Herpetological Conservation and Biology 16(3):506–512.
Submitted: 19 March 2020; Accepted: 26 July 2021; Published: 16 December 2021.

Decline of the Seal Salamander, *Desmognathus monticola*, in Florida, USA

Chace R. Holzheuser[1,3] *and D. Bruce Means*[1,2]

[1]*Department of Biological Science, Florida State University, 600 West College Avenue, Tallahassee, Florida 32306, USA*
[2]*Coastal Plains Institute and Land Conservancy, 1313 Milton Street, Tallahassee, Florida 32303, USA*
[3]*Corresponding author, email: c.holzheuser@gmail.com*

Abstract.—**The southernmost population of Seal Salamanders (*Desmognathus monticola*), and the only known population in Florida, USA, was documented in 1970 within the Bluff Springs Campground, Escambia County. Since its discovery, no other formal studies have been conducted on the population and its contemporary status is unknown, although specimens were taken as museum vouchers or photographed until 2002. We therefore investigated the current status of Seal Salamanders in Florida. From 2017 to 2019, 13 field herpetologists conducted 16 search events for a total of 57.17 search hours and no *D. monticola* were found. Thus, Seal Salamanders have not been documented in Florida since 2002 and appear to be extirpated from the only known location in the state. We hypothesize that the apparent decline is likely due, at least in part, to the extensive clear-cut silviculture within the study site that has caused sedimentation of the ravines and altered the original microhabitat necessary for survival. Other potential causes of decline, such as agricultural run-off and disease, cannot be ruled out. We recommend conducting additional surveys for *D. monticola* at Bluff Springs Campground and other nearby creeks to better determine the status of the species in the region.**

Key Words.—amphibian; Coastal Plains; Desmognathines; disappearance; isolated populations; Plethodontidae; relict populations

Introduction

Salamanders are often the most abundant vertebrates in forest communities (Burton and Likens 1975a,b; Petranka 1998) and perform important ecological functions by acting as both predators and prey (Best and Welsh 2014; Hickerson et al. 2017). Their decline, extirpation, and potential extinction can have dramatic effects on the environment through disruption of predator-prey interactions and alteration of nutrient cycles (Stuart et al. 2008). Because salamanders are also sensitive to habitat encroachment, disease, contamination, and climate change, their declines serve as an indication that environmental health may be compromised (Vitt et al. 1990).

Recent studies show that salamanders have experienced precipitous declines since at least the 1950s, especially in the eastern U.S. (Houlahan et al. 2000; Highton 2005). In Florida, the severe declines have been reported in several species, including Reticulated Flatwoods Salamanders (*Ambystoma bishopi*; U.S. Fish and Wildlife Service 2009), Frosted Flatwoods Salamanders (*A. cingulatum*; Means et al. 1996), Southern Dusky Salamanders (*Desmognathus auriculatus*; Dodd 1998; Means and Travis 2007), presumed Spotted Dusky Salamanders (*D.* cf. *conanti*; Means and Travis 2007), and Striped Newts (*Notophthalmus perstriatus*; Means and Means 2005; Farmer et al. 2017). Although some declines of salamanders in the U.S. have been attributed to known causes, such as disease (Berger et al. 1998) and habitat modification (Alford and Richards 1999), many remain enigmatic and unexplained. Unfortunately, the current health and status of many species are unknown. Given the seemingly precarious position of salamanders, it is important to investigate and document the occurrence, abundance, and health of any species or population that is currently lacking contemporary data (Bailey et al. 2019). Because many species are cryptic and elusive, repeated sampling for salamanders is necessary to confidently determine their status (MacKenzie and Royle 2005).

The southernmost population of Seal Salamanders (*Desmognathus monticola*) occupies a single area in the far west panhandle of Florida (Means and Longden 1970) about 82 km from the closest known records of other populations in Alabama. Despite being the only known population in Florida, no studies have been conducted on the population since its discovery by Means and Longden (1970). Although not listed as a species of conservation concern by state or federal agencies, the Florida Natural Areas Inventory (FNAI) ranks *D. monticola* as S1, which suggests that the species is critically imperiled in Florida because of extreme rarity (Hipes et al. 2001). Given the documented decline of several species of salamanders in the state, we

