

BEFORE THE SECRETARY OF THE INTERIOR
PETITION TO LIST THE YELLOW-SPOTTED WOODLAND SALAMANDER
(*Plethodon pauleyi*) UNDER THE ENDANGERED SPECIES ACT AS AN
ENDANGERED OR THREATENED SPECIES AND TO CONCURRENTLY
DESIGNATE CRITICAL HABITAT

AUGUST 24, 2022



Kevin Hutcheson

CENTER FOR BIOLOGICAL DIVERSITY

APPALACHIAN MOUNTAIN ADVOCATES

APPALACHIAN VOICES

CITIZENS COAL COUNCIL

THE CLINCH COALITION

COAL RIVER MOUNTAIN WATCH

DOGWOOD ALLIANCE

FOREST KEEPER

HEARTWOOD

KENTUCKY HEARTWOOD

KENTUCKY WATERWAYS ALLIANCE

NOTICE OF PETITION

Secretary Debra Haaland
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240
Secretary_of_the_Interior@ios.doi.gov

Shannon Estenoz
Principal Deputy Assistant Secretary
Fish and Wildlife and Parks
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240
Shannon_Estenoz@ios.doi.gov

Director Martha Williams
U.S. Fish and Wildlife Service
1849 C Street NW
Washington, DC 20240
Martha_Williams@fws.gov

Gary Frazer
Assistant Director for Ecological Services
U.S. Fish and Wildlife Service
1840 C Street NW
Washington, DC 20240
Gary_Frazer@fws.gov

Leopoldo Miranda-Castro
Region 4 U.S. Fish and Wildlife Service
1875 Century Blvd, Suite 200
Atlanta, GA 30345
Leopoldo_Miranda@fws.gov

Wendi Weber, Regional Director
Region 5 / U.S. Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035-9589
Wendi_Weber@fws.gov

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, 5 U.S.C. § 553(e); and 50 C.F.R. § 424.14(a), the Center for Biological Diversity and its partners hereby petition the Secretary of the Interior, through the United States Fish and Wildlife Service (“FWS,” “Service”), to protect the yellow-spotted woodland salamander (*Plethodon pauleyi*) as an endangered or threatened species and to concurrently designate critical habitat.

The yellow-spotted woodland salamander is biologically and ecologically significant. The salamander occurs across four states in the Southern and Mid-Atlantic United States: West Virginia, Virginia, Kentucky, and Tennessee.

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

The Center for Biological Diversity and its partners also request that critical habitat be designated for the yellow-spotted woodland salamander concurrently with the species being listed, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12. Critical habitat is essential to protecting the yellow-spotted woodland salamander from further harm and population decline. Yellow-spotted woodland salamander critical habitat consists of rock outcrops, surrounding buffer habitat, upland habitat, and migratory corridors between sites, which are essential to their long-term genetic health and survival.

Eleven organizations are petitioning the U.S. Fish and Wildlife Service to list the yellow-spotted woodlands salamander and to designate critical habitat. These organizations include national conservation groups and Appalachian-focused community organizations. These organizations recognize the important role of the yellow-spotted woodland salamander and its habitat across Appalachia.

The **Center for Biological Diversity** (“Center”) is a nonprofit, public interest environmental organization dedicated to the protection of imperiled species and the habitat and climate they need to survive through science, policy, law, and creative media. The Center is supported by more than 1.7 million members and online activists throughout the country. The Center works to secure a future for all species, great or small, hovering on the brink of extinction. The Center submits this petition on its own behalf and on behalf of its members and staff with an interest in protecting the yellow-spotted woodland salamander and its habitat.

Appalachian Mountain Advocates is a nonprofit public interest law and policy organization dedicated to fighting for clean water and a clean energy future. Appalachian Mountain Advocates use law and science to protect Appalachia's people, land, forests, air, and water.

Appalachian Voices brings people together to protect the land, air, and water of Central and Southern Appalachia and advance a just transition to a generative and equitable energy economy. Since 1997, Appalachian Voices has been seeking economic solutions that create community wealth and sustain Appalachia's mountains, forests, and waters.

Citizens Coal Council works for justice in the coalfields through informing, empowering, and working for and with communities affected by the mining, processing, and use of coal. The Citizens Coal Council prioritizes five initiatives in their work: environmental justice, climate change, sustainable and thriving economies, transparency and accountability, and clean energy.

The Clinch Coalition is dedicated to protecting and preserving the forest, wildlife, and watersheds of national forests and surrounding communities for present and future generations. The Clinch Coalition focuses on the Clinch River watershed and the wildlands of southwest Virginia.

Coal River Mountain Watch is focused on stopping the destruction of communities and the environment by mountaintop removal mining, to improve the quality of life in Appalachia, and to rebuild sustainable communities. Coal River Mountain Watch combines local knowledge with technical expertise to protect the health of Appalachian communities affected by the coal industry.

Dogwood Alliance advances environmental justice and climate action by mobilizing diverse voices to protect Southern forests and communities from logging. For more than 25 years, Dogwood Alliance has fought threats to forests and frontline communities in the South.

Forest Keeper is a nonprofit organization focused on protecting national forests and public lands in the East. Forest Keeper works in the field, in the courtroom, and in Congress to secure strong protections for public lands and waters. Forest Keeper actively monitors forests and rivers across Appalachia and work to ensure that clean water, rare species, community voices, environmental justice, and ecosystem health are prioritized in forest management.

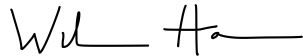
Heartwood is a regional network that protects forests and supports community activism in the Eastern United States through education, advocacy, and empowerment. Founded in 1991, Heartwood works to protect and restore Eastern forests.

Kentucky Heartwood protects and defends Kentucky's public wildlands. Since 1992, Kentucky Heartwood has worked to protect the old-growth, rare species, and biological diversity of the 700,000-acre Daniel Boone National Forest and other public lands in Kentucky.

Kentucky Waterways Alliance is a member-supported nonprofit organization working to protect, restore, and celebrate Kentucky's waterways since 1993. Kentucky Waterways Alliance focuses on protecting Kentucky's lakes, rivers, streams, and wetlands, which support thriving ecosystems, healthy wildlife populations, abundant recreation, and dependable clean water supplies for future generations.

Please contact Will Harlan at 828-230-6818 or email wharlan@biologicaldiversity.org if you have any questions or need any clarification on the information in this petition.

Sincerely,

A handwritten signature in black ink, appearing to read "Will Harlan". The signature is written in a cursive style with a horizontal line extending to the right.

Will Harlan
Senior Campaigner and Scientist
Endangered Species Program
Center for Biological Diversity
338 Merrimon Avenue
Asheville, NC 28801
wharlan@biologicaldiversity.org
828-230-6818

**Yellow-Spotted Woodland Salamander (*Plethodon pauleyi*) Petition
Table of Contents**

Executive Summary	7
Introduction	9
Biological Information	11
Taxonomy.....	11
Appearance.....	18
Behavior.....	21
Diet.....	21
Life cycle.....	23
Habitat.....	25
Current and historic distribution.....	27
Population Status	33
Threats	36
Present or threatened destruction, modification, or curtailment of habitat or range.....	36
Overutilization.....	44
Disease and predation.....	46
Inadequacy of existing regulations.....	48
Inadequacy of federal mechanisms	
Inadequacy of state mechanisms	
Other natural or manmade factors affecting the continued existence of the species.....	54
Request for Critical Habitat	61
Conclusion	62
Literature Cited	63

EXECUTIVE SUMMARY



Kevin Hutcheson

The yellow-spotted woodland salamander (*Plethodon pauleyi*) is one of the most endangered salamanders on the planet. Only 65 yellow-spotted woodland salamanders have been observed in the past twenty years. Only a few hundred yellow-spotted woodland salamanders likely remain.

The yellow-spotted woodland salamander is a slender, purplish-brown salamander with rows of yellow spots that distinguish it from other members of the Wehrle's salamander species complex. Two genetic studies in 2018 and 2019 confirmed that the yellow-spotted woodland salamander is a distinct species.

The yellow-spotted woodland salamander only lives in coal country. The salamander occurs on 21 isolated rock outcrops in central Appalachia targeted by industrial mining. Mountaintop removal mining blasts apart these shale and sandstone outcrops to access coal seams. More than 500 mountains and 1.4 million acres of forests have been destroyed by mountaintop removal mining in Appalachia.

Two known *P. pauleyi* occurrences have been wiped out by mining in the past decade, and many others have likely been obliterated over the past 40 years. The yellow-spotted woodland salamander has already lost significant portions of its range to mining, and it will continue to face destruction, modification, and curtailment of its range for the foreseeable future.

Most of the remaining *P. pauleyi* sites consist of only a single individual and are no longer viable. Many are on private lands, and 13 occurrences of *P. pauleyi* are along roads or near mines. One site in Virginia was recently bulldozed by road equipment.

P. pauleyi is listed as Critically Imperiled and a Species of Greatest Conservation Need in Kentucky and Tennessee. The yellow-spotted woodland salamander is critically endangered across the entirety of its range, and it warrants immediate listing as an endangered species with concurrent designation of critical habitat.

INTRODUCTION



Bryce Wade

Appalachia is one of the most biologically diverse landscapes in North America. The steep slopes and deep hollers of Appalachia are a global biodiversity hotspot for freshwater mussels, birds, and amphibians, especially salamanders. Appalachia harbors more salamander species than anywhere on Earth.¹

Appalachia is also one of the most degraded landscapes on the continent.² Coal mining, especially mountaintop removal mining, have flattened more than 500 mountains, destroyed more than 5,900 square miles of forests, and buried more than 2,000 miles of Appalachian streams.³

The yellow-spotted woodland salamander (*Plethodon pauleyi*) lives exclusively in coal country, from West Virginia to east Tennessee. It occurs only on shale and sandstone outcrops, which are also targeted by mining companies for their coal seams. Most of the yellow-spotted woodland salamander's habitat has been destroyed by mining, including two known occurrences in the past decade.

The yellow-spotted woodland salamander is one of the world's most endangered species. Despite extensive surveying across remaining rock outcrop habitat, only 65 individuals have been observed in the past twenty years. Approximately 200-400 yellow-spotted woodland salamanders likely remain.

¹ Mitchell *et al.* 1999. 136-141.

² Oliphant 2017. 1

³ EPA 2011.

All five factors identified in Section 4 of the Endangered Species Act jeopardize the survival of the yellow-spotted woodland salamander: habitat destruction, overutilization, disease and predation, inadequacy of existing regulations, and natural and manmade factors.⁴ Mining, clear-cut logging, and roads are annihilating *P. pauleyi* habitat. Salamanders are also poached for the wildlife trade, and they are threatened by at least three pandemic diseases (Ranavirus, *Bd*, and *Bsal*). Over 50 percent of yellow-spotted woodland salamanders also harbor a deadly internal parasite. Climate change, acid deposition, recreation, invasive species, and pollution are additional threats to the yellow-spotted woodland salamander's long-term survival. *P. pauleyi* is also inherently vulnerable as a microhabitat specialist with low reproductive rates and small, isolated populations. Existing federal and state mechanisms have been wholly inadequate to save this species from imminent extinction.

Protecting *P. pauleyi* and its habitat would protect other rare and imperiled species, including green salamanders (*Aneides aeneus*), rock outcrop plants and lichens, and endangered fish and mussels.

The yellow-spotted woodland salamander is listed as Critically Imperiled in Kentucky and Tennessee. They occur on 21 remaining rock outcrops in Appalachia, often near roads or on private lands targeted by the coal mining industry. Many of the remaining populations consist of a single individual and are no longer viable.

The yellow-spotted woodland salamander will go extinct unless it is listed immediately as an endangered species and its remaining habitat is protected.

⁴ ESA Section 4 (16 U.S.C. § 1533(a)(1)).

BIOLOGICAL INFORMATION

Taxonomy

The yellow-spotted woodland salamander (*Plethodon pauleyi*) is a newly described species. Decades of field observations and genetic research led to the 2019 *Zootaxa* publication of “Re-evaluation of the Wehrle’s salamander species group using genomic data, with a description of a new species” by Dr. Zachary Felix, Dr. Jessica Wooten, Dr. Todd Pierson, and Dr. Carlos Camp.⁵



Bryce Wade

Salamanders have survived for more than 200 million years through three mass extinction events. The oldest salamander fossil is over 230 million years old.⁶

The lungless salamander family—Plethodontidae—is the largest group of salamanders, with 478 species. Plethodontidae originated in North America, likely in present-day Appalachia, and split from its sister group, Amphiumidae, at the K-T boundary event 66 million years ago.⁷

Plethodontidae, in addition to being speciose, is also the most differentiated in morphology, ecology, and behavior.⁸ The Appalachians likely played an important role in shaping plethodontid diversity. Appalachia’s old mountains, stable geologic history, relatively cool and

⁵ Felix, Wooten, Pierson, and Camp 2019. 440.

⁶ Schoch 2020. 11584.

⁷ Shen *et al.* 2016. 67.

⁸ Vietes, Min, and Wake 2007. 19903.

moist climate, montane elevation gradients, abundant streams, and long period of salamander occupation contributed to the diversification of plethodontid salamanders.⁹

Plethodontid salamanders are concentrated in Appalachia, but they occur throughout the Americas from Canada to the Amazon, in Europe, and one species is found in Asia. Lacking lungs, plethodontids respire through their skin and through the mucous membrane in their throat and mouth. Their skin and mucous membranes must remain moist to absorb oxygen. All plethodontids have a nasolabial groove extending from their nostrils to their upper lip.¹⁰

Today, nearly half of Plethodontidae species are considered vulnerable, endangered, or critically endangered by the IUCN.¹¹

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

Within the Plethodontidae family, *Plethodon* is the most speciose genus of salamanders, also with a center of diversity in the Southern Appalachians. Most of the world's salamander species are concentrated in Appalachia and the Mesoamerican Highlands. In Appalachia, 77 species of salamanders can be found—more than any other region globally.¹²

Plethodon are known commonly as woodland salamanders, although they inhabit a variety of habitats. Some *Plethodon* species live most of their lives in or near water, while others are entirely terrestrial. All 56 *Plethodon* species are endemic to North America.¹³ They inhabit mesic forests in western and eastern North America, and they are especially diverse in Appalachia.¹⁴ The number of recognized *Plethodon* species grown from 17 to 57 in the past 75 years. Genomic data has revealed cryptic, molecularly divergent forms in what were once thought to be single, widespread species.¹⁵

Plethodon speciation tend to be morphologically conservative in that speciation is often not accompanied by morphological diversification.¹⁶ However, some species of *Plethodon* exhibit morphological distinctiveness, as exemplified by the Wehrle's salamander (*Plethodon wehrlei*) species group.

The *Plethodon wehrlei* species group is widely distributed across physiographic regions from New York to North Carolina, and notable genetic and morphological variation exists. The *P. wehrlei* species group consists of moderately large, dark brown salamanders with rounded tails,

⁹ Kozak *et al.* 2006. 539.

¹⁰ Lanza and Nistri. 1998. 74.

¹¹ IUCN 2022.

¹² Binkovitz 2013.

¹³ Frost 2020.

¹⁴ Petranka 1998. 108.

¹⁵ Wake 2009. 333.

¹⁶ Camp and Wooten 2016; Adams *et al.* 2009; Kozak *et al.* 2006. 539.

webbed feet, but a stunning array of morphological and genetic diversity has existed within this species group.¹⁷

A 2018 phylogeographic study of the *P. wehrlei* species group by Kuchta *et al.* used mtDNA and nuDNA to demonstrate evidence for six distinct clades.¹⁸ The clades were then described as northern *wehrlei*, yellow-spotted *wehrlei*, *Plethodon jacksoni*, southern *wehrlei*, *Plethodon dixi*, and *Plethodon punctatus*.¹⁹

In 2019, Felix, Wooten, Pierson, and Camp 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 *P. wehrlei* species group and to test the monophyly of the yellow-spotted *wehrlei*. Next, they used a suite of phylogenomic methods to estimate relationships among major *wehrlei* clades, focusing on the evolutionary history of yellow-spotted *wehrlei*. 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 yellow-spotted *wehrlei*.

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

***Plethodon wehrlei* / Wehrle's salamander:** this species corresponds to the northern *wehrlei* 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.

***Plethodon jacksoni* / Blacksburg salamander:** this species now includes the southern *wehrlei* clade, and its range includes southwestern Virginia, northwestern North Carolina. It often shows two rows of red dorsal spots.

***Plethodon dixi* / Dixie Cavern salamander:** cave-dwelling micro-endemic found only in two caves in Roanoke County, Virginia. It has no dorsal spots.

***Plethodon punctatus* / Cow Knob salamander:** occurs in higher elevations of the Ridge and Valley ecoregion, primarily on Shenandoah and North Mountains of Virginia and West Virginia. It has no dorsal spots.

***Plethodon pauleyi* / yellow-spotted woodland salamander:** two rows of yellow dorsal spots; lighter gray ventral coloration with less mottling; two costal grooves between adpressed limbs; smaller snout-vent length than *P. wehrlei*. Rock outcrop specialist found on shale and sandstone in the Cumberland Plateau.

¹⁷ Kozak *et al.* 2006. 539.

¹⁸ Kuchta *et al.* 2018. 285.

¹⁹ *Ibid.*

Plethodon wehrlei, *P. jacksoni*, *P. punctatus*, and *P. dixi* had been previously described in the scientific literature since the 1950s. However, the yellow-spotted clade was a newly described species, which was named *Plethodon pauleyi* after Dr. Thomas Pauley, professor emeritus at Marshall University who has led decades of *P. wehrlei* and other salamander research.

Plethodon pauleyi shares the morphology typical of woodland salamanders of the genus *Plethodon* and exhibits the expanded webbing between the toes found in other members of the *P. wehrlei* group. *Plethodon pauleyi* also shares the whitish, irregular mottling that is found along the margin of the lateral and ventral sides of other members of the species group.²⁰

The most obvious feature that distinguishes *P. pauleyi* from *P. wehrlei*, *P. punctatus*, *P. dixi*, and *P. jacksoni* is the presence of two rows of yellow, dorsal spots. These loosely paired spots begin at or posterior to the insertion of the forelimbs and run down the dorsum to just posterior to the insertion of the hind limbs. These spots normally number between 6 and 12 on a side.²¹

Neither *P. dixi* nor *P. punctatus* normally have dorsal spots, and spots on *P. wehrlei* and *P. jacksoni* are reddish in color, never yellow. The spots are fainter in older individuals.²²

Plethodon pauleyi is also distinguishable from other members of the species group by its ventral coloration. It has a grayish, translucent venter with lightly pigmented mottling, whereas *P. wehrlei* and *P. punctatus* both have darkly pigmented venters with little mottling and a noticeably lighter gular region. Compared to the relatively dark, salt-and-pepper mottling on the venter of both *P. dixi* and *P. jacksoni*, the mottling on the venter of *P. pauleyi* is more lightly pigmented.²³

Additionally, *P. pauleyi* can be differentiated by having only two costal grooves between the adpressed limbs as opposed to three or four in *P. wehrlei*, *P. jacksoni*, and *P. dixi*, and 2 or 3 in *P. punctatus*.²⁴

Finally, *P. pauleyi* appears to mature at smaller snout-vent length sizes than *P. wehrlei*.²⁵ In a sample of over 1,000 *P. wehrlei* from New York, Pennsylvania, and West Virginia the smallest *P. wehrlei* female with yolked eggs was 60 millimeters snout-vent length, and the smallest mature males were greater than 56 millimeters.²⁶ The holotype *P. pauleyi* female is 52.4 millimeters snout-vent length, and the holotype male is 51.5 millimeters snout-vent length.

