Eastern Mud Salamander (*Pseudotriton montanus*)
Status in Maryland

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EXECUTIVE SUMMARY

The eastern mud salamander (*Pseudotriton montanus montanus*) is a species of Greatest Conservation Need (GCN) currently under review by the Maryland DNR Natural Heritage Program for listing as a rare, threatened, or endangered species (MD DNR Heritage Program 2004). To determine the distribution and abundance of *P. montanus* in Maryland, we compiled historical (1926-1977) and extant (1977-2006) locality data from museums, literature, unpublished data, and extensive personal communications with herpetologists, and we conducted field surveys for *P. montanus* in 2006. Identification of this species during the larval stage is difficult and creates uncertainty about accuracy of a few locality records. We studied live and vouchered specimens collected from Maryland and provide a comparison table and photographs to aid in distinguishing the species from the northern red salamander (*Pseudotriton ruber*). We created a database of locality records and mapped clusters of locality records (element occurrences) using spatial software (ArcGIS 9.0).

Our field survey sites were conducted at historical localities, uncertain extant localities, and additional locations on the Eastern Shore. We surveyed floodplain and seep habitat by lifting cover objects and raking mud and detritus, and we surveyed aquatic habitat with electroshocking. We observed the species at 2 of 46 sites surveyed for a total of three adults and one to three larvae. Twelve extant localities for *P. montanus* exist in Maryland, a decline of 43% from the 28 historical localities present. Only one extant record exists for the species on the Eastern Shore. Most extant records are of a single individual observed once. All extant records are of fewer than 4 individuals observed at a time, with 16 or fewer individuals recorded over several years at the same location. We recommend the species for listing as Rare or higher threat level due to few extant populations, few numbers of individual *P. montanus* observed per population, as well as, the widespread habitat degradation of Maryland's stream (MD DNR 2005 Volume 14) and seep habitat used by this species. Listing the species as Rare would provide opportunity to further track populations and survey historical localities for more data upon which to evaluate whether the species is Threatened or Endangered.

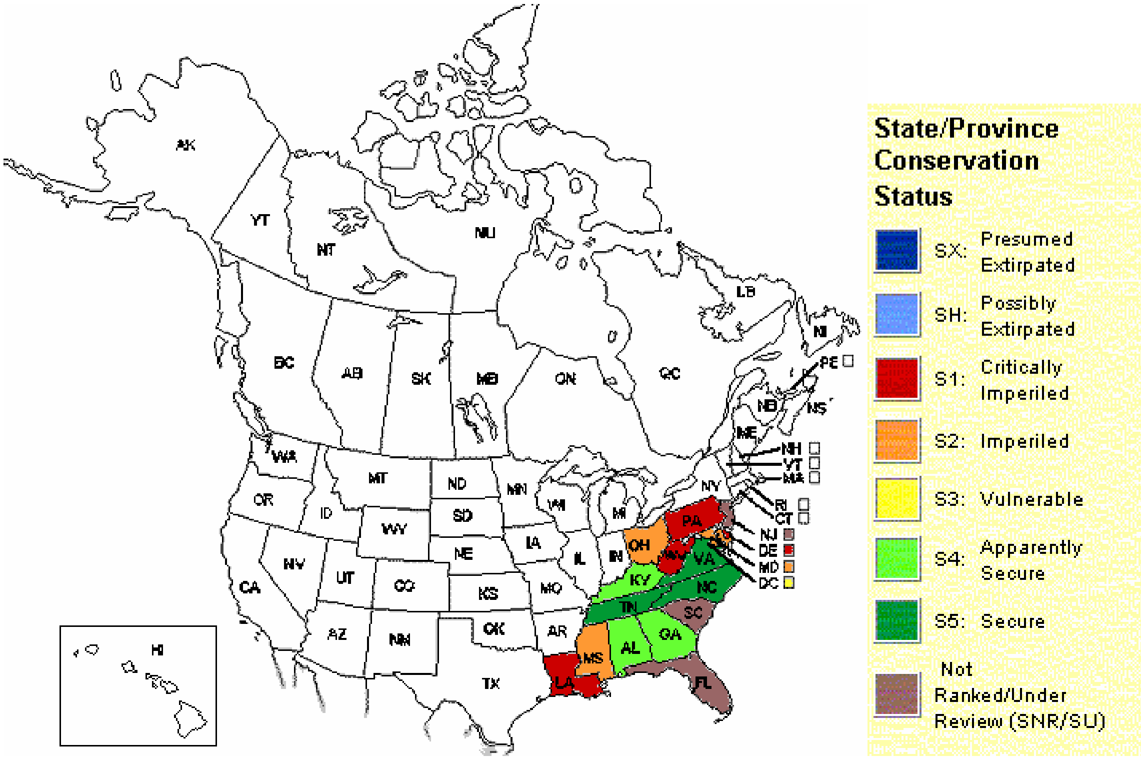
INTRODUCTION

The eastern mud salamander (*Pseudotriton montanus montanus*) is a species of Greatest Conservation Need (GCN) currently under review by the Maryland DNR Natural Heritage Program for listing as a rare, threatened, or endangered species (MD DNR Heritage Program 2004). The species is of regional conservation concern to the Northeast Association of Fish and Wildlife Agencies (MD DNR Heritage Program 2004) and is considered imperiled (S2 rank) by NatureServe (2006; Figure 1). Recent surveys of Maryland streams by Maryland Department of Natural Resources's (DNR) Maryland Biological Stream Survey (MBSS) and others (e.g., Strain and Raesly 2006) revealed few or no observations of *P. montanus*. Limited observations may be due to rarity, patchy distribution, difficulty in detecting the species, or difficulty in distinguishing the species from northern red salamanders (*Pseudotriton ruber*). The distribution, relative abundance, and habitat tolerances of *P. montanus* in Maryland are not known.

Our primary goal was to collect locality data to accurately determine the distribution and abundance of *P. montanus* in Maryland. We compiled locality data from museums, literature, unpublished data, and personal communications with local and regional herpetology experts. We conducted field surveys in 2006 to obtain current distribution and abundance data for *P. montanus*. Field surveys included targeted sampling for *P. montanus* and incidental herpetofauna observations conducted as part of standard Maryland Biological Stream Survey (MBSS) sampling and targeted MBSS sampling conducted for other GCN species and special management areas. Secondary goals of our research included identifying characteristics of larvae that distinguish the species from *P. ruber*; collecting natural history data for individuals observed; estimating habitat tolerance limits (based on coincident physical, chemical, and landscape data); and describing successful search methods. In addition to the information on *P. montanus*, this report includes an appendix of all GCN herpetofauna species encountered during this and other MBSS surveys in 2006. The locality information is provided to aid Natural Heritage Program in continued management of Maryland's herpetofauna.

STUDY SPECIES

P. montanus adults range in total length from 7 to 21 cm (Martof 1975, Petranka 1998). Juvenile coloration is orange, red, or salmon and older adults tend to be reddish brown to chocolate brown (Martof 1975). The dorsum of both juveniles and adults is flecked with a few round, black spots (Martof 1975, Petranka 1998, White and White 2002). Brown eyes, shorter snout (1 to 1.5 eye widths; Smith 1978), and round black spots distinguish *P. montanus* from *P. ruber*, which have a yellow iris with a black transverse bar (Pfingsten and Downs 1989), longer snout (1.5 to 2 eye Figure 1. Global conservation status of the eastern mud salamander; ranking provided by NatureServe.



widths; Smith 1978), and more numerous and irregularly shaped spots (Martof 1975, Petranka 1998, White and White 2002). Larvae of the two species are difficult to tell apart. Larvae from different geographic regions vary in pigmentation patterns and ontogenetic development (Petranka, pers. comm.). Older *P. montanus* larvae from other states typically have widely scattered black spots on a uniformly brown dorsum and sides (*P. ruber* larvae usually lack distinct spots and are uniformly mottled; Birchfield and Bruce 2000, Petranka 1998) but may have streaking (Wayne Van Devener, pers. comm.; see also Plate 27-D, Pfingsten and Downs). Hatchling *P. montanus* are light brown above and white below, with stream type morphology (White and White 2002). Metamorphosis occurs at approximately 40mm snout to vent length during the second year after hatching (Hunsinger 2005).

P. montanus inhabit muddy areas in and near springs, seeps, wet floodplains, swamps, and slow flowing streams (White and White 2002). The species is subterranean and found in mucky, partially decomposed organic matter (i.e., not inorganic clay or silt; Means 2000). Adults may rest vertically in tunnels just under the surface of the mud (Heckscher 1995). The geographic range of *P. montanus* includes the Mid-Atlantic and Southeastern United States and is found in all states from New Jersey west to Ohio, south to Louisiana, and southeast to Florida.

METHODS

Locality Records

Locality records were classified "extant" (present to 30 years ago; 1977-2006) or "historical" (>30 years ago), following Natural Heritage Program protocol. We obtained locality records from museum collections, literature, unpublished data, personal communications, and field surveys we conducted in 2006. Data were obtained from records held in the following institutions and accessed through HerpNET data portal (http://www.herpnet.org/) on 15 February 2006: Field Museum of Natural History (FMNH), Los Angeles County Museum of Natural History (LACM), James R. Slater Museum (PSM), and Illinois Natural History Survey (INHS). We obtained a list of museums from which to request data from the Combined Index to Herpetology Collections (http://www.calacademy.org/research/herpetology/Comb_Coll_Index/Index.html). Data were obtained from the following institutions (curator indicated): United States National Museum (USNM; Kevin de Queiroz), Towson [State] University Museum (TSU; Bob Miller), Maryland Natural History Museum (MNHM; Herb Harris), and Carnegie Museum of Natural History (CM; Steve Rogers). Data were obtained from University of Florida (FLMNH) through the online portal (www.flmnh.ufl.edu/scripts/dbs/herps_pub.asp) on 15 February 2006.

