Rock Gnome Lichen
(*Gymnoderma lineare*)

5-Year Status Review:
Summary and Evaluation

Photo credit: Michelle Henson/USFWS

U.S. Fish and Wildlife Service
Southeast Region
Asheville Ecological Services Field Office
Asheville, North Carolina

March 2026

5-YEAR STATUS REVIEW
Rock Gnome Lichen (*Gymnoderma lineare*)

GENERAL INFORMATION

Current Classification: Endangered

Lead Field Office: Asheville Ecological Services Field Office

Review Author(s): Michelle Henson, Asheville Ecological Services Field Office, U.S. Fish and Wildlife Service

Reviewers:

Lead Regional Office: Southeast Region, Carrie Straight

Cooperating Field Office(s):

Georgia Ecological Services, James (Mincy) Moffett, Jr.
South Carolina Ecological Services, Melissa Chaplin
Tennessee Ecological Services, Daniel Elbert
Virginia Ecological Services, Kimberly Maison

Date of original listing: February 17, 1995 (60 FR 3557; January 18, 1995)

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants (50 CFR 424.11). The U.S. Fish and Wildlife Service (Service) evaluated the best available information about rock gnome lichen's biology, habitat, and threats to inform this status review.

We announced initiation of this review in the Federal Register on June 6, 2024 (89 FR 48437) with a 60-day comment period. We received no public comments during the public comment period. The primary sources of information used in this analysis were from peer-reviewed reports, agency reports, unpublished survey data and reports, and personal communication with recognized experts. This review was completed by the Asheville Ecological Services Field Office in Asheville, North Carolina. All literature and documents used for this review are on file at the Field Office. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on rock gnome lichen.

FR Notice citation announcing the species is under active review:
June 6, 2024 (89 FR 48437)

Species' Recovery Priority Number at start of 5-year review (48 FR 43098):
5 (species with a high degree of threat and a low recovery potential)

Review History:
Previous 5-year reviews recommending no change in status were signed on March 28, 2013, and August 27, 2020 (Service 2013, 2020).

REVIEW ANALYSIS

Listed Entity

Taxonomy and nomenclature
As discussed in past 5-year reviews (Service 2013, 2020), *Gymnoderma lineare* has been reclassified to *Cetradonia linearis* (Wei and Ahti 2002). This change is accepted by the Consortium of Lichen Herbaria (Consortium of Lichen Herbaria 2025). A name change to a monotypic genus would change the recovery priority number of the taxon from 5 to 4. This updated nomenclature does not impact our assessment of the listed entity (e.g., does not change its distribution, biology, life history, or threats), and it is still considered a valid entity by the Service. Until we finalize a technical correction of the name, we will continue to reference the species using the name as it was listed.

Distinct Population Segment (DPS) (61 FR 4722)
The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing of a DPS to only vertebrate species. Because the species under review is not a vertebrate, the DPS policy does not apply.

Recovery Criteria

Recovery Plan or Outline
Recovery Plan for the Rock Gnome Lichen (*Gymnoderma lineare*), U.S. Fish and Wildlife Service

Date Issued: September 30, 1997

Recovery plans are not regulatory documents and provide guidance to the Service, States, and other partners on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. If the recovery criteria defined in the plan are still valid, meeting recovery criteria can indicate that the species no longer requires protection under the Act. However, when recommending whether a listed species should be delisted, the Service must apply the factors in section 4(a) of the Act (84 FR 45020).

The criteria for delisting in the recovery plan (Service 1997) are identified as:

Criterion 1. 40 populations are stable for a minimum of 10 years (not more than a 10-percent cumulative decline in coverage at each stable population and no extirpation of other populations over the 10-year monitoring period)

Criterion 2. 40 populations are in protective ownership (either on public land, such as parks and forests, where the managing agency is providing continuous monitoring and protection for the

species, or on private land, where a long-term protection/management agreement with the owner is in place)

These criteria have not been met.

Biology and Habitat Summary

Rock gnome lichen is endemic to the southern Appalachian Mountains of North Carolina, Tennessee, South Carolina, Virginia, and Georgia. It grows primarily on vertical rock faces above 1,500 meters but can also occur in lower-elevation deep river gorges. The species forms dense colonies on rocks and boulders and exhibits a distinctive morphology with blue-gray, finger-like lobes that are white on the lower surface. Little is known about the life history and population biology of the species, including growth rates, distribution mechanisms, and what constitutes a genetic individual (Allen et al. 2016). These knowledge gaps, combined with the lack of consistent long-term monitoring, limit the ability to accurately assess population trends and long-term viability.