Felix et al. found no evidence of introgression between *P. pauleyi* and the other species within the *P. wehrlei* group, which is especially meaningful given the proximity of *P. pauleyi* populations to populations of *P. wehrlei*.²⁷ Kuchta et al. (2018) provided additional evidence of

²⁰ Felix et al. 2019. 440.

²¹ *Ibid.*

²² *Ibid.*

²³ *Ibid.*

²⁴ *Ibid.*; Fowler and Dunn 1917. 7.

²⁵ Felix et al. 2019. 441.

²⁶ Hall and Stafford 1972. 300.

²⁷ *Ibid.*

genetic divergence between this species and *P. wehrlei* populations as close as one kilometer across the New River in West Virginia with no signs of hybridization.

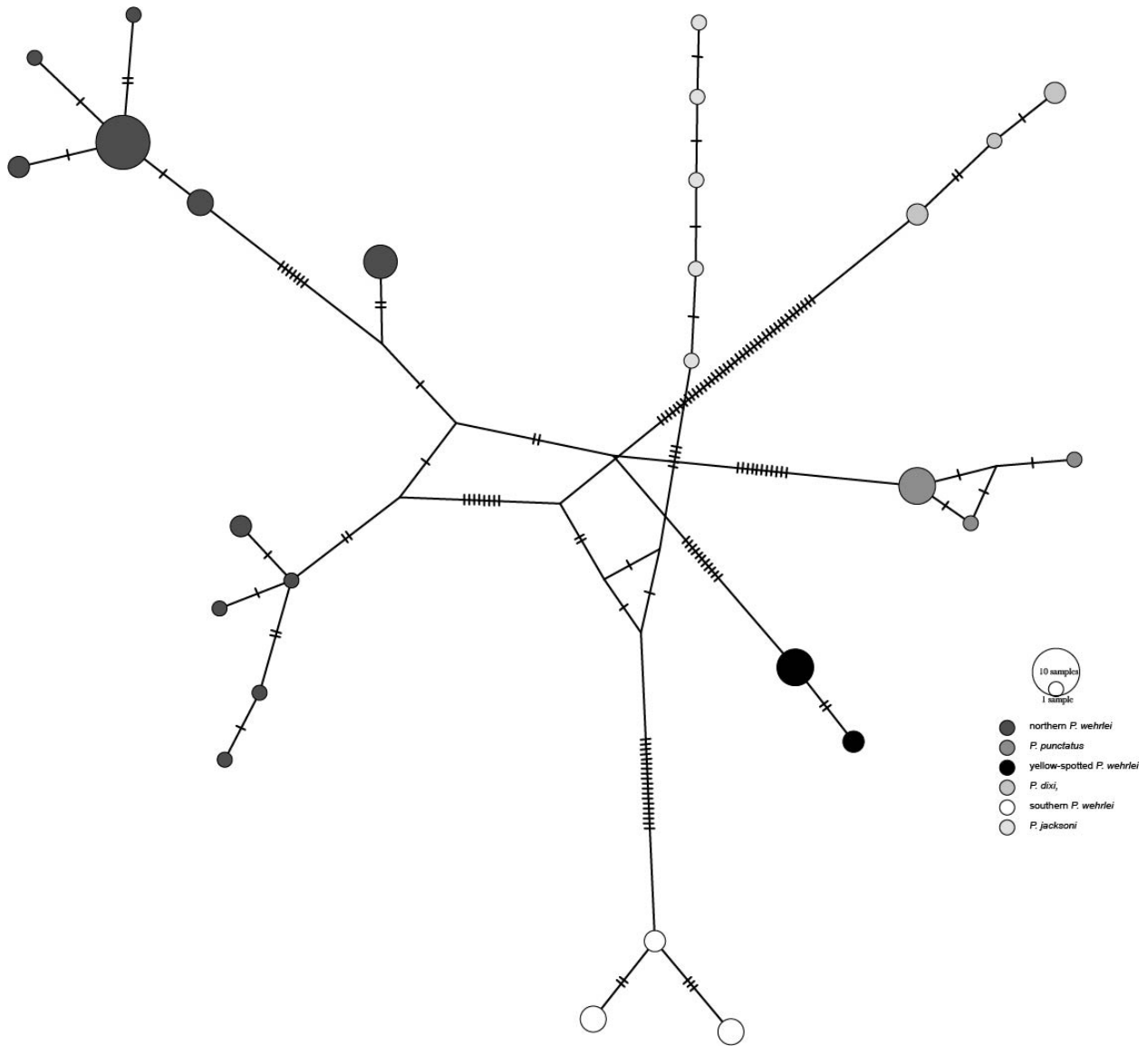
Felix et al conclude: “Our data provide strong evidence for the distinctiveness and monophyly of *P. pauleyi*....It is genetically unique....Because this form is genetically, morphologically, and ecologically distinct and thus clearly represents an independently evolving lineage, it meets the criteria of species under the General Lineage Species Concept.”²⁸

Subsequent research has corroborated their 2019 findings, and *P. pauleyi*, the yellow-spotted woodland salamander, is now recognized as a distinct species.²⁹

²⁸ Felix, Wooten, Pierson, and Camp 2019. 441-444; de Queiroz 1998. 57; de Queiroz 2005. 6601.

²⁹ AmphibiaWeb 2021; NatureServe 2021.

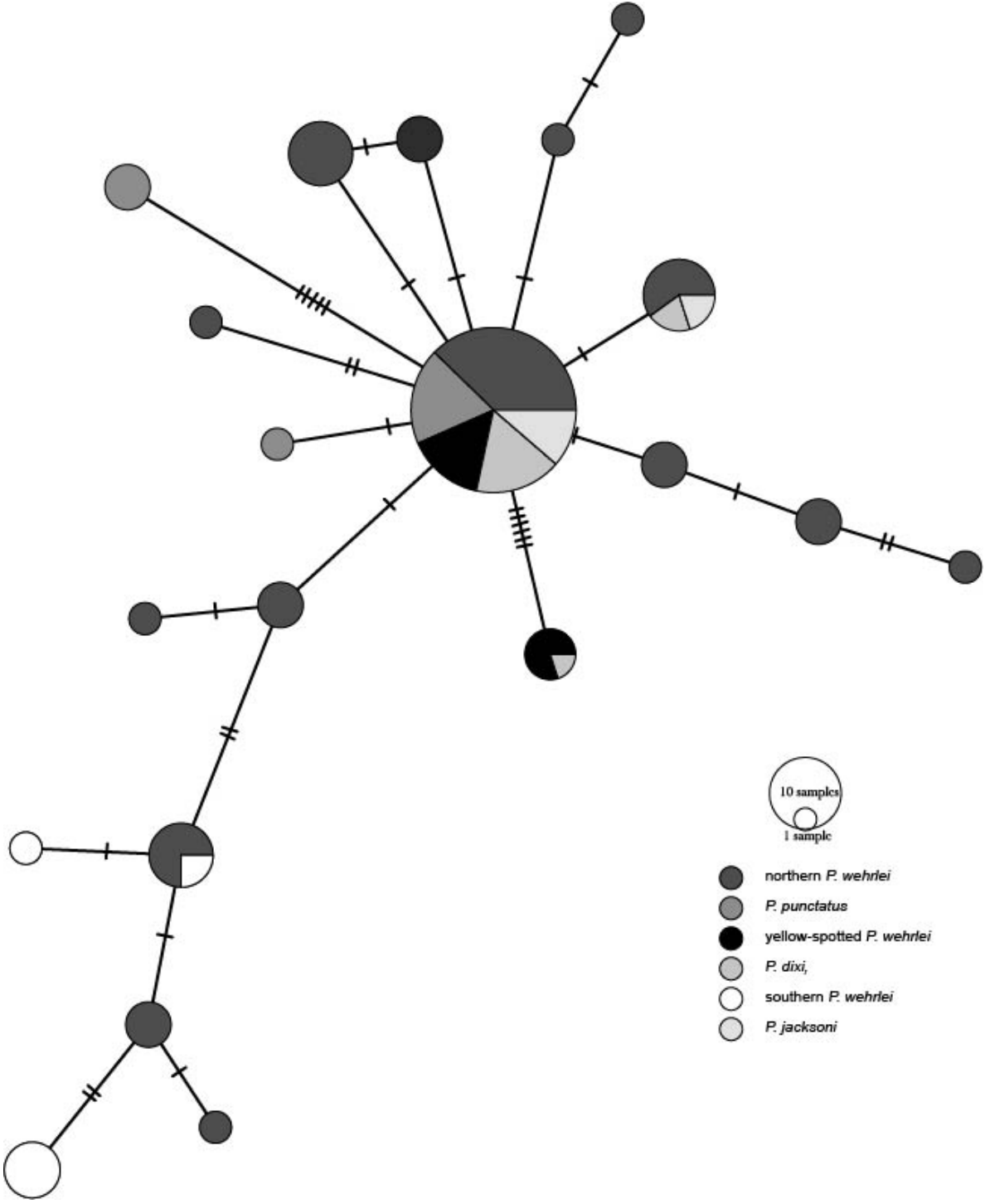
Figure 1: Mitochondrial Genetics Network for *P. pauleyi* and *P. wehrlei* species complex



Jessica Wooten

*Mitochondrial CYTB gene sequence data shows that the yellow spotted variant (*P. pauleyi*) is completely distinct from the other members in the wehrlei species complex.*

Figure 2: Nuclear Genetics Network for *P. pauleyi* and *P. wehrlei* species complex



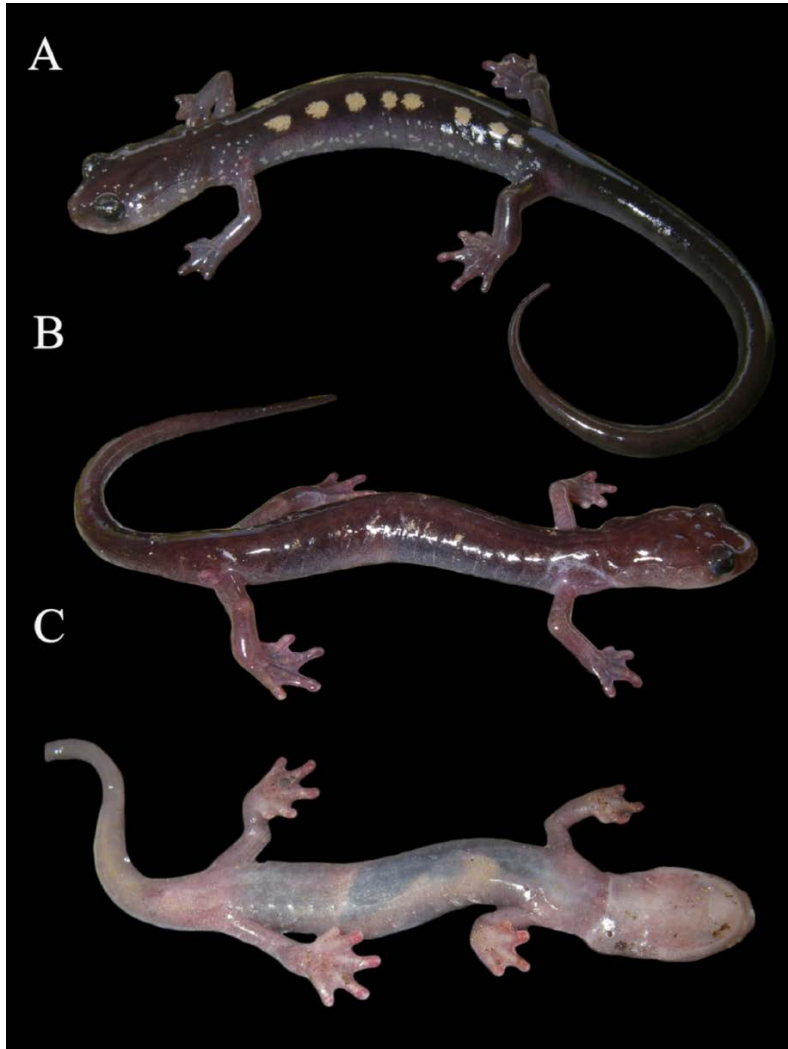
Jessica Wooten

Nuclear sequencing using the ILF nuclear marker shows that *P. pauleyi* is very distinct from other members of the species complex.

Appearance

Yellow-spotted woodland salamanders (*P. pauleyi*) are large and slender, with gray-brown bodies and two rows of yellow spots along their dorsum.³⁰

The dorsum is typically black to lead-gray and marked by two rows of conspicuous yellow, round, irregularly edged spots, each approximately 1 to 2 mm in diameter. The left and right rows may have differing numbers of yellow spots, but there are usually between 6-10 spots (6-8 most common).³¹



Felix, Wooten, Pierson, and Camp

Holotype and allotype of Plethodon pauleyi. (A) is live mature female; (B) is dorsal view of male allotype; (C) is ventral view of male allotype.

³⁰ Virginia Herpetological Society 2021.

³¹ Felix, Wooten, Pierson, and Camp 2019. 440-442.

Tiny white flecks are often scattered across the head and neck between the forelimbs and along the dorsal surfaces of the brachia. These are often most abundant on and above the eyes as well as directly above the insertion of the limbs.³²

The sides of the face and trunk are usually gray and marked with irregularly edged, white mottling distributed from the lips, down each side at the margin of the lateral and ventral sides, to the insertion of the hind limbs.³³

The venter between limbs and extending onto the tail is salt-and-pepper gray and translucent, through which internal organs are clearly visible. The throat has larger, light-colored mottling similar to the sides of the animal and with fewer melanophores than the rest of the venter; however, the contrast is not as stark as in other *P. wehrlei* species. The toes of all four feet possessed obvious webbing.³⁴

Yellow-spotted woodland salamanders have 17 costal grooves, with two costal grooves between the adpressed limbs.³⁵ The tail is distinctly rounded in cross-section. Nasolabial grooves are present. Yellow-spotted woodland salamanders, like all plethodontids, use their nasolabial groove for courtship, foraging, and avoiding predators. Salamanders tap their nose to an object, and then capillaries within its nostrils move the scent up the groove into the vomeronasal organ of the nose.³⁶

Adults range from 100-170 millimeters from head to tail, or 50-75 millimeters snout-vent length. Yellow-spotted woodland salamanders have a slightly smaller snout-vent length than other members of the *P. wehrlei* species complex. Males are slightly smaller than females.³⁷

Males possess an enlarged mental gland in the sub-mandibular region which secrete pheromones that increase female receptivity to courtship and mating. The mental gland is around two millimeters at maturity and swells when males are in mating condition. Males also distinguish themselves from females by having cloacal papillae.³⁸

Juveniles appear to have darker dorsal trunks and limbs that lighten and become more purplish as they age. Yellow spots are brighter in juveniles and become fainter and more fragmented in larger or older individuals.³⁹

Yellow-spotted woodland salamanders are moderately robust and resemble slimy salamanders (*Plethodon glutinosus*). However, slimy salamanders have white or brassy flecking on their dorsum, grayish throats, and 16 costal grooves.⁴⁰

³² *Ibid.* 440-441.

³³ *Ibid.* 440.

³⁴ *Ibid.*

³⁵ *Id.* 441.

³⁶ Reynolds 2011. 215.

³⁷ *Ibid.*

³⁸ *Id.* 442.

³⁹ *Ibid.*

⁴⁰ Reynolds 2011. 216.

Like other *wehrlei* salamanders, *P. pauleyi* possess partial webbing on their hind toes. The webbing extends nearly to the tip of the first two toes on the hind foot.



Bryce Wade

Diet and Behavior

As a newly described species, much is still unknown about *P. pauleyi*. However, the yellow-spotted woodland salamander likely has a diet similar to its sibling species in the *Plethodon wehrlei* species complex. They 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.⁴¹

They forage for prey on rock outcrops, trees, and forest floors. Most foraging occurs nocturnally, but yellow-spotted woodland salamanders are occasionally seen foraging during the day during wet, foggy, and dark conditions. Optimal foraging occurs in warm, wet conditions.⁴²

They are typically solitary and sedentary animals. In the warmer months, they forage at night and stay underground or deep in rock crevices during the day to avoid desiccation.⁴³ They will move vertically in the soil depending on moisture conditions.⁴⁴ The salamanders hibernate from October to March, with higher-elevation individuals hibernating as early as September and emerging in late April.⁴⁵

They remain in their same home area their entire lives. Males' and juveniles' home range is estimated at 13 square meters; females' home range is 24 square meters—nearly twice as large.⁴⁶ Male salamanders aggressively defend their territories from conspecifics and heterospecifics, especially during autumn mating season.⁴⁷ They have been observed biting the tails off smaller species of salamanders.⁴⁸

Snakes are the primary predator of *P. pauleyi* and other salamanders in the *wehrlei* species complex. Northern ring-necked snakes (*Diadophis punctatus edwardsii*) are the only documented predator, but eastern garter snakes (*Thamnophis sirtalis*), shrews, and ground-foraging birds including sparrows, grouse, and towhees also likely prey on *P. pauleyi*.⁴⁹

When threatened, these salamanders will remain immobile to avoid detection. Salamanders in the *wehrlei* species complex have the longest immobility duration within the entire 56-species *Plethodon* genus.⁵⁰ They also produce odorous and noxious cutaneous secretions that make them undesirable to predators.

Another defense mechanism is autotomy. They can detach their tails from their bodies, which provides a distraction and an opportunity to escape predators. The route of tail breakage occurs

⁴¹ Petranka 2010. 105.

⁴² Gibbs and Karraker 2006. 913.

⁴³ *Ibid.*

⁴⁴ *Ibid.*

⁴⁵ Petranka 2010. 106.

⁴⁶ Lannoo 2005. 203.

⁴⁷ Mitchell and Gibbons 2010. 136.

⁴⁸ Petranka 2010. 106.

⁴⁹ Mitchell and Gibbons 2010. 137.

⁵⁰ Dodd 1989. 468.

in a constricted area of the tail, where there is an area of cutaneous and muscular weakness at the end of the first caudal segment. The entire tail is shed, which can comprise two-thirds of their total body length. A cylinder of skin closes over the wound at the end of the body.⁵¹ These salamanders can completely regenerate their tails within weeks or months.⁵²

P. pauleyi appear to be most active in early spring and fall.⁵³ Most observations occur in April, soon after *P. pauleyi* emerge from hibernation. *P. pauleyi* estivate deep in the cool, moist, shaded crevices of rock outcrops during the warmer, drier summer months. They become more active again in the fall during breeding season.⁵⁴



Bryce Wade

⁵¹ Wake 1967. 265.

⁵² Lannoo 2005. 203.

⁵³ Hutcheson pers. comm. 2022.

⁵⁴ *Ibid.*

Life Cycle

While the yellow-spotted woodland salamander's unique life cycle has not yet been fully investigated, salamanders in the sibling *P. wehrlei* species complex mate monogamously. Males breed once annually, and females usually breed once every two years.⁵⁵

These salamanders typically mate in the fall. During mating season, males extend their testes externally from their bodies and then retract them internally after mating.⁵⁶ Beginning in September, males produce spermatophores, which are masses of spermatozoa embedded in a gelatinous nutrient packet. They also produce pheromones to attract females. Males' mental glands on their chins enlarge during courtship and secrete pheromones that enhance female responsiveness. To administer the pheromone, males slap females with their chins, secreting the pheromone directly into her nares. They may also wipe their chins along the female's dorsum while scraping her skin with their maxillary teeth.⁵⁷

During mating, the female straddles the male's tail while they both walk forward together. The male deposits his spermatophore on the ground. Still straddling the male's tail, the female walks forward, guided by the male's tail to the spermatophore. Females can choose whether to take up the spermatophore. If she chooses, the female lowers herself onto the spermatophore and takes in the sperm caps through her cloaca to fertilize her eggs.⁵⁸

Females nest in underground cavities or rock outcrop crevices. In the spring, they lay 6-24 unpigmented eggs in grape-like clusters. Females brood their eggs until they hatch. The incubation period is approximately 72 days for most *Plethodon* species. During this time, females do not actively forage.

