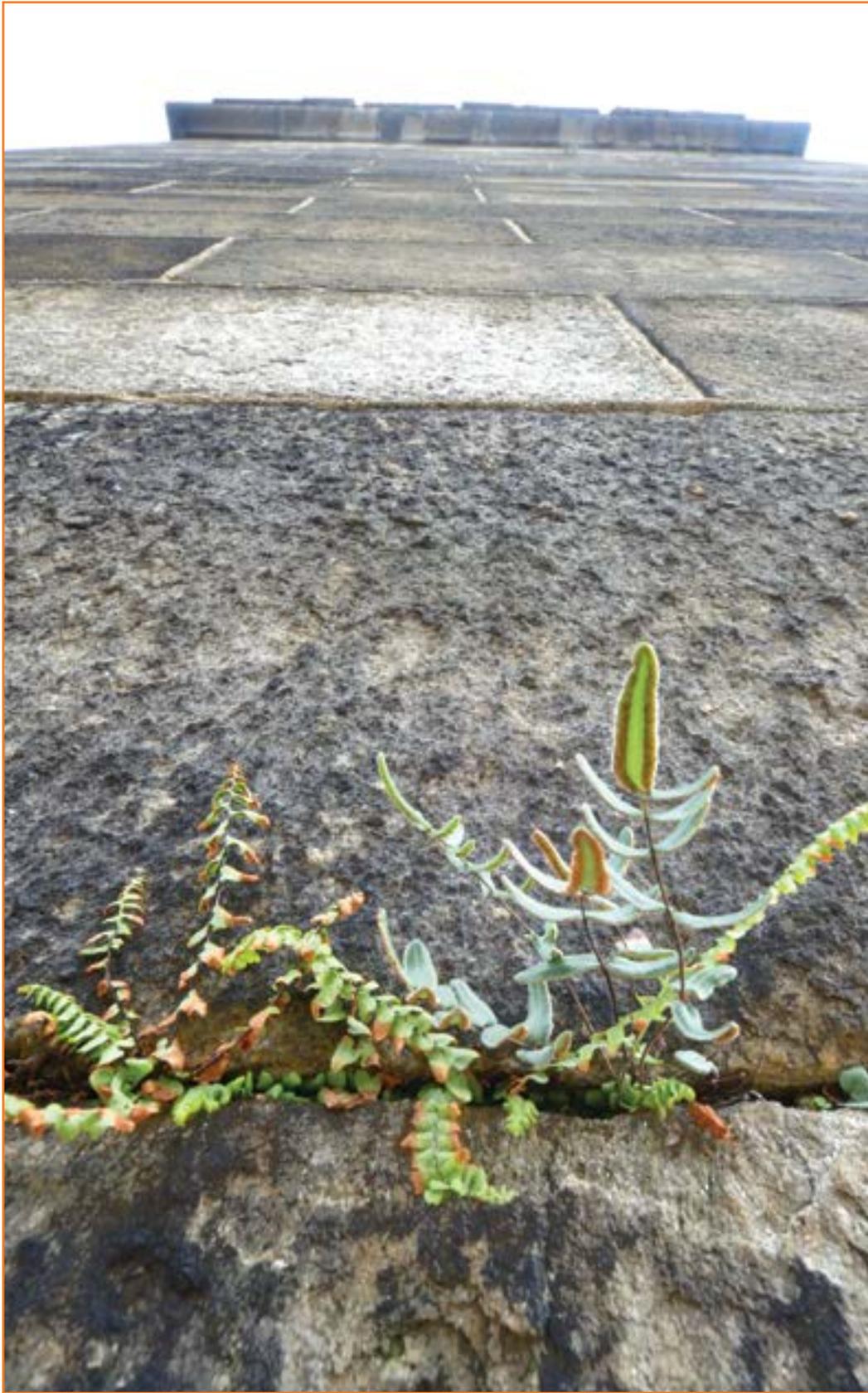


Figure 18.5 Effects of drought and heat on two ferns. Purple-stemmed cliffbrake (the taller fern) looks healthy compared to ebony spleenwort, whose leaves have turned brown at the tips. Photographed July 29, 2012.

Favorable ingredients in mortar

In 1920, Edgar Wherry, who became one of Philadelphia's foremost experts on ferns, published the results of studies on the acidity of soil around the roots of ferns that grow in rocks. He had invented a method for measuring acidity of soil in the field, and he applied his new technology to ferns in different habitats. In Pennsylvania he found purple-stemmed cliffbrake growing on limestone, sandstone, schist, and shale. It thrived in soil of neutral pH, but became stunted in acidic soil low in calcium. Wherry concluded that the primary determinant of the suitability of habitat for this fern is type of soil rather than type of rock.¹³ Applying his findings to Eastern State Penitentiary, one might hypothesize that calcium carbonate in the wall's mortar endows the wall's scanty soil with calcium and buffer needed to maintain a neutral pH, especially helpful in acid rain.