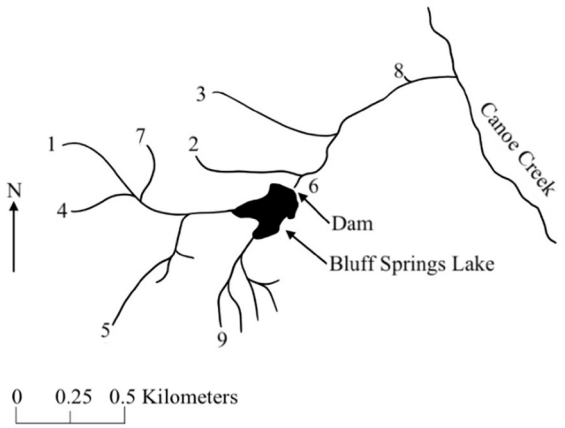

Figure 1. Series of ravines within Bluff Springs Campground, Escambia County, Florida, USA, forming an unnamed tributary of Canoe Creek. Ravines 1–5 are locations from where Seal Salamanders (*Desmognathus monticola*) were collected since their discovery in 1969 until the last individual was reported in 2002.

investigated the current status of *D. monticola* in Florida and comment on the presumed factors associated with the species' apparent decline.

Material and Methods

Study site.—*Desmognathus monticola* in Florida, USA, is historically known from a series of ravines that form an unnamed tributary of Canoe Creek in Escambia County (Fig. 1). A dam erected across the ravines created Bluff Springs Lake. The lake and ravines lie entirely within the private property of Bluff Springs Campground (30°56'0"N, 87°20'35"W), owned by the Alabama/Northwest Florida and Gulf Mission Centers of the Community of Christ.

Desmognathus monticola was first found in Florida in 1969 by D. Bruce Means (DBM) and Clive J. Longden who collected individuals from the uppermost 50–100 m of each ravine in Bluff Springs Campground (Means and Longden 1970). These ravines consisted of spring seepage through Citronelle clay, sand, and gravel (Means and Longden 1970). We designated each ravine a number for ease of reference (Fig. 1), which reflected the same convention used in fieldnotes of DBM.

We also searched the Global Biodiversity Information Facility (GBIF) for museum records of *D. monticola* from Florida. From the first discovery of this population in 1969 until the last individual was photographed in 2002, 80 *D. monticola* were encountered in approximately 10.5 person hours of fieldwork (Table 1). Seventy-nine of these 80 individuals were collected, preserved, and deposited in the Florida Museum of Natural History (UF: 28148–28218, 68564, 159810,160346, 160596, 160597, 161050–161052). The number of salamanders collected varied widely among the years of survey, including 74 specimens deposited in 1979, one in 1974, one in 1984, and three in 1995. The three specimens collected in 1995 were found after two person-hours of searching. The last recorded individual was found during a 1.5 person-hours search on 31 January 2002 (Fig. 2) but was not collected.

Table 1. Survey dates, individuals encountered and time afield for two species of Desmognathine salamanders, Seal Salamanders (*Desmognathus monticola*) and presumed Spotted Dusky Salamanders (*D.* cf. *conanti*), in Bluff Springs Campground, Escambia County, Florida, USA, from 1969 to 2019. Month abbreviations are Nov = November, Dec = December, Mar = March, Jan = January, Apr = April, and Sep = September.

Date	No. of *D. monticola*	No. of *D.* cf. *conanti*	Person-hours	*D. monticola*/h	*D.* cf. *conant*/h	Collectors	DBM-Field Note Pg. No.
23 Nov 1969	15	20	2	7.5	10	Means and Longden	1242
5 Dec 1969	19	30	3	6.33	10	Means	1248
6 Dec 1969	14	Present	Not Recorded	N/A	N/A	Means	1248
17 Dec 1969	26	5	2	13	2.5	Means and Longden	1258
6 Mar 1974	2	Not recorded	Not Recorded	N/A	N/A	Means et al.	1858
8 May 1984	1	Not recorded	Not recorded	N/A	N/A	Moler and Mansell	N/A
5 Jan 1995	3	about 5	2	1.5	2.5	Means and Means	2440
31 Jan 2002	1	23	1.5	0.67	15.3	Means	3034
13 May 2017	0	Not recorded	5.5	0	N/A	Kleinhenz et al.	N/A
25 Apr 2019	0	Not recorded	22.17	0	N/A	Beamer et al.	N/A
5 May 2019	0	Not recorded	11	0	N/A	Kleinhenz et al.	N/A
6 May 2019	0	40	9	0	11.1	Means and Holzheuser	4286 - 4287
7 May 2019	0	11	2.5	0	7	Means and Holzheuser	4288 - 4289
16 Sep 2019	0	2	4	0	1	Means and Holzheuser	4294 - 4295
17 Sep 2019	0	11	2	0	5.5	Means and Holzheuser	4296

Figure 2. Seal Salamander (*Desmognathus monticola*) collected from Bluff Springs Campground, Escambia County, Florida, USA, 31 January 2002. This is the last individual documented from Florida. (Photographed by D. Bruce Means).