The 1995 listing rule and the 1997 Recovery Plan described the distribution of rock gnome lichen in terms of 'populations', but the criteria used to group sites into populations are unclear from the available species files. For the purposes of this review, references to the number of populations at the time of listing and publication of the Recovery Plan are consistent with original documents. Moving forward, however, the Service will define populations in accordance with NatureServe's 2024 element occurrence mapping standards for plants.

When the species was federally listed in 1995, the listing rule recognized 32 extant populations in NC and TN (Service 1995; Table 1). In the Recovery Plan, 35 populations were recognized (Service 1997). At the time of the 2013 5-year review, 61 populations were documented with the core range continuing to occur in NC (Service 2013).

Table 1. Estimated number of extant populations of rock gnome lichen throughout its range. Data sources include the 1995 final listing rule, 1997 recovery plan, and 5-year reviews (Service 1995, 1997, 2013, 2020), and current data (2025). Parentheses indicate the number of protected populations in the table.

State	1995 Populations	1997 Populations	2013 Populations	2020 Populations	2025 Populations
North Carolina	25	25	52	58	58 (52)
Tennessee	7	7	6	7	6 (6)
South Carolina	NA	1	1	1	1 (1)
Georgia	NA	1	1	1	1 (1)
Virginia	NA	NA	1	1	1 (1)
Total	**32**	**34**	**61**	**68 (62)**	**67 (61)**

By 2020, the number of known populations had increased to 68, reflecting 7 new populations documented since the 2013 5-year review. Current data indicate the species occupies 67 populations. The apparent reduction in populations is attributable to changes in population delineation rather than biological loss: one new population has been discovered in NC, one population previously reported as extirpated has been found, and three populations reported in

the 2020 5-year review have since been aggregated into subpopulations to align with NatureServe's element occurrence mapping standards.

An evaluation conducted for the 2020 5-year review identified 62 populations in protective ownership. Currently, there are 61 populations under protective ownership. These protected lands include properties owned and managed by the U.S. Forest Service (USFS), State Parks (Chimney Rock, Elk Mountain, and Mt. Mitchell in North Carolina, and Caesar's Head in South Carolina), the National Park Service (Great Smoky Mountains (GRSM) and BLRI), municipal watersheds (City of Asheville – North Fork Watershed and BeeTree Watershed, and Town of Waynesville – Waynesville Watershed), non-profit conservation organizations (The Nature Conservancy, Southern Appalachian Highlands Conservancy, and Highlands-Cashiers Land Trust), the North Carolina Wildlife Resources Commission (Silver Gamelands), and the North Carolina Forest Service (Headwaters State Forest). While protective ownership reduces the risk of direct habitat loss, continuous long-term monitoring is needed to evaluate progress toward recovery plan objectives and to reliably assess population trends over time.

Currently, the only long-term monitoring for the species occurs at five sites within the Great Smoky Mountains National Park. From 2021 to 2023, five long-term monitoring plots were established in GRSM. One round of data collection has occurred at these sites, with plans to revisit plots every 3 to 5 years. In addition to site-specific surveys, NPS biologists are actively scouting for new populations throughout the park. To improve the accuracy and efficiency of long-term monitoring, Blue Ridge Parkway staff are developing a ground-based lidar detection method to rapidly estimate percent cover change over time (Ulrey 2025, pers. comm.).

In addition to population status, recent research has provided new insights into the species' biology and ecological interactions. Paulsen et al. (2024) examined the microbiome of rock gnome lichen to investigate co-evolutionary relationships between microbial symbionts and lichen host. The study identified 19 core amplicon sequence variants (ASVs), which represent unique microbial DNA sequences distinguished by single nucleotide differences, indicating a high degree of host specificity and long-term stability of microbial associations. Microbial communities in lichens play key functional roles in thallus maintenance by facilitating nitrogen fixation, metabolism, vitamin production, and pathogen defense. In the study, microbiome diversity and composition varied among populations, and bacterial community composition strongly differed by environmental factors such as geography, habitat, and temperature. These findings are consistent with the genomic work of Allen et al. (2018), which showed strong geographic structuring and isolation by distance among populations. Because the microbiome exhibits a similarly structured geographic pattern, the loss of any single population can result in the loss of unique host genetic diversity and site-specific microbial symbionts that support the long-term survival of the species.

Threats (Five-Factor Analysis) Summary

The status of a species is determined from an assessment of factors specified in section 4 (a)(1) of the Act. A summary of this assessment is detailed below. In GRSM, National Park Service biologists conduct pre-project surveys for trail, road, or facility work to identify potential impacts to rock gnome lichen. This includes conducting surveys in project areas where rock gnome lichen may occur, educating trail crews and other staff how to identify the species and its

habitat, and implementing mitigation measures to avoid or minimize impacts when the species is present (Sabo 2025, pers. comm.).