Select specimens were inspected for correct species identification at USNM and MNHM. Unpublished data and personal communications were obtained from greater than twenty herpetologists with areas of expertise including first-hand locality observations and leads for and compilations of locality records (Appendix A). Locality data per observation were entered into a MS Access database and provided to Natural Heritage Program electronically. The distribution of locality records was mapped in a shapefile (ArcGIS 9.0 software) and provided to Natural Heritage Program electronically.

Identification

Correct identification of a species is necessary to collect accurate field data and to assess validity of historical and extant locality records. We used four methods to assure accurate species identification of *Pseudotriton* spp. larvae: 1) compile and study existing literature and keys, 2) inspect museum specimens and consult with a museum specialist for Plethodon salamanders at the U.S. National Museum about identification of a live larva captured during 2006 surveys, 3) raise the larva to metamorphosis and record observations, and 4) correspond with local and regional herpetology experts to obtain unpublished information (Appendix A).

The larva we raised to metamorphosis was kept from May 3, 2006 to October 23, 2006 in an aquarium. Water was collected from a spring known to contain breeding amphibian populations. We changed water in the aquarium every 1-3 days. The salamander was fed at the time of water change with aquatic biota netted from a pond. The salamander pursued and ate a variety of small organisms from pond water, but would not eat black worms or tiny earthworms. Aquatic vegetation and leaf litter was placed in the aquarium to provide refuge and structure and was replaced with each water change.

Site Selection and Survey Method, Targeted Field Surveys

We conducted targeted surveys at 46 sites and an additional 11 sites visited were unsampleable due to tidal influence, safety concerns, no permission, or dry streambed (Appendix B). We searched sites in the Coastal Plain and Piedmont with recent, uncertain observations (to confirm species identification at potentially extant sites); historical observations (to determine continued occupation and changes in range); and no observations (to confirm accuracy of estimated range on the eastern shore of Maryland).

We utilized three survey methods: raking mud and detritus, lifting cover objects, and electroshocking. *P. montanus* can be found near the surface of the mud by quickly raking away the top layer of mud or detritus to expose mud salamanders in vertical burrows (Heckscher, 1995). We quickly raked away the top 1-8cm of dark, saturated mud and leaf litter to expose any salamanders. We raked with either a small trowel or wore rubber gloves and raked by hand. Habitat searched with this method included seeps, springs, and floodplain wetlands. Area (m^2) raked was recorded. Lifting logs (A. Norden, MDNR, pers. comm.) or artificial cover (e.g., wood, linoleum, carpet; Herb Harris, pers. comm.) to detect individuals under cover objects is a recommended method for detecting the species in springs and swamps. We lifted and replaced logs and rocks >4cm x 4cm on saturated soils in seeps and floodplain. The quantity of cover objects lifted was recorded. Electroshocking is a method regularly used by MBSS that has successfully detected *Pseudotriton* spp. larvae in streams. One person operated a backpack electroshocker (Smith-Root 12-B) and used the anode net to catch larvae, while a second person used a net to catch additional larvae observed. We electroshocked intermittently in streams, oxbows, and seasonal pools and focused in habitats with muck, leaf packs, and debris. Electroshocking effort was quantified by total seconds the shocker was in use. At each site, we recorded: downstream coordinates, site access, sky code (North American Amphibian Monitoring Program protocols; www.pwrc.usgs.gov/NAAMP/protocol/definitions.html), incidental herpetofauna species, incidental crayfish species, description of "appropriate" habitat available, Hydrolab measurements of water chemistry (pH, dissolved oxygen, specific conductivity, temperature) using MBSS protocols (Kazyak 2001), and total search time and linear distance searched. Datasheets for sites searched and datasheets for *P. montanus* observed are in Appendix C.

Data recorded per *P. montanus* specimen collected (*N*=4 certain, *N*=2 probable) included snout to vent length, total length, age class, comments on color or behavior, and method of capture (Appendix C). We also described characteristics upon which the identification was based and photographed eye color, supraotic pore pattern, dorsal view, and lateral view. Habitat variables measured included: cover and substrate (wood, rock, muck, leaf litter, water, other), associated plant and animal species <2m, general description of vegetation, photographs of habitat at approximately 2m and 20m scales, and distance to stream. Seep type (rheocrene, limocrene, helocrene; Bruce 2003 after Lindegaard 1995) and type of wetland at $10m^2$ scale (NWI classification, Cowardin et al 1979) were recorded but data were not reported here because correct identification of seep types was uncertain and NWI class was not useful at small scale. We describe soil type (National Soil Information System (NASIS), U.S. Department of Agriculture, Natural Resources Conservation Service; geospatial data obtained from MD DNR) for locations of *P. montanus* specimens collected during field surveys.

RESULTS

Locality Records

We compiled 123 locality records for *P. montanus* in Maryland and an additional 18 records of *Pseudotriton* spp. salamanders for which identification was uncertain. Locality records refer to one individual, or, one museum accession number or literature reference (i.e., may refer to greater than one individual).

Extant records, including this study, include 25 observations occurring at approximately 12 element occurrences (i.e., clusters of observations that may represent the same population) in the state (Appendix D). Extant records were obtained from Southerland et al. (2003, pers. comm.), Smithberger and Swarth (1993), Towson State University Museum (data provided by Bob Miller, pers. comm.), Don Forester (Towson University, pers. comm.), Taylor et al. (1984; Scott Smith, MD DNR, pers. comm.), R. Legere (unpublished data; Scott Smith MD DNR, pers. comm.), Chris Swarth and Karyn Molines (Jug Bay Wetlands Sanctuary, unpublished data), Strain and Raesly (2006; Gabriel Strain, Frostburg University, pers. comm.), MD DNR Foley and Smith (1999), and this study. Records for which species identification is, in our opinion, uncertain include 17 extant records. These records were identified as uncertain if 1) literature and personal communication strongly suggested uncertainty of species identification (i.e., Heckscher 1995 for Worcester County records), and 2) identification was based solely on eggs or larvae without voucher photographs or specimens (e.g., MBSS records); see below for discussion of larval identification.

Locality records include 97 historical records occurring at approximately 28 element occurrences in the state (Appendix E). A few literature and museum records may duplicate the same observation. Harris (1975) provides a distributional map that reports many records from other sources. We included two of 29 historical records mapped in Harris (1975) that were the only records for a county (Worcester) and were thus not duplicates of other historical records. We categorically defined published historical records as species identification of "certain" because most records have museum vouchers that could be inspected. Historical records were obtained from museums (see Methods), Fowler (1941) reference to the collection of the United States Fish and Wildlife Service, Herbert Harris (1975; unpublished data), Frank Hirst (pers. comm.), and Arnold Norden (Maryland Department of Natural Resources, pers. comm.).

Species Identification, Literature and Personal Communications

Adult *P. montanus* can be readily distinguished from *P. ruber* by three characteristics: 1) distinct, round, few spots on dorsum (*P. ruber* have oblong, touching spots), 2) brown eyes (*P. ruber* have yellow eyes and a black tranverse bar across the eye), and 3) a short snout 1-1.5 eye widths in length (*P. ruber* have a snout 1.5-2 eye widths in length) (Conant 1957; Smith 1978; Powell et al. 1998; Petranka 1998). However, to the inexperienced observer unfamiliar with these characteristics, the species can look nearly identical (Appendix F).

Larval *P. montanus* are not easily distinguished from larval *P. ruber* and we compiled a chart comparing attributes of each species (Appendix G). Standard keys (e.g., Altig and Ireland 1984) are insufficient to distinguish species in many populations of *Pseudotriton* spp. (Birchfield and Bruce 2000). For small hatchling *Pseudotriton* spp. larvae less than 9 month-1year old, Ralph Pfingsten (pers. comm.) states he can not see any difference. James Petranka (pers. comm.) advised us that there is "likely much regional geographic variation so you probably will have to work the identifications out for your region. Ontogenetic variation is also marked and poorly described for most salamander species." Larval *Pseudotriton* spp. have not been studied in Maryland, to our knowledge. The nearest populations that have been studied are in Ohio (for a different subspecies, *Psedotriton montanus diasticus*; Pfingsten and Downs 1989), South Carolina and North Carolina (where coloration varies remarkably between upper Piedmont/Blue Ridge and lower Piedmont/Coastal Plain populations; Bruce 1974; 1975; 1978; 2003; pers. comm.).

Preserved specimens of *P. montanus* in the MBSS collection had been identified as *P. montanus* by regional herpetology experts (i.e., Don Forester, Towson University and MBSS staff). Several specimens were reviewed during this study and were identified as *P. ruber* (i.e., by Addison Wynn, U.S. National Museum; Herb Harris; and Rebecca Chalmers). We used count of costal grooves, prevalence of mottling, absence of spots, and, for some specimens, presence of transverse eye bar to identify larval specimens as *P. ruber*. The fact that regional experts disagree emphasizes the difficulty in differentiating larvae of the *Psedotriton* species.

Birchfield and Bruce (2000) attempted to find morphological measurements with which to identify the *Pseudotriton* species (as well as identify larvae of the similar-looking *Gyrinophilus porphyriticus* and *Stereochilus marginatus*). They concluded that variables used in their study may not sufficiently identify species. With that caveat, they suggested familiarity with local variation in pigmentation and pattern can be combined with subtle differences in body proportions to identify *Pseudotriton* larvae (Birchfield and Bruce 2000). Body proportion differences included: *P. montanus* has more attenuated (longer and thinner) limbs and slightly larger eyes than *P. ruber,* and bushier gills when syntopic with *P. ruber* (Birchfield and Bruce 2000). Ralph Pfingsten (pers. comm.) also described *P. montanus* larvae as having longer and more filamentous gills than those of *P. ruber*, such that "if you were to overlap the longest gill of *P. montanus* across the head they will distinctly overlap. The longest gills of *P. ruber* will seldom overlap, and if so, only very slightly." Other herpetologists cautioned that although syntopic populations of *P. montanus* do have longer gills than *P. ruber,* gill length is a phenotypically plastic character in both species (Richard Bruce, pers. comm.) and that, generally, individuals that are in muddier, less oxygenated waters have longer gills regardless of species (Steven Price, pers. comm.).