Hatchlings do not undergo an aquatic larval stage. Instead, they are direct-developing salamanders that emerge from eggs as miniature adults. Direct development also results in an increase in egg size and duration of the embryonic stage. Once hatchlings emerge from the eggs, they are independent and grow rapidly in their first year.⁵⁹

Males reach sexual maturity at three years and begin mating at age four. Females reach sexual maturity at age five.⁶⁰

⁵⁵ Highton *et al.* 2012. 278.

⁵⁶ Mitchell and Gibbons 2010. 136.

⁵⁷ *Ibid.*

⁵⁸ Wells 2007. 451-515.

⁵⁹ Petranka 2010. 324.

⁶⁰ Green and Pauley 1987. 189.

The life span of yellow-spotted woodland salamanders in the wild is unknown, but their close relatives, northern slimy salamanders (*Plethodon glutinosus*) can live more than 20 years in captivity.⁶¹

⁶¹ Snider and Bowler 1992. 5-7.

Habitat

Yellow-spotted woodland salamanders are rock outcrop specialists. Rock outcrops are exposed bedrock or sedimentary deposits. Overlying cover has been removed from rock outcrops by erosion or tectonic uplift. Yellow-spotted woodland salamanders inhabit steep shale and sandstone outcrops along the Appalachian Plateau, especially along the escarpment.⁶²

The Appalachian Plateau is an elevated tableland characterized by rugged terrain, steep mountains, deep river gorges, a moderate climate, and abundant rainfall.⁶³ The plateau is heavily forested and dissected by streams with dendritic drainage. The Plateau is called the Cumberland Plateau through Kentucky and Tennessee; in Virginia and West Virginia, it is referred to as the Allegheny Plateau.⁶⁴

The climate of the Appalachian Plateau is temperate and varies because of topographic influences. Precipitation is distributed uniformly throughout the year, with a total annual precipitation of 125 centimeter (45 inches). The late summer and early fall seasons tend to be drier.

The rocks that now form the Appalachian Plateau were laid down in an ancient shallow sea over 350 million years ago. These sediments were deposited in horizontal layers thousands of feet thick. The resulting pressure compacted and hardened these sediments into layers of limestone, shale, sandstone, and coal.⁶⁵

Coal formed from dead trees, ferns, and cycads that accumulated as organic-rich sediment in swamps over 300 million years ago. Most of the coal mined in Kentucky, Tennessee, Virginia, and West Virginia comes from the Appalachian Plateau.⁶⁶

Surface mining and mountaintop removal mining are concentrated around the rock outcrops inhabited by *P. pauleyi*. Both mining techniques clear land of all trees and vegetation surrounding shale and sandstone outcrops. Explosives blast apart rock outcrops to access coal seams. Heavy machinery digs away the coal and then dumps the extra rock and soil—called overburden—into valleys and waterways.⁶⁷

Surface mining and mountaintop removal mining sites in the Cumberland Plateau and Allegheny Mountains overlap nearly identically with *P. pauleyi* habitat. *P. pauleyi* primarily inhabits the same shale and sandstone rock outcrops targeted by mining companies for their coal seams.⁶⁸

⁶² Felix, Wooten, Pierson, and Camp 2019. 442.

⁶³ Davies 2016.

⁶⁴ Chowns 2016.

⁶⁵ Davies 2016.

⁶⁶ *Ibid.*

⁶⁷ EPA 2006.

⁶⁸ Felix and Wooten, pers. comm. 2022.

P. pauleyi is found in river valleys as low as 600 feet in elevation and up to 4,800 feet in the Allegheny Mountains.⁶⁹ They are most often found climbing on rocks after dark or sheltering in crevices during the day.⁷⁰

They inhabit the crevices of outcrops and often shelter deep in the rocks or underground. They also are found in the shale talus below outcrops.⁷¹

P. pauleyi salamanders appear to have similar habitat and surface activity similar to green salamanders (*Aneides aeneus*), with whom they co-occur.⁷² Both occur in rock outcrops and surrounding closed canopy forests. Forest habitats include spruce-fir forests, yellow beech and northern hardwood forests, and mixed deciduous and coniferous forests with an abundance of rocks, boulder fields, and downed woody debris. All salamanders in the *wehrlei* species complex are found predominantly in mature forests.⁷³

P. pauleyi specimens have been collected in pitfall traps in West Virginia and Kentucky, indicating that individuals venture away from rock outcrops into surrounding closed-canopy forests.⁷⁴ They have also been found in trees near rock outcrops and beneath logs in adjacent closed-canopy forests.⁷⁵

With their ability to inhabit rock outcrops, *P. pauleyi* appears to be more tolerant of dry conditions than other *wehrlei* species, but they are still vulnerable to desiccation.⁷⁶ When forests surrounding rock outcrops are removed by mining, timber harvests, or fire, snakes and other reptiles consume or replace *P. pauleyi* and co-occurring green salamanders.

Rock outcrop vegetation includes a mixture of low-growing lifeforms, especially lichens, mosses, and short-statured forbs.⁷⁷ Shrubs, mosses, and stunted trees are usually present in patches, where crevices or deeper soil accumulations are present. Additional rock outcrop herbs may be present, including *Heuchera villosa*, *Hylotelephium telephioides*, *Krigia montana*, and *Paronychia argyrocoma*, along with more widespread herbs of open areas such as *Danthonia compressa*, *Danthonia spicata*, *Houstonia caerulea*, *Potentilla canadensis*, and *Schizachyrium scoparium*.⁷⁸

⁶⁹ Petranka 2010. 108.

⁷⁰ Felix, Wooten, Pierson, and Camp 2019. 442.

⁷¹ Hutcheson pers. comm. 2022.

⁷² Reynolds 2011. 216.

⁷³ Petranka 2010. 108.

⁷⁴ Waldron *et al.* 2001. 2; J. Felix unpublished data 2022.

⁷⁵ Felix unpublished data 2022; Hutcheson pers. comm. 2022.

⁷⁶ Mitchell and Gibbons 2010. 136.

⁷⁷ Wisser and White 1999. 119.

⁷⁸ Schafale and Weakley, 1990. 113.

DISTRIBUTION



Kevin Hutcheson

Plethodon pauleyi is known from only 21 remaining sites in Tennessee, Kentucky, Virginia, and West Virginia, all within the Central Appalachian ecoregion south of the New River.⁷⁹

Many of the 21 remaining occurrences of *P. pauleyi* are on private lands and are currently unprotected. 13 occurrences of *P. pauleyi* are along roads or near mines and logging sites. *P. pauleyi* salamander populations at two previously known sites have likely been extirpated by coal mining.

Despite extensive surveying in rock outcrop habitat across central Appalachia, only 65 individuals have been observed in the past 20 years. Most occurrences consist of only a single individual. Only five sites have more than five salamanders.

The northern populations are found in the more heavily dissected portion of the Plateau, especially in the New River Gorge and Bluestone River Gorge. The southernmost populations are mainly associated with Pine Mountain, Ky., on the eastern edge of the Appalachian Plateau.⁸⁰

Maps of intensive surface mining and mountaintop removal mining sites in the Cumberland Plateau and Allegheny Mountains overlap nearly identically with *P. pauleyi* habitat (see Figure 5). *P. pauleyi* exclusively inhabits shale and sandstone rock outcrops often targeted by mining

⁷⁹ Felix, Wooten, Pierson, and Camp 2019. 442.

⁸⁰ Felix, Wooten, Pierson, and Camp 2019. 443.

companies for their coal seams.⁸¹ One yellow-spotted woodland salamander occurrence in Virginia is located along a road near Wise County's largest strip mine.⁸² Another Virginia population was recently bulldozed by road construction equipment.⁸³ Many *P. pauleyi* populations have likely already been extirpated by the intensification of surface mining and mountaintop removal mining in the past 40 years.

On the yellow-spotted woodland salamander's northern edge, *P. pauleyi* and *P. wehrlei* occur within one kilometer of each other with no signs of hybridization between the two species. Similarly, *P. pauleyi* distribution directly overlaps with southern *wehrlei* / *Plethodon jacksoni* distribution in the south, but there are no indications of introgression. *P. pauleyi* is found predominantly on or near rock outcrops and surrounding closed-canopy forests, while southern *wehrlei* / *P. jacksoni* is more widely distributed.

P. pauleyi is separated from *P. wehrlei* to the north by the New River. This river is an apparent remnant of the ancient Teays River, and its course has remained relatively unchanged since forming at least three million years ago.⁸⁴ It is one of the only major rivers that flows north. As one of North America's oldest rivers, the New River represents an important biogeographical barrier for organisms, especially terrestrial salamanders.⁸⁵

Figure 3: Current distribution niche models for *Plethodon wehrlei* species complex, including *Plethodon pauleyi*

Blue region: *P. wehrlei* (northern *wehrlei*) / Wehrle's salamander

Red region: *P. punctatus* / Cow Knob salamander

Purple region: *P. jacksoni* + southern *wehrlei* / Blacksburg salamander

Green region: *P. pauleyi* / yellow-spotted woodland salamander

Not shown: *P. dixi* / Dixie Cavern salamander, which only occurs in two caves near Salem, Va.

Purple dots indicate occurrences of P. pauleyi salamanders. Other dots indicate occurrences of other salamanders in the wehrlei species complex.

⁸¹ Felix and Wooten, pers. comm.

⁸² Hutcheson, pers. comm. 2022.

⁸³ *Ibid.*

⁸⁴ Berendzen *et al.* 2003. 1139.

⁸⁵ Kuchta *et al.* 2016. 288.

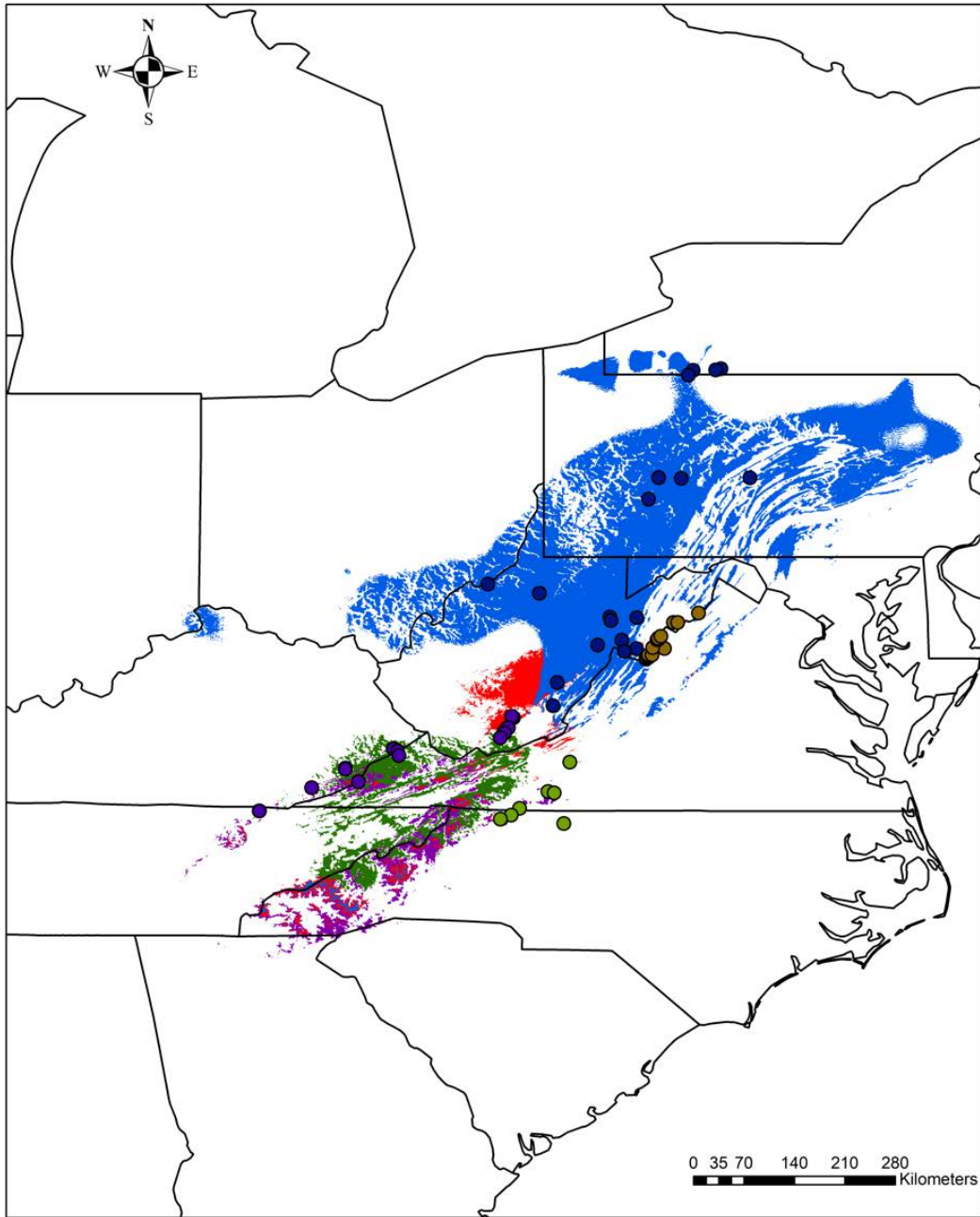
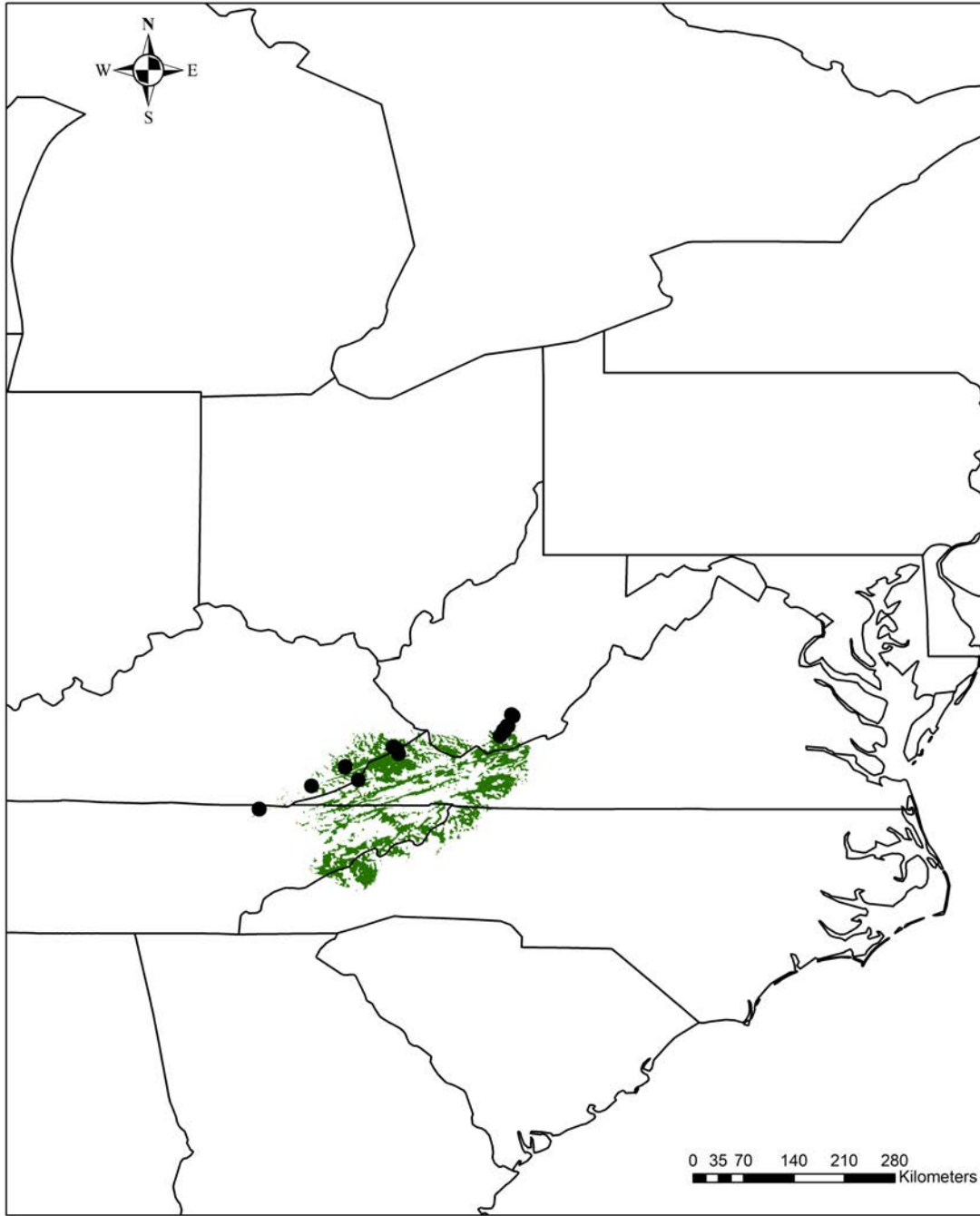


Figure 4: Current distribution niche model for *Plethodon pauleyi*



Range map for P. pauleyi. Black dots indicate known occurrences. P. pauleyi's range extends from the New River Gorge in West Virginia to Pine Mountain, Ky./Tenn. Maps by Jessica Wooten

The New River and cold temperatures appear to be limiting factors in *P. pauleyi*'s northern distribution. Climate models suggest that populations of *P. pauleyi* are more similar to southern populations of *wehrlei*, not northern populations. Low temperatures may prevent *P. pauleyi* populations from being able to thrive, move, or survive in colder climates.⁸⁶

P. pauleyi is also found in rock outcrops along the Bluestone River, approximately 60 kilometers south of the New River Gorge. Four of the 21 occurrences are found in the vicinity of the Bluestone River.⁸⁷

To the south, *P. pauleyi* occurrences are concentrated along Pine Mountain in southeastern Kentucky and northeast Tennessee. Pine Mountain is a thrust fault ridge extending from Jellico, Tenn., to Elkhorn City, Ky. Pine Mountain stretches 200 kilometers in a northeast/southwest direction and is 40 kilometers wide.⁸⁸ Pine Mountain is the westernmost escarpment of the mountain-building collision between the North American continental plate and African continental plate 230 million years ago.⁸⁹ Pine Mountain elevation currently reaches 998 meters, but during the Paleozoic, it was nearly 4,000 meters high. This thrust fault became a major barrier to migration of native biota.⁹⁰

Unlike most of the surrounding mountains and ridges of the Appalachian Plateau, Pine Mountain contains few coal deposits. Instead, it contains more limestone and a karst topography that has largely escaped intensive coal mining. As a result, nine *P. pauleyi* salamander sites are found along the Pine Mountain ridgeline—more than anywhere else.⁹¹ One of these sites is located in Pine Mountain Wildlife Management Area, but the other eight sites are on private, unprotected lands.⁹²

A few additional sites may be discovered on shale and sandstone rock outcrops in the western Appalachian Plateau, but they likely do not occur frequently in the Ridge and Valley to the east. Biologists have searched suitable habitat in adjacent eastern counties in the Ridge and Valley and have not found any yellow-spotted woodland salamanders.⁹³

Green salamanders (*Aneides aeneus*), Cumberland plateau salamanders (*Plethodon kentucki*), and Allegheny Mountain salamander co-occur with *P. pauleyi* and may be potential competitors for food and habitat. However, all these species have ranges outside of the rock outcrops of the Appalachian Plateau. Green salamanders tend to inhabit the edges of rock faces where *P. pauleyi* occur.⁹⁴

⁸⁶ Wooten 2022, pers. comm.

⁸⁷ Felix unpublished data 2022. Hutcheson pers. comm. 2022.

⁸⁸ Rodgers 2001. 1-3.

