

**BEFORE THE SECRETARY OF THE INTERIOR**  
**PETITION TO LIST THE DIXIE CAVERNS SALAMANDER AS A THREATENED OR**  
**ENDANGERED SPECIES UNDER THE ENDANGERED SPECIES ACT**



*Photo: Dixie Caverns Salamander by Kevin Hutcheson*

**CENTER FOR BIOLOGICAL DIVERSITY**

**August 5, 2025**

**Notice of Petition**

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Dear Secretary Burgum,

Pursuant to Section 4(b) of the Endangered Species Act (ESA), 16 U.S.C. §1533(b); section 553(e) of the Administrative Procedure Act (APA), 5 U.S.C. §553(e); and 50 C.F.R. §424.14(a), the Center for Biological Diversity (Center) hereby petitions the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS), to protect the Dixie Caverns salamander (*Plethodon dixi*) as a threatened or endangered species under the ESA.

This petition requests listing of the Dixie Caverns salamander based on the present and threatened destruction, modification and curtailment of its habitat; predation; diseases like *Ranavirus* and chytrid fungus; inadequacy of existing regulatory mechanisms; and other factors affecting its existence, such as climate change and isolation of populations.

The Center also requests that critical habitat be designated concurrently with the listing, pursuant to 16 U.S.C § 1533(a)(3)(A) and 50 C.F.R. § 424.12. Critical habitat is essential to protecting the Dixie Caverns salamander from further decline.

The USFWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on USFWS. USFWS must issue an initial finding as to whether the petition “presents substantial scientific or commercial information indicating that the petitioned action may be warranted.” 16 U.S.C. § 1533 (b)(3)(A). USFWS must make this initial finding “(t)o the maximum extent practicable, within 90 days after receiving the petition.”

The Center for Biological Diversity is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law, supported by more than 1.7 million members and online supporters. The Center works to secure a future for all species, great or small, hovering on the brink of extinction.

We submit this petition on behalf of our staff and members who hold an interest in protecting the Dixie Caverns salamander.

Submitted this 5th day of August, 2025.

Sincerely,

/s/ Trisha Sharma

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## Executive Summary

The Center for Biological Diversity (Center) requests that the U.S. Fish and Wildlife Service (USFWS) protect the Dixie Caverns salamander (*Plethodon dixi*) as a threatened or endangered species under the Endangered Species Act (ESA), and that the USFWS concurrently designate critical habitat. This rare lungless salamander, found only in a small karst region of Roanoke County, Virginia, is facing severe and immediate threats to its continued existence. This salamander was recently elevated from subspecies to distinct species, but it has already experienced dramatic population declines and lacks any targeted conservation protections.

*Plethodon dixi* is a micro-endemic amphibian known from only three locations within a 25 square kilometer area, all near development, roads, or recreational activity. It inhabits cool, moist caves and surrounding forested hillsides and is highly sensitive to disturbance. The species relies on cutaneous respiration and direct development, making it particularly vulnerable to habitat degradation, desiccation, and climate fluctuations. Since its initial discovery in the 1950s, the core population may have dropped from over 300 individuals to just 60 in a recent survey, and another population may have already been extirpated by forest clearcutting.

This petition identifies four of the five ESA listing factors as threats to the species: habitat destruction, disease and predation, inadequate regulatory mechanisms, and other environmental or anthropogenic pressures. Deforestation, especially for projects like the Mountain Valley Pipeline, has degraded forest habitat, and ongoing highway construction over Dixie Caverns has damaged cave systems and increased pollution. Proposed nearby development threatens to further degrade the habitat provided by Dixie Caverns. Furthermore, the species is at risk from diseases including *Ranavirus* and those caused by chytrid fungi, which have caused mass declines in other amphibians. These stressors are compounded by climate change and the species' limited distribution and dispersal ability.

Existing state and federal regulations have failed to protect the Dixie Caverns salamander. While Virginia has laws like the Cave Protection Act, they are difficult to enforce on private lands (where all known populations of the salamander occur) and do not mandate the monitoring or habitat management that this salamander species needs to survive. The species is recognized as a rare species by state natural heritage programs but still lacks any formal protection. Its restricted range and habitat specificity leave it highly susceptible to extinction from a single catastrophic event or further environmental degradation.

The Center for Biological Diversity strongly urges the USFWS to list *Plethodon dixi* under the ESA and designate its remaining habitat as critical. Given the salamander's extremely limited distribution, few and isolated populations, and lack of current legal protections, ESA listing is essential to prevent its extinction.