Two patterns of pigmentation are observed in larval *P. montanus*. One pattern consists of "spots on the dorsum and sides of *P. montanus* [that] are much more distinct and fewer in number than those of *P. ruber*" (Appendix F; Ralph Pfingsten, pers. comm.; Richard Bruce, pers. comm). Faint streaking may also be present (Richard Bruce, pers. comm.). *P. montanus* larvae with spots are reported from the lower Piedmont and Coastal Plain of North Carolina (Richard Bruce, pers. comm.). The second pattern observed in some populations of *P. montanus* consists of "prominent dark streaks and reticulations that run longitudinally" (whereas "*P. ruber* has a flecked pattern, an irregular array of tiny dark flecks on the back and sides") (Richard Bruce, pers. comm.). The streaking pattern is reported from larvae in the Upper Piedmont and Blue Ridge of South Carolina and North Carolina (Richard Bruce, pers. comm.) and Pennsylvania (Wayne Van Devender, pers. comm.). In addition to "dark flecks arranged into longitudinal streaks, especially on the posterior of the body and the anterior part of the tail", Wayne Van Devender (pers. comm.) reports that *P. montanus* larvae are thinner than *P. ruber* larvae. Photographs of *P. montanus* in Salamanders of Ohio (Pfingsten and Downs 1989) illustrate both a larva with spots (Plate 28—A) and a larva with streaks (Plate 27—D).

Steven Price (pers. comm.) described a novel method of distinguishing the species that we were unable to duplicate or verify with other herpetologists. The supraotic lateral line pores on *P. montanus* larvae have a distinct mask shape around the eyes whereas the pore pattern of *P. ruber* is somewhat messy and extends down the side of the cheek (Appendix F).

Habitat is another method used to discern the species, however, the two species can co-occur (Bruce 1968, 2003). Maryland *Pseudotriton* spp. specimens identified by habitat (i.e., seep versus stream) include some Towson University Museum *P. ruber* specimens (Bob Miller, pers. comm.). Typical habitat for *P. montanus* includes bottom land swamp-forest streams with clay or silt substrate (Bruce 2003), wet pockets of organic matter along swampy creeks, and mucky depressions and seeps in the floodplains of streams of Strahler order 3 or greater (Means 2000). *P. ruber* are typically found in ravine streams (Means 2000), streams with sand and leaf packs (Bruce 2003, pers. obs. this study), or free flowing hillside seeps that may have large volumes of water (Ralph Pfingsten, pers. comm.).

Costal groove count for *P. montanus* ranges 16 to 17 (Petranka 1998), but Addison Wynn (U.S. National Museum, pers. comm.) suggests that variation may be due to differences in counting methods by different observers, or the same observer at different times. He classifies specimens by costal groove count of 16 for *P. montanus* and 17 for *P. ruber*. Counting costal grooves is easiest with preserved specimens (Addison Wynn, pers. comm.) or viewed from close-up photographs displayed on a computer screen (pers. obs.).

Field Data 2006, Larva Raised to Metamorphosis

We captured a *P. montanus* larva May 3, 2006 and raised it to metamorphosis October 23, 2006 (Appendix H). We believe the larva to be *P. montanus* because, three days before metamorphosis, the larva had eyes with brown pupils, a slender body, long gills, and scattered, round black spots on the dorsum. The larva exactly resembles a photograph of a *P. montanus* larva (Plate 28—A.) in Salamanders of Ohio (Pfingsten and Downs 1989). The larva grew from 61mm total length and 33mm snout to vent length on May 3, to 64mm total length and 36mm snout to vent length on August 3 and 65.5mm total length and 40.1mm snout to vent length on October 18, 2006. Gills were long when photographed October 18 (Appendix H), but were approximately 90% absorbed three days later on October 21, and on October 24 the salamander escaped and was not again observed.

It was difficult to definitively identify this larva. We brought the larva to Maryland herpetologist Herb Harris on June 29, 2006. Harris declined to identify the larva and stated he used habitat (i.e., mucky springs=*P. montanus*; streams=*P. ruber*), or, presence of adult specimens in the same location to identify larvae. We sent a photograph of the larva to Richard Bruce, Ralph Pfingsten, and Steven Price. Bruce and Price thought the larva was *P. montanus.* Pfingsten declined to positively identify the larva; the larva appeared to have too many spots, spots that were not distinct enough, and the photo we provided did not clearly illustrate if gills were long enough for the larva to be a *P. montanus*. We asked other herpetologists to identify the larva, but many were not confident of larval identification for this species. We then brought the salamander to Addison Wynn, a Museum Specialist with the US National Museum who specializes in Plethodon salamanders, on July 12, 2006. Wynn counted 16 costal grooves and said the larva "could be" a *P. montanus*. He exclusively used count of costal grooves to identify the species and stated it was less certain on a live specimen because preservatives cause costal grooves to become more indented and visible than they are in life, and the live specimen moved around.

Field Data 2006, Pseudotriton spp. at Uncertain Extant Localities

We observed larval *P. ruber* in great abundance (*N*=9) at one site (SENE-104-H-2006, unnamed tributary to Goshen Branch) in Montgomery County at which the MBSS had previously documented *P. montanus*. Earlier records for this site were likely *P. ruber* specimens misidentified as *P. montanus*. We identified the *P. ruber* larvae by their yellow eyes, transverse bar on eyes of some specimens, lack of round black spots, and presence of many mottled spots that completely covered the dorsum (Appendix I). The site was located in a sandy stream in an open field; there was no muck. There are no confirmed extant records of *P. montanus* for Howard or Montgomery counties. Other sites at which we observed *P. ruber*, but not *P. montanus*, during our surveys of uncertain extant localities include: PAXL-102-H-2006 (Saint Thomas Creek), BRET-101-H-2006 (Moll Dyers Run) and BRIG-101-H-2006 (unnamed tributary to Cattail Creek). The *P. ruber* larvae were typically found in leaf packs in streams with sandy (i.e., appropriate for *P. ruber;* Bruce 2003) substrate. We found one *P. ruber* at Vineyard Springs, Patapsco State Park (site PATL-102-H-2006, Soapstone Branch) near historical localities for *P. montanus* ("Vineyard Springs" and "near Glen Artney"; Harris personal collection #A231 and #A253). Sites at which we observed small (<50 mm)

Pseudotriton spp. larva that we were unable to definitely identify to species, but we believe to be *P. ruber* because of mottling and lack of few, clear spots, include one individual each at: BRIG-101-H-2006 (unnamed tributary to Cattail Creek), PRMT-154-X-2006 (unnamed tributary to Potomac River), PRMT-155-X-2006 (unnamed tributary to Potomac River), SOUT-201-H-2006 (Flat Creek) and STMA-101-H-2006 (unnamed tributary to Jarboesville Run) (Appendix J).

Field Data 2006, Search Effort

We visited 57 sites, of which 46 were surveyed a total of one to three times. The average duration per initial site visit was 77 minutes (*N*=46, *SD*=55.8, range=10-374). Search effort during initial site visit averaged 26.5 cover objects lifted (*N*=46, *SD*=26.4, range=1-124), 19.4m^2 of muck or seep detritus raked (*N*=46, *SD*=25.5, range=1-110), and 487.3 seconds with the electroshocker turned on (*N*=46, *SD*=657.6, range=124-3035). Distance searched along stream averaged 128m (*N*=46, *SD*=171.2, range=13-1000).

Field Data 2006, P. montanus Observations

We observed three adult *P. montanus;* two alive and one dead (Table 1). The living adults had bright red coloration; brown pupils; few, black, round spots on the dorsum; and snout length 1.5 times the lateral width (1.1mm) of the eye (Table 1). They were found under water-saturated, well-decayed logs and did not move upon first removal of their cover. We observed the dead adult with a dead *Pseudotriton* spp. larva at the base of a hillside seep in a deep (approximately 30cm) pool filled with leaf litter. Specimens were fixed with 10% formalin, transferred to water for three weeks, and stored in 40% ethanol in the MBSS voucher collection. We initially identified the dead larva as *P. ruber*, based on quantity and irregular shape of spots, however, after extended preservation, the costal grooves on the larva became more prominent and we counted 16 (i.e., likely *P. montanus*). In addition to the dead larva, we observed a second larva at the same site (SOUT-201-H-2006, Flat Creek) that may have been *P. montanus*, and captured a third larva that we raised to metamorphosis (Table 1).

We found the adult *P. montanus* under logs on mucky floodplain, immediately adjacent to a hillside seep (Appendix K). The larvae and dead adult were in the outflow of a hillside seep in microhabitat

Table 1. Eastern mud salamanders (*Pseudotriton montanus*) observed during field surveys for the species in the Coastal Plain of Maryland, 2006.