Field surveys.—In 2017 and 2019, we and 11 other field herpetologists spent 57.17 person hours on 16 events searching for *D. monticola* in seven ravines within Bluff Springs Campground (Fig. 1). We surveyed ravines 1 and 4–9 (Fig. 1) for one-hour increments both day and night following traditional search methods for *D. monticola* (e.g., flipping logs or rocks and sifting leaf litter along the stream margins) and focused on the first 50–100 m of stream flow to recreate the search methods and locations used by Means and Longden (1970). We were unable to survey ravines 2 and 3 because large amounts of woody debris from recent clear-cut silviculture prevented our search. We did not survey for larvae because the streams are cohabitated by *D.* cf. *conanti*, whose larvae are difficult to distinguish from *D. monticola.* When we encountered a salamander, we documented the species and GPS coordinates and released the individual at the point of capture.

Statistics.—We collected data on the number of *D. monticola* captured per search hour per person (individuals collected/h) from historic and current field notes. For years with multiple surveys (1969 and 2019), we averaged the individuals [Ind]/h together by year to compensate for daily and seasonal changes in capture rate. We used R statistical software (R Core Team 2020) to calculate simple linear regression and determine the change in annual Ind/h from 1969 until 2019. We report all values ± one standard error when applicable. Because early surveys were not systematic and were spread across several decades, we did not calculate detection probability (MacKenzie and Royale 2005). We encountered and documented the abundance of other species of salamanders, but capture data for these species were not included in earlier fieldnotes; consequently, we were unable to conduct reliable analyses of their change over time.

Figure 3. Satellite imagery of ravine heads (black within white points) in Bluff Springs Campground, Escambia County, Florida, USA, showing extensive clear-cut silviculture (light colored areas) in 2019. (Image from Google Earth).

Results

In 2017 and 2019, we found no *D. monticola* during 57.17 person hours of searching (Table 1). During the original surveys, Means and Longden (1970) reported the presence of large rocks of compacted clay or sandstone, and friable to solid ravine walls along the stream margins where they found *D. monticola.* We did not find any habitat matching that description and surmise it was destroyed by recent clear-cut silviculture (Fig. 3).

In 1969, *D. monticola* was encountered at an average rate of 8.94 ± 2.06 individuals per search hour (Ind/h; Table 1). Starting from the first records in 1969, the number of individuals encountered per search hour declined significantly at a rate of 0.18 ± 0.039 Ind/h ($F_{1,3}$ = 20.39, P = 0.020, r^2 = 0.87) per year until reaching 0.67 Ind/h in 2002 and presumably 0.0 Ind/h shortly thereafter (Fig. 4). We are unaware of any surveys between 2002 and 2017. We readily encountered other species of salamanders, including presumed Spotted Dusky Salamanders (*D.* cf. *conanti*), Southern Two-lined Salamanders (*Eurycea cirrigera*) and Red Salamanders (*Pseudotriton ruber*) through 2019.

Discussion

Desmognathus monticola in Bluff Springs Campground, Escambia County, Florida, USA, has declined precipitously since the 1970s. This is the only site in Florida where the salamander is known to occur and it has not been seen since 2002. Thus, *D.*

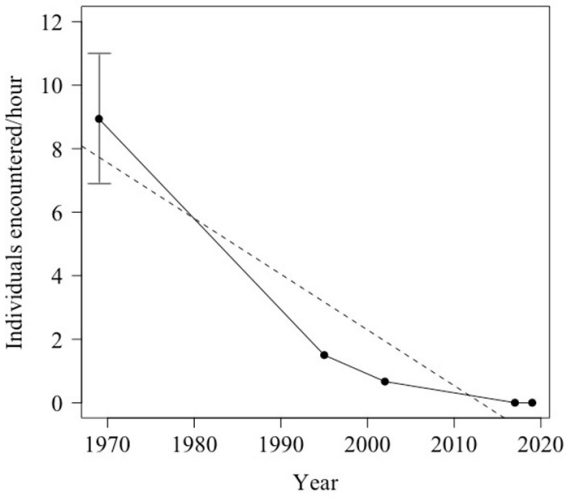

Figure 4. Average yearly encounters of Seal Salamanders (*Desmognathus monticola*) per search hour ± standard error from 1969 to 2019 within Bluff Springs Campground, Escambia County, Florida, USA. The dotted line is the trend line from Regression analysis.