Photo: Dixie Caverns Salamander by Yinan Li, iNaturalist

## Introduction

The southeastern United States is one of the most biologically diverse regions in North America and contains the greatest diversity of salamanders in the world (Petranka 1998, p. 1). Its unique geology and various microhabitats have allowed for evolution of endemic species with narrow habitat requirements, such as the Dixie Caverns salamander (“*Plethodon dixi*” or “salamander”).

The Dixie Caverns salamander is a member of the family of lungless salamanders known as *Plethodontidae*. It is the largest group of salamanders, with around 500 different species (AmphibiaWeb 2025). Over half of these are considered vulnerable, endangered, or critically endangered by the International Union for Conservation of Nature (IUCN 2025). These salamanders rely on cutaneous respiration (through the skin) and are adapted to stream, arboreal, terrestrial, fossorial, and cave habitats that provide the appropriate moisture levels required for their unique respiratory system (AmphibiaWeb 2025).

The species is known only from a small area of karst terrain near and within Dixie Caverns in Roanoke County, Virginia. Southwestern Virginia sits at the edge of Appalachia’s vast karst belt.



The region is characterized by limestone caves, sinkholes, and underground streams (VDCR 2025a). The Dixie Caverns salamander inhabits moist caves and forested hillsides and is only found in three locations within a 25 km<sup>2</sup> area, all of which are close to roads, development, or recreational activity.

Four of the five factors identified in Section 4 of the ESA jeopardize the survival of the Dixie Caverns salamander: habitat destruction, disease and predation, inadequacy of existing regulatory mechanisms, and other natural and manmade factors. 16 U.S.C. § 1533(b). Clear cutting for pipeline development has modified and perhaps destroyed the habitat of the Fort Lewis Mountain population of the Dixie Caverns salamander. These salamanders are also threatened by at least three amphibian diseases (*Ranavirus*, *Batrachochytrium dendrobatidis* (*Bd*), and *Batrachochytrium salamandrivorans* (*Bsal*)). Climate change, recreation, and pollution are also threats to the Dixie Caverns salamander's survival. These threats exacerbate natural vulnerabilities inherent to the salamander as a microhabitat specialist that is susceptible to desiccation and has a low reproductive rate.

Existing federal and state mechanisms have been inadequate to halt the species' decline, as evidenced by a reduction in the size of the population within Dixie Caverns. Further, the species' known populations occur on privately managed land and therefore do not benefit from ongoing management or monitoring by state or federal government. Federal ESA protection is essential to save the species from imminent extinction.

## **Biology**

### Taxonomy & Description

*Plethodon dixi* is a member of the lungless salamander family known as *Plethodontidae*, which consists of over 500 salamander species and is the largest group of salamanders (AmphibiaWeb 2025). *Plethodontidae* also has the most differentiated morphology, ecology, and behavior, likely because of the unique habitat attributes of the Appalachian Mountains. These mountains provide stable geology, a cool, moist climate, montane elevation gradients, and abundant streams. The result has been long periods of salamander occupation and thus, diversification of plethodontid salamanders (Kozak et al. 2006, p. 539).

The Dixie Caverns salamander was recently validated as a distinct species, having previously thought to be a rare, cave-dwelling form of *P. wehrlei* (Wehrle's salamander). In 2019, Dr. Zachary Felix, Dr. Jessica Wooten, Dr. Todd Pierson, and Dr. Carlos Camp published genetic research that validated *P. dixi* as a distinct species, along with a few others that collectively make up the *P. wehrlei* species complex (Felix et al. 2019, p. 436). Felix et al.'s study further validated research published in 2018 by Shawn Kuchta, Ashley Brown, and Richard Highton that recognized *P. dixi* as a valid species because of its genetic divergency and phenotypic distinctiveness (Kuchta et al. 2018).

The 2018 study by Kuchta et al. used mtDNA and nuDNA to demonstrate evidence for six distinct clades (Kuchta *et al.* 2018, p. 285). The clades were then described as northern *wehrlei*, yellow-spotted *wehrlei*, *Plethodon jacksoni*, southern *wehrlei*, *Plethodon dixi*, and *Plethodon punctatus* (Kuchta *et al.*, 2018, p. 285).

In 2019, Felix et al. further investigated the phylogeny of the *Plethodon wehrlei* group with improved geographic sampling and molecular data. Felix et al. constructed a preliminary Bayesian phylogeny from DNA sequences of the mitochondrial cytochrome b (Cyt-b) gene to delineate major clades within the *P. wehrlei* species group and to test the monophyly of the different clades. Next, they used a suite of phylogenomic methods to estimate relationships among major *wehrlei* clades. Finally, they coupled these molecular results with an analysis of morphological characters from specimens representing most major *wehrlei* clades. They used all these data to evaluate the taxonomic status of *P. dixi* and the other clades (Felix *et al.* 2019, p. 436-444).