DESCRIPTION	SITE					
	PRMT-151-X Charles County	SOUT-201-H Anne Arundel County				
Individual	Adult/Juvenile	Larva, Raised	Adult/Juvenile	Adult, Dead	Larva, Dead, Uncertain Species	Larva, Uncertain Species
Date of Observation	8/24/2006	5/3/2006	8/10/2006	8/10/2006	8/10/2006	8/10/2006
Snout to Vent Length (mm)	—	33.0	40.5	83.0	54.0	44.9
Total Length (mm)	—	61.0	62.6	109.0	75.0	25.5
Color	Bright red	Few, distinct black spots	Red salmon	Pale, dark round spots	Spots few, irregular	Many spots, reticulations
Comments	Did not move upon lifting of cover object	Doesn't move much	Did not move upon lifting of cover object	Dead, rotting, hole in head	Dead, rotting, long gills	Long red gills
Habitat						
Cover	Log: well saturated and rotted, 30x10cm	Water, black muck	Log: well saturated, 120x 20cm	Leaf litter, water	Leaf litter, water	Leaf litter, water
Substrate	Muck (dark brown)	Water, black muck	Bark (on dark brown muck)	Leaf litter, water, muck	Leaf litter, water, muck	Leaf litter, water, muck
Plants (<2m)	Skunk cabbage	Skunk cabbage	NY fern, Jack in the Pulpit, Indian cucumber	NY fern, skunk cabbage	NY fern, skunk cabbage	Skunk cabbage, cinnamon fern
Animals (<2m)	—	Snail	Earthworm	Dead larval *Pseudotriton*	Dead adult *P. montanus*	*E. bislineata* (3) and eggs
General	Floodplain, base of hillside seeps; red maple, holly	Hillside seep; sweet gum, beech, red oak, laurel	Floodplain, base of hillside seeps; red maple, laurel	Hillside seep; red maple, laurel	Hillside seep; red maple, laurel	Hillside seep; red maple, laurel
Soil Type	GvE-gravelly land, steep	WBA-Widewater and issue soils, 0 to 2% slopes, frequently flooded	AsF-Annapolis fine sandy loam, 25 to 40% slopes	WBA-Widewater and issue soils, 0 to 2% slopes, frequently flooded	WBA-Widewater and issue soils, 0 to 2% slopes, frequently flooded	AsF-Annapolis fine sandy loam, 25 to 40% slopes
Water Chemistry	Stream (seep unsampleable) 6/9/2006	Not sampled	Collected from surface of seep	Collected from hole dug in seep	Collected from surface of seep	Collected from surface of seep
Temperature (^{o}C)	18.1	—	20.4	14.51	15.35	17.21
pH	6.79	—	5.48	4.69	4.99	5.31
Specific Conductance (µS/cm)	0.066	—	0.075	0.148	0.138	0.00
Dissolved Oxygen (ppm)	8.3	—	4.24	4.00	5.74	2.61
Distance to Stream (m)	8	25	1 to trib.	1 to trib.	1 to trib.	1 to trib.

dominated by leaf litter, spring water, and mucky substrate (Appendix K). The soils (NASIS) at the *P. montanus* locations were: GvE (gravelly land, steep); WBA (Widewater and issue soils, 0 to 2% slopes, frequently flooded) and AsF (Annapolis fine sandy loam, 25 to 40% slopes). Extensive trash, including batteries, was observed on the hillside seep at site SOUT-201-H-2006 near the *P. montanus* observations. Coordinates of the trash are provided to assist with management of the site: State Plane N 14159.327, E 433801.611 (NAD 83m).

Field Data 2006, Ecological Associations

Fourteen amphibian and reptile species were observed at the two sites with *P. montanus* (Table 2). One *Pseudotriton* spp. larvae at site SOUT-201-H-2006 was found in a hillside seep <10cm from three Northern two-lined salamanders (*Eurycea bislineata*) entwined around each other and a mass of eggs. All herpetofauna GCN species encountered by the MBSS during 2006 field surveys are presented to assist Heritage with managing herpetofauna (Appendix L).

Table 2. Amphibian and reptile species observed at sites with *P. montanus*

SPECIES		PRESENCE AT SITE	
Common name	Latin name	PRMT-151-X	SOUT-201-H
Amphibians			
E. Mud Salamander	*Pseudotriton montanus*	Present	Present
N. Red Salamander	*Pseudotriton ruber*		Present
N. Two-Lined Salamander	*Eurycea bislineata*	Present	Present
Gray Tree Frog	*Hyla versicolor*		Present
Pickerel Frog	*Rana palustris*		Present
Redbacked Salamander	*Plethodon cinereus*		Present
N. Green Frog	*Rana clamitans*	Present	Present
American Bullfrog	*Rana catesbiana*	Present	
American Toad	*Bufo americanus*	Present	
Fowler's Toad	*Bufo fowleri*	Present	
Green Treefrog	*Hyla cinerea*	Present	
Reptiles			
E. Box Turtle	*Terrapene carolina*		Present
E. Snapping Turtle	*Chelydra serpentina*		Present
N. Black Racer	*Coluber constrictor*		Present
E. Garter Snake	*Thannophis sirtalis*	Present	

DISCUSSION

Conservation Status

Extant records for *P. montanus* in Maryland include approximately 12 element occurrences (clusters of observations that likely comprise one population, with species-specific definition; see NatureServe http://www.natureserve.org/explorer/). The extant and historical distribution of the species includes the Coastal Plain and Piedmont. Extant locality records are approximately 26% fewer than historical locality records. Similarly, extant element occurrence locations (i.e., separate populations) are approximately 43% fewer than the number of historical element occurrences. Extant records cover a 30 year span while historical records cover 50 years. Current records are from different locations than historical records.

We were unable to detect the species at any historical localities during 2006 sampling. Even at sites where the species had reliably been found in high abundance (e.g., Battle Creek Cypress Swamp, Priest's Corner) and for which specific location data existed, we did not find *P. montanus*. Some historical localities were degraded with high volume of trash, oily sheen to water and mud, and evidence of floodplain scouring (e.g., Priest's Corner). These sites seem unlikely to harbor the species today. At other sites, we were unable to detect the springs described in historical records (e.g., Battle Creek Cypress Swamp; Solley; Herb Harris pers. comm.), perhaps due to a change in hydrology such as a lowered water table, or our inability to locate the exact historical site using locality records which typically did not provide coordinates.

Species can be present but not detected, and this is particularly likely for *P. montanus* because of its subterranean habits. To attempt to address the detectability question, we resurveyed the two sites at which we had found the species. At site PRMT-151-X-2006 we did not detect the species again during two subsequent surveys. At site SOUT-201-H-2006, we observed two adults and two *Pseudotriton* spp. larvae during a second visit. We also resurveyed five sites in the Nanjemoy area at which we did not detect the species during initial or subsequent surveys. Given the amount of time and area spent searching for *P. montanus* in this study and in surveys reported by Strain and Raesly (2006), as well as the >2,500 stream sites surveyed by the MBSS since 1994, suggest this species is rare in addition to difficult to detect.

Future Survey Recommendations

Identification. We recommend documentation of all specimens observed, because of difficulty in species identification. Adult specimens should be photographed to show a close-up of the brown iris and a full-body view of the spots on the dorsum. Records of larvae should be documented with multiple close-up photographs of dorsum and lateral views. Snout to vent length and costal grooves should be counted. Genetic markers are available (Wayne Van Devender, pers. comm.) and would provide a more reliable identification of larvae.

Our experience with one *P. montanus* larva raised to metamorphosis suggests that the species can be definitively identified by the presence of a very few, scattered, black spots on the dorsum and 16 (i.e., 14 between legs plus 2; Petranka 1998) costal grooves. Large *P. ruber* larvae are relatively easy to identify by mottling and numerous, irregular spots; a canthus rostralis-like stripe from eye to nose; 17 costal grooves; and yellow eyes with a black transverse bar. Additional observations are needed to determine if *P. montanus* larvae in Maryland can have transverse "stripes" rather than spots.

Survey Methods. We recommend the two methods by which we found the species: lifting cover objects and raking mud and detritus. Specifically, we recommend searching under well-rotted, water-saturated logs along the flood plain of Coastal Plain streams and gently raking by hand through 1-8cm of mud and leaf litter located <1m from the top of hillside seeps where groundwater first exits the land. This uppermost band of pools, tunnels, and muck in the hillside seep may not be immediately visible and may occur under a layer of leaf litter. Other extant records have been observed under cover objects, including a log (Southerland et al. 2003; Mark Southerland pers. comm.) and a funnel trap (Strain and Raesly 2006; Gabriel Strain, pers. comm.) and in the open with no cover (Gabriel Strain, pers. comm.). Future survey efforts conducted at probable locations may benefit from use of introduced cover objects (e.g., plywood, sheet metal, carpet, cardboard; Harris 1975; Herb Harris pers. comm.) placed directly on saturated muck soils occurring on flood plain or hillside seeps. Cover boards may be useful for monitoring due to their ease of use and consistency of search effort over repeated visits. Since adults and recently transformed juvenile *P. montanus* come out and move about on some rainy nights (Wayne Van Devender, pers. comm.), rainy night surveys (i.e., with strong lights, such as mountain bike lamps) may be useful if safety and convenience are not prohibitive.

Management Recommendations

We recommend protection of site-scale habitat and watershed integrity where extant populations of *P. montanus* exist. Maintaining water tables at natural levels will protect important hillside seep habitats. Protecting forest cover and minimizing impervious surface in the catchment surrounding the population will help maintain natural flow and volume of streams and prevent floodplain scouring, which we believe may eliminate important habitat occupied by the species. At site SOUT-201-H-2006, we recommend immediate removal of trash in the floodplain. We recommend informing counties of the extant locations of this rare salamander species and ask them to prohibit construction and encroachment on steep slopes bordering the streams.

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APPENDIX A. Herpetologists consulted for information on Maryland locality records of, search techniques for and identification of larvae of the eastern mud salamander (*Pseudotriton montanus*).

Ronn Altig, Professor and photographer, Mississippi rga2@ra.msstate.edu
Richard Bruce, Emeritus Professor, Western Carolina U., NC, ebruce1563@aol.com
Don Forester, Professor, Herpetology, MD dforester@towson.edu 410-704-2385
William Grogan, Professor, MD wlgrogan@salisbury.edu 410-543-6498
Jim Grow, herpetologist, OH gnarley@dragonbbs.com
Herb S. Harris, herpetologist, photographer, MD hsharris@juno.com 410-969-1431 (h)
Christopher Heckscher, Chief Zoologist, DE christopher.heckscher@state.de.us 302-653-2880
Richard Highton, Emeritus Professor, MD, rhighto1@umd.edu 301-405-6919
Frank Hirst, botanist and herpetologist, MD 410-632-1362
Sandra Mattfeldt, USGS PWRC Biological Technician, MD smattfeldt@usgs.gov
Bob Miller, herpetologist, MD exherper@hotmail.com
Arnold Norden, Central Region Planning Chief, MD, bnorden@dnr.state.md.us 410-260-8406
James Petranka, Professor, U NC petranka@unca.edu 828-232-5153
Ralph Pfingsten, herpetologist and author, OH rap347@wideopenwest.com
Steven Price, Herp. Lab Research Coordinator, NC sjprice@davidson.edu 704-894-2868
Richard Raesly, Professor, Frostburg State University, MD rraesly@frostburg.edu 301-687-4713
Gian Rocco, Research Assistant, Coop. Wetlands Center, PA gxr124@psu.edu 814-865-2180
Scott Smith, Eastern Region Ecologist, MD, sasmith@dnr.state.md.us 410-827-8612 x103
Gabriel Strain, M.S. candidate, Frostburg State University gstrain54@yahoo.com 301-687-3190
Mark Southerland, Senior Scientist, MD SOUTHERLANDMAR@versar.com
Christopher Swarth, Sanctuary Director, MD jugbay@toad.net
Stephen G. Tilley, Professor, Genetics, MA stilley@science.smith.edu 413-585-3817
Wayne Van Devender, Professor, NC vandevenderr@appstate.edu 828-262-6907
Linda Weir, USGS NAAMP Coordinator, MD lweir@usgs.gov 301-497-5932
Addison Wynn, Museum Specialist, U.S. National Museum, D.C. wynna@si.edu 202-633-0737

Appendix B. Sites surveyed for eastern mud salamander (*Pseudotriton montanus*) by the Maryland Biological Stream Survey in Maryland, 2006.
Figure B.1. Map of sites surveyed.