⁸⁹ *Ibid.*

⁹⁰ *Ibid.*

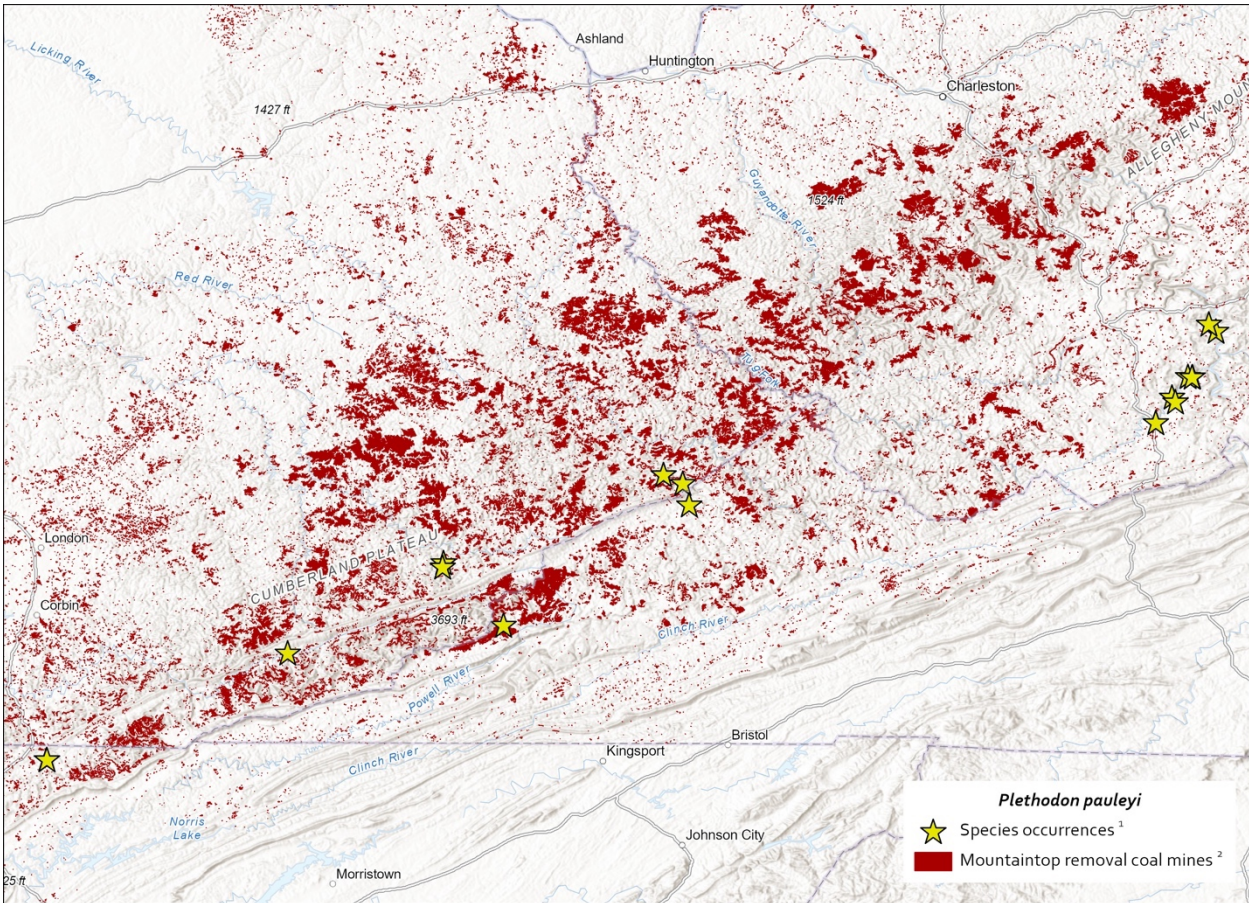
⁹¹ Felix unpublished data 2022. Hutcheson pers. comm. 2022. Wooten pers. comm. 20022.

⁹² *Ibid.*

⁹³ Hutcheson pers. comm. 2022.

⁹⁴ *Ibid.*

Figure 5: Overlap of *P. pauleyi* distribution and Appalachian mining sites



Data Sources:
 1. Zootaxa Vol. 4609 No. 3: 24 May 2019
 2. SkyTruth MTM data

Map by: K. Clauser
 Center for Biological Diversity
 June 8, 2022

Remaining Plethodon pauleyi occurrences (yellow stars) occur in areas heavily affected by mountaintop removal mining (red). Many P. pauleyi populations have likely already been lost.

POPULATION STATUS



Kevin Hutcheson

Plethodon pauleyi persists in 21 sites across Tennessee, Kentucky, Virginia, and West Virginia.⁹⁵ Most of the remaining sites consist of only one or a few individuals and are likely no longer viable.⁹⁶

Most of the 21 remaining occurrences of *P. pauleyi* are on private lands and are currently unprotected.⁹⁷ Eight occurrences of *P. pauleyi* are along roads or near mines and logging sites.⁹⁸

A total of 65 individuals have been observed in the past 20 years. At least two of those individuals and their habitat have been destroyed by mining operations in the past decade.⁹⁹ Last year, a yellow-spotted woodland salamander population was bulldozed by road equipment in Dickenson County, Va.¹⁰⁰ All of Virginia's known populations occur along roads, with some only a few feet from the road's edge.¹⁰¹

⁹⁵ Felix, Wooten, Pierson, and Camp 2019. 442.

⁹⁶ *Ibid.*

⁹⁷ *Ibid.*

⁹⁸ *Ibid.*

⁹⁹ *Ibid.*

¹⁰⁰ Hutcheson pers. comm. 2022.

¹⁰¹ Virginia Department of Wildlife Resources 2021.

Figure 6: Summary of yellow-spotted woodland salamander occurrence and abundance across its four-state Appalachian range

State	Total Known Remaining Sites*	Total Observed Salamanders
West Virginia	8	29
Virginia	7	10
Kentucky	5	18
Tennessee	1	8
Total	21	65

* At least three *P. pauleyi* sites have been destroyed by mining activities and road construction in the past decade.

Coal mining, especially mountaintop removal mining, increased and intensified for most of the past four decades, and 56 new permits for mountaintop removal mining have been issued in the past three years.¹⁰² Many undocumented sites of *P. pauleyi* have likely been lost to industrial mining and logging (see Figure 5).¹⁰³

More *P. pauleyi* salamanders may exist at remaining sites than have been observed, especially since their habitat is often difficult to survey.¹⁰⁴ However, extensive surveying across two decades has yielded few new *P. pauleyi* observations. For the past eight years, intensive surveys have been conducted for the Virginia Department of Conservation and Recreation and the U.S. Forest Service in yellow spotted woodland salamander rock outcrop habitat. Many other salamanders have been observed, but no yellow-spotted woodland salamanders have been found.¹⁰⁵

State-funded surveys in Virginia’s Jefferson National Forest have exhaustively searched shale and sandstone outcrops and identified green salamanders, whose habitat overlaps with that of *P. pauleyi*, but no yellow-spotted woodland salamanders have been observed in any of those surveys.¹⁰⁶ Any remaining *P. pauleyi* are more likely to occur on unprotected privately held lands.¹⁰⁷

Eight known sites are on public lands in New River Gorge National Park and Preserve, Bluestone National River, Pine Mountain Wildlife Management Area, and Lilley Cornett Woods,

¹⁰² Biggers 2021.

¹⁰³ Felix unpublished data. 2022. Hutcheson pers. comm. 2022. Wooten pers. comm. 2022.

¹⁰⁴ Felix pers. comm. 2022.

¹⁰⁵ Dr. Walter Smith pers comm. 2022.

¹⁰⁶ *Ibid.*

¹⁰⁷ *Ibid.*

which provide some level of habitat protection. However, there are likely only 200 - 400 total *P. pauleyi* salamanders across all remaining sites.¹⁰⁸

NatureServe lists *P. pauleyi* as Critically Imperiled in Kentucky.¹⁰⁹ The state of Tennessee also has listed *P. pauleyi* as Critically Imperiled and a Species of Greatest Conservation Need.¹¹⁰ With only 65 individuals observed in the past two decades, the yellow-spotted woodland salamander is critically endangered and in urgent need of immediate protection.

¹⁰⁸ Wooten pers. comm. 2022.

¹⁰⁹ NatureServe 2022.

¹¹⁰ Kentucky Fish & Wildlife 2022; Tennessee Wildlife Resources Agency 2022.

THREATS

The yellow-spotted woodland salamander is threatened by all five factors: habitat destruction, overutilization, disease and predation, inadequacy of existing regulations, and other natural or manmade factors.

1. Present or threatened destruction, modification, or curtailment of habitat or range



Dennis Dimick / Creative Commons

Mining

The yellow-spotted woodland salamander only lives in coal country. All 21 of its remaining occurrences are exclusively on shale and sandstone rock outcrops, which are also targeted by coal mining operations for their coal seams. The only yellow-spotted woodland salamander observed in Virginia was located along a road near an active strip mine.¹¹¹ At least two *P. pauleyi* sites have been destroyed by mining in the past decade.¹¹²

This species' range overlaps nearly identically with the footprint of industrial coal mining and mountaintop removal mining operations in central Appalachia habitat (*see Figure 5*). Many *P. pauleyi* populations have likely already been extirpated by the intensification of surface mining and mountaintop removal mining in the past 40 years. It has already lost significant portions of its range to mining, and it will continue to face destruction, modification, and curtailment of its range for the foreseeable future.

Since 1970, more than two billion tons of coal have come from central Appalachian coalfields.¹¹³ More coal was mined in West Virginia in the past decade than in the 1950s. Mechanization, heavy equipment, and the use of explosives have made coal mining more efficient, less labor intensive, and more environmentally destructive. Over the past three decades, over half of coal

¹¹¹ Hutcheson. pers. comm. 2022.

¹¹² Felix unpublished data. 2022. Hutcheson pers. comm. 2022. Wooten pers. comm. 2022.

¹¹³ Britton-Purdy 2016.

produced in Appalachia has come from mountaintop removal mining—a hyper-efficient mix of explosives, draglines and dozers that undoes hundreds of millions of years of geology in minutes.¹¹⁴

In mountaintop removal mining, miles of forests are clear-cut and denuded. Then mining companies detonate explosives that blast away several hundred feet of mountaintop shale and sandstone to expose layers of coal. Mountaintops are essentially flattened, and the remaining rubble, called overburden, is dumped into valleys and waterways.¹¹⁵

According to the EPA, more than 1.4 million acres of native Appalachian forests have been destroyed and was unlikely to recover on the degraded soils left behind by mountaintop removal mining. Over 2,000 miles of Appalachian streams had been buried by mountaintop removal mining waste, which contains carcinogenic heavy metals that accumulate in aquatic life.¹¹⁶

Using detailed satellite data, Duke University researchers found that forty years of mountaintop coal mining have made parts of Central Appalachia 40 percent flatter than they were before excavation. Other areas have become artificially steeper by blasts and cuts into mountainsides.¹¹⁷

The researchers also estimate conservatively that the volume of blasted rock generated by mountaintop removal mining in central Appalachia is about 6.4 billion cubic meters, which is 32 times the volume of material spewed by Mount Saint Helens in 1980.¹¹⁸ That same amount would cover Manhattan in 240 feet of rubble. The lead author of the study speculated that a fuller accounting of overburden might double or triple their estimate.¹¹⁹ Most of that rubble is dumped into valleys, covering rock outcrops and clogging waterways.

Mountaintop removal mining has destabilized central Appalachian topography, resulting in increased rockslide and landslides.¹²⁰ Rockslides and landslides can instantaneously destroy the limited number of rock outcrops inhabited by the yellow-spotted woodland salamander and other co-occurring salamanders.¹²¹

¹¹⁴ *Ibid.*

¹¹⁵ Appalachian Voices 2017.

¹¹⁶ US EPA 2011.

¹¹⁷ Ross, McGlynn, and Bernhardt 2016.

¹¹⁸ *Ibid.*

¹¹⁹ Britton-Purdy 2021.

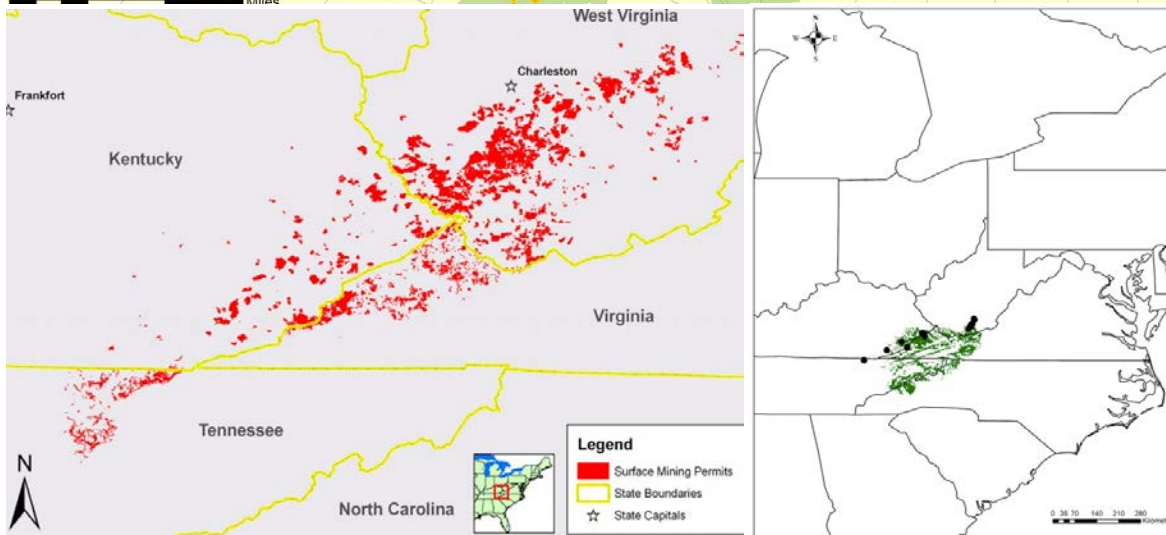
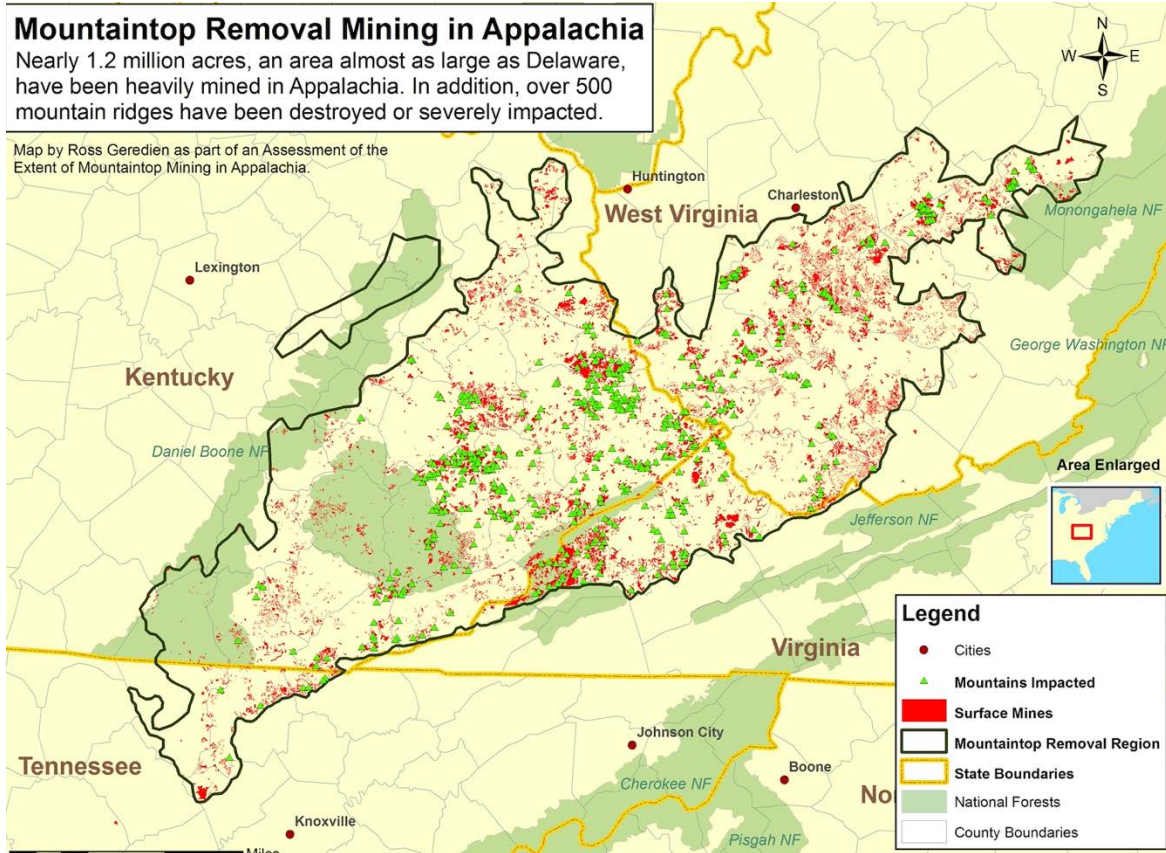
¹²⁰ Wooten 2017. 364–65.

¹²¹ Apodaca pers. comm. 2020.

Mountaintop Removal Mining in Appalachia

Nearly 1.2 million acres, an area almost as large as Delaware, have been heavily mined in Appalachia. In addition, over 500 mountain ridges have been destroyed or severely impacted.

Map by Ross Geredien as part of an Assessment of the Extent of Mountaintop Mining in Appalachia.



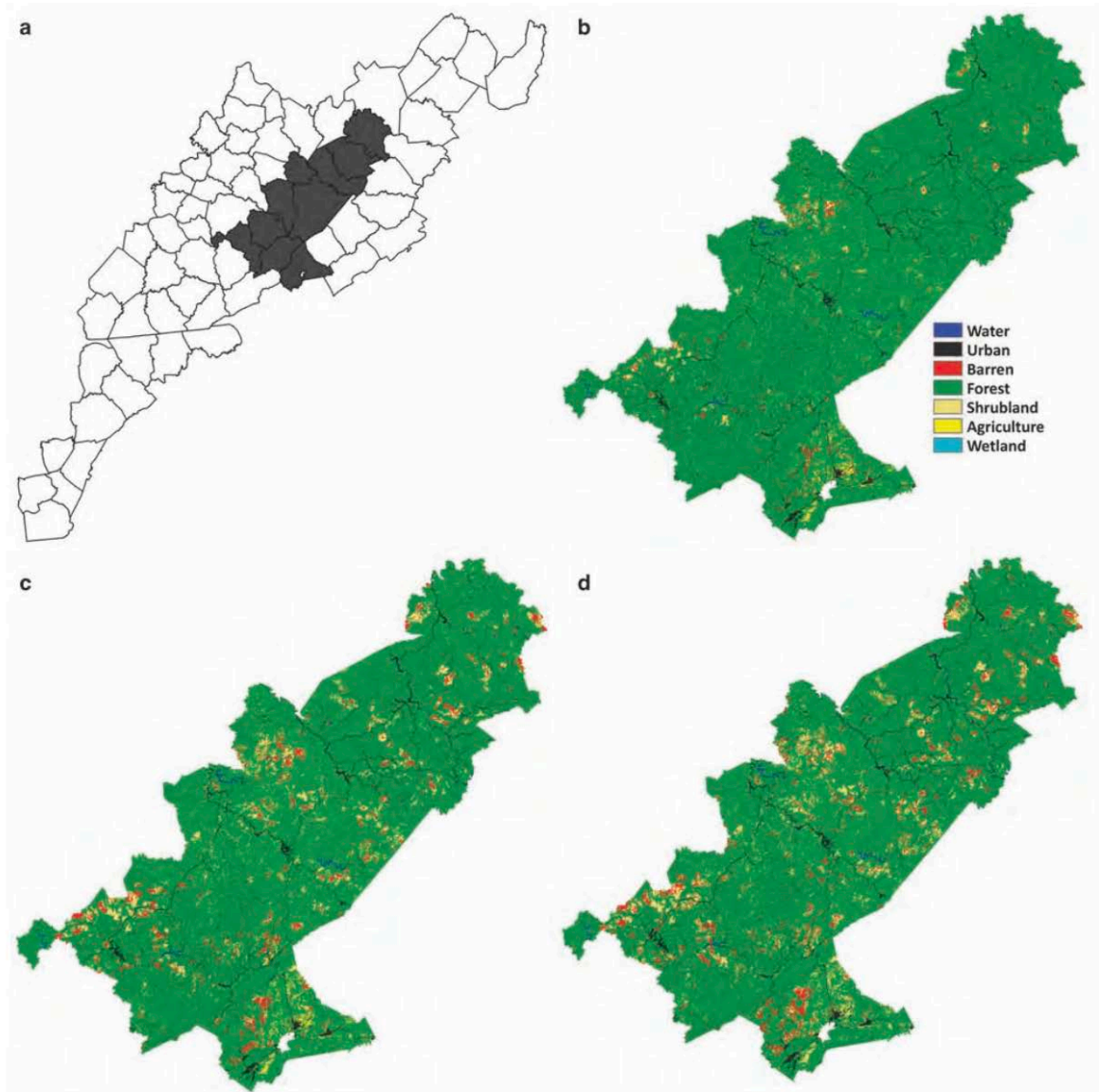
Maps courtesy Appalachian Voices and Dr. Jessica Wooten

Maps of mountaintop removal mining sites (top) and surface mining permits (left) in the Appalachian Plateau overlap strongly with *P. pauleyi* distribution (right).