Felix et al. concluded that genomic data provided strong evidence for five distinct species within the *P. wehrlei* group. All five of these sister species are distinguishable genetically and morphologically:

<b><i>Plethodon wehrlei</i></b>	<b>Wehrle's salamander</b>	This species corresponds to the northern <i>wehrlei</i> genetic clade identified by Felix et al. Its range extends from New York to West Virginia. It sometimes shows two rows of red dorsal spots.
<b><i>Plethodon dixi</i></b>	<b>Dixie Caverns salamander</b>	Cave-dwelling micro-endemic found in Roanoke County, Virginia. It has bronze mottling on its back and no dorsal spots.
<b><i>Plethodon jacksoni</i></b>	<b>Blacksburg salamander</b>	This species now includes the southern <i>wehrlei</i> clade and its range includes southwestern Virginia and northwestern North Carolina. It often shows two rows of red dorsal spots.
<b><i>Plethodon punctatus</i></b>	<b>Cow Knob salamander</b>	Occurs in higher elevations of the Ridge and Valley ecoregion, primarily on the Shenandoah and North Mountains of Virginia and West Virginia. It has no dorsal spots.
<b><i>Plethodon pauleyi</i></b>	<b>yellow-spotted woodland salamander</b>	Two rows of yellow dorsal spots. Lighter gray ventral coloration with less mottling. Two costal grooves between adpressed limbs, smaller snout-vent length than <i>P. wehrlei</i> , rock outcrop specialist found on shale and sandstone in the Cumberland Plateau.

*Plethodon dixi* was first described by Pope & Fowler in 1949 as being similar to *P. wehrlei* but smaller and having different coloration (Neff 2018, p. 21). *P. wehrlei* is generally brownish-purple with white to cream spots that fuse to form blotches on their flanks, whereas *P. dixi* is described as being smaller (66mm snout-vent length) and having a slender body with a dark gray

to black back with gold to brassy flecks or mottling in a broad, irregular stripe down its back. Numerous small white spots are found on its back and sides, and hind feet may have more webbing than its sister species (VDWR 2025).



Photo: Dixie Cavern salamander by Ty Smith, iNaturalist

Kingdom	Phylum	Class	Order	Family	Subfamily	Genus	Species
Animalia	Chordata	Amphibia	Urodela	Plethodontidae	Plethodontinae	Plethodon	dixi

### Reproduction, Diet, & Behavior

Since *P. dixi* was identified as a distinct species relatively recently, certain information about its specific behavior and life history has not been studied in detail but is presumed to mirror that of closely related species within the *P. wehreli* species complex.

Individuals of this species are likely sedentary and solitary and maintain the same home range throughout their lives (Reed 2019). These salamanders are carnivores that consume a wide variety of invertebrates. Ants, springtails, mites, beetles, and spiders are primary prey for juveniles; adults will eat larger prey, including grasshoppers, crickets, katydids, millipedes, centipedes, leafhoppers, lepidopteran larvae, aphids, isopods, crane flies, weevils, snails, and segmented worms (Petranka 2010, p. 108-113). Plethodontid salamanders are generally most active, including foraging, at night during moist, humid conditions (Lewis *et al.* 2014, p. 201).



Most salamanders in the *P. wehrlei* species complex mate monogamously. Male salamanders breed annually, and female salamanders breed biannually (Reed 2019). Courtship and mating behaviors of *P. dixi* are presumed to involve chemical communication and physical interaction, as seen in related *Plethodon* species. Male *Plethodon* salamanders use pheromones produced in a mental gland beneath their jaw to attract females and administer their pheromones to the females. The female then straddles the male's tail and can choose whether to pick up the spermatophores deposited on the ground to fertilize her eggs (Wells 2007, p. 451-515; Reed 2019; Petranksa 2010, p. 324). The incubation period between egg-laying and hatching is around 72 days, at which time the young salamanders are independent (Reed 2019). These salamanders utilize direct development—a reproductive strategy in which eggs hatch into fully formed miniature adults, bypassing an aquatic larval stage. This adaptation may be advantageous in cave systems where standing water bodies for larvae may be absent or unreliable.

### Habitat Requirements

As ectotherms reliant on cutaneous respiration, Plethodontid salamanders are constrained to habitat that has appropriate moisture and temperature levels (Oswald 2013, p. 1). They are susceptible to desiccation if conditions become too dry, and are thus often found below ground, in caves, or beneath cover objects like rocks or logs (Lewis *et al.* 2014, p. 1).

The Dixie Caverns salamander inhabits karst caves and terrestrial habitat consisting of upland forests and woodlands on forested hillsides. They are generally found in rock crevices and under rocks, logs, and leaves, as these spaces create the cool, moist microclimates that they require (NatureServe 2025).