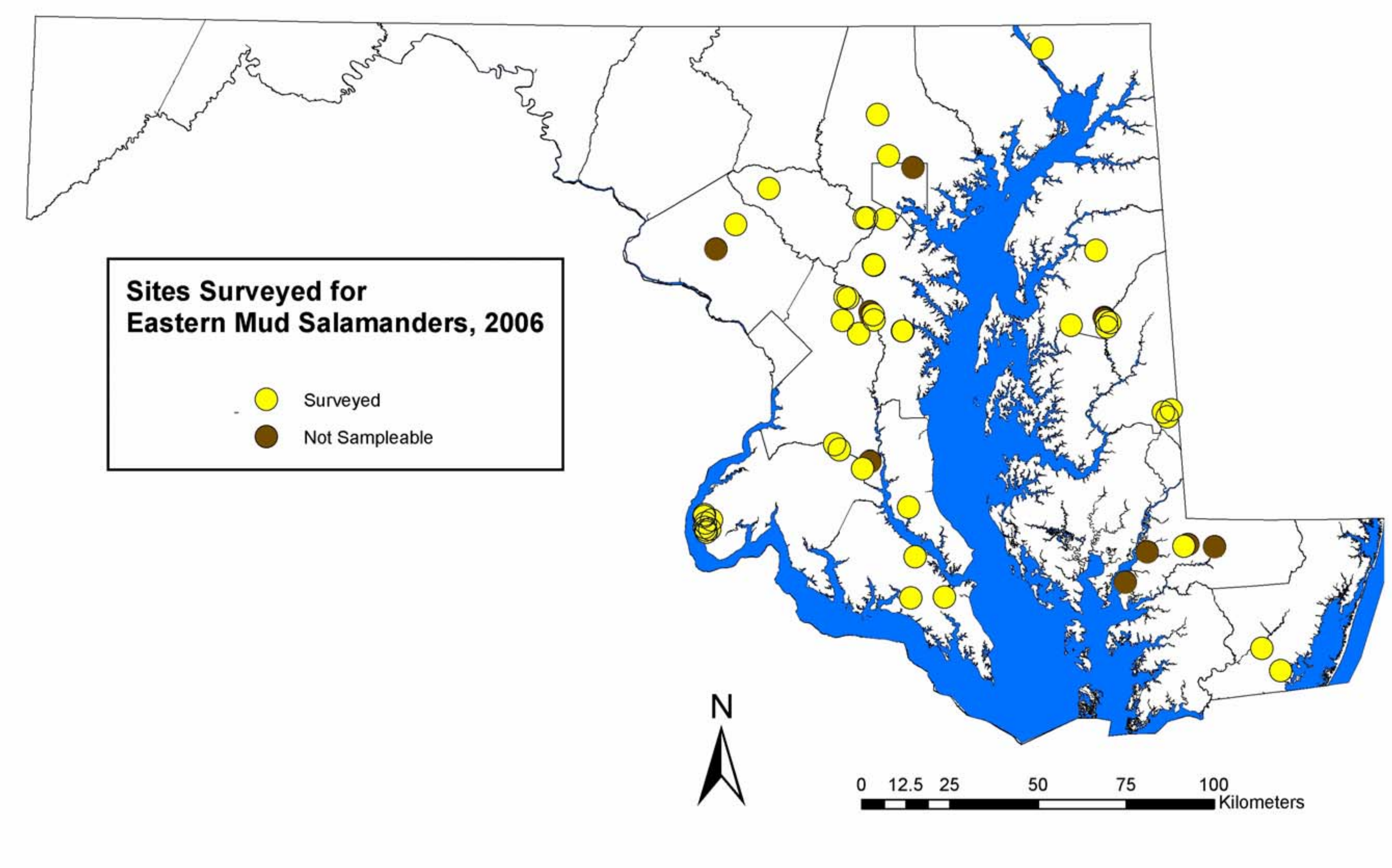


Table B.1. Coordinates of sites surveyed; bold indicates sites at which *P. montanus* observed. Coordinates in NAD 83 meters, Degrees Minutes Decimal Seconds.

SITEYR	LENGTH_M	LATITUDE	LONGITUDE	X	Y	SAMPLED
BACK-201-H-2006	0	39 21 32.813	76 34 26.855	436704	187959	N-10-Need permission, in middle of golf
BRET-101-H-2006	75	38 15 43.070	76 35 18.115	436026	66162	Y
BRIG-101-H-2006	184	39 18 21.966	77 02 56.013	395783	181989	Y
CHIN-101-H-2006	52	38 03 55.683	75 23 33.480	541053	45511	Y
JONE-301-H-2006	340	39 23 23.109	76 39 17.878	429724	191331	Y
LOCH-103-H-2006	13	39 29 44.631	76 41 26.467	426607	203086	Y
LOPC-101-H-2006	116	38 07 24.918	75 27 08.696	535698	51871	Y
LOWI-103-H-2006	0	38 23 05.238	75 36 03.943	522218	80651	N-10-Poor habitat, unsafe depth
MACK-120-H-2006	143	38 43 46.747	75 45 38.564	507754	118727	Y
MACK-121-H-2006	74	38 44 06.909	75 44 06.906	509959	119379	Y
MACK-122-H-2006	147	38 43 02.493	75 44 54.744	508831	117377	Y
NANJ-151-X-2006	109	38 27 43.152	77 14 03.692	379546	88310	Y
NANJ-152-X-2006	75	38 26 17.007	77 14 22.172	379091	85655	Y
NANT-102-H-2006	116	38 23 13.794	75 42 00.200	513569	80787	Y
NANT-103-H-2006	0	38 23 31.580	75 41 15.121	514655	81351	N-1-Dry streambed
NANT-105-H-2006	0	38 22 27.944	75 49 12.164	503105	79231	N-6-Tidally influenced
NANT-108-H-2006	0	38 17 53.644	75 53 31.470	496914	70695	N-6-Tidally influenced
OCTO-201-H-2006	156	39 39 41.849	76 08 44.852	473305	221803	Y
PATL-102-H-2006	504	39 13 53.473	76 43 40.743	423486	173743	Y
PATL-103-H-2006	448	39 13 53.013	76 44 06.762	422862	173727	Y
PATL-104-H-2006	122	39 13 43.206	76 39 59.430	428795	173444	Y
PAXL-102-H-2006	115	38 22 00.277	76 34 21.208	437355	77799	Y
PAXL-106-H-2006	0	38 36 35.626	76 43 05.966	424533	104740	N-10- Need Permission
PAXL-216-H-2006	290	38 35 34.567	76 44 34.432	422398	102851	Y
PAXL-224-H-2006	322	38 29 38.786	76 35 38.163	435424	91928	Y
PAXU-105-H-2006	133	39 01 46.321	76 47 55.229	417432	151304	Y
PAXU-106-H-2006	1000	39 01 35.976	76 47 18.173	418324	150987	Y
PAXU-107-H-2006	200	38 59 04.710	76 42 25.688	425374	146342	Y
PAXU-108-H-2006	588	38 59 05.825	76 42 43.592	424943	146375	Y
PAXU-109-H-2006	0	38 59 29.929	76 43 00.615	424531	147117	N-10-poor habitat, sandy stream
PAXU-110-H-2006	0	38 58 55.146	76 42 52.900	424720	146045	N-10-poor habitat, sandy stream
PAXU-502-H-2006	95	38 58 15.190	76 42 12.971	425685	144816	Y
PRMT-108-H-2006	67	38 28 14.555	77 15 30.715	377439	89284	Y
PRMT-151-X-2006	45	38 28 30.267	77 15 24.047	377602	89768	Y
PRMT-152-X-2006	75	38 28 13.584	77 15 29.928	377458	89254	Y
PRMT-154-X-2006	75	38 27 15.333	77 15 16.726	377773	87457	Y
PRMT-155-X-2006	75	38 26 34.092	77 15 25.900	377547	86186	Y
PRMT-156-X-2006	75	38 26 11.234	77 15 08.500	377967	85480	Y
PRMT-157-X-2006	75	38 25 48.317	77 15 02.853	378102	84773	Y
SEAS-126-H-2006	82	39 08 40.115	75 58 27.370	488669	164543	Y
SENE-104-H-2006	88	39 12 55.013	77 09 27.843	386378	171917	Y
SENE-107-H-2006	0	39 09 07.512	77 13 18.822	380820	164913	N-8-County park under construction, nee
SEVE-202-H-2006	73	39 06 43.657	76 42 15.931	425563	160495	Y
SEVE-203-H-2006	75	39 06 37.751	76 42 14.082	425608	160313	Y
SOUT-201-H-2006	291	38 56 31.188	76 36 40.945	433691	141639	Y
STMA-101-H-2006	58	38 15 50.003	76 28 42.067	445653	66425	Y
TUCK-103-H-2006	0	38 58 22.871	75 57 01.529	490949	145534	N-1-Too dry
TUCK-104-H-2006	48	38 57 50.974	75 56 38.029	491526	144557	Y
TUCK-105-H-2006	77	38 56 54.092	75 56 31.272	491709	142805	Y

TUCK-201-H-2006	0	38 58 10.928	75 56 53.355	491150	145168	N-8&4-Archery range
TUCK-202-H-2006	120	38 57 34.895	75 55 55.939	492545	144073	Y
WEBR-101-H-2006	13	38 56 10.080	76 45 16.939	421267	140945	Y
WEBR-102-H-2006	61	38 58 10.754	76 48 28.905	416636	144655	Y
WEBR-112-H-2006	68	38 56 09.658	76 45 16.650	421274	140932	Y
WYER-202-H-2006	111	38 57 15.516	76 03 34.742	481506	143354	Y
ZEKE-102-H-2006	129	38 39 15.728	76 50 01.202	414478	109652	Y
ZEKE-103-H-2006	93	38 38 28.618	76 49 04.495	415852	108202	Y

Appendix C. Datasheets used for surveying eastern mud salamanders (*Pseudotriton montanus*), 2006.