Mysterious absence in Center City

The question remains why purple-stemmed cliffbrake does not colonize masonry downtown. Matthew Wild and Daniel Gagnon at the University of Quebec in Montreal recently investigated the rarity of this fern in Canada. They evaluated habitats where the fern grows and compared them to habitats nearby where the fern does not grow. They could find no significant difference between occupied and unoccupied habitats. They suggested that the fern's rarity is due to constraints on dispersal rather than habitat.¹⁴

Buildings, rivers, and pavement in Center City theoretically are barriers to dispersal, but they would not be expected to block dustlike spores blown by wind. Spores of ferns have been recovered in the jet stream, and they are resistant to the cold and ultraviolet radiation expected at high altitudes. They are a primary reason ferns have colonized remote oceanic islands more often than have flowering plants, and they were the means by which ferns recolonized the island of Krakatau after volcanic destruction of the island's vegetation.¹⁵ The maximum diameter of spores of purple-stemmed cliffbrake is 60 microns,¹⁶ about the thickness of human hair,¹⁷ and typical for spores of ferns.¹⁸ The dryness of the fern's habitat on the wall of Eastern State Penitentiary would be expected to facilitate release of its spores as aerosols. The way urban heat islands pull in surrounding air¹⁹ should draw spores downtown.

Center City might harbor the fern's enemies, such as insects. I have found scale insects on the leaves of purple-stemmed cliffbrake growing on a retaining wall at the Fairmount Water Works. Insects, however, infrequently eat ferns compared to flowering plants,²⁰ and the scale insects on the purple-stemmed cliffbrake caused no sign of injury. Edgar Wherry was able to cultivate this fern in a system of nested flower pots,²¹ and the plant has been recommended for rock gardens.²² One might expect that a plant so easily cultivated could establish colonies downtown.



Figure 18.6 Yellow scale insects on leaf of purple-stemmed cliffbrake growing on a stone retaining wall at the Fairmount Water Works. Despite the infestation, the fern looks healthy and has produced spores, located in the brown granular material along the lower margin of the leaf.

Weathering required for colonization

All of the habitats of this fern just north and south of Center City are distinctive in the same way: they are old and weathered. Reports outside of Philadelphia have called attention to purple-stemmed cliffbrake colonizing historic structures, such as an old wall in Washington, DC,²³ a prison in Carlisle, Pennsylvania,²⁴ and a brick kiln in Fairfax, Virginia.²⁵ In 1899 Ellsworth Jerome Hill, observing this species in a quarry, noted the importance of weathering:

No *Pellaea* was seen on any of these artificially made exposures, though various mosses and other forms of vegetation were well established. The fern, wherever found, grew upon rocks weathered to a dark gray, and with an exposure doubtless of many centuries' duration, or dating back to the time when a glacier carved out the rock bed of the river, its face only changing by the slow process of disintegration.

It is not easy to account for this preference of the fern for the old weathered surface. There is noticeable, however, a marked difference in the color of the recently exposed stone and that long subjected to weathering. Some chemical change is produced by atmospheric agencies, for the freshly exposed surfaces are soon stained with yellow or drab due to the presence of iron-oxide. This color is not seen on surfaces long exposed. The absence of the *Pellaea* may not be due to the presence of certain metallic ingredients in excess, but they suggest a possible or partial cause of it.²⁶

Weathering may include colonization by lichens, algae, fungi, or bacteria that purple-stemmed cliffbrake may require for extraction of minerals and nutrients from rocky substrate. Microbial biofilms coating rock are themselves complex ecosystems,²⁷ and how the fern might engage them has not been studied. The rough texture of weathered surfaces may trap spores and contribute to purple-stemmed cliffbrake spore banks, analogous to seed banks.²⁸

In Britain until the late nineteenth century, mortar was made of lime, sand, ash, loam, straw, and dung. It weathered quickly. After 1870, the constituents of mortar shifted to cement and sand, and sometimes furnace slag, which weathered more slowly; these walls must age 40 to 80 years before they host flowering plants. In London, saxifrage occurs only on walls that are at least 150 years old.²⁹ American mortar shifted to Portland cement around 1880.³⁰

Habitat loss due to property maintenance

The establishment of this fern in masonry in Philadelphia may require weathering or old mortar or both. In Center City property owners view weathering of masonry as a sign of structural deterioration, which induces them to institute sandblasting, painting, or pointing. This fern is absent from Center City probably because people want neither weathering nor plants on the facades of their buildings. Purple-stemmed cliffbrake takes three to four years to mature and produce spores;³¹ this long period affords property owners ample opportunity to intervene before the plant has completed its life cycle.



Figure 18.7 Purple-stemmed cliffbrake on a crumbling brick wall of an old industrial building just south of Center City. Fern on left is unidentified. Buildings with masonry in such poor repair are rare in Center City. This building has since been torn down.

The suggestion that lack of weathered masonry excludes the fern from Center City deserves qualification. Some weathering of masonry in Center City is tolerated, or even encouraged, as evidenced by silvergreen bryum moss (*Bryum argenteum*), which grows on impermeable surfaces including rock, brick, mortar, asphalt, and concrete. It also populates soil and tree trunks. Unlike purple-stemmed cliffbrake, however, it keeps a low profile and presents an inconspicuous target; its ability to fill the inter-

stices of crevices makes it hard to eradicate; and its growth between bricks on patios and walkways is viewed as decorative rather than destructive.



Figure 18.8 Silvergreen bryum moss (*Bryum argenteum*) with spore capsules. In Center City it contributes to weathering that conditions brick or stone for colonization by other plants.

Purple-stemmed cliffbrake bears ecological similarities to common milkweed and the organ pipe mud dauber. All three are common outside but not inside Center City. All are vulnerable to destruction through property maintenance. All stand out as attractive targets for persecution. In Center City, persecution has been effective in eradicating each of them.