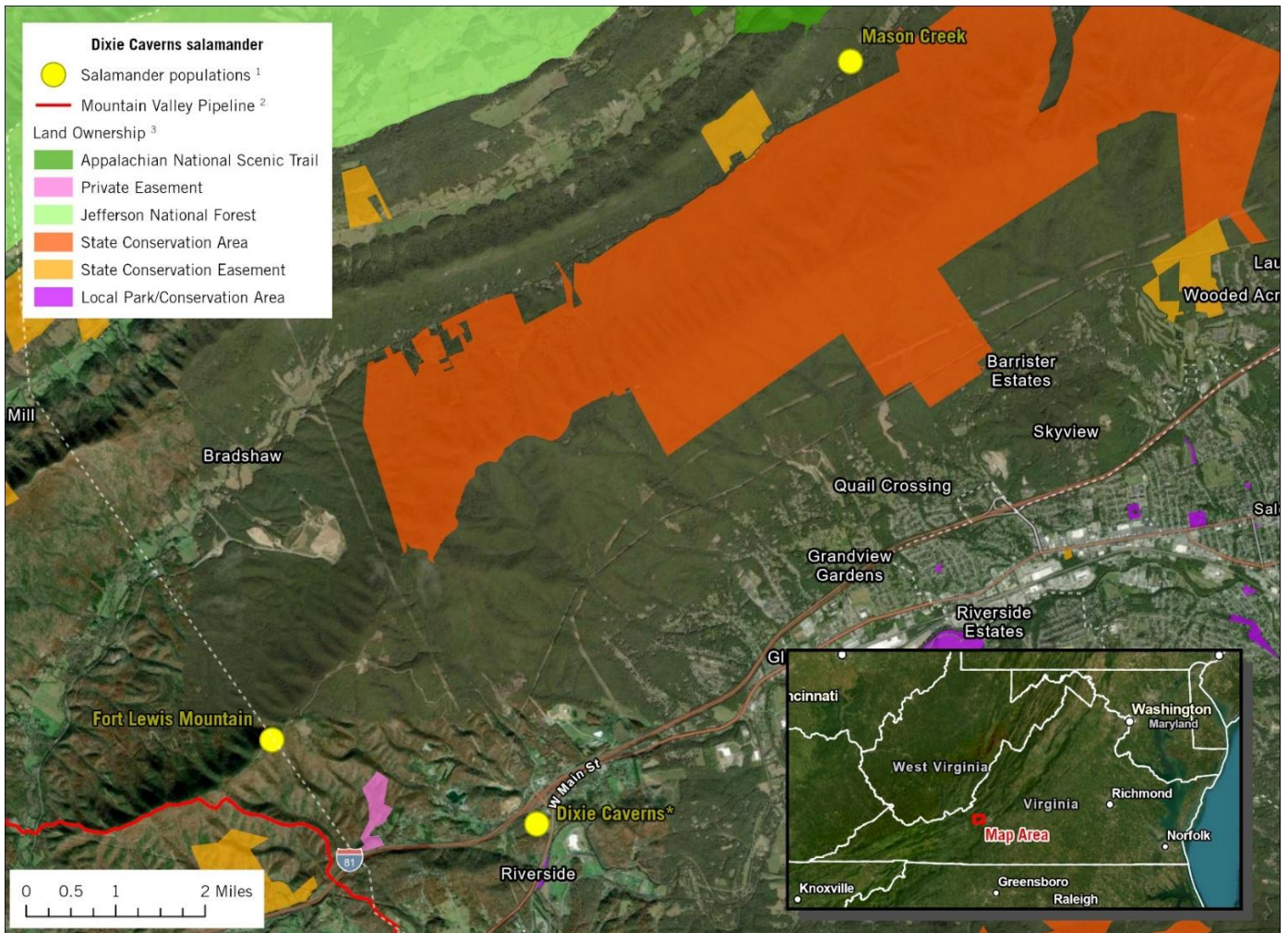
### Population Status & Distribution

The Dixie Caverns salamander is classified by NatureServe as a G1 “critically imperiled” species and occurs in just three known locations in Roanoke County, Virginia, all within about 25 km<sup>2</sup> of each other. The species was initially found in and immediately around Dixie Caverns in Roanoke, Va. Two additional occurrences have been documented since then—one on the ridgeline of Fort Lewis Mountain and the other near Mason Creek (Kuchta *et al.* 2018; Button 2019, p. 756).<sup>1</sup> The area where the Fort Lewis Mountain population was found was clearcut to allow for construction of a pipeline shortly after its discovery and the population's survival has not been confirmed (Button 2019, p. 756).