Eastern Mud Salamander SEARCH Form, MBSS

Page 1 of ___

SITE Watershed Code ____ Segment ____ Type ____ Year 2006 County ____

Reviewed By: ____________

2nd Reviewer: ____________

DATE Year 06 Month ____ Day ____

Observed (Y/N) ____ **If yes, # individuals observed:** ____

Start ____ (Military) **Sampleability (Y/N)** ____ **If no, sampleability code:** ____

End ____ (Military) **CREW** ____________

STREAM ____________

Sky code: ____ **LOCALITY** ____________

SITE ACCESS ____________

Downstream ____ ____

Upstream ____ ____

____ ____

LatLong NAD83 meters DecimalDegrees, Garmin Etrex

If other, circle: Grid system (State Plane, UTM, lat/long), Datum (NAD83, NAD27, HARN), Grid Units (DD, DMS, DDM), GPS make/model: ________

SEARCH EFFORT

PERSON	HABITAT	METHOD	TIME Min (seconds if electroshocking)	# Cover objects	AREA (M^2)

STREAM WATER QUALITY

Sampleability ____ (Y/N)

Temp (C) ____

PH (meter) ____

Cond (ms/cm) ____

DO (ppm) ____

INCIDENTAL HERPTOFAUNA

Seen	Heard	Retained (Y/N)	

CRAYFISH

Seen	Retained (Y/N)	

COMMENTS: (How much appropriate habitat? Was all appropriate habitat searched?) ____________

Eastern Mud Salamander ***SEARCH Form, MBSS***

Common Names of Herpetofauna

SALAMANDERS:
Eastern Mud Salamander
Eastern Tiger Salamander(E)
Eastern Hellbender(E)
Four-Toed Salamander
Green Salamander(E)
Jefferson Salamander (W)
Long Tailed Salamander
Marbled Salamander
Mountain Dusky Salamander Mudpuppy(E)
Northern Dusky Salamander
Northern Two-Lined Salamander
Northern Slimy Salamander
Northern Spring Salamander
Red Spotted Newt
Red Salamander
Redback Salamander
Salamander (unknown)
Seal Salamander
Spotted Salamander
Valley and Ridge Salamander
Wehrle's Salamander(I)

TOADS:
American Toad
Eastern Narrowmouth Toad(E)
Eastern Spadefoot Toad
Fowler's Toad
Toad (unknown)

LIZARDS:
Broadhead Skink
Coal Skink(E)
Five-Lined Skink
Ground Skink
Northern Fence Lizard
Six-Lined Racerunner
Southeastern Five-Lined Skink

TURTLES:
Bog Turtle(E)
Common Musk Turtle
Common Snapping Turtle
Common Map Turtle(I)
Eastern Box Turtle
Eastern Painted Turtle
Eastern Mud Turtle
Eastern River Cooter
Eastern Spiny Softshell Turtle
Midland Painted Turtle
Northern Diamondback Terrapin
Red Belly Turtle
Red-Eared Slider
Spotted Turtle
Wood Turtle

FROGS:
Barking Treefrog(E)
Bullfrog
Carpenter Frog(I)
Frog (unknown)
Gray Treefrog
Green Treefrog
Green Frog
Hylid Frog (unknown)
Mountain Chorus Frog(I)
New Jersey Chorus Frog
Northern Spring Peeper
Northern Leopard Frog
Northern Cricket Frog
Pickerel Frog
Ranid Frog (unknown)
Southern Leopard Frog
Upland Chorus Frog
Wood Frog

SNAKES:

SEARCH AREA Habitat types:
ST = stream/oxbow pools
SP = seep/spring
FO = forested wetland/swamp
SS = shrub wetland
EM = emergent wetland/marsh
AQ = floating vegetation wetland/pond
OW = no vegetation wetland/pond/quarry
UP = upland
OT = other (describe)

SEARCH METHOD types:
M = dig or rake mud
C = lift natural cover objects (logs, rocks)
V = visual
N = net
E = electrofish
CB = coverboards
DF = drift fence
LL = leaf litter bags
O = other (describe)

SKY CODE:
0 = Few clouds
1 = Partly cloudy (scattered) or variable sky
2 = Cloudy (broken) or overcast
4 = Fog or smoke
5 = Drizzle
7 = Snow
8 = Showers
(code from North American Amphibian Monitoring Program)

SAMPLEABILITY CODE:
1 = Dry streambed, no seeps or wetlands
2 = Too Deep
4 = Excessive Vegetation
6 = Tidally Influenced
7 = Permission Denied
8 = Unsafe (describe in comments)

Eastern Mud Salamander OBSERVATION Form, MBSS

SITE Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year 2006 County ☐☐ E. Mud. Sal. Individual # ☐ Reviewed By: ______

DATE Year 06 Month ☐☐ Day ☐☐ **TIME** (Military) ☐☐☐☐ **OBSERVER:** ______ 2nd Reviewer: ______

Location of individual ☐☐.☐☐☐☐☐ ☐☐.☐☐☐☐☐

LatLong NAD83 meters DecimalDegrees, Garmin Etrex

If other, circle: Grid system (State Plane, UTM, lat/long), Datum (NAD83, NAD27, HARN), Grid Units (DD, DMS, DDM), GPS make/model: ______

Microhabitat

Cover (Y/N)	Substrate (Y/N)		Comments
☐	☐	Wood	______
☐	☐	Rock	______
☐	☐	Muck	______
☐	☐	Leaf litter	______
☐	☐	Water	______
☐	☐	Other (describe)	______

Associated (<2m) animals ______

Associated (<2m) plants ______

Temperature (C) by animal ☐☐.☐

Seep type ☐ Distance to stream ☐☐ (M)

"Amount of available habitat": ______

NWI Classification (10m²)

System ☐ Class ☐☐ Water regime ☐

Subsystem (N/A forPalustrine) ☐ Subclass ☐ Soil Modifier ☐

Special modifiers ☐☐

Total length ☐☐☐ (Mm) Snout-eye length ☐☐☐ (Mm)

Snout-vent length ☐☐☐ (Mm) Eye Width ☐☐☐ (Mm)

Age class: ☐ (Adult, Juvenile, Larvae, Egg)

Comments (color, tail regen, breeding, behavior)

______

Specific characteristics upon which ID was based:

______

Any questions about identification or taxonomy?

______

Specimen taken? ☐ (Y/N) Live? ☐ (Y/N)

Original fixative Formalin ☐ (Y/N) Ethanol ☐ (Y/N)

Capture/observation method: ______

Potential threats, protection, or management needs?

______

PHOTOS: 1) Supraotic pores / eye color, 2) dorsal, 3) lateral, 4) 2m habitat, 5) 20m habitat

Time	#	Description	Time	#	Description
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______
☐☐☐☐	☐	______	☐☐☐☐	☐	______

Eastern Mud Salamander ***HABITAT OBSERVATION Form, MBSS***

SEEP TYPE

R=Rheocrene Discharges over small area, immediately forms 1st order stream, characteristically in narrow ravines

L=Limocrene Discharges into small, pond-like basin of relatively still water, the outflow of which forms 1st order stream. Characteristically found in floodplains of larger streams, often at the base of a slope along floodplain boundary.

H=Helocrene Ground water discharges over relatively large areas, forming wide channels of slow-moving, thin sheets of water which eventually narrow to form 1st order streams. Characteristically found in broader ravines or relatively flat areas along the length of 2nd and higher order streams. (Lindegaard 1995, Bruce 2003)

Classification of Wetlands and Deepwater Habitats of the United States
Cowardin ET AL. 1979 as modified for National Wetland Inventory Mapping Convention

SYSTEM: P - PALUSTRINE

CLASS	RB – ROCK BOTTOM	UB – UNCONSOLIDATED BOTTOM	AB – AQUATIC BED	US – UNCONSOLIDATED SHORE	ML – MOSS-LICHEN	EM – EMERGENT	SS – SCRUB-SHRUB	FO – FORESTED	OW – *OPEN WATER/ Unknown Bottom*
Subclass	1 Bedrock 2. Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular 5 *Unknown Submergent* 6 *Unknown Surface*	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*	

SYSTEM: R - RIVERINE

SUBSYSTEM: 1 – TIDAL; 2 – LOWER PERENNIAL; 3 – UPPER PERENNIAL; 4 – INTERMITTENT; 5 – *UNKNOWN PERENNIAL*

CLASS	RB – ROCK BOTTOM	UB – UNCONSOLIDATED BOTTOM	*SB – STREAMBED	AB – AQUATIC BED	RS – ROCKY SHORE	US – UNCONSOLIDATED SHORE	**EM – EMERGENT	OW – *OPEN WATER/ Unknown Bottom*
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular 5 *Unknown Submergent* 6 *Unknown Surface*	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent	

* STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM.
** EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS.