monticola appears to be extirpated from the state. We are not certain of the cause, but habitat modification associated with impoundment of ravines, silvicultural practices, and agricultural practices likely are associated with the decline. Furthermore, disease and collections may have exacerbated the decline of this population, which appears to be small and geographically isolated from other populations of *D. monticola* to the north. For example, based on records at GBIF, the nearest population is approximately 82 km to the northwest in Monroe County, Alabama (Auburn Museum AUM–28221). Gene flow is often reduced in relatively small and isolated populations; consequently, they are sensitive to various stressors, including disease, habitat loss, contamination, and inbreeding depression (Frankham et al. 2002).

The population of *D. monticola* at the Bluff Springs Campground is not only geographically isolated from other populations, but gene flow is likely low or non-existent among individuals inhabiting the various ravines. Although little is known concerning the dispersal of larvae, they typically inhabit small gravel bars and seepage areas of stream beds (Folkerts 1968). The dam forming Bluff Springs Lake was constructed at an unknown time but was completed before Means and Longden (1970) conducted their first surveys in 1969 and destroyed habitat used by larvae, functionally isolating the salamanders into three groups. Two of these ravine groupings are upstream of the reservoir (1, 4, 5, 7, and 9) and one is below the dam (2, 3, 6, and 8). Isolated populations are particularly prone to inbreeding depression (Allentoft and O'Brien 2010). Such a loss of genetic variability increases extinction risk (Shaffer 1990) by reducing the evolutionary potential to survive environmental changes and disease, as well as increasing the acquisition of deleterious alleles (Hedrick and Kalinowski 2000).

Aquatic and semi-aquatic fauna, including salamanders, are often sensitive to activities that alter the upland watershed, such as silviculture. Specifically, Petranka et al. (1993) and Moseley et al. (2008) show that clear-cutting can have severe impacts on populations of *D. monticola* and other salamanders by changing pH, altering stream substrate, and increasing sedimentation. Interstitial spaces created by large rocks and gravel form important cover and habitat for adult and juvenile *D. monticola* (Petranka 1998). Following a clear-cut harvest, these spaces become impacted with fine sediment runoff, which fill interstitial spaces and prevent use by the species. Sedimentation is proposed as a dominant cause of decline of stream salamanders (Corn and Bury 1989; Lowe and Bolger 2002; Lowe et al. 2004; Stoddard and Hayes 2005; Ashton et al. 2006).

The description by Means and Longden (1970) of the habitat where they found *D. monticola* (e.g., large rocks of compacted clay or sandstone, and friable to solid ravine walls along the stream margins) matches the description of typical *D. monticola* habitat in other locations (Petranka 2008). This habitat is currently absent from Bluff Springs Campground site as we found no such habitat during our recent surveys. Since the discovery of the population in 1969, the forest within the ravines has been harvested twice using clear-cut forest management without consideration of best-management practices for streamside management zones. Although we do not know the history of logging in the area, the most recent clear-cut occurred in early 2019 a few months before our surveys began. The Board of Directors of Bluff Springs Campground will not replant trees and will terminate future silviculture practices in the area (Scott McCauslin, pers. comm.). Runoff from bare soil following clear-cuts flows through ravines and can lead to sedimentation within the streams (Ash 1997), which we suggest has covered and obliterated rocky microhabitat occupied previously by *D. monticola.* Additionally, increased irradiance in the stream beds associated with tree removal can stimulate rapid plant growth and cause the ravines to be choked with woody and herbaceous brush (Lockaby et al. 2004).

Sedimentation and other harmful effects of silviculture can be either temporary (Ash 1997) or avoided by using best-management practices (Hatten et al. 2018), but frequent clearcutting may create a chronic effect through repeated runoff events (Beschta 1978; Moseley et al. 2008). Also, because the Bluff Springs Campground population appears isolated, it is unlikely that individuals persist in nearby undisturbed habitat, which could act as a refuge to repopulate disturbed areas of Bluff Springs following forest recovery.