This species is in need of greater population survey efforts to assess declines across all known populations. A 2019 survey of Dixie Caverns found just 60 salamanders where 322 had been documented in 1951 (Neff 2018, p. 29; Fowler 1951).

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<sup>1</sup> Documentation of the Mason Creek population can be found in the supporting information for Kuchta *et al.*'s study, available at: <https://onlinelibrary.wiley.com/doi/abs/10.1111/zsc.12281>.



\*Potentially two populations, Dixie Caverns & New Dixie Caverns  
 Data Sources: 1 - Fort Lewis Mountain population (Button, S., 2019), Dixie Caverns & Mason Creek (Kutcha et al., 2018); 2 - Roanoke County VA; 3 - USGS Protected Areas Database (4.0)  
 Map by: K. Clauser, Center for Biological Diversity, May 2025

## ESA Listing Factors

### A. Present or threatened destruction, curtailment, or modification of habitat or range

The Dixie Caverns salamander is threatened by habitat loss and degradation caused by deforestation, road construction, development, and recreation in the three locations where it is found.

**Deforestation:** The entire *P. wehrlei* species group is affected by deforestation occurring across Appalachia for purposes such as industrial mining, commercial logging, road construction, oil and gas development, and clearing of private forests (Sayler *et al.*, p. 109-115). At least one population of the Dixie Caverns salamander is threatened by deforestation associated with construction of the Mountain Valley Pipeline. The forested area where the Fort Lewis Mountain population of the salamander occurs was clearcut in 2018 to allow for construction of the pipeline.



Salamanders like the Dixie Caverns salamander require shade provided in large part by caves and rock crevices, forest canopy, and fallen logs. Clearcutting its forested habitat makes an area unsuitable for the species, particularly when no caves are present, as seems to be the case for the Fort Lewis Mountain population (Button 2019, p. 756). Lungless salamanders are highly sensitive to environmental disturbances that modify temperature, humidity, or soil moisture because they utilize cutaneous respiration, and their skin must stay moist to facilitate gas exchange (Petranka *et al.* 1993, p. 367). They are also unlikely to successfully disperse following clearcutting because they are thought to be philopatric, and return to or remain in their small home ranges.

Clearcutting destroys forest microhabitats by eliminating the vital shade created by canopy cover, reducing leaf litter, increasing soil-surface temperature, and reducing soil-surface moisture (Petranka *et al.*, 1993, p. 367). Increases can be as dramatic as 6 degrees Celsius between an undisturbed forest and a clearcut forest (Gibbs & Karraker 2006, p. 916). In addition to the direct impacts to areas that are clearcut, edge effects can also degrade adjacent forested habitat (Rucker *et al.* 2022, p. 4). One study on the impacts of clearcutting on salamanders in Appalachia found that salamander population sizes were up to five times larger in mature forest stands as compared to areas that were recently clearcut (Petranka *et al.* 1993, p. 363). Clearcutting was also associated with the loss of an entire local population of *Plethodon jordani* and declines of several other closely related plethodontids (Ash 1998, p. 756; Button 2019, p. 756).