MODIFIERS

In order to more adequately describe the wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME

- A Temporarily Flooded
- B Saturated
- C Seasonally Flooded
- D *Seasonally Flooded/ Well Drained*
- E *Seasonally Flooded/ Saturated*
- F Semipermanently Flooded
- G Intermittently Exposed
- H Permanently Flooded
- J Intermittently Flooded
- K Artificially Flooded
- W Intermittently Flooded/Temporary
- Y Saturated/Semipermanent/ Seasonal
- Z Intermittently Exposed/Permanent
- U *Unknown*

SOIL	SPECIAL MODIFIERS	
g Organic n Mineral	b *Beaver* d *Partially Drained/Ditched* f Farmed	h *Diked/Impounded* r Artificial Substrate s *Spoil* x Excavated

Appendix D. Extant records, including this study, include 25 observations occurring at approximately 12 element occurrences (i.e., clusters of observations that may represent the same population) in Maryland.

Figure D.1. Map of extant locality records for the eastern mud salamander (*Pseudotriton montanus*) in Maryland.

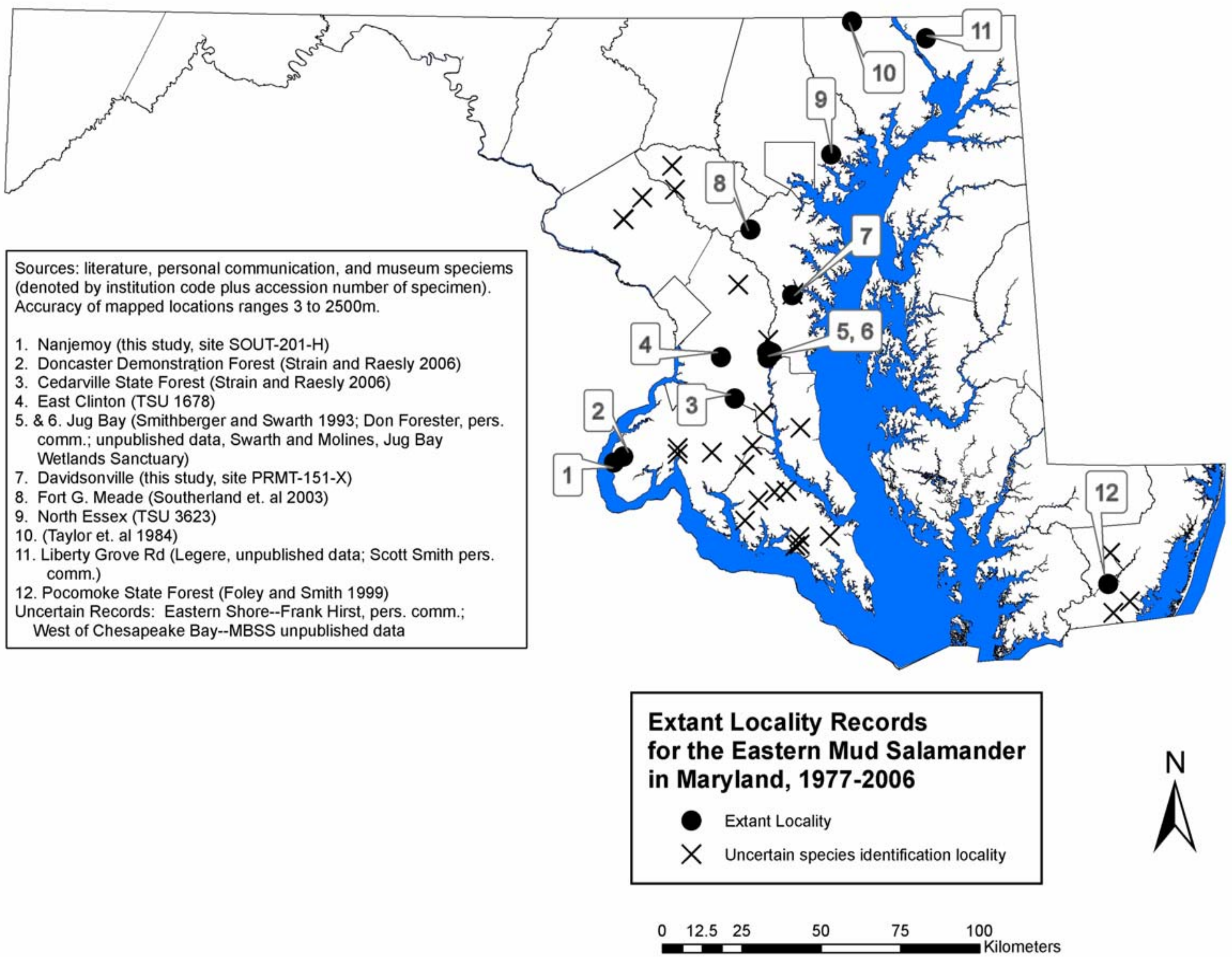


Table D.1. Extant(1977-2006) locality records for the eastern mud salamander (*Pseudotriton montanus*) in Maryland.

Voucher	Source of Data (count of records)	Observer(s)	County and Year(s) of Observation	
	2006 Field Surveys			
Photo, specimen	Chalmers 2006 (this report) (3)	Rebecca Chalmers	Anne Arundel	2006
Photo	Chalmers 2006 (this report) (1)	Rebecca Chalmers	Charles	2006
Photo	Strain and Raesly 2006 (1)	Gabriel Strain	Charles	2006
Photo	Strain and Raesly 2006 (1)	Gabriel Strain	Prince George's	2006
	Museum			
Specimen	Towson State University Museum (2)	J. D. Zyla	Prince George's	1987
Specimen		R. W. Miller	Baltimore	1980
	Literature			
0	Southerland et al. 2003 (1)	Mark Southerland, Steve Harriott, Fred Kelley, David Baxter	Anne Arundel	2002
Photo	Smithberger and Swarth 1993 (2)	Smithberger, S and C. Swarth.	Anne Arundel	1988
0	MD DNR Foley and Smith 1999 (1)	Dan Foley	Worcester	1995
	Unpublished Data/ Pers. Comm.			
Photo of at least one specimen	Swarth, Chris and Karyn Molines, unpublished data obtained 2006, Jug Bay Wetlands Sanctuary (2)	Paul Gaskin, M.Quinlan	Anne Arundel	1988
		Mike Quinlan	Anne Arundel	'96,'99-'00,'02,'04
		Nancy McAllister	Anne Arundel	1999
		Beth Wright	Anne Arundel	1999
		Robert Frezza	Anne Arundel	2003
Photo	Don Forester, Towson University, pers. comm. (1)	Don Forester	Anne Arundel	2003
0	Taylor et al. 1984; Scott Smith MD DNR pers. comm.	Steve Beall	Harford	1977
0	R. Legere, unpublished data, Scott Smith MD DNR pers. comm.	Rich Legere, Dave Holland, Eric Harran	Cecil	1992
	Uncertain Records			
0	Heckscher 1995; Frank Hirst and Arnold Norden, pers. comm. (3)	Frank Hirst	Worcester*	1979, 1981
0	Heckscher 1995; Frank Hirst and Arnold Norden, pers. comm. (1)	Frank Hirst, Arnold Norden	Worcester*	1981
Photos and vouchers for some records	MD Biological Stream Survey (11)	MBSS staff	Howard**	1997
		MBSS staff	Montgomery**	1994
		MBSS staff	Prince George's**	1994, 1997
		MBSS staff	Calvert**	1994
		MBSS staff (Rebecca Chalmers, 2006)	Anne Arundel**	1997, 2006
		MBSS staff (Rebecca Chalmers, 2006)	Saint Mary's**	1995, 2000, 2006
		MBSS staff (Rebecca Chalmers)	Charles**	2006

* Uncertain: Identification of one record based on eggs. Heckscher (1995) and personal communication with Frank Hirst and Arnold Norden state that identification to species is uncertain and cannot be confirmed.
** Uncertain: Identification based on larvae and few voucher specimens.

Appendix E. Historical (1926-1976) locality records, including this study, include 97 observations occurring at approximately 28 element occurrences (i.e., clusters of observations that may represent the same population) in Maryland.

Figure E.1. Map of historical locality records for the eastern mud salamander (*Pseudotriton montanus*) in Maryland.