We cannot rule out other causes of extirpation of *D. monticola* from Florida. Agriculture practices around Bluff Springs Campground are intensive and possibly impact the suitable habitat through agrochemical runoff and seepage into the surficial aquifer that feeds the ravine streams (Katz et al. 1999). Amphibian pathogens, such as chytrid fungus and Ranavirus, have negatively impacted many species of amphibians globally (Daszak et al. 1999) but reports of chytrid fungus and Ranavirus infection in *D. monticola* are sparse (Gray et al. 2009; Davidson and Chambers 2011; Sutton et al. 2015), which prevent a definitive determination of their population-level impacts. We do not believe over collection of *D. monticola* caused the extirpation. We searched several stream heads in the Bluff Springs tributary system that biologists did not collect from in the past and found no individuals. Even so, pathogens and over-collection may have at least partially contributed to the declines.

If extant, the population of *D. monticola* at Bluff Springs is small and remaining individuals are difficult to find. Furthermore, undiscovered populations may inhabit tributaries of Canoe Creek that have not yet been surveyed. Additional surveys of Bluff Springs Campground and other tributaries should be conducted to better ascertain the status of *D. monticola* in Florida. Given recent advances and successes in use of environmental DNA (eDNA) to detect rare and elusive salamanders (Goldberg et al 2011; Pierson et al. 2016), we recommend conducting eDNA surveys in streams of all ravines within Bluff Springs Campground. Remaining species of stream-dwelling salamanders within Bluff Springs Campground should be tested for pathogens to ascertain the likelihood of their impact on *D. monticola.* Because of the apparent absence of typical habitat of *D. monticola* (Means and Longden 1970), we also recommend that future surveys include analyses of the sediment composition. Quantification of change in ravine geomorphology over time may reveal the amount of time needed for habitat recovery following poor forest management practices.

Acknowledgments.—We thank Scott and Jeanette McCauslin, caretakers of the Bluff Springs Campground, and the Alabama/Northwest Florida and Gulf Mission Centers of the Community of Christ for permission to conduct our fieldwork on their property. We thank David Beamer, Matthew Fedler, Alex Pyron, and Peter Kleinhenz for information regarding their fieldwork in 2017 and 2019. We also thank Ryan Means for assistance in the field. These data were collected under Florida Fish and Wildlife Conservation Commission permit number LSSC-13-00013B.

Literature Cited

Alford, R.A., and S.J. Richards. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics 30:133–165.

Allentoft, M.E., and J. O'Brien. 2010. Global amphibian declines, loss of genetic diversity and fitness: a review. Diversity 2:47–71.

Ash, A.N. 1997. Disappearance and return of plethodontid salamanders to clearcut plots in the Southern Blue Ridge Mountains. Conservation Biology 11:983–989.

Ashton, D.T., S.B. Marks, and H.H. Welsh, Jr. 2006. Evidence of continued effects from timber harvesting on lotic amphibians in Redwood Forests of northwestern California. Forest Ecology and Management 221:183–193.

Bailey, L.L., P. Jones, K.G. Thompson, H.P. Foutz, J.M. Logan, F.B. Wright, and H.J. Crockett. 2019. Determining presence of rare amphibian species: testing and combining novel survey methods. Journal of Herpetology 53:115–124.

Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Goggin, and H.B. Hines. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proceedings of the National Academy of Sciences 95:9031–9036.

Beschta, R.L. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. Water Resource Research 14:1011–1016.

Best, M.L., and H.H. Welsh, Jr. 2014. The trophic role of a forest salamander: impacts on invertebrates, leaf litter retention, and the humification process. Ecosphere 5:1–19.

Burton, T.M., and G.E. Likens. 1975a. Energy flow and nutrient cycling in salamander populations in the Hubbard Brook Experimental Forest, New Hampshire. Ecology 56:1068–1080.

Burton, T.M., and G.E. Likens. 1975b. Salamander populations and biomass in the Hubbard Brook experimental forest, New Hampshire. Copeia 1975:541–546.

Corn, P.S., and R.B. Bury. 1989. Logging in western Oregon: responses of headwater habitats and stream amphibians. Forest Ecology and Management 29:39–57.

Daszak, P., L. Berger, A.A. Cunningham, A.D. Hyatt, D.E. Green, and R. Speare. 1999. Emerging infectious diseases and amphibian population declines. Emerging Infectious Diseases 5:735–748.