Factor A: the present or threatened destruction, modification, or curtailment of its habitat or range

The 2013 and 2020 5-year reviews identified recreational hiking and rock climbing as threats to the species. Trampling has been documented at five NC populations (North Carolina Natural Heritage Program (NCNHP) 2025), but the severity and extent are difficult to quantify due to the absence of standardized monitoring data. Anecdotal field observations also suggest that desiccation (see below under Factor E) increases susceptibility to damage from sloughing caused by trampling and rock climbing (Ulrey 2025, pers. comm.)

Sedimentation in streams may also threaten the species. North Carolina Natural Heritage Program observations at Johns Branch and the upper portion of Whigg Branch show that increased sedimentation alters vegetation structure associated with the rock and boulders in the creek. In areas with heavier sedimentation, rock gnome lichen is absent, while mosses and other lichens tend to have greater coverage, suggesting these altered habitat conditions may have resulted in the decline of rock gnome lichen. Sedimentation could be associated with topographic relief and past land management actions; however, it is noted that erosion and runoff were observed along these branches where no recent timber harvest has occurred (NCNHP Survey of Rock Gnome Lichen Report 2025).

Factor B: overutilization for commercial, recreational, scientific, or education purposes

The Service is not aware that overutilization is currently a threat to the species. However, those working with the species should be mindful of the potential for unauthorized collection and report any observations to the Service.

Factor C: disease or predation

The Service is not aware that disease or predation is currently a threat to the species.

Factor D: the inadequacy of existing regulatory mechanisms

Federal Protections. U.S. Forest Service (USFS) regulation 36 CFR 261.9 prohibits removing or damaging any plant that is classified as a threatened, endangered, sensitive, rare, or unique species (USFS 2003). Additionally, Forest Service Manual 2673 establishes policy that prohibits the removal and collection of any threatened or endangered plants on USFS lands under Federal jurisdiction except when authorized by permits (USFS 2009). Gathering and removing plants or plant parts is currently prohibited in National Park System areas unless specifically authorized by federal statute, treaty rights, or conducted under the limited circumstances authorized by existing codified regulations (NPS 2025).

State Protections. Rock gnome lichen is state listed as endangered in North Carolina, Tennessee, and Georgia. The North Carolina Plant Conservation and Protection Act (North Carolina Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants listed under that statute. However, the statute does not protect the species or its habitat

from destruction in conjunction with development projects or otherwise legal activities. Plant species are afforded even less protection in South Carolina, where they are protected only from disturbance where they occur on those properties owned by the state and specifically managed as South Carolina Heritage Preserves (South Carolina Code of Regulations, Part 123 § 200-204). Rock gnome lichen is protected under the Tennessee Rare Plant Protection Act of 1985 (T.C.A. 51-901), which forbids persons from knowingly uprooting, digging, taking, removing, damaging, destroying, possessing, or otherwise disturbing for any purpose, any endangered species from private or public land without the written permission of the landowner. The Virginia Endangered Plant and Insect Species Act (Chapter 10 § 3.2-1000 through 1011 of the Code of Virginia, as amended) primarily regulates collection and trade in listed species. Georgia's Wildflower Preservation Act of 1973 provides protections for the species on any public lands from cutting, digging, pulling, or removing unless the State has authorized such acts.

Existing regulatory mechanisms are inadequate to protect the species from threats, especially those discussed below under Factor E.

Factor E: other natural or manmade factors affecting its continued existence

Rock gnome lichen has specialized habitat requirements for bare rock faces with a specific amount of moisture and light. Most of the populations are small in terms of individuals and total area covered by the lichen, making it likely that there is little genetic variability in the species. With the species' slow growth rate and small population sizes, even relatively small declines could pose a significant threat to the long-term survival and recovery of the species.

Previous 5-year reviews identified air pollution and acid rain as primary threats (Service 2013, 2020). A recent report summarizing rock gnome lichen monitoring from 1983 to 2008 documented substantial declines in sulfate and nitrogen ion deposition from acid rain (Woodward 2021). These improvements in air quality likely enhanced growing conditions for the species during that period. Currently, acid rain is not considered a primary threat but should be revisited if air quality trends reverse.