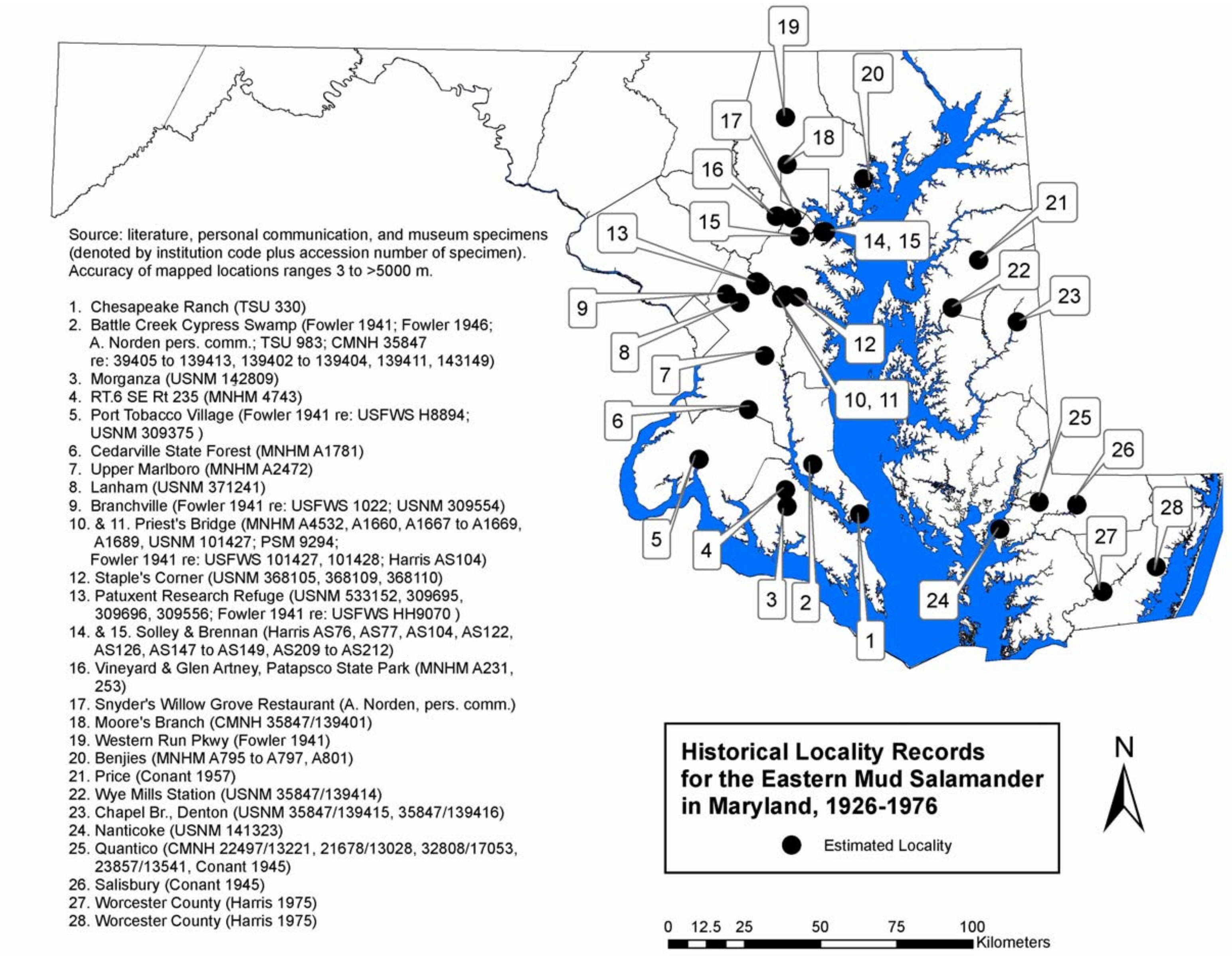


Table E.1. Table of historical locality records for the eastern mud salamander (*Pseudotriton montanus*) in Maryland.

Source of Data (count of records)	Observer(s)	County	Year(s) of Observation
Museum			
Carnegie Museum of Natural History (22)	James A. Fowler	Baltimore	1941
		Calvert	1937, 1943, 1945, 1947
		Caroline	1952
		Queen Anne's	1951
	J Dolan	Wicomico	1942-43, 1945, 1954
Towson State University Museum (2)	"Strott"	Calvert	1966
	G. J. Jacobs	Calvert	1964
University of Florida (3)	Bob Simmons	Anne Arundel	1958
	Herb Harris	Anne Arundel	1962
USFWS collection (3)	James A. Fowler	Prince George's	1940, <1941
		Charles	1940
Field Museum of Natural History (1)	Worthington	?	1965
Los Angeles County Museum of Natural History (1)	R. D. Worthington	Prince George's	1965
James R. Slater Museum (1)	Kilman	Anne Arundel	1958
Illinois Natural History Survey (1)	Ron Brandon	Calvert	1956
U.S. National Museum (17)	Names withheld from public by museum to protect collectors from harassment	Prince George's	'26,'29,'40-42,'47,'59
		Charles	1940
		Wicomico	1949
		Anne Arundel	1936, 1958, 1962
		Saint Mary's	1959
Maryland Natural History Museum (20)	Names not provided (Harris, pers. comm.)	Anne Arundel	1935-36, 1947, 1962
		Baltimore	'35,'40-41,'45-46,'46, '58-59
		Prince George's	1947
		Charles	1960
		Saint Mary's	
Unpublished Data			
Herb Harris, personal collection (16)	Herb Harris	Anne Arundel	1958-60, 1962
		Baltimore	1962
Literature			
Harris 1975 (unstated; >29)*	Unknown; observers may be listed in acknowledgements	Worcester (also: Wicomico, Queen Anne's, Baltimore, Anne Arundel, Prince George's, Saint Mary's, and Charles)*	<1975
Personal Communication			
Arnold Norden, MDDNR (unstated; >10)	Arnold Norden	Anne Arundel	<1970's
		Calvert	<1970's

* This is a secondary source for which original observation data is not reported, thus, records may be duplicates of other historical records. Records are imprecisely mapped. This report includes only the two observations from Worcester County, because these are the only historical records for this county and these records are not duplicated.

Appendix F. Eastern mud salamanders (*P. montanus*) can be distinguished from Northern red salamanders (*P. ruber*).

Figure F.1 Eastern mud salamander (*P. montanus*) from site PRMT-151-X-2006, Nanjemoy; note round spots that do not touch each other and brown eyes.

Figure F.2 Northern red salamander (*P. ruber*) from site PATL-102-H, Patapsco State Park; note irregularly shaped spots, spots that touch each other, and yellow eyes with a black tranverse bar.

Figure F.3 Photograph by Ralph Pfingsten illustrating typical pigmentation and patterns of *P. montanus*: note black, round spots and long, bushy gills.

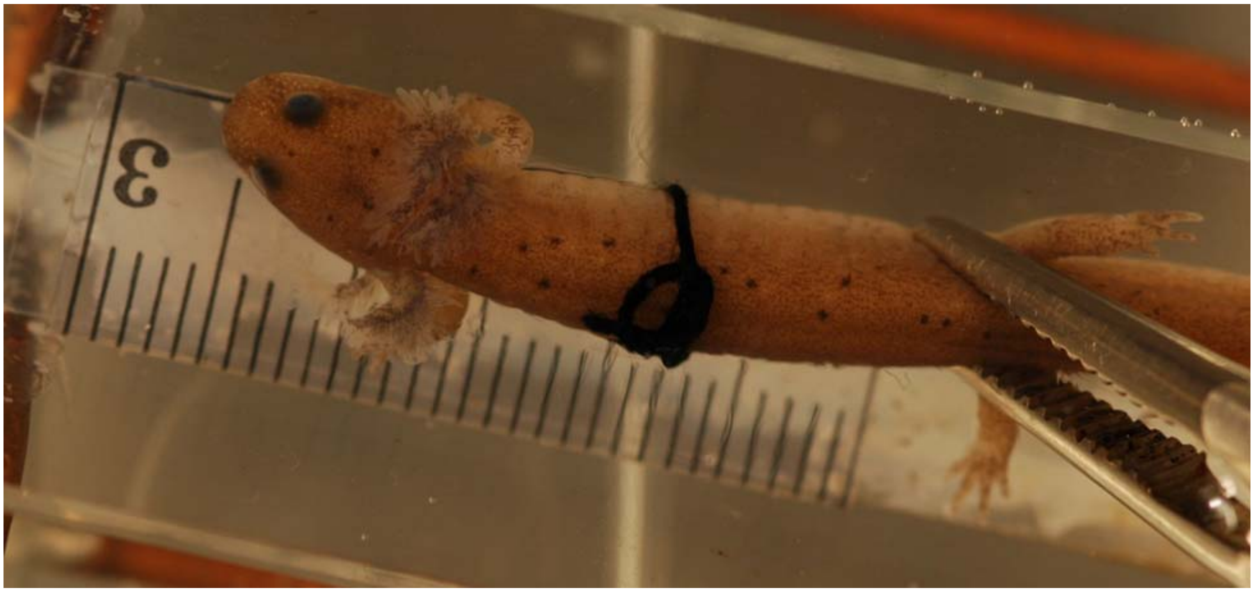


Figure F.4 Photograph by Ralph Pfingsten illustrating typical pigmentation and patterns of *P. ruber*: note mottling and lack of distinct spots.

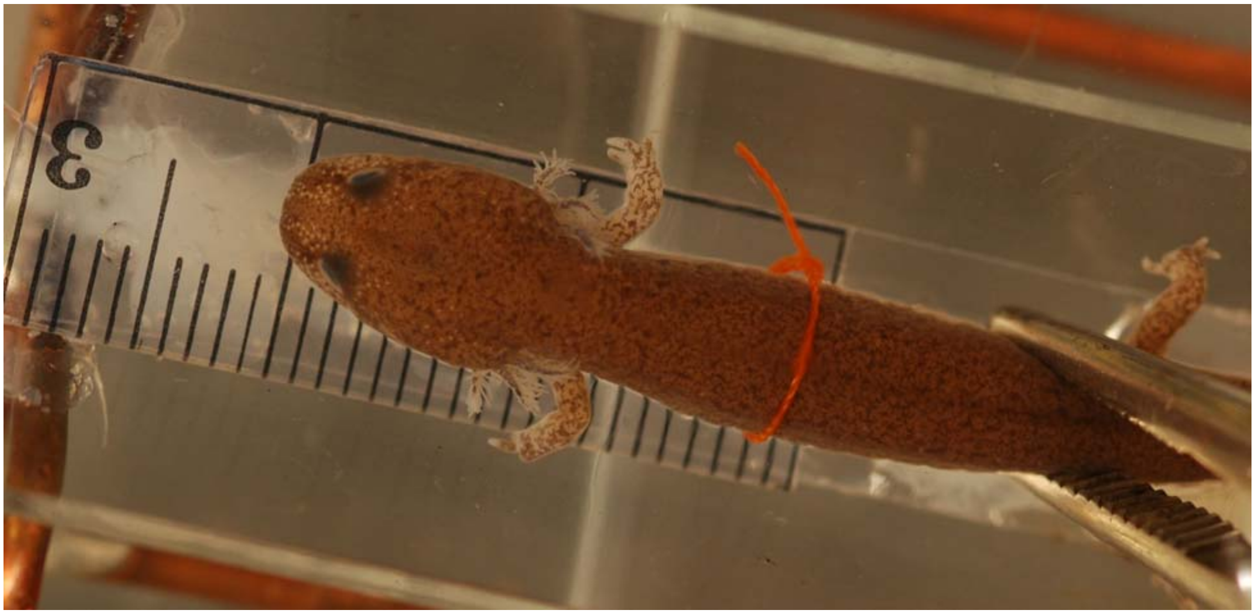