Davidson, S.A., and D.L. Chambers. 2011. Occurrence of *Batrachochytrium dendrobatidis* in amphibians of

Wise County, Virginia, USA. Herpetological Review 42:214.

Dodd, C.K., Jr. 1998. *Desmognathus auriculatus* at Devil's Millhopper State Geological Site, Alachua County, Florida. Florida Scientist 61:38–45.

Farmer, A.L., K.M. Enge, J.B. Jensen, D.J. Stevenson, and L.L. Smith. 2017. The Striped Newt (*Notophthalmus perstriatus)*. Herpetological Conservation and Biology 12:585–598.

Folkerts, G.W. 1968. The genus *Desmognathus* Baird, (Amphibia: Plethodontidae) in Alabama. Ph.D. Dissertation, Auburn University, Auburn, Alabama, USA. 129 p.

Frankham, R., D.A. Briscoe, and J.D. Ballou. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge, UK.

Goldberg, C.S., D.S. Pilliod, R.S. Arkle, and L.P. Waits. 2011. Molecular detection of vertebrates in stream water: a demonstration using Rocky Mountain Tailed Frogs and Idaho Giant Salamanders. PLoS ONE 6(7): https://doi.org/10.1371/journal.pone.0022746.

Gray, M.J., D.L. Miller, and J.T. Hoverman. 2009. First report of Ranavirus infecting lungless salamanders. Herpetological Review 40:316.

Hatten, J.A., C. Segura, K.D., Bladon, V.C. Hale, G.G. Ice, and J.D. Stednick. 2018. Effects of contemporary forest harvesting on suspended sediment in the Oregon Coast Range: Alsea Watershed Study Revisited. Forest Ecology and Management 408:238–248.

Hedrick, P.W., and S.T. Kalinowski. 2000. Inbreeding depression in conservation biology. Annual Review of Ecology and Systematics 31:139–162.

Hickerson, C.A.M., C.D. Anthony, and B.M. Walton. 2017. Eastern Red-backed Salamanders regulate top-down effects in a temperate forest-floor community. Herpetologica 73:180–189.

Highton, R. 2005. Declines of eastern North American woodland salamanders (*Plethodon*). Pp. 34–46 *In* Amphibian Declines: The Conservation Status of United States Species. Lannoo, M. (Ed.). University of California Press, Berkeley, California, USA.

Hipes, D., D.R. Jackson, K. NeSmith, D. Printiss, and K. Brandt. 2001. Field Guide to the Rare Animals of Florida. Florida Natural Areas Inventory. State of Florida Department of Transportation, Tallahassee, Florida, USA.

Houlahan, J.E., C.S. Findlay, B.R. Schmidt, A.H. Meyer, and S.L. Kuzmin. 2000. Quantitative evidence for global amphibian population declines. Nature 404:752–755.

Katz, B.G., H.D. Hornsby, J.K. Bohlke, and M.F. Mokray. 1999. Sources and chronology of nitrate contamination in spring waters, Suwannee River Basin, Florida. Water-Resources Investigations Report 99-4252, U.S. Geological Survey, Tallahassee, Florida, USA. 54 p.

Lockaby, B.G., R. Governo, B. Rummer, and C. Colson. 2004. Silvicultural management within streamside management zones of intermittent streams: effects on decomposition, productivity, nutrient cycling, and channel vegetation. Southern Journal of Applied Forestry 28: 211–224.

Lowe, W.H., and D.T. Bolger. 2002. Local and landscape-scale predictors of salamander abundance in New Hampshire headwater streams. Conservation Biology 16:183–193.

Lowe, W.H., K.H. Nislow, and D.T. Bolger. 2004. Stage-specific and interactive effects of sedimentation and trout on a headwater stream salamander. Ecological Applications 14:164–172.

MacKenzie, D.I., and J.A. Royle. 2005. Designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology 42:1105–1114.

Means, D.B., and C.J. Longden. 1970. Observations on the occurrence of *Desmognathus monticola* in Florida. Herpetologica 26:396–399.

Means, D.B., and R.C. Means. 2005. Effects of sand pine silviculture on pond-breeding amphibians in the Woodville Karst Plain of North Florida. Pp. 56–61 *In* Amphibians and Reptiles: Status and Conservation in Florida. Meshaka, W.E., and K.J. Babbitt (Eds.). Krieger, Malabar, Florida, USA.