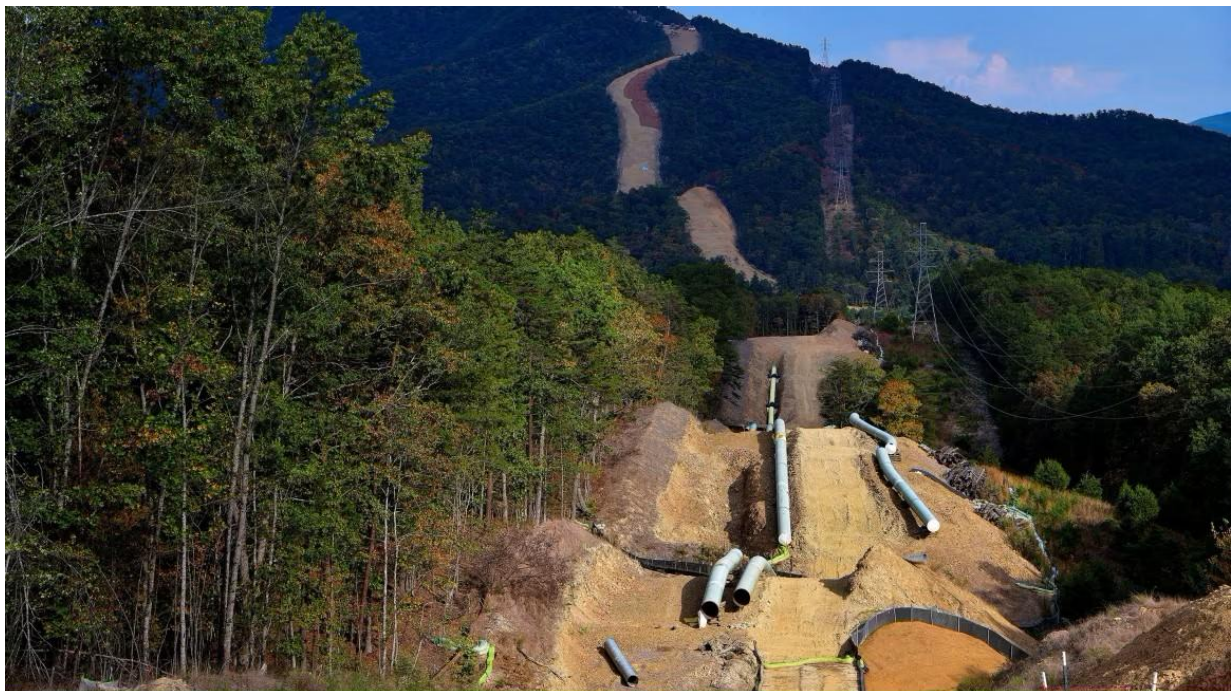


Photo: Mountain Valley Pipeline near Elliston, VA by Charles Mostoller<sup>2</sup>

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<sup>2</sup> Mostoller, C. (2023, July 12). *Lengths of pipe from the Mountain Valley Pipeline near Elliston, VA., waiting to be put in the ground* [Photograph]. New York Times. <https://www.nytimes.com/2023/07/12/climate/mountain-valley-pipeline-courts.html>.

**Roads:** Dixie Caverns salamander habitat is also threatened by roads and road construction. Interstate Highway 81 runs directly over Dixie Caverns and past highway construction has cracked the karst topography and caused pollution to enter the cave (Fidler 2025, pers. comm.). Additional highway construction is expected as the Virginia Department of Transportation (VDOT) plans to widen the portion of I-81 that runs over the caverns (VDOT 2025). This ongoing construction is likely to once again rain pollution down on sensitive salamanders and threatens the geology of the cave system that provides their habitat. Stormwater runoff from Highway I-81 and Highway 460 also regularly floods the caves and threatens the salamanders by introducing additional pollution to the caves. Hollow karst terrain is highly susceptible to pollution because the surface runoff permeates the ground via caves and sinkholes directly and does not go through any natural soil filtration (Zokaite 1997, p. 5).

**Development:** Known populations of the Dixie Caverns salamander occur relatively close to urban areas in Roanoke, Virginia and are at risk from development. Development on karst topography creates risks of sinkhole subsidence and flooding and contamination of groundwater and wildlife habitat (Belo 2003, p. 1). A large hotel is currently proposed for development directly adjacent to Dixie Caverns (Kincaid 2025). The parcels of land where the hotel is proposed are currently undeveloped, and the construction would cause additional runoff and pollution to enter the caves and disrupt the salamander habitat. Future parking lot runoff would be an ongoing source of pollution.

**Recreation:** Recreation may also disturb or modify the Dixie Caverns salamander's habitat. Dixie Caverns are a popular "show cave" in Virginia and attract around 30,000 visitors per year (Berrier 2014). Human activities can threaten wildlife in caves by introducing or worsening the spread of diseases, including amphibian chytrid fungus, causing physical disturbance to cave habitat, and trampling of cave wildlife (Elliott 2017, p. 1; Howarth 1981, p. 57-60). Disturbance by humans can also interfere with breeding, feeding, and other behaviors.

## **B. Disease or predation**

The Dixie Caverns salamander is vulnerable to viral and fungal diseases including *Ranavirus*, *Batrachocytrium dendrobatidis* (*Bd*), and *Batrachochytrium salamandrivorans* (*Bsal*).

**Ranavirus:** *Ranavirus* refers to a group of viral pathogens in the genus *Ranavirus* that affect cold blooded vertebrates including amphibians (Gray *et al.* 2009, p. 316). Diseases caused by *Ranavirus* are responsible for amphibian die-offs throughout North America, including in the southeastern United States (Blackburn *et al.* 2015, p. 357). *Ranavirus* has been detected in other plethodontid salamanders in Virginia, such as the green salamander (*A. aeneus*). Spotted salamander (*Ambystoma maculatum*) die-offs in the Appalachian region in the early 2000s have also been attributed to *Ranavirus* (Gray *et al.* 2009, p. 316). One study documented *Ranavirus* infection among 10 species of plethodontid salamanders and an overall presence of 81% among the species (Gray *et al.* 2009, p. 31). The presence of *Ranavirus* in salamanders that are closely

related to the Dixie Caverns salamander indicates that the species could be at risk of significant decline from these pathogens.