Vivian Stockman/Southwings

Figure 6: Landcover change in Kentucky, Virginia, and West Virginia from Mining



*Maps show (a) the location of the 10 counties in which mountaintop mining is concentrated, and land cover in those counties in (b) 1992, (c) 2001, and (d) 2006. The increase in barren and shrubland is the result of mountaintop mining, and it has contributed to the forest fragmentation. The analysis is based on the National Land Cover Database (www.mrlc.gov). Maps courtesy of Dr. James Wickham et al. and published previously in *Bioscience* June 2013: “The Overlooked Terrestrial Impacts of Mountaintop Removal Mining.”*

Although economic forces and new energy sources have led to a decline in coal production over the past decade, industrial coal mining continues in Appalachia—and will continue for decades. Appalachia produced more than 150 million tons of coal in 2020. The Appalachian Regional

Commission forecasts an increase in industrial coal production in the next decade due to increased coal exports.¹²² The U.S. Energy Industry Association anticipates industrial coal mining to continue and potentially expand beyond 2050 as overseas markets expand, global population and demand increases, and carbon capture technologies become economically competitive.¹²³

The Appalachian basin accounted for about 40% of the US annual coal production since 1970, and the mountaintop mining region contributes substantially to that total. Coal mining is expected to continue throughout this century.¹²⁴

West Virginia has approved 56 new mining permits since 2018.¹²⁵ In April 2021, West Virginia regulators permitted a new mountaintop removal mining operation on 1,085 acres in Raleigh County near one of the remaining sites where the yellow-spotted woodland salamander is found.¹²⁶

Fewer than 60 individuals of the yellow-spotted woodland salamander cling to 21 remaining sand and shale outcrops across central Appalachia, most of them on private, unprotected lands. Already, much of its rock outcrop habitat has been blasted away and buried by industrial mining. Two known occurrences of *P. pauleyi* in Kentucky have already been destroyed by mining.¹²⁷

Logging and deforestation

The yellow-spotted woodland salamander's closed-canopy forest habitat is also disappearing. *P. pauleyi* depends on the shade, moisture, and protection of mixed mesophytic forests surrounding rock outcrops. Industrial mining, commercial logging, road construction, development, and the clearing of private forests have reduced forest cover across central Appalachia.¹²⁸ Mining has been the dominant land use conversion in central Appalachia contributing to the loss of forests.¹²⁹ Over 5,900 square kilometers of forests in central Appalachia have been destroyed by mining-related activity.¹³⁰ *P. pauleyi* and the entire *wehrlei* species group are negatively affected by the loss of closed canopy forests.¹³¹

Because the yellow-spotted woodland salamander requires shade provided by forest canopies, canopy removal causes the loss or evacuation of the species that use the area.¹³² Studies of the green salamander, which co-occurs with *P. pauleyi* and has similar habitat requirements, show that once an area is deforested, it can take decades for a closing canopy to provide enough shade

¹²² Appalachian Regional Commission 2021.

¹²³ Gordon 2021.

¹²⁴ Milici 2000. 1.

¹²⁵ *Ibid.*

¹²⁶ Tony 2021.

¹²⁷ Felix unpublished data, 2022. Hutcheson pers. comm. 2022.

¹²⁸ Saylor *et al.* 2016. 109-115.

¹²⁹ *Ibid.*

¹³⁰ Pericak *et al.* 2013. 1-2.

¹³¹ Niemiller and Reynolds 2011. 217.

¹³² Snyder 1991. 167.

for the species to recolonize.¹³³ The vegetation on mined sites showed little evidence of forest recovery and is dominated by nonnative grasses and trees for decades.¹³⁴

Mining and logging have resulted in a shift of herpetofauna found on rock outcrops. Herpetofauna have shifted from salamanders on shaded, undisturbed sites to snakes, lizards, and other reptiles on mined sites because of the loss of mixed mesophytic forest conditions.¹³⁵

Mountaintop mining results in both direct forest loss and forest fragmentation. As the number of forest patches increases and the average area of the remaining patches declines, the proportion of the remaining forest that can be classified as *interior* declines, and the proportion of the remaining forest that can be classified as *edge* increases. Edge forests tend to be warmer, drier, and windier than interior forests. They also are more susceptible to invasive species and canopy tree mortality and have higher concentrations of pollutants than interior forests.¹³⁶

Salamander abundance declines in fragmented forests and edge forest habitat. Even 28 years after mining and logging, salamander relative abundance was lower in reclaimed mine sites and edge habitats than in mature forest. Salamander abundance increased in forests with increasing distance from forest edges.¹³⁷

Large-scale logging continues in central Appalachia, fragmenting habitat and further isolating salamander populations.¹³⁸ Logging limits salamander dispersal, decreases leaf litter depth, and reduces canopy cover for *P. pauleyi* salamanders.¹³⁹ Reduced salamander populations have been observed after logging.¹⁴⁰ Logging and clearing activities from construction, transportation, and energy infrastructure are common in the Appalachian Plateau and can have a disproportionately large impact on the species.

Roads

Roads degrade and destroy the yellow-spotted salamander's habitat and result in increased salamander mortality. Just last year, road equipment has bulldozed a yellow-spotted woodland salamander population in Dickenson County, Va.¹⁴¹ All four of Virginia's remaining *P. pauleyi* sites occur adjacent to roads, with some occurrences only a few feet from the road's shoulder.¹⁴²

Mining roads, logging roads, and an expanding network of vehicle roads and highways in Appalachia have fragmented otherwise continuous forested habitat.¹⁴³ Roads also fragment

¹³³ Snyder 1991. 167.

¹³⁴ Wickham 2013.

¹³⁵ Wood *et al.* 2001.

¹³⁶ Weathers *et al.* 2001. Harper *et al.* 2005.

¹³⁷ Williams 2003.

¹³⁸ Corder 2001. 24.

¹³⁹ Clipp and Anderson 2014. 2687.

¹⁴⁰ *Ibid.*

¹⁴¹ Hutcheson pers. comm. 2022.

¹⁴² Virginia Department of Wildlife Resources 2021.

¹⁴³ Semlitsch *et al.* 2006. 160.

interior forests and create more edge forests, which result in unsuitable habitat along their boundaries.¹⁴⁴ Soil moisture, shade, and cover tend to decrease near roads, increasing the risk of desiccation and predation.¹⁴⁵

The Appalachian Development Highway System is a 3,090-mile network of roads and highways in central Appalachia connecting rural communities to the interstate system. Two of its priority corridors—Corridors G and I—are located within a few kilometers of yellow-spotted woodland salamander habitat.¹⁴⁶ Construction of this rural highway network has begun, and earlier this year, the U.S. Department of Transportation received \$1.2 billion in additional funding for these roads and highways, an increase of 146%.¹⁴⁷

More roads and highways will fracture the habitat of *P. pauleyi* and further isolating this rare Appalachian endemic. Population sizes are already extremely low in the 21 remaining occurrences of *P. pauleyi*, which may be impairing the species' genetic fitness. Most of the remaining populations consist of only one or a few individuals. Roads further fragment and isolate salamander populations, leading to inbreeding depression, loss of genetic connectivity, reduced gene flow, and ultimately local extirpations and species extinction.¹⁴⁸

Road mortality has been documented in the co-occurring green salamander, which shares habitat with the yellow-spotted woodland salamander in central Appalachia. Green salamanders experience significant road mortality crossing roads during the post-hibernation migration from their hibernation crevices.¹⁴⁹

Road mortality may be particularly detrimental to species with slow reproductive rates and low juvenile recruitment such as *P. pauleyi*. Female yellow-spotted woodland salamanders breed biannually and lay as few as six eggs.

Roads, mining, and logging are annihilating yellow-spotted woodland salamander habitat across the Appalachian Plateau. Kentucky Department of Fish & Wildlife and Tennessee Wildlife Resources Agency note that *P. pauleyi* occurs in a region where logging and surface mining are common. *P. pauleyi* is listed as Critically Imperiled in Kentucky and Tennessee.¹⁵⁰ Habitat loss is the greatest threat to this species. Without Endangered Species Act listing and critical habitat designation, the yellow-spotted woodland salamander faces imminent extinction.

¹⁴⁴ Marsh and Beckman 2004; Clipp and Anderson 2014. 2690.

¹⁴⁵ Clipp and Anderson 2014. 2690.

¹⁴⁶ ARC 2022.

¹⁴⁷ US DOT 2022.

¹⁴⁸ Clipp and Anderson 2014. 2690.

¹⁴⁹ Cupp 1991. 173.

¹⁵⁰ Felix, Wooten, Pierson, and Camp 2019. 442.

2. Overutilization



Bryce Wade

Given their rarity and unique appearance, yellow-spotted woodland salamanders are also threatened by poachers collecting them from the wild for the pet trade. Overcollection has been identified as a likely contributing factor in the sharp decline of green salamanders (*Aneides aeneus*), which co-occur with yellow-spotted woodland salamanders.¹⁵¹

The rarity of the yellow-spotted woodland salamander makes it more difficult to collect. However, poaching even one or two *P. pauleyi* salamanders results in a significant impact to this species. And many *P. pauleyi* occurrences are easily accessible along roadsides. All of Virginia's remaining occurrences are adjacent to roads.¹⁵²

Virginia Department of Wildlife Resources identifies pet trade poaching as a significant threat to salamanders in Appalachia.¹⁵³ The demand for salamanders and other amphibians in the United States is at an all-time high, and the U.S. is the largest importer and exporter of amphibians worldwide.¹⁵⁴ According to the U.S. Fish and Wildlife Service, "The illegal trade of endangered salamanders, especially the prettiest and most brightly colored species, has been going on for

¹⁵¹ Corser 2001. 119; Snyder 1991. 176.

¹⁵² Virginia Department of Wildlife Resources 2021.

¹⁵³ Virginia DWR 2021.

¹⁵⁴ Herrell 2014. 104.

years — and the U.S. is a hot spot for the illegal market.”¹⁵⁵ Yellow-spotted woodland salamanders—along with the green salamanders with whom they share rock outcrop and arboreal habitat—are prime targets for poachers.¹⁵⁶

¹⁵⁵ Ossola 2016.

¹⁵⁶ Corser 2001. 119.

3. Disease and predation

Disease

The yellow-spotted woodland salamander is especially vulnerable to parasitic, viral, and fungal diseases including Ranavirus, *Batrachochytrium dendrobatidis* (*Bd*), and *Batrachochytrium salamandrivorans* (*Bsal*).

B. magnavulvaris

The yellow-spotted woodland salamander, along with the other *wehrlei* species— is known to host the protozoan endoparasite *Batracholandrois magnavulvaris*. This intestinal nematode infected half of all *P. wehrlei* individuals in a 2001 study. Research in 2021 found that 15 percent of captive salamanders died from gastrointestinal parasites.¹⁵⁷

Ranavirus

Disease caused by Ranavirus are responsible for amphibian die-offs throughout North America, including the southeastern United States, and may contribute to population declines.¹⁵⁸ Ranavirus has been detected in the co-occurring green salamander (*A. aeneus*) in Virginia.¹⁵⁹

Batrachochytrium dendrobatidis (*Bd*)

Chytridiomycosis, the disease caused by *Bd* (or amphibian chytrid fungus), has also caused amphibian declines and extirpations worldwide.¹⁶⁰ Infection rates of *Bd* vary throughout the Southeastern United States, with 17 species of plethodontid salamanders testing positive for *Bd* in recent studies.¹⁶¹ *Bd* is believed to have played a role in the declines of plethodontid salamanders in Central America, and it has been shown to be lethal to plethodontid salamanders in the western United States.¹⁶² *Bd* has been detected in the co-occurring green salamander (*A. aeneus*) in Virginia, which could easily transmit the virus to *P. pauleyi*.¹⁶³

Batrachochytrium salamandrivorans (*Bsal*)

All salamanders in the United States are threatened by the potential introduction of *Bsal*, a highly pathogenic chytrid fungus originating in Asia that was recently discovered as a novel cause of the amphibian disease chytridiomycosis.¹⁶⁴ The invasion of *Bsal* into North America could lead to rapid epizootic declines and extinctions of salamanders, as there are no effective means of

¹⁵⁷ Hallinger 2021.

¹⁵⁸ Hoverman *et al.* 2012. 36–37.

¹⁵⁹ Blackburn *et al.* 2015. 357.

¹⁶⁰ Lips *et al.* 2006. 3165; Blackburn *et al.* 2015. 357.

¹⁶¹ Blackburn *et al.* 2015. 357.

¹⁶² Lips *et al.* 2006; Blackburn *et al.* 2015. 357.

¹⁶³ Blackburn *et al.* 2015. 357.

¹⁶⁴ Martel *et al.* 2013. 15325.

controlling its spread once it is established in wild populations.¹⁶⁵ This disease caused a dramatic mortality event in fire salamanders (*Salamandra salamandra*) in the Netherlands, and it has already spread to Belgium.¹⁶⁶ There is also evidence of its spread in international trade and a high risk of *Bsal* introduction into the United States.¹⁶⁷ *Bsal* has not yet been reported in the United States, but published predictive models of *Bsal* host vulnerability in North America identified Appalachia as a zone of high risk.¹⁶⁸ Infection experiments show that the yellow spotted woodland salamander's family—Plethodontidae—is the second-most susceptible family to *Bsal*.¹⁶⁹

Predation

The yellow-spotted salamander depends on shaded rock outcrops surrounded by closed canopy forests. Mining and logging have removed nearly 6,000 square miles of forest across the Appalachian Plateau, creating more edge habitat and favorable rock outcrop conditions for predators of the yellow-spotted woodland salamander.¹⁷⁰ Edge forests tend to be warmer, drier, and windier than interior forests, and they also are more susceptible to invasive species.¹⁷¹ Edge forests created by logging and mining also shift the herpetofauna of a rock outcrop from predominantly salamanders to primarily reptiles as a result of the loss of mixed mesophytic conditions.¹⁷²

As a result, yellow-spotted woodland salamanders face increasing predation from snakes, especially as surrounding forests are clear-cut and rock outcrops become increasingly exposed. Northern ring-necked snakes, common garter snakes, and juvenile black rat snakes are opportunistic predators that can occupy exposed rock outcrop habitats and prey upon yellow-spotted woodland salamanders.¹⁷³ More rock outcrop exposure from mining and logging activity also leaves *P. pauleyi* eggs more vulnerable to predators.¹⁷⁴

¹⁶⁵ Yap *et al.* 2015. 481.

¹⁶⁶ Martel *et al.* 2013. 15325; Burke 2015. 6.

¹⁶⁷ Cunningham *et al.* 2015. 468.

¹⁶⁸ Yap *et al.* 2015. 481.

¹⁶⁹ Martel *et al.* 2014. 630.

¹⁷⁰ Pericak *et al.* 2013. 1.

¹⁷¹ Wood and Williams 2013. 815.

¹⁷² *Id.* 817-18.

¹⁷³ Brodman 2004. 2-4.

¹⁷⁴ *Ibid.*

4. Inadequacy of existing regulations

Existing international, federal, regional, state, and local regulatory mechanisms are inadequate to protect against threats to the yellow-spotted woodland salamander, which include habitat destruction, degradation, and fragmentation from industrial mining, logging, and roads; poaching; disease; predation; pollution; landslides; invasive species; recreational impacts; and climate change. These existing mechanisms have not slowed or prevented the decline of the species from the individual and combined impact of these ongoing threats.

National Environmental Policy Act

The National Environmental Policy Act and federal regulatory mechanisms are inadequate to protect the yellow-spotted woodland salamander from extinction. NEPA requires federal agencies to analyze the effects of their actions on the environment through environmental assessments and environmental impact statements. These analyses include adverse impacts to rare and imperiled species and habitats, and potential alternative actions that may be less adverse.¹⁷⁵ However, NEPA ultimately contains no substantive requirements that would require federal agencies to choose less adverse alternatives. In most cases, development that destroys the yellow-spotted woodland salamander's habitat is not subject to NEPA because of a lack of a federal nexus. Accordingly, NEPA does not guarantee that the yellow-spotted woodland salamander or its habitat will be protected from adverse federal actions.

Surface Mining Control and Reclamation Act

The Surface Mining Control and Reclamation Act (SMCRA) is the primary federal law regulating coal mining's impact on lands and waters. The Act's provisions are enforced by the Office of Surface Mining Reclamation and Enforcement (OSMRE) and state agencies.¹⁷⁶

SMCRA requires mining companies to avoid impacts to federally listed species. However, because the yellow-spotted woodland salamander is not yet federally listed, it is not afforded any specific protections.

SMCRA also requires mining companies to restore lands to a condition capable of supporting the uses it could support before mining, or to "higher or better uses."¹⁷⁷ Mining companies must also:

1. restore the approximate original contour of the land by backfilling, grading, and compacting;
2. minimize disturbances to the hydrologic system by avoiding acid mine drainage and preventing additional contributions of sedimentation to nearby streams and other water bodies;

¹⁷⁵ 42 U.S.C. §§ 4321.