High-elevation lichens in the southern Appalachians are especially vulnerable to increased temperatures, reduced relative humidity, and high vapor pressure deficits, factors that limit growth, dispersal, tolerance to heat, desiccation, and deterioration (Smith et al. 2018, Worthy et al. 2025). Allen and Lendemer (2016) modeled eight high-elevation southern Appalachian lichen species and projected over 93% loss of current habitat by 2050-2070, with little suitable habitat north of their present ranges. Although rock gnome lichen was not included in their analysis, its narrow distribution, restriction to high-elevation rocky substrates, and reliance on cool moist microclimates suggest the species may respond similarly to projected climatic shifts. The authors further noted that their projections were likely conservative due to their overprediction of habitat suitability, underscoring the severity of anticipated habitat and microclimatic changes for high-elevation lichens endemic to the southern Appalachians. In addition, the limited migration capacity of lichen species on isolated, high-elevation cliffs or deep river gorges exacerbates these risks, representing a significant range-wide threat to rock gnome lichen.

Additional threats arise from the decline of high-elevation forest tree species that maintain the shaded, humid micro-climate essential to rock gnome lichen. Eastern hemlock (*Tsuga*

canadensis), severely impacted by hemlock woolly adelgid (*Adelges tsugae*) (Kantola et al. 2014), and Fraser fir (*Abies fraseri*), heavily affected by balsam woolly adelgid (*Adelges piceae*), have both experienced extensive losses with infestations often leading to tree mortality within just a few years. The resulting canopy decline within rock gnome habitat increases solar radiation and desiccation stress, further compounding the threats of increases in temperature, reduced humidity, and other limitations previously discussed.

Synthesis

Rock gnome lichen is a blue-gray squamulose lichen that occurs on rocks and boulders in mid- to high-elevation habitats of the southern Appalachians. There are currently 67 populations known across Georgia, North Carolina, South Carolina, Tennessee, and Virginia, with the core of the range in North Carolina (58 populations) and Tennessee (6 populations). In 2020, there were 62 populations on protected land. Currently, 61 populations occur on conservation lands where the managing agency provides ongoing protection for the species. Although land ownership and management provide protection from direct habitat loss, populations are not subject to consistent, long-term monitoring, limiting the ability to accurately detect trends in population condition over time. While some historic threats, such as acid rain, have declined, ongoing changes to temperature, humidity, and associated habitat alteration are expected to intensify, posing long-term risks by reducing high elevation refugia and increasing desiccation. Canopy loss from pests, including hemlock woolly adelgid and balsam woolly adelgid further degrades habitat quality, and recreational activities such as hiking and rock-climbing cause trampling damage. Additionally, sedimentation in streams may alter vegetation structure on occupied rock surfaces, affecting habitat suitability for the species. Overall, the available information and data indicate that rock gnome lichen continues to meet the definition of an endangered species under the Endangered Species Act.

RECOMMENDED FUTURE ACTIVITIES

Recovery Activities

- Identify visitor use patterns and install signage, trail reroutes or fencing to minimize trampling and inadvertent disturbance in high impact and sensitive areas.
- Enhance public outreach and education efforts to raise awareness of the species and its vulnerability to microhabitat disturbance on lichen habitat.
- Protect occupied habitat through conservation easements, land acquisition, or formal management agreements with public and private landowners.

Monitoring and Research Activities

- Conduct standardized population monitoring to track trends in colony health, size, and extent across the species' range.
- Monitor and mitigate canopy loss in spruce-fir forests adjacent to rock gnome lichen sites to maintain cool, humid microclimates essential for the species' survival.
- Update and expand occurrence data through targeted surveys at riparian corridors, headwater streams, and within historically occupied areas. In addition to rock outcrops,

future searches should focus on in-stream habitat downstream of, or near, occupied rock outcrops.
- Investigate microclimatic requirements (e.g., humidity, temperature, shade) to inform habitat management and climate resilience planning.
- Assess impacts of future weather patterns, including shifts in precipitation, fog frequency, and temperature on lichen survival and habitat suitability.
- Study dispersal mechanisms and reproductive ecology of the species to understand its colonization potential and population dynamics.

REFERENCES

Allen, J. L., & Lendemer, J. C. (2016). Climate change impacts on endemic, high-elevation lichens in a biodiversity hotspot. *Biodiversity and Conservation*, *25*(3), 555-568.

Consortium of Lichen Herbaria (2025) http//:lichenportal.org/portal/index.php. Accessed on December 11.

Kantola, T., Lyytikäinen-Saarenmaa, P., Coulson, R. N., Strauch, S., Tchakerian, M. D., Holopainen, M., ... & Streett, D. A. (2014). Spatial distribution of hemlock woolly adelgid induced hemlock mortality in the Southern Appalachians. *Open Journal of Forestry*, 4(05), 492-506.