**Chytrid Fungus:** Amphibian chytrid fungus has played a primary role in the declines of amphibian species with small ranges (Sutton *et al.* 2015a, p. 1-2). One disease caused by chytrid fungus known as *Batrachochytrium dendrobatidis* (*Bd*) (or amphibian chytrid fungus), has also caused amphibian declines worldwide (Blackburn *et al.* 2015, p. 357). Seventeen species of plethodontid salamanders have tested positive for *Bd* in past studies (Blackburn *et al.* 2015, p. 357). *Bd* is thought to have caused declines of plethodontid salamanders in Central America and the western United States (Blackburn *et al.* 2015, p. 357).

Another amphibian disease from chytridiomycosis threatens salamanders in the United States, including the Dixie Caverns salamander. The chytrid fungus *Batrachochytrium salamandrivorans* (*Bsal*) was recently discovered as a novel cause of chytridiomycosis (Martel *et al.* 2013, p. 15325-15326). *Bsal* originated in Asia and has already spread to wild European salamanders via the international salamander pet trade (Yap *et al.* 2015, p. 481). It could spread throughout North America causing rapid salamander declines and even extinctions because there are few methods of controlling its spread once it is established in wild populations (Yap *et al.* 2015, p. 481-482). The southeastern United States is a high-risk zone for the spread of *Bsal* and *Plethodontidae* is a particularly susceptible family (Yap *et al.* 2015, p. 481-482).

### **C. Inadequacy of existing regulatory mechanisms:**

Known occurrences of the Dixie Caverns salamander are on private land, leaving the species vulnerable to ongoing habitat degradation and loss. It does not benefit from monitoring or conservation efforts by the state, and ESA protection is the only regulatory mechanism likely to prevent its extinction.

**Virginia Cave Protection Act:** Virginia's Cave Protection Act, codified in Title 10.1, Chapter 10 of the Code of Virginia, aims to establish legal safeguards for the state's caves, recognizing their ecological, geological, and cultural significance. Virginia Cave Protection Act (1988), Va. Code Ann. § 10.1-1006. The Act defines a "cave" as any naturally occurring void or system of interconnecting passages beneath the earth's surface, including features like caverns, sinkholes, and rock shelters, but excluding man-made excavations. It prohibits activities such as defacing cave surfaces, removing natural materials like speleothems, disturbing archaeological or paleontological sites, and harming cave-dwelling organisms without appropriate permits. Violations of these provisions can result in penalties ranging from Class 1 to Class 3 misdemeanors, depending on the specific offense.

While this law may provide certain protections to cave dwelling species in theory, in reality, its effectiveness is limited by the fact that approximately 95% of Virginia's caves are located on private property, limiting the state's ability to enforce conservation measures (Hubbard 2014, p. 4). Further, the law does not require targeted monitoring for sensitive wildlife and is thus



unlikely to improve the status of the Dixie Caverns salamander. Also, based on available survey data, the species has declined significantly in the caves despite the existence of this law.

**Federal Environmental Statutes:** Statutes like the National Environmental Policy Act and the National Forest Management Act may in certain situations provide at least some protection for species and their habitats that occur on federal public land by requiring assessment of environmental impacts and conservation practices. However, known populations of the Dixie Caverns salamander do not benefit from these statutes because populations do not occur on federal public land.

**Virginia Conservation Program:** The Virginia Department of Conservation and Recreation (VDCR) maintains a Natural Heritage Program which aims to identify and protect Virginia's biodiversity (VDCR 2025b). In furtherance of these goals, the VDCR maintains an inventory of natural community types, significant caves, and plant and animal species that are important to the state's natural heritage and are likely to be lost without conservation action in the near future (Roble 2025, p. 1). The Dixie Caverns salamander appears on Virginia's rare animals list, which means that the state considers it to "merit tracking [its] status and population trends and conducting field inventory to locate new occurrences" (Roble 2025, pp. 1, 4). Despite this designation by the state, the species has not benefitted from targeted protections or research and continues to decline.

#### **D. Other natural or manmade factors affecting the continued existence of the species**

The Dixie Caverns salamander is further threatened by climate change and associated habitat loss. It is also inherently vulnerable as a micro-endemic because of its small number of occurrences confined to a small geographic area.