¹⁷⁶ *Ibid.*

¹⁷⁷ *Ibid.*

3. reclaim the land as soon as practicable after the coal has been extracted, and even as the mining operation moves forward; and
4. establish a permanent vegetative cover in the affected area.¹⁷⁸

Unfortunately, the law has many shortcomings and loopholes. As a result, problems with mine reclamation have persisted since its passage in 1977. Nearly four decades since SMCRA was enacted, the on-the-ground implementation and enforcement of this important law is almost nonexistent.¹⁷⁹ SMCRA creates misaligned incentives for both the regulating agency and industry. These misaligned incentives leave open the possibility for reclamation to be inadequate or absent altogether.¹⁸⁰

Stream buffer rules surrounding mines, especially for mountaintop removal sites, are often not enforced.¹⁸¹ SMCRA requires all mining operations to be bonded to ensure adequate funds are available for site reclamation. Unfortunately, mining companies—along with state and federal regulators—frequently fail to accurately assess the costs of reclamation when securing reclamation bonds. Regulators also allow operators to use financial instruments that don't provide adequate funds. As a result, taxpayers are often left paying for the cost of reclamation, or the land remains barren and scarred for decades, and the streams continue to be poisoned by polluted mine runoff.¹⁸²

Even when reclamation occurs, in most cases, it fails to meet the minimum standards set forth by SMCRA. Most reclamation has consisted of seeding primarily nonnative grasses over a flattened, heavily compacted, denuded landscape with extremely degraded soils.¹⁸³ Highly diverse central Appalachian montane forests and rock cliffs are obliterated and not restored.¹⁸⁴

There are more than 48,529 abandoned mines in the United States, according to the enhanced Abandoned Mine Lands Inventory maintained by the Office of Surface Mining (OSM).¹⁸⁵ However, most haven't even been mapped, and according to Department of the Interior, there are as many as 500,000 abandoned mines the U.S.¹⁸⁶ There are nearly 5,200 coal-related abandoned mine sites that have yet to be fully reclaimed, amounting to an estimated \$3 billion worth of health and safety problems and more than \$2 billion of general welfare, environmental and non-coal problems.¹⁸⁷

SMCRA lacks adequate funding, personnel, and enforcement. As a result, species residing on or near abandoned mines are not protected.¹⁸⁸ SMCRA also does not provide any protections for yellow-spotted woodland salamanders or their existing shale and sandstone rock outcrop habitat.

¹⁷⁸ Squillace 2009.

¹⁷⁹ NRDC 2015. 5.

¹⁸⁰ Yonk 2019. 3.

¹⁸¹ Copeland 2005. 3-5.

¹⁸² Dixon 2021. 19-21.

¹⁸³ Acton *et al.* 2011. 10266.

¹⁸⁴ Zipper *et al.* 2011. 752-753.

¹⁸⁵ SkyTruth 2015.

¹⁸⁶ Federal Mining Dialogue 2021.

¹⁸⁷ *Ibid.*

¹⁸⁸ *Ibid.*

SMCRA permits the continued destruction of yellow-spotted woodland salamanders and their habitat.

Clean Water Act

Section 404 of the Clean Water Act regulates the discharge of dredge or fill material into the waters of the United States. In coal mining operations, this includes discharges of rock and soil into streams and wetlands as part of valley fills.¹⁸⁹

The U.S. Army Corps of Engineers and the U.S. EPA are responsible for administering section 404. Section 404 requires that project proponents obtain a permit before undertaking activities in the waters of the United States that involve dredge or fill material. However, most permits are issued, and the Corps and EPA lack funding, personnel, and enforcement of permit provisions.¹⁹⁰ There has not been a single documented instance of successful recovery of stream function following reclamation in a stream affected by mountaintop mining.¹⁹¹

In addition, Section 404 of the Clean Water Act does not prohibit or protect shale and sandstone rock faces from mining operations. Under the CWA section 404 program, destruction of yellow-spotted woodland salamander habitat continues to be authorized.¹⁹²

National Forest Management Act and 2012 Planning Rule

The National Forest Management Act (NFMA) of 1976 regulates the multiple uses of the nation's forests including to "provide for diversity of plant and animal communities..." (g)(3)(B). Additional requirements for forest management based on NFMA state that to comply with ecosystem integrity and diversity requirements the plan must "...maintain the diversity of plant and animal communities and support the persistence of most native species in the plan area."¹⁹³

The 2012 Planning Rule strengthened this law by requiring national forest plans "to provide the ecological conditions necessary to contribute to the recovery of threatened and endangered species, and to conserve candidate and proposed species."¹⁹⁴ Forest plans are also required to be more adaptive, science-based, and developed with a stronger level of public involvement. They also are to consider climate change, landscape-scale restoration, and ecosystem services, among other values that are to be more formally integrated into a more efficient and responsive planning framework.¹⁹⁵

¹⁸⁹ U.S. EPA 2022.

¹⁹⁰ Evans *et al.* 2021. 11.

¹⁹¹ Bernhardt and Palmer 2011. 39.

¹⁹² Wickham 2013. 335.

¹⁹³ See Section 219.9 of the National Forest Management Act.

¹⁹⁴ 36 CFR §219.15.

¹⁹⁵ Nie 2018.

Unfortunately, the National Forest Management Act and the 2012 Planning Rule are inadequate for the conservation of the yellow-spotted woodland salamander because only one *P. pauleyi* site occurs in a national forest. The site in Jefferson National Forest contains only a single known individual. Most *P. pauleyi* occurrences are on private lands. In addition, *P. pauleyi* on national forest lands remain vulnerable to the impacts of timber harvests, mining, pipelines, oil and gas drilling, and road construction, which are all permitted in the Jefferson National Forest.

National Park Service Organic Act

The Organic Act of 1916 established the National Park Service as an agency under the Department of the Interior with the purpose of promoting uses of national park lands while protecting them from impairment.¹⁹⁶ Two amendments to the Organic Act in 1970 and 1978 united national parks under a single system and further directed the Park Service to manage parks in a way that would not degrade park values.¹⁹⁷ However, the Organic Act provides broad discretion to the National Park Service in developing management policies and regulations. Each individual unit develops specific management policies suited to its park uses and resources.¹⁹⁸

P. pauleyi have been found in the New River Gorge National Park and Preserve, the country's newest national park. The New River Gorge National Park was previously a National River managed by the National Park Service since 1978. Recreational rock climbing is one of the most popular activities in the New River Gorge. The sandstone cliffs of the New River Gorge are home to over 1,400 established routes. The New River Gorge is the most extensive and popular climbing destination east of the Mississippi.¹⁹⁹

The impacts of rock climbing on rock outcrop species such as the yellow-spotted woodland salamander are significant (*see Other Natural or Manmade Factors: Recreation*). Climbers often “clean” routes by removing moss, lichen, and other vegetation from the rock faces. They destroy or modify rock crevices inhabited by salamanders and insert bolts and anchors in these crevices. Climbers and hikers also inadvertently trample salamanders sheltering in the talus beneath rock faces. Yellow-spotted woodland salamanders have been found in the loss scree beneath rock outcrops.²⁰⁰

Management policies in the New River Gorge promote recreational rock climbing and visitation to the detriment of yellow-spotted woodland salamanders and their habitat.

Convention on International Trade in Endangered Species

CITES is an international agreement between governments aimed at ensuring the international trade in wildlife and plants does not threaten the survival of species through trade monitoring and regulation. The yellow-spotted woodland salamander is not currently listed under the CITES

¹⁹⁶ 16 U.S.C. §1.

¹⁹⁷ Pub. L. 95-250, Title I, §101(b), Mar. 27, 1978, 92 Stat. 166 1.

¹⁹⁸ U.S. DOJ 2015.

¹⁹⁹ Verbeck 2019.

²⁰⁰ Hutcheson pers. comm. 2022.

appendices and therefore does not receive any protection. CITES also does not address domestic poaching and trafficking, or other threats such as habitat destruction and degradation that threatens the species.

Appalachian Regional Reforestation Initiative

The Appalachian Regional Reforestation Initiative was established in 2004 with the primary objective of encouraging surface mine reforestation through a method called the Forestry Reclamation Approach (FRA). The FRA is a series of field-tested guidelines directed at establishing and advancing forest succession on mined lands.²⁰¹ Despite advances in the reforestation of reclaimed mine sites brought about by the Appalachian Regional Reforestation Initiative, there are several thousands of hectares of mined sites reclaimed prior to the establishment of the FRA where reforestation has not occurred. It is estimated that there are more than 300,000 hectares (741,000 acres) across the eastern United States where reforestation on reclaimed mine sites has not occurred or met expected outcomes.²⁰²

State Regulatory Mechanisms

Kentucky

One of the 21 remaining *P. pauleyi* occurrences is found on state lands in the Hensley-Pine Mountain Wildlife Management Area. Timber harvests and active management occurs in this area.²⁰³

One population of *P. pauleyi* occurs in Lilley Cornett Woods, owned by Eastern Kentucky University. This 660-acre forest is registered with the Department of the Interior as a Natural Landmark. Over 250 acres of Lilley Cornett Woods is old-growth forest. It is also home to the Lilley Cornett Woods Appalachian Ecological Research Station. Scientific research is the primary use of Lilley Cornett Woods. Hunting and the collection of plants and animals are prohibited. This population is well-protected currently, but the property was previously owned by the Kentucky Division of Forestry, which prioritizes active timber management.

P. pauleyi is critically imperiled in Kentucky. The state natural heritage area program identifies surface mining, timber harvests, and habitat and population fragmentation as its primary threats.²⁰⁴ The yellow-spotted woodland salamander is also identified in Kentucky's Conservation Wildlife Conservation Strategy as a Species of Greatest Conservation Need.²⁰⁵ However, there are no legally actionable state-level mechanisms or enforcement measures to protect yellow-spotted woodland salamander populations or their habitat in Kentucky.

²⁰¹ Zipper *et al.* 2011. 752.

²⁰² *Ibid.*

²⁰³ Kentucky Department of Game and Inland Fisheries 2022.

²⁰⁴ NatureServe 2022.

²⁰⁵ Kentucky's Comprehensive Wildlife Conservation Strategy 2013.

West Virginia

One of the 21 remaining *P. pauleyi* occurrences is in Pipestem Resort State Park. The type specimen for the yellow-spotted woodland salamander originated in this location.²⁰⁶ While state parks are often protected areas for rare species, Pipestem Resort State Park is one of the most developed and most visited state parks in the region. Pipestem Resort State Park includes two hotels, a golf course, and an aerial tramway to the bottom of the gorge.

In 2018, West Virginia Governor Jim Justice proposed SB 270, a bill that would allow logging in Pipestem Resort State Park and all West Virginia State Parks.²⁰⁷ The bill was supported by the West Virginia Department of Natural Resources. Governor Justice remains in office and supporters have pledged to reintroduce a similar bill.²⁰⁸

Virginia

The yellow-spotted woodland salamander has been observed in five locations in Virginia—all along roadways. Some occurrences are on rock outcrops less than six feet from the road. At least one *P. pauleyi* population in Virginia has already been destroyed by road construction. No state laws or regulations protect the yellow-spotted woodland salamander in Virginia.

Tennessee

The yellow-spotted woodland salamander has only been observed in two locations in Tennessee, and one of those locations is on private land. The Tennessee Wildlife Resources Agency has listed *Plethodon pauleyi* as Critically Imperiled.²⁰⁹ The yellow-spotted woodland salamander is also identified in Tennessee's Wildlife Action Plan as a Species of Greatest Conservation Need.²¹⁰ However, there are no legally actionable state-level mechanisms or enforcement measures to protect yellow-spotted woodland salamander populations or their habitat in Tennessee.

²⁰⁶ Felix, Wooten, Pierson, and Camp 2019. 444.

²⁰⁷ Steelhammer 2018.

²⁰⁸ Lawrence 2018.

²⁰⁹ TWRA 2015.

²¹⁰ *Ibid.*

5. Other natural or manmade factors

Climate change

The yellow-spotted woodland salamander is highly vulnerable to climate change Barrett et al. modeled the climate change vulnerabilities of 21 high-priority amphibian species in the southeastern U.S. and forecasted that the yellow-spotted woodland salamander and other *wehrlei* species salamanders could lose 93% of its climatically suitable habitat by 2050 compared to 2011.²¹¹

Regions in the Appalachian Mountains are projected to experience particularly high losses of climatically suitable habitat.²¹² Because the yellow-spotted woodland salamander is a higher altitude microhabitat specialist, it is particularly vulnerable to climate change effects on its habitat because it has few alternative options available for migration.²¹³ Its vulnerability is compounded by its low dispersal.²¹⁴

Climate change is expected to affect amphibians at the individual and population levels through a number of pathways including shifts in phenology and range; habitat alterations including changes in hydrology, vegetation, and soil; changes in pathogen-host dynamics, predator-prey relationships and competitive interactions which can alter community structure; and interactions with other stressors such as UV-B radiation and contaminants, all of which can affect survival, growth, reproduction and dispersal capabilities.²¹⁵

As ectothermic animals, salamanders such as *P. pauleyi* are strongly influenced by the external environment, particularly temperature and moisture.²¹⁶ Climate change has also been implicated in stimulating the emergence of infectious amphibian diseases at the local and global scale. Increases in climate variability and extreme weather events resulting from climate change appear to provide an advantage to pathogens, such as chytridiomycosis (chytrid fungus), which is driving amphibian declines worldwide.²¹⁷

Yellow-spotted woodland salamanders and other plethodontids are particularly vulnerable to changes in temperature and precipitation. Another rock outcrop habitat specialist that co-occurs with the yellow-spotted woodland salamander—the green salamander (*Aneides aeneus*)—experienced a significant population crash in the 1980s that may have been caused drought or unusually low winter temperatures that persisted for unusually long periods of time.²¹⁸ The effects of these population crashes have persisted for decades, and green salamander populations have never fully recovered.²¹⁹ If drought periods were prolonged enough, they could have

²¹¹ Barrett et al. 2014. 287.

²¹² *Id.* 290–292.

²¹³ Böhm et al. 2016. 3-4.

²¹⁴ *Id.* 4-5.

²¹⁵ Wright et al. 2015. 579-580.

²¹⁶ Carey and Alexander 2003. 113.

²¹⁷ *Ibid.*

²¹⁸ Snyder 1991. 168.

²¹⁹ Apodaca pers. comm. 2020.

eliminated any refuge microhabitats.²²⁰ Climate change may increase the incidence of drought and severe weather episodes, creating synergistic negative effects on the yellow-spotted woodland salamander and its rock outcrop and forest habitat.²²¹

Invasive species

Surface coal mining sites in Appalachia are among the most disturbed landscapes in North America.²²² Acidic soils, abundant precipitation, and extremely high levels of disturbance with heavy equipment make the Appalachian Plateau a haven for nonnative invasive species.²²³ Species including multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), autumn olive (*Eleagnus umbellata*), kudzu (*Pueraria montana*), and Chinese privet (*Ligustrum sinense*) can drastically change the ecosystem by outcompeting native species. Yellow-spotted woodland salamanders occur exclusively in areas targeted by industrial mining and clear-cut logging operations. These heavily disturbed sites are the first places that nonnative invasive species take hold and spread.²²⁴

A single multiflora rose bush can produce up to one million seeds per year, and the fruits remain viable for 20 years. Besides seed dispersal by birds, vegetative spread is also common. *Rosa multiflora* is tolerant to various soils, moisture, and light conditions, and can be found in open woodlands, forest edges and areas that have experienced disturbance.²²⁵

Japanese barberry is also commonly found on or near Appalachian mining sites. *Berberis thunbergii* is a dense spiny shrub that was introduced from Japan as an ornamental plant. Its seeds are dispersed by birds and mammals, although expansion through vegetative growth is also common. *Berberis thunbergii* can tolerate both shade and drought and proliferates on disturbed mining sites.²²⁶

Autumn olive is one of the most frequently encountered invasive species at industrial mining sites in Appalachia.²²⁷ *Eleagnus umbellata* is a deciduous shrub with sharp thorns and red berries that each contain thousands of seeds dispersed by birds and small mammals. Autumn olive can tolerate drought and erosion better than most native species in Appalachia and can proliferates rapidly.²²⁸

Industrially mined sites contained more than twice the number of invasive plant species compared to continually forested sites.²²⁹ Calinger *et al.* found that coal mine sites are

²²⁰ Snyder 1991. 168.

²²¹ *Ibid.*

²²² Oliphant 2017. 179.

²²³ Wickham 2013. 342.

²²⁴ *Ibid.*

²²⁵ Amrine 2002. 265.

²²⁶ Silander 1999. 189.

²²⁷ Oliphant 2017. 179-180.

²²⁸ *Ibid.*

²²⁹ *Ibid.*

significantly more likely to have invasive species than sites continuously forested.²³⁰ Strip mining, including mountaintop removal mining, creates a window of opportunity for the introduction and proliferation of invasive species.²³¹ In many instances, mountaintop removal sites are seeded with nonnative species as part of reclamation efforts. Autumn olive (*Eleagnus umbellata*) is often planted at mine reclamation sites because of its ability to spread quickly and grow under harsh conditions.²³²

Roads also increase the abundance and prevalence of invasive plant species.²³³ Multiflora rose is especially more abundant along roads that have fragmented interior forests and created more edges, which increase light and temperature and decrease soil moisture. Roads also provide corridors and vectors for dispersal of invasive species.²³⁴

Yellow-spotted woodland salamanders occur exclusively on shale and sandstone outcrops and adjacent forests that have been targeted for decades by strip mining in Appalachia. Invasive species in these heavily disturbed landscapes provide a compounding threat to the survival of the few remaining yellow-spotted woodland salamanders.

Pollution

Yellow spotted woodland salamanders occur exclusively in one of the most degraded and heavily polluted regions in the country.²³⁵ Industrial coal mining—and the accompanying clear-cut logging, road construction, and the filling of river valleys with overburden—have resulted in massive air and water pollution across the Appalachian Plateau.

Mountaintop mining in Appalachia has led to a permanent loss of headwater streams, often near yellow-spotted woodland salamander habitat.²³⁶ There are no documented cases of recovery in streams affected by mountaintop mining.²³⁷

Coal mining also alters the hydrological characteristics and degrades the biological composition of the streams in the region. The overburden deposited in adjacent valleys buries headwater streams.²³⁸ Mine-affected streams also have high selenium concentrations, which can bioaccumulate and produce toxic effects in amphibians, including reproductive failure, physical deformity, and mortality.²³⁹

²³⁰ Calinger 2015. 2-3.

²³¹ *Ibid.*

²³² *Ibid.*

²³³ *Id.* 12-13.

²³⁴ *Id.* 2.

²³⁵ Oliphant 2017. 180.

²³⁶ U.S. EPA 2011.

²³⁷ Wickham 2013. 335-336.

²³⁸ U.S. EPA 2011.

²³⁹ Wood 2013. 815.

In the headwaters of yellow-spotted woodland salamander habitat, heavy metals like lead, copper, aluminum, and manganese exceed toxicity thresholds for miles downstream. Salamanders are especially vulnerable to water pollution and depend on pristine headwaters for survival. Streams from heavily mined watersheds harbor 40 percent fewer species than streams with cleaner water.²⁴⁰ Streams filled with mining overburden averaged about half as many species of salamanders, and far fewer individual salamanders, as the undisturbed streams.²⁴¹

Even after mines are no longer operational, the release of alkaline mine drainage from weathering of rock and site waste at mine sites elevates conductivity and concentrations of metallic ions that negatively impact aquatic biota, leading to decreases in aquatic biodiversity.²⁴² Additionally, pollutants can be transferred across food webs to terrestrial ecosystems, where they can directly affect yellow-spotted woodland salamanders and their habitat.²⁴³

Acid precipitation may represent a serious threat to *P. pauleyi*. Amphibians like the yellow-spotted woodland salamander are particularly sensitive to direct and indirect effects of acid precipitation because adults are high in the food chain and amphibian skin is highly permeable to toxic substances.²⁴⁴ Embryos and larvae are also particularly sensitive to developmental effects from acid precipitation.²⁴⁵ Salamanders appear to be vulnerable to declines and mortality from the effects of acid precipitation.²⁴⁶ Yellow-spotted woodland salamanders' rock outcrop habitat is especially affected by acid precipitation,, which can accelerate the weathering of calcareous rock like limestone that is often found in *P. pauleyi* outcrops.