National Park Service (NPS) (2025). 36 CFR § 2.1 – Preservation of natural, cultural and archeological resources. In *Code of Federal Regulations*. https://www.ecfr.gov/current/title-36/part-2/section-2.1

North Carolina Natural Heritage Program (2025). Element Occurrence records and scorecard for *Gymnoderma lineare*. Print date May 2, 2025.

North Carolina Natural Heritage Program (2025). Survey of Rock Gnome Lichen (*Gymnoderma lineare*) in the Upper Santeetlah Watershed, Nantahala National Forest, Cheoah Ranger District. Print date April 11, 2025.

Paulsen, J., Allen, J. L., Morris, N., Dorey, J., Walke, J. B., & Alter, S. E. (2024). Geography, Climate, and Habitat Shape the Microbiome of the Endangered Rock Gnome Lichen (*Cetradonia linearis*). *Diversity*, *16*(3), 178.

Sabo, I. (2025). Great Smoky Mountains National Park, National Park Service. Personal communication, email dated July 14, 2025.

Smith, R. J., Nelson, P. R., Jovan, S., Hanson, P. J., & McCune, B. (2018). Novel climates reverse carbon uptake of atmospherically dependent epiphytes: Climatic constraints on the iconic boreal forest lichen *Evernia mesomorpha*. *American Journal of Botany*, *105*(2), 266-274.

Ulrey, C. (2025). Blue Ridge Parkway, National Park Service. Personal communication, Microsoft Teams call with M. Henson, U.S. Fish and Wildlife Service on July 14, 2025.

U.S. Fish and Wildlife Service (1995). *Gymnoderma lineare* (Rock Gnome Lichen) Determined to be Endangered. *Federal Register,* 60(11), 3557 – 3562.

U.S. Fish and Wildlife Service (1997). Recovery Plan for Rock gnome lichen (*Gymnoderma lineare*) (Evans) Yoshimura and Sharp. Atlanta, GA. 30 pp.

U.S. Fish and Wildlife Service (2013). Rock gnome lichen (*Gymnoderma lineare*) 5-Year Review: Summary and Evaluation. Asheville, North Carolina. 15 pp.

U.S. Fish and Wildlife Service (2020). Rock gnome lichen (*Gymnoderma lineare*) 5-Year Review: Summary and Evaluation. Asheville, North Carolina. 17 pp.

U.S. Forest Service (2003). Plant and Animal Collecting on National Forest – Regulation 36 CFR 261. Accessed at: https://www.ecfr.gov/current/title-36/chapter-II/part-261#261

U.S. Forest Service (2009). Forest Service Manual 2600 – Wildlife, Fish and Sensitive Plant Habitat Management, Chapter 2670 – Threatened, Endangered and Sensitive Plants and Animals, Section 2673.1 – Federally Listed Threatened and Endangered Species. U.S. Forest Service, National Headquarters, Washington, D.C. 24 pp.

Wei, J.-C., and Ahti, T. (2002). *Cetradonia*, a New Genus in the New Family Cetradoniaceae (Lecanorales, Ascomycota). *The Lichenologist*, 34,19–31.

Woodward, A. (2021). Rock gnome lichen (*Gymnoderma lineare*) monitoring assessment, southern Appalachian Mountains, 1983–2008 (No. 2021-1011). US Geological Survey. https://pubs.usgs.gov/of/2021/1011/ofr20211011.pdf

Worthy, F. R., Schaefer, D. A., Goldberg, S. D., Wanasinghe, D., Li, H. L., Thiyagaraja, V., ... & Wang, X. Y. (2025). Simulated climate change impacts health, growth, photosynthesis, and reproduction of high-elevation epiphytic lichens. *Ecosphere*, 16(4), e70224.

RESULTS / SIGNATURES

U.S. Fish and Wildlife Service
Status Review of Rock Gnome Lichen

Status Recommendation:

On the basis of this review, we recommend the following status for this species (50 CFR § 424.11). A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened.
____ Uplist to Endangered.
____ Delist:
____ *The species is extinct.*
____ *The species is recovered.*
____ *New information indicates the species does not meet the definition of an endangered or threatened species.*
____ *The listed entity does not meet the statutory definition of a species.*
__X__ No change needed.

FIELD OFFICE APPROVAL:

Acting for **Field Supervisor, Asheville Ecological Services Field Office, U.S. Fish and Wildlife Service**

Approve GARY PEEPLES Digitally signed by GARY PEEPLES Date: 2026.03.10 15:26:26 -04'00'

COOPERATING REGIONAL OFFICE APPROVAL:

We emailed this 5-year review to the Northeast Regional Office for their concurrence prior to finalizing the document. We will retain any comments that we received, as well as verification of concurrence from other regions, in the administrative record for this 5-year review.