**Climate Change:** The Dixie Caverns salamander and its relatives in the *P. wehrlei* species complex are highly vulnerable to climate change. Lungless salamanders like the Dixie Caverns salamander are microhabitat specialists and are sensitive to environmental factors like moisture and temperature (Milanovich *et al.* 2010, p. 12189). They are ectothermic, and prolonged droughts are a significant risk to the species as they could eliminate the cool, moist microhabitats that the salamander requires (Sayler *et al.* 2016, p. 168). A 2014 study modeling habitat loss in the southeastern United States for high-priority amphibian species found that salamanders in the *P. wehrlei* species complex could lose 93% of climatically suitable habitat by 2050 compared to 2011 (Barrett *et al.* 2014, p. 287). The southeastern United States, including the Appalachian Mountains are projected to lose the most habitat for amphibian species that are considered especially vulnerable to climate change (Barret *et al.* 2014, p. 282).

In addition to habitat loss due to loss of suitable environmental characteristics, climate change threatens the salamander through various pathways. The effects of climate change are expected to exacerbate existing stressors like amphibian diseases and could introduce additional stressors like invasive species (Barret *et al.*, 2014, p. 282). Climate change also threatens to change

pathogen-host dynamics, predator-prey relationships, breeding behaviors, and competition between species, all of which can affect survival, reproduction, and dispersal (Carey & Alexander 2003, p. 118-119).

Additionally, these salamanders have low vagility and are unlikely to be able to migrate to suitable habitat in different locations (Sutton *et al.* 2015b, p. 2-3). Development and clearcutting, such as for the Mountain Valley Pipeline, also create barriers that further limit salamander migration (Rucker *et al.* 2022, p. 4).

**Few Isolated Populations:** The Dixie Caverns salamander is vulnerable to local extirpation and species-level extinction because of its small number of occurrences and limited geographic distribution. Species with fewer populations and smaller ranges are at higher risk in part because they can go extinct following a catastrophic event that affects the entire range (Wolf *et al.* 2015, p. 205). The Dixie Caverns salamander only occupies three known locations across a very small range and could therefore be wiped out by a period of environmental variation or a range-wide catastrophic event.

Further, the populations are isolated by barriers such as fragmented habitat, roads, urban development, and the species' limited dispersal capabilities, which prevent gene flow between populations (Addis & Lowe 2022, p. 1). This creates a risk of inbreeding depression and reduced genetic fitness that threatens the species' long-term health and survival (Wolf *et al.* 2015, p. 5).

### **Request for Critical Habitat**

The Center for Biological Diversity requests and strongly recommends that known locations with Dixie Caverns salamander populations be designated as critical habitat concurrent with the species' listing under the Endangered Species Act.

The ESA requires the Secretary to designate critical habitat concurrent with a determination that a species is threatened or endangered. 16 U.S.C. § 1533(a)(3)(A). Critical habitat is defined in the ESA as:

- (i) The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protections; and
- (ii) Specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.

16 U.S.C. § 1532(5).

Congress acknowledged that the protection of habitat is vital to the recovery and survival of listed species. It was stated that merely classifying a species as endangered or threatened is only the first step in guaranteeing its survival. The determination of the habitat necessary for the species' continued existence is equally or more important. If the protection of endangered and threatened species is dependent largely on the preservation of the species' habitat, then the ultimate effectiveness of the ESA will depend on the designation of critical habitat. H.R. Rep. No. 94-887, at 3 (1976).

The Dixie Caverns salamander is threatened by habitat loss and modification and urgently needs critical habitat protection to be issued concurrently with its designation as a threatened or endangered species. The species has evolved to utilize the particular karst caves and forests where it is found in Roanoke County, Virginia, and it is unlikely to survive without habitat protections.

### **Conclusion**



*Photo: Jake Scott, CalPhotos*

The Dixie Caverns salamander is a critically imperiled amphibian that is in dire need of substantive legal protections that can only be provided by the Endangered Species Act. Amphibians across the globe are experiencing population declines and species extinction due to threats such as habitat loss, fungal diseases, climate change, and development. Without swift action, the Dixie Caverns salamander is likely to follow suit and face imminent extinction.

The namesake population of the Dixie Caverns salamander that is found within Dixie Caverns appears to have already experienced rapid population declines since the 1950s when the species

was discovered (Neff 2018, p. 29). A more recently discovered population at Fort Lewis Mountain may have already been extirpated by clearcutting its forest habitat. The salamander does not currently benefit from any targeted monitoring or conservation efforts that could prevent its extinction, making federal protection essential to the species' continued existence.

Listing the Dixie Caverns salamander under the Endangered Species Act, along with the designation of critical habitat, represents the only viable path toward preserving this unique and irreplaceable species. Federal protection would trigger necessary safeguards, mobilize scientific resources, and initiate recovery efforts that are currently absent. The ESA has been instrumental in preventing the extinction of hundreds of species, and it must now be applied to ensure the Dixie Caverns salamander has a future in the wild. The Center for Biological Diversity urges swift and decisive action to prevent the irreversible loss of this Appalachian endemic.

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