The yellow-spotted woodland salamander is also vulnerable to pollution from roads and the use of heavy machinery, including heavy metal contamination from tires, gasoline, motor oil, and subsequent residues; de-icing products; vehicle emissions; and herbicide applications.²⁴⁷ High skin permeability exacerbates the susceptibility of amphibians to the alteration of microhabitat conditions on roads and in adjacent habitats.²⁴⁸ Toxic chemicals emitted from vehicles and compounds used in mining operations and related use of heavy machinery and road construction may act as endocrine disruptors in amphibians, reducing reproductive abilities and survivorship.²⁴⁹

Recreation

Recreational activities in the Appalachian Plateau can cause destruction of yellow-spotted woodland salamander habitat. The greatest contemporary impacts to *P. pauleyi* and other cliff biota are recreational activities such as hiking and rock climbing.²⁵⁰ Climbers can degrade rock

²⁴⁰ Simonin 2021; Wood 2013. 815-816.

²⁴¹ Muncy *et al.* 2014. 115.

²⁴² Evans 2021. 7.

²⁴³ *Ibid.*

²⁴⁴ Pierce 1993. 66.

²⁴⁵ *Ibid.*

²⁴⁶ Pough and Wilson 1997. 531.

²⁴⁷ Andrews *et al.* 2006. 13, 49–51.

²⁴⁸ *Ibid.*

²⁴⁹ Andrews *et al.* 2006. 13.

²⁵⁰ Clark and Hessel 2015. 1-2.

face ecosystems by removing soils and vegetation on cliff faces, introducing exotic species, and disturbing wildlife.²⁵¹ One of the country's most popular climbing spots is the New River Gorge, which is also home to the yellow-spotted woodland salamander. Climbers are likely causing some level of degradation to the rock outcroppings inhabited by the salamander by cleaning rocks, removing vegetation, and covering rocks with chalk.²⁵²

Recreational activities within the yellow-spotted woodland salamander's range are increasing. More than 1.7 million recreational users visited the New River Gorge in 2021, and it expects at least a 20 percent increase in the next decade.²⁵³ Yellow-spotted woodland salamanders are often found in the loose shale scree below steep rock outcrops, and hikers may inadvertently crush salamanders underfoot in the talus.

Recreation is also surging along Pine Mountain, which now hosts a 100-mile trail race and the country's newest long-distance hiking trail, the 120-mile Pine Mountain Trail.²⁵⁴ Rock climbers also flock to Pine Mountain for some of the region's most celebrated sandstone climbing with over 300 routes.²⁵⁵ These climbing routes are located directly in yellow-spotted woodland salamander habitat.

Sustainable climbing, hiking, and other recreation can flourish along with the yellow-spotted woodland salamander and its habitat. For example, the New River Gorge National Park and Preserve consists of more than 72,000 acres, including more than 200 miles of trails and 1,400 established climbing routes. Only two known populations of *P. pauleyi* occur within the New River Gorge.²⁵⁶ Protecting those populations can be achieved easily while still providing ample and diverse recreation opportunities.

Federal protections for *P. pauleyi* will ensure that hiking and climbing do not jeopardize the few remaining populations of the yellow-spotted woodland salamander.

In addition, recreational herping threatens *P. pauleyi*. This rare species has become increasingly popular among herpers, and increased visitation may threaten the yellow-spotted woodland salamander's habitat and survival.²⁵⁷

Inherent vulnerability of habitat specialists

P. pauleyi is a microhabitat specialist, which makes it particularly vulnerable to habitat loss and fragmentation.²⁵⁸ Because rock outcrops are generally poorly represented in the landscape, yellow-spotted woodland salamander populations are highly susceptible to activities that destroy or degrade these rock outcrops and the surrounding forests.²⁵⁹

²⁵¹ Clark and Hessler 2015. 2.

²⁵² C. Wilson pers. comm. 2020.

²⁵³ Lawrence 2021.

²⁵⁴ Blue Ridge Outdoors 2014.

²⁵⁵ Breaks 2022.

²⁵⁶ Starr 2021.

²⁵⁷ Hutcheson pers. comm. 2022.

²⁵⁸ Patton et al. 2019. 749.

²⁵⁹ Buhlmann and Mitchell 2006. 33, 79.

Yellow-spotted woodland salamanders may experience more intraspecific and interspecific aggression as available habitat becomes increasingly limited. Male salamanders in the *P. wehrlei* species complex, including *P. pauleyi*, are territorial. They will exhibit aggressive behavior when other salamanders enter their territory.²⁶⁰ Currently, yellow-spotted woodland salamanders more often occupy central rock outcrop habitat and green salamanders tend to occur along the edges of the rock outcrop.²⁶¹ However, as territory for both species diminishes, increased conflict, displacement, and mortality may result.

In addition, the yellow-spotted woodland salamander's specialized rock outcrop habitat has led to breeding populations being patchily distributed.²⁶² Habitat specialization contributes strongly to species extinction risk.²⁶³ Females return to their preferred breeding sites because there are limited options for alternate locations. Conditions of outcrop crevices can change due to factors such as erosion, landslides, rockslides, severe weather, and sedimentation of crevices.²⁶⁴ Range-restricted specialists with low vagility like the yellow-spotted woodland salamander are particularly vulnerable to habitat fragmentation and loss, threatening their long-term genetic health and survival.²⁶⁵

Inherent vulnerability of small, isolated populations

Female yellow-spotted woodland salamanders breed biannually and lay as few as six eggs.²⁶⁶ As a result, it is extremely vulnerable to local extirpation and species-level extinction.

P. pauleyi is also more vulnerable to extinction because of its small population, small number of occurrences, and limited geographic distribution, which undermine its overall viability.²⁶⁷

Generally, species with smaller or fewer populations are more likely to become extinct.²⁶⁸ For a species to be viable, it should have stable population sizes and growth rates (resiliency), several resilient populations over a broad geographic range (redundancy), and diverse populations of adequate size (representation).²⁶⁹ Only 65 yellow-spotted woodland salamanders have been observed across 21 occurrences in a restricted geographical area. Most of these occurrences consist of only one or a few individuals. These occurrences are confined to a few steep rock outcrops scattered across a heavily disturbed industrial landscape.

The yellow-spotted woodland salamander's small, discrete populations scattered widely across the landscape make the species especially vulnerable. Its already-precarious population size makes it even less likely for the species to overcome the compounding threats of habitat destruction, habitat fragmentation, genetic isolation, disease, predation, and climate change. *P.*

²⁶⁰ Cupp 1980. 157-158.

²⁶¹ Hutcheson pers. comm. 2022.

²⁶² Patton *et al.* 2019. 749.

²⁶³ Colles *et al.* 2009. 849.

²⁶⁴ Apodaca pers. comm. 2020.

²⁶⁵ Corser 2001. 124.

²⁶⁶ Mitchell and Gibbons 2010. 136.

²⁶⁷ Felix, Wooten, Pierson, and Camp 2019. 444-446.

²⁶⁸ Shaffer and Stein 2000. 307; Wolf *et al.* 2015. 5.

²⁶⁹ USFWS 2016. 6.

pauleyi has been especially affected by habitat loss and fragmentation, which has further isolated populations and prevented gene flow between sites. Because of its small population size and low juvenile recruitment, inbreeding depression and reduced fitness are concerns.²⁷⁰ Low reproductive rates and small clutch sizes are compounding threats to the species' genetic fitness and survival.

The yellow-spotted woodland salamander's critically low population, low reproductive rate and recruitment, and few patchy, isolated occurrences demonstrate the species' low resiliency, redundancy, and representation, which makes *P. pauleyi* even more vulnerable to extinction.²⁷¹ Its small range and clumped distribution also makes the yellow-spotted woodland salamander more susceptible to stochastic or genetic population declines or local extirpations.²⁷² Without federal protection, the remaining yellow-spotted woodland salamanders clinging to a few rock outcrops are headed toward extinction.

²⁷⁰ Shoemaker 2013. 329-330.

²⁷¹ Shaffer and Stein 2000. 307; Wolf *et al.* 2015. 5.

²⁷² *Ibid.* Wooten pers. comm.

REQUEST FOR CRITICAL HABITAT

The petitioner encourages the U.S. Fish and Wildlife Service to designate critical habitat for the yellow-spotted woodland salamander concurrent with its listing. Critical habitat as defined by Section 3 of the ESA is: (i) the specific areas within the geographical area occupied by a 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 protection; and (ii) the 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 recognized that the protection of habitat is essential to the recovery and/or survival of listed species, stating that: “classifying a species as endangered or threatened is only the first step in ensuring its survival. Of equal or more importance is the determination of the habitat necessary for that species’ continued existence... If the protection of endangered and threatened species depends in large measure on the preservation of the species’ habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat.”²⁷³

The yellow-spotted woodland salamander urgently needs critical habitat protection to be issued concurrently with its endangered species designation. The yellow-spotted woodland salamander will not survive without protection of its rock outcrops, surrounding closed canopy forests, water resources, and migration corridors. Critical habitat is essential to protecting the yellow-spotted woodland salamander from further harm and population decline. *P. pauleyi* critical habitat consists of shale and sandstone rock outcrops across the Appalachian Plateau, surrounding closed canopy forests, water resources, and migratory corridors between sites, which are essential to the yellow-spotted woodland salamander’s health and survival.

²⁷³ H. Rep. No. 94-887, 1976. 3.

CONCLUSION



Jacob Hutton / Curtis Cox

The yellow-spotted woodland salamander is one of the country's most endangered salamanders and one of the world's most imperiled species. Most of the 21 remaining occurrences of *P. pauleyi* consist of only a single individual and are no longer viable. Only a few hundred individuals remain, and their habitat is increasingly destroyed by mining and roads. Without urgent protection, the yellow-spotted woodland salamander faces imminent extinction.

Coal mining has already destroyed significant portions of the yellow-spotted woodland salamander's habitat and will continue to threaten the survival of this species. *P. pauleyi* is further jeopardized by logging of adjacent closed-canopy forests, road construction, poaching, pandemic viral and fungal diseases, climate change, invasive species, and pollution. *P. pauleyi* is also inherently vulnerable as a microhabitat specialist with low reproductive rates, small clutch sizes, and isolated populations. Existing federal and state regulations have utterly failed to safeguard the yellow-spotted woodland salamander. This critically imperiled species will go extinct without immediate action from the U.S. Fish & Wildlife Service.

Only a few hundred yellow-spotted woodland salamanders likely remain. The yellow-spotted woodland salamander has been clinging to the rock outcrops of Appalachia for millions of years. But now, to keep holding on, it urgently needs federal listing and critical habitat protections.

LITERATURE CITED

- Acton, P., J. Fox, J. Campbell, A. Jones, H. Rowe, D. Martin, and S. Bryson. 2011. Role of soil health in maintaining environmental sustainability of surface coal mines. *Environmental Science and Technology*: (45) 10265-10272.
- Adams, D., C. Berns, K. Kozak, and J. Wiens. 2009. Are rates of species diversification correlated with rates of morphological evolution? *Proceedings of the Royal Society: B*, 276, 2729–2738. doi.org/10.1098/rspb.2009.0543.
- AmphibiaWeb: *Plethodon wehrlei*. 2018. AmphibiaWeb. University of California, Berkeley, California. amphibiaweb.org.
- Amrine J.W. *Multiflora Rose*. 2002. In: Van Driesche R.V., Lyon S., Blossey B., Hoddle M. RR, editor. *Biological Control of Invasive Plants in the Eastern United States*. Morgantown, WV: USDA Forest Service Publication No. FHTFT-2002-4. 265–292. dnr.state.il.us/stewardship/cd/biocontrol/22multiflorarose.html.
- Andrews, K. M., J.W. Gibbons, and D.M. Jochimsen. 2006. Literature Synthesis of the Effects of Roads and Vehicles on Amphibians and Reptiles. Federal Highway Administration (FHWA), U.S. Department of Transportation, Report No. FHWA-HEP-08-005. Washington, D.C. 13, 149-151.
- Appalachian Regional Commission. 2021. FY 2021 Status of the Appalachian Development Highway System. Appalachian Development Highway System. arc.gov/appalachian-development-highway-system/.
- Barrett, K., N. Nibblelink, and J.C. Maerz. 2014. Identifying priority species and conservation opportunities under future climate scenarios: amphibians in a biodiversity hotspot. *Journal of Fish and Wildlife Management* 5: 282–297.
- Beane, J., A. Braswell, J. Mitchell, W. Palmer, J. Harrison. 2010. *Amphibians and Reptiles of the Carolinas and Virginia*. Chapel Hill, North Carolina: The University of North Carolina Press. 112.
- Beneski, J. 1989. Adaptive significance of tail autotomy in the salamander, *Desmognathus fuscescens*. *Journal of Herpetology*, 23/3: 322-324.
- Bernhardt, E., and M. Palmer. 2011. The environmental costs of mountaintop mining valley fill operations for aquatic systems of Central Appalachia. *Annals of the New York Academy of Sciences*: (1223), 39-57.
- Biggers, Jeff. 2021. We still blow up mountains to mine coal: Time to end the war on Appalachia. Salon: May 1. [salon.com/2021/05/01/we-still-blow-up-mountains-to-mine-coal-time-to-end-the-war-on-appalachia/](https://www.salon.com/2021/05/01/we-still-blow-up-mountains-to-mine-coal-time-to-end-the-war-on-appalachia/).

Binkovitz, Leah. 2013. The Surprisingly Colorful Salamanders of Appalachia. Smithsonian Magazine: June 18. <https://www.smithsonianmag.com/smithsonian-institution/the-surprisingly-colorful-salamanders-of-appalachia-813148/>.

Blackburn, M., J. Wayland, W.H. Smith, J.H. McKenna, M. Harry, M.K. Hamed, M.J. Gray, and D.L. Miller. 2015. First report of Ranavirus and Batrachochytrium dendrobatidis in Green Salamanders (*Aneides aeneus*) from Virginia, USA. *Herpetological Review* 46(3): 357–364.

Bliss, M. and K. Cecala. 2017. Terrestrial salamanders alter antipredator behavior thresholds following tail autotomy. *Herpetologica*: 73(2): 94-99. doi.org/10.1655/Herpetologica-D-16-00059.1.

Blue Ridge Outdoors Magazine. 2014. Kentucky's Pine Mountain and the Cloudsplitter Ultra. August: blueridgeoutdoors.com/running/kentuckys-pine-mountain-cloudsplitter-ultra/.

Böhm M., D. Cook, H. Ma, A.D. Davidson, A. García, B. Tapley, P. Pearce-Kelly, and J. Carr. 2016. Hot and bothered: using trait-based approaches to assess climate change vulnerability in reptiles. *Biological Conservation*: 204, 32-41.

Breaks Interstate Park. 2022. Reach new heights: Rock climbing at Breaks Interstate Park. Breaks Interstate Park Commission: breakspark.com/rock-climbing.

Buhlmann, K. and J. Mitchell, eds. 2006. Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-1, 2nd Edition. 31, 79.

Burke, K.L. 2015. New Disease Emerges as Threat to Salamanders. 103 *American Scientist*. 1: 6.

Calinger, K., E. Calhoun, H. Chang, J. Whitacre, J. Wenzel, L. Comita, and S. Queenborough. 2015. Historic mining and agriculture as indicators of occurrence and abundance of widespread invasive plant species. *PLoS One*: (10)6. doi.org/10.1371/journal.pone.0128164

Camp, C. and J. Wooten. 2016. Hidden in plain sight: cryptic diversity in the Plethodontidae. *Copeia*: 104, 111–117. doi.org/10.1643/OT-14-150.

Carey, C. and M.A. Alexander. 2003. Climate change and amphibian declines: is there a link? *Diversity and Distributions* 9: 111–121.

Chowns, T. 2016. Appalachian Plateau Geologic Province. *New Georgia Encyclopedia*: georgiaencyclopedia.org/articles/science-medicine/appalachian-plateau-geologic-province/.

Clark, P. and A. Hessel. 2015. The effects of rock climbing on cliff-face vegetation. *Applied Vegetation Science*. [doi:10.1111/avsc](https://doi.org/10.1111/avsc). 1-12.

Clipp, H. and J. Anderson. 2014. Environmental and anthropogenic factors influencing salamanders in riparian forests: A review. *Forests*: (5) 2679-2702.

- Colles A., L.H. Liow, and A. Prinzing. 2009. Are specialists at risk under environmental change? Neocological, paleoecological and phylogenetic approaches. *Ecological Letters* 12: 849-863.
- Copeland, C. 2015. Mountaintop Mining: Background on Current Controversies. Congressional Research Service. 7-5700. <https://sgp.fas.org/crs/misc/RS21421.pdf>.
- Corser, J. D. 2001. Decline of disjunct green salamander (*Aneides aeneus*) populations in the southern Appalachians. *Biological Conservation* 97: 119–126.
- Cunningham, A., K. Beckmann, M. Perkins, et al. 2015. Surveillance: Emerging disease in UK amphibians. *Veterinary Record* 176 (18): 468.
- Cupp, P. and T. Towles. 1983. A new variant of *Plethodon wehrlei* in Kentucky and West Virginia. *Transactions of the Kentucky Academy of Science*: 44, 157-178.
- Davies, William. 2016. Physiography of Appalachia. U.S. Geological Survey. November 1: quarriesandbeyond.org/articles_and_books/min_res_appalachian_region/physiography.html.
- Dixon, E. 2021. Repairing the Damage: Cleaning up the air, land, and water damaged by the coal industry before 1977. Ohio River Valley Institute: 3-21. <https://ohiorivervalleyinstitute.org/wp-content/uploads/2021/04/AML-Report-Dixon-ORVI-V1.1-4.pdf>.
- Dodd, Kenneth. 1989. Duration of immobility in salamanders, genus *Plethodon* (Caudata: Plethodontidae). *Herpetologica*: January, (45) 4. 468.
- Evans, M., K. Kay, C. Proctor, C. Thomas, and J. Malcolm. 2021. Linking mountaintop removal mining to water quality for imperiled species using satellite data. *PLoS One*: (16) 7-12. doi.org/10.1371/journal.pone.0239691.
- Federal Mining Dialogue. 2021. “Concentration of abandoned mines.” Abandoned mines: a threatening legacy. Abandonedmines.gov.
- Felix, Z.I, J.A. Wooten, and J. Rigsby. 2011. Taxonomic affinities of the yellow-spotted isolates of the Wehrle’s salamander (*Plethodon wehrlei*): preliminary data. *Southeastern Biology*: 58, 406-407.
- Felix, Z. I., J. A. Wooten, T. W. Pierson, and C. D. Camp. 2019. Re-evaluation of the Wehrle’s salamander (*Plethodon wehrlei* Fowler and Dunn) species group (Caudata: Plethodontidae) using genomic data, with the description of a new species. *Zootaxa* 4609(3):429-448.
- Fowler, H. and E. Dunn. 1917. Notes on salamanders. *Proceedings of the Academy of Natural Sciences of Philadelphia*: 69 (1), 7-28.
- Fowler, J. 1951. Preliminary observations on an aggregation of *Plethodon dixi*. *Herpetologica*: 7, 147-148.
- Fox, Douglas. 2022. Junk DNA deforms salamanders’ bodies. *Scientific American*. February 1: scientificamerican.com/article/junk-dna-deforms-salamander-bodies/.