Means, D.B., and J. Travis. 2007. Declines in ravine-inhabiting dusky salamanders of the southeastern US Coastal Plain. Southeastern Naturalist 6:83–97.

Means, D.B., J.G. Palis, and M. Baggett. 1996. Effects of slash pine silviculture on a Florida population of Flatwoods Salamander. Conservation Biology 10:426–437.

Moseley, K.R., W.M. Ford, J.W. Edwards, and T.M. Schuler. 2008. Long-term partial cutting impacts on *Desmognathus* salamander abundance in West Virginia headwater streams. Forest Ecology and Management 254:300–307.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C., USA.

Petranka, J.W., M.E. Eldridge, and K.E. Haley. 1993. Effects of timber harvesting on southern Appalachian salamanders. Conservation Biology 7:363–370.

Pierson, T.W., A.M. McKee, S.F. Spear, J.C. Maerz, C.D. Camp, and T.C. Glenn. 2016. Detection of an enigmatic plethodontid salamander using environmental DNA. Copeia 104:78–82.

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org.

Shaffer, M.L. 1990. Population viability analysis. Conservation Biology 4:39–40.

Stoddard, M.A., and J.P. Hayes. 2005. The influence of forest management on headwater stream amphibians at multiple spatial scales. Ecological Applications 15:811–823.

Stuart, S.N., M. Hoffmann, J.S. Chanson, N.A. Cox, R.J. Berridge, P. Ramani, B.E. Young. 2008. Threatened Amphibians of the World. Lynx Edicions. Barcelona, Spain.

Sutton, W.B., M.J. Gray, J.T. Hoverman, R.G. Secrist, P.E. Super, R.H. Hardman, J.L. Tucker, and D.L. Miller. 2015. Trends in Ranavirus prevalence among plethodontid salamanders in the Great Smoky Mountains National Park. EcoHealth 12:320–329.

United States Fish and Wildlife Service (USFWS). 2009. Endangered and threatened wildlife and plants; determination of endangered status for Reticulated Flatwoods Salamander; designation of critical habitat for Frosted Flatwoods Salamander and Reticulated Flatwoods Salamander. Federal Register 74(26):6700–6774.

Vitt, L.J., J.P. Caldwell, H.M. Wilbur, and D.C. Smith. 1990. Amphibians as harbingers of decay. BioScience 40:418–418.

Chace Holzheuser is a graduate student working towards a Ph.D. in Ecology and Evolutionary Biology in the Department of Biological Science at Florida State University, Tallahassee. Chace received his B.S. in Wildlife and Fisheries Sciences from Texas A&M University, College Station, USA, in 2015, and an A.A. in Spanish Language and Latin American Culture from the Defense Language Institute, Monterey, California, USA, in 2014. His interest in reptile and amphibian conservation has driven him to pursue a dissertation project emphasizing amphibian declines and conservation genomics. He aims to understand why herpetofauna decline, how the declines affect ecosystem functions, and how best to prevent and reverse further declines. He has conducted research in Texas, Panama, Costa Rica, Ecuador, and Florida ranging from natural history investigations on high-altitude anurans to amphibian pathology in the coastal plains of Florida. (Photographed by Karen Lips).

D. Bruce Means is the founder and President Emeritus of the Coastal Plains Institute (CPI) and Land Conservancy and Courtesy Professor in the Department of Biological Science, Florida State University, Tallahassee, Florida, USA. He is a triple alumnus of FSU, receiving his Ph.D. in 1975. He served as the Director of Tall Timbers Research Station from 1976 to 1984 and founded CPI in 1984 where he has served to the present. Salamanders of the genus *Desmognathus* have been one focus of his research for five decades. He described Apalachicola Dusky Salamanders (*Desmognathus apalachicolae*, Means and Karlin 1989) from Florida and Valentine's Dusky Salamander (*Desmognathus valentinei*, Means, Lamb, and Bernardo 2017) from the eastern Gulf Coastal Plain, redescribing Southern Dusky Salamanders (*D. auriculatus*) in that paper. A field ecologist with more than 50 y experience, his main research interests center on fire ecology, Longleaf Pine ecosystem, tropical biology, tepui ecology, biogeography, pond ecology, amphibians and reptiles, and rare and endangered species. He has published more than 300 scientific research papers, popular articles, and technical reports, and 11 books. (Photographed by D. Bruce Means).