- Frost, D. R. 2019. Amphibian Species of the World: An Online Reference. Version 6.0. American Museum of Natural History, New York, USA.
research.amnh.org/herpetology/amphibia/index.html.
- Gibbs, J. and N. Karraker. 2006. Effects of warming conditions in Eastern North American forests on red-backed salamander morphology. *Conservation Biology*: 920) 3, 913-917. DOI: 10.1111/j.1523-1739.2006.00375.x.
- Gordon, Meghan. US EIA: Global energy demand to grow 47% by 2050. S&P Global: October 6. spglobal.com/commodityinsights/en/market-insights/latest-news/oil/100621-global-energy-demand-to-grow-47-by-2050-with-oil-still-top-source-us-eia.
- Graham, M. 2007. Distribution and conservation genetics of the Cow Knob salamander, *Plethodon punctatus* Highton (Caudata: Plethodontidae). Marshall University, Huntington, West Virginia.
- Green, N. and T. Pauley. 1987. Amphibians and Reptiles in West Virginia. University of Pittsburgh Press. 188-197.
- Hall, R.J., and D.P. Stafford, D.P. 1972. Studies in the life history of Wehrle's Salamander, *Plethodon wehrlei*. *Herpetologica*: 28, 300-309.
- Herrell, A. and A. van der Meijden. 2014. An analysis of the live reptile and amphibian trade in the USA compared to the global trade in endangered species. *Herpetological Journal*: April (24) 2.
- Highton, R. 1962. Revision of North American salamanders of the genus *Plethodon*. *Bulletin of the Florida State Museum*, 6, 235-367.
- Highton, R. 1972. Distributional interactions among eastern North American salamanders of the genus *Plethodon*. In: Holt, P.C. (Ed.), *The distributional history of the biota of the southern Appalachians. Part III. Vertebrates*. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 139-188.
- Highton, R. and A. Larson, A. 1979. The genetic relationships of the salamanders of the genus *Plethodon*. *Systematic Biology*, 28, 579-599. doi.org/10.2307/sysbio/28.4.579.
- Highton, R. and J.R. MacGregor. 1983. *Plethodon kentucki* Mittleman: A valid species of Cumberland Plateau woodland salamander. *Herpetologica*: 39, 189-200.
- Highton, R. 1987. *Plethodon wehrlei* Fowler and Dunn. *Catalogue of American Amphibians and Reptiles*: 402, 1-3.
- Highton, R. 1988. *Plethodon punctatus* Highton. *Catalogue of American Amphibians and Reptiles*, 414, 1-2.
- Highton, R., A.P. Hastings-Picard, C. Palmer, R. Watts, R., C.A. Hass, M. Culver, and S.J. Arnold. 2012. Concurrent speciation in the eastern woodland salamanders (genus *Plethodon*):

DNA sequences of the complete albumin nuclear and partial mitochondrial 12s genes. *Molecular Phylogenetics and Evolution*: 63, 278-290. doi.org/10.1016/j.ympev.2011.12.018.

Hutcheson, K., A. Miller-Murphy, B. Wade, and T. Pierson. 2021. *Plethodon pauleyi* (Yellow-spotted woodland salamander): USA, Virginia, Wise County. *Herpetological Review*: (52)1, 75.

Hutton, J. and C. Cox. 2020. *Plethodon pauleyi*. *Herpetological Review*. Natural History Notes. June: 294.

IUCN SSC Amphibian Specialist Group, 2018. *Plethodon wehrlei*. IUCN Red List of Threatened Species. iucn.org. dx.doi.org/10.2305/IUCN.UK.20141.RLTS.T59362A56286906.en.

Jaekel, M. and D.B. Wake. 2007. Developmental processes underlying the evolution of a derived foot morphology in salamanders. *Proceedings of the National Academy of Sciences of the United States of America*: 104, 20437–20442. doi.org/10.1073/pnas.0710216405.

Joy, J.E. and R.B. Tucker. 2001. *Cepedietta michiganensis* (Protozoa) and *Batracholandros magnavulvaris* (nematoda) from plethodontid salamanders in West Virginia, U.S.A. *Comparative Parasitology* 68(2):185-189.

Kentucky Department of Fish and Wildlife Resources. 2022. Amphibia CWCS Species List and Wildlife Action Plan. fw.ky.gov/WAP/Pages/Amphibia.aspx.

Kentucky Department of Game and Inland Fisheries. 2022. Hensley - Pine Mountain Wildlife Management Area. app.fw.ky.gov/Public_Lands_Search/detail.aspx?Kdfwr_id=136.

Kozak, K.H., D.W. Weisrock, and A. Larson. 2006. Rapid lineage accumulation in a non-adaptive radiation: phylogenetic analysis of diversification rates in eastern North American woodland salamanders (Plethodontidae: *Plethodon*). *Proceedings of the Royal Society: B*, 273, 539–546.

Kuchta, S.R., A.D. Brown, A.D., and R. Highton. 2018. Disintegrating over space and time: paraphyly and species delimitation in the Wehrle's salamander complex. *Zoologica Scripta*: 47, 285–299. doi.org/10.1111/zsc.12281.

Lannoo, M. 2005. *Amphibian Declines: The Conservation Status of United States Species*. Los Angeles, California: University of California Press. 203-220.

Lanza, B., S. Vanni, and A. Nistri. 1998. *Encyclopedia of Reptiles and Amphibians*. H.G. Cogger and R.G. Zweifel (Eds.). Academic Press: 74-75.

Lawrence, C. 2018. DNR and Justice Administration defend parks logging plan. *West Virginia Metro News*: January 21. wvmetronews.com/2018/01/21/dnr-and-justice-administration-defend-parks-logging-plan/.

Lawrence, C. 2021. Park designation delivers on promised increase in visitors at New River Gorge. *West Virginia Metro News*: December 21. wvmetronews.com/2021/12/21/park-designation-delivers-on-promised-increase-in-visitors/.

- Lips, K. R., F. Brem, R. Brenes, et al. 2006. Emerging infectious disease and the loss of biodiversity in a Neotropical amphibian community. *Proceedings of the National Academy of Sciences*. 103: 3165–3170.
- Marvin, G. A. 1996. Life history and population characteristics of the salamander *Plethodon kentucki* with a review of *Plethodon* Life Histories. *American Midland Naturalist*: 136(2), 385. doi.org/10.2307/2426742.
- Martel, A., M. Blooi, C. Adriansen et al. 2014. Recent introduction of a chytrid fungus endangers Western Palearctic salamanders. *Science* 346: 630–631.
- Martel, A., A. Spitzen-van der Sluijs, M. Blooi, and W. Bert. 2013. *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. 110 *Proceedings of the National Academy of Sciences*. 15325–15329.
- Milici, R. 2000. Production trends of major U.S. coal producing regions. U.S. Geological Survey: *Proceedings of the Pittsburgh Coal Conference*. 1.
- Mitchell, J., and W. Gibbons. 2010. *Salamanders of the Southeast*. Athens, Georgia: University of Georgia Press. 136-141.
- Muncy, B., S. Price, S. Bonner, and C. Barton. 2014. Mountaintop removal mining reduces stream salamander occupancy and richness in southeastern Kentucky (USA). *Biological Conservation* 180: 115-121. doi: 10.1016/j.biocon.2014.9.040.
- National Park Service. 2001. Geology and history of the Cumberland Plateau. Big South Fork National River and Recreation Area: <https://www.nps.gov/biso/planyourvisit/upload/webgeo.pdf>.
- Natural Resources Defense Council. 2015. *Undermined Promise II: A report on the reclamation and enforcement of Surface Mining Control and Reclamation*. underminedpromise.org
- NatureServe. *Plethodon pauleyi*. 2022. NatureServe Web Service. Arlington, Virginia. natureserve.org: accessed 16 March 2022. explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.1131185/*Plethodon pauleyi*.
- Newman, W.B. 1954. A new plethodontid salamander from southwestern Virginia. *Herpetologica*: 10, 9-14.
- Nie, M. 2018. The Forest Service's Planning Rule and Its Implementation. *Journal of Forestry*: 68-69. doi.10.1093/jofore/fvy055.
- O'Donnell, K., R. Semlitsch. 2015. Advancing terrestrial salamander population ecology: The central role of imperfect detection. *Journal of Herpetology*, 49/3: 533-540.
- Oliphant, A., R. Wynne, C. Zipper, W. Ford, P. Donovan, and J. Li. 2017. Autumn olive (*Eleagnus umbellata*) presence and proliferation on former surface coal mines in Eastern USA. *Biological Invasions*: (19) 179-195. doi.org/10.1007/s10530-016-1271-6.

- Ossola, A. 2016. A deadly fungus could lead to a lucrative black market in salamanders, The Verge. February 17: theverge.com/2016/2/17/11027432/salamander-trade-ban-bsal-fungus-black-market (citing Christina M. Meister, a spokeswoman with the Service).
- Patton, A., J.J. Apodaca, J.D. Corser, C.R. Wilson, L.A. Williams, A.D. Cameron, and D.B. Wake. 2019. A New Green Salamander in the Southern Appalachians: Evolutionary History of *Aneides aeneus* and Implications for Management and Conservation with the Description of a Cryptic Microendemic Species. *Copeia* 107(4): 748–763.
- Pericak A., C. Thomas, D. Kroodsma, M. Wasson, M. Ross, N. Clinton, et al. 2018. Mapping the yearly extent of surface coal mining in Central Appalachia using Landsat and Google Earth engine. *PLoS One*: 13(7):1-15. doi.org/10.1371/journal.pone.0197758 PMID: 30044790.
- Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press: Washington, 322-330.
- Petranka, J. 2010. Salamanders of the United States and Canada. Washington, D.C.: The Smithsonian Institute. 108-113.
- Pierce, B.A. 1993. The effects of acid precipitation on amphibians. *Ecotoxicology*. 2: 65–77.
- Pope, C.H. and J.A. Fowler. 1949. A new species of salamander (*Plethodon*) from southwestern Virginia. *Natural History Miscellanea Chicago Academy of Sciences*: 47, 1-4.
- Pough, F. H. and R.E. Wilson. 1997. Acid precipitation and reproductive success of *Ambystoma* salamanders. *Water, Air, and Soil Pollution*. 7: 531–544.
- Powell, R., R. Conant, J. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America. Boston, New York: Houghton Mifflin Harcourt. 266-271.
- de Queiroz, K. 1998. The general lineage concept of species, species criteria, and the process of speciation: a conceptual unification and terminological recommendations. In: Howard, D.J. & Berlocher, S.H. (Eds.), *Endless Forms: Species and Speciation*. Oxford University Press: 57-75.
- de Queiroz, K. 2005. Ernst Mayr and the modern concept of species. *Proceedings of the National Academy of Sciences of the United States of America*: 102, 6600-6607.
- Rissler, L.L. & J.J. Apodaca. 2007. Adding more ecology into species delimitation: ecological niche models and phylogeography help define cryptic species in the black salamander (*Aneides flavipunctatus*). *Systematic Biology*: 56, 924–942. doi.org/10.1080/10635150701703063.
- Rodgers, Bruce. 2001. General Geologic Information for the Tri-States of Kentucky, Virginia, and Tennessee. Southeastern Geological Society. 1-18.
- Ross, M., B. McGlynn, and E. Bernhardt. 2016. Deep Impact: Effects of mountaintop mining on surface topography, bedrock structure, and downstream waters. *Environmental Science Technology*. Feb 16: 50(4): 2064-74.
- Ross, Matthew. 2016. Central Appalachia flatter due to mountaintop mining. *Duke Today*: February 5. today.duke.edu/2016/02/mountaintopmining.

- Ross M., B. McGlynn, and E. Bernhardt. 2016. "Deep Impact: Effects of Mountaintop Mining on Surface Topography, Bedrock Structure, and Downstream Waters," *Environmental Science and Technology*, January 22, 2016. doi: 10.1021/acs.est.5b04532.
- Sayler, K. W. Acevedo, and J. Taylor. 2016. Status and Trends of Land Change in the Eastern United States 1973-2000. U.S. Geological Survey. dx.doi.org/10.3133/pp1794D. 71-125.
- Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh. 113-145.
- Schoch, R., R. Werneburg, and S. Voigt. 2020. A Triassic stem salamander from Kyrgystan and the origin of salamanders. *PNAS*: May. 11584-11588. pnas.org/doi/10.1073/pnas.2001424117.
- Shaffer, M.L. and B. Stein. 2000. Safeguarding our precious heritage. Stein B.A., L.S. Kutner, and J.S. Adams, eds. *Precious Heritage: The Status of Biodiversity in the United States*. Oxford University Press. 301-322.
- Shen, X., D. Liang, M.Y. Chen, R. Mao, D. Wake. 2016. Enlarged multilocus data set provides surprisingly younger time of origin for Plethodontidae, the largest family of salamanders. *Systematic Biology*: (65) 1, 66-81. doi.org/10.1093/sysbio/syv064.
- Silander J. and D. Klepeis. 1999. The invasion ecology of Japanese barberry (*Berberis thunbergii*) in the New England landscape. *Biological Invasions*. Kluwer Academic Publishers. 1: 189-201. link.springer.com/article/10.1023/A:1010024202294.
- Simonin, M., J. Rocca, J. Gerson, E. Moore, A. Brooks et al. 2021. Consistent declines in aquatic biodiversity across diverse domains of life in rivers impacted by surface coal mining. *Ecological Applications*: doi.org/10.1002/eap.2389.
- SkyTruth. 2015. The latest data on mountaintop mining in Central Appalachia. Mountaintop mining. Skytruth.org.
- Snider, A. and J. Bowler. 1992. Longevity of Reptiles and Amphibians in North American Collections. Second Edition. Oxford, Ohio: Society for the Study of Amphibians and Reptiles. 5-7.
- Snyder, D.H. 1991. The green salamander (*Aneides aeneus*) in Tennessee and Kentucky, with comments on the Carolinas' Blue Ridge populations. *Journal of the Tennessee Academy of Science*. 66(4): 165–169.
- Squillace, Mark. 2009. The Environmental Effects of Strip Mining. *The Strip Mining Handbook*. 2009. University of Colorado. sites.google.com/site/stripmininghandbook/chapter-2-1.
- Starr, Stephen. America's newest national park is a haven for hiking, climbing, and rafting. *National Geographic*. February 24, 2021. nationalgeographic.com/travel/article/escape-crowds-at-newest-national-park-new-river-gorge-west-virginia.

Staub, N. 2016. The age of Plethodontid salamanders: A short review on longevity. *Copeia*, 104/1: 118-123.

Stephenson, S. 2013. A Natural History of the Central Appalachians. West Virginia University. 212-220.

Steelhammer, R. 2018. Conservation groups oppose bill to allow logging in West Virginia State Parks. *Charleston Gazette-Mail*: January 17, 2018.
wvgazettemail.com/news/legislative_session/conservation-groups-oppose-bill-to-allow-logging-in-wv-state-parks/article_6632305a-bff5-5631-a836-e517b0acbe17.html

Tennessee Wildlife Resources Agency. 2022. Tennessee Wildlife Action Plan.
tn.gov/twra/wildlife/action-plan.html.

Tony, M. 2021. DEP approves Raleigh County surface mine despite health and environmental concerns. *West Virginia Gazette Mail*. May 24:
wvgazettemail.com/news/energy_and_environment/dep-approves-raleigh-county-surface-mine-application-despite-health-and-environmental-concerns/article_13aa2a95-df75-5682-ac92-b4bb871ff4c3.html.

US Department of Transportation. 2022. President Biden and U.S. Department of Transportation announce \$1.2 billion for highways in rural Appalachia. January 25: transportation.gov/briefing-room/president-biden-and-us-department-transportation-announce-12-billion-highways-rural.

U.S. Department of Justice. 2022. NPS Organic Act. Environment and Natural Resources Division. justice.gov/enrd/nps-organic-act.

U.S. Environmental Protection Agency. 2005. Mountaintop Mining/Valley Fills in Appalachia: Final Programmatic Environmental Impact Statement. June 25: www.epa.gov/region03/mtntop/index.htm.

US EPA. 2006. Level III Ecoregions of the Continental United States. National Health and Environmental Effects Resource Lab, Corvallis, Oregon, map M-1.

U.S. EPA. 2011. The Effects of Mountaintop Mines and Valley Fills on Aquatic Ecosystems of The Central Appalachian Coalfields. U.S. Environmental Protection Agency, Washington, DC: EPA/600/R-09/138F.

US EPA. 2022. Overview of Clean Water Act Section 404. epa.gov/cwa-404/overview-clean-water-act-section-404.

US Forest Service. 2009. Ecological Subregions of the United States, USDA Forest Service. fs.fed.us/land/pubs/ecoregions/ch18.html.

Verbeck, Tiffany. 2019. “The Ultimate Guide to Climbing West Virginia’s New River Gorge.” *Matador Network*: matadornetwork.com/read/rock-climbing-new-river-gorge/.

- Vietes, D., M. Min, and D. Wake. 2007. Rapid diversification and dispersal during periods of global warming by plethodontid salamanders. *PNAS*: (104) 50, 19903-19907. doi.org/10.1073/pnas.0705056404
- Virginia Department of Wildlife Resources. 2022. Species of Greatest Conservation Need. 2015 Virginia Wildlife Action Plan. bewildvirginia.org/species/.
- Virginia Department of Wildlife Resources. 2021. Wildlife Corridor Diversity Products. VA DWR Staff Review Comments and Discussion. October 18, 2021.
- Virginia Herpetological Society. 2021. Yellow spotted woodland salamander (*Plethodon pauleyi*). virginiaherpetologicalsociety.com/amphibians/salamanders/yellow-spotted-woodland-salamander/yellow-spotted-woodland-salamander.php.
- Wake, D. and I. Dresner. 1967. Functional morphology and evolution of tail autotomy in salamanders. *Morphology*: (122) 4, 265-305.
- Wake, D.B. 2009. What salamanders have taught us about evolution. *Annual Review of Ecology, Evolution, and Systematics*: 40, 333-352.
- Waldron, J.L., T.K. Pauley, Z.I. Felix, W.J. Humphries, and A.J. Longenecker. 2001. The herpetofauna of the Bluestone National Wild and Scenic River. *Proceedings of the West Virginia Academy of Science*: 73, 1-10.
- Wells, Kentwood. 2007. *Natural History of Amphibian Production. The Ecology and Behavior of Amphibians*. Chicago: University of Chicago Press.
- Wickham, J. P. Wood, M. Nicholson et al. 2013. The overlooked terrestrial impacts of mountaintop removal mining. *BioScience*: 63, 335-348.
- Wiens, J.J., T.N. Engstrom, and P.T. Chippindale. 2006. Rapid diversification, incomplete isolation, and the “speciation clock” in North American salamanders (genus *Plethodon*): testing the hybrid swarm hypothesis of rapid radiation. *Evolution*: 60, 2585-2603. doi.org/10.1111/j.0014-3820.2006.tb01892.x.
- Wiser, S. K., and P. S. White. 1999. High-elevation outcrops and barrens of the southern Appalachian Mountains. In: Anderson, R. C., J. S. Fralish, and J. M. Baskin, editors. *Savannas, barrens and rock outcrop plant communities of North America*. Cambridge University Press. 119-132.
- Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. *BioScience* 65: 200–207.
- Wood, P. and J. Williams. 2013. Terrestrial salamander abundance on reclaimed mountaintop removal mines. *Wildlife Society Bulletin*: 37(4), 815-823.

Wright, A. N., Schwartz, M. W., Hijmans, R. J., and Shaffer, H. B. (2015). Advances in climate models from CMIP3 to CMIP5 do not change predictions of future habitat suitability for California reptiles and amphibians. *Climatic Change*, 134, 579–591.

Yap, T.A., M.S. Koo, R.F. Ambrose, D.B. Wake, and V.T. Vredenburg. 2015. Averting a North American biodiversity crisis: A newly described pathogen poses a major threat to salamanders via trade. *Science*. 6247: 481–482.

Yonk, R., J. Smith, and A. Wardle. 2019. Exploring the policy implications of the Surface Mining Control and Reclamation Act. Utah State University: Political Science Commons, 1-10.

Zipper, C. J. Burger, J. Skousen, P. Angel, C. Barton, V. Davis, and J. Franklin. 2011. Restoring forests and associated ecosystem services on Appalachian coal surface mines. *Environmental Management*: (47) 751-765.

Zipper, C., M.B. Adams, and J. Skousen. 2021. “The Appalachian Coalfield in Historical Context.” *Appalachia’s Coal Mined Landscapes*. Springer Nature Switzerland: 2-26.

Zug, G.R. 2008. Lungless salamander. *Encyclopedia Britannica*: britannica.com/animal/lungless-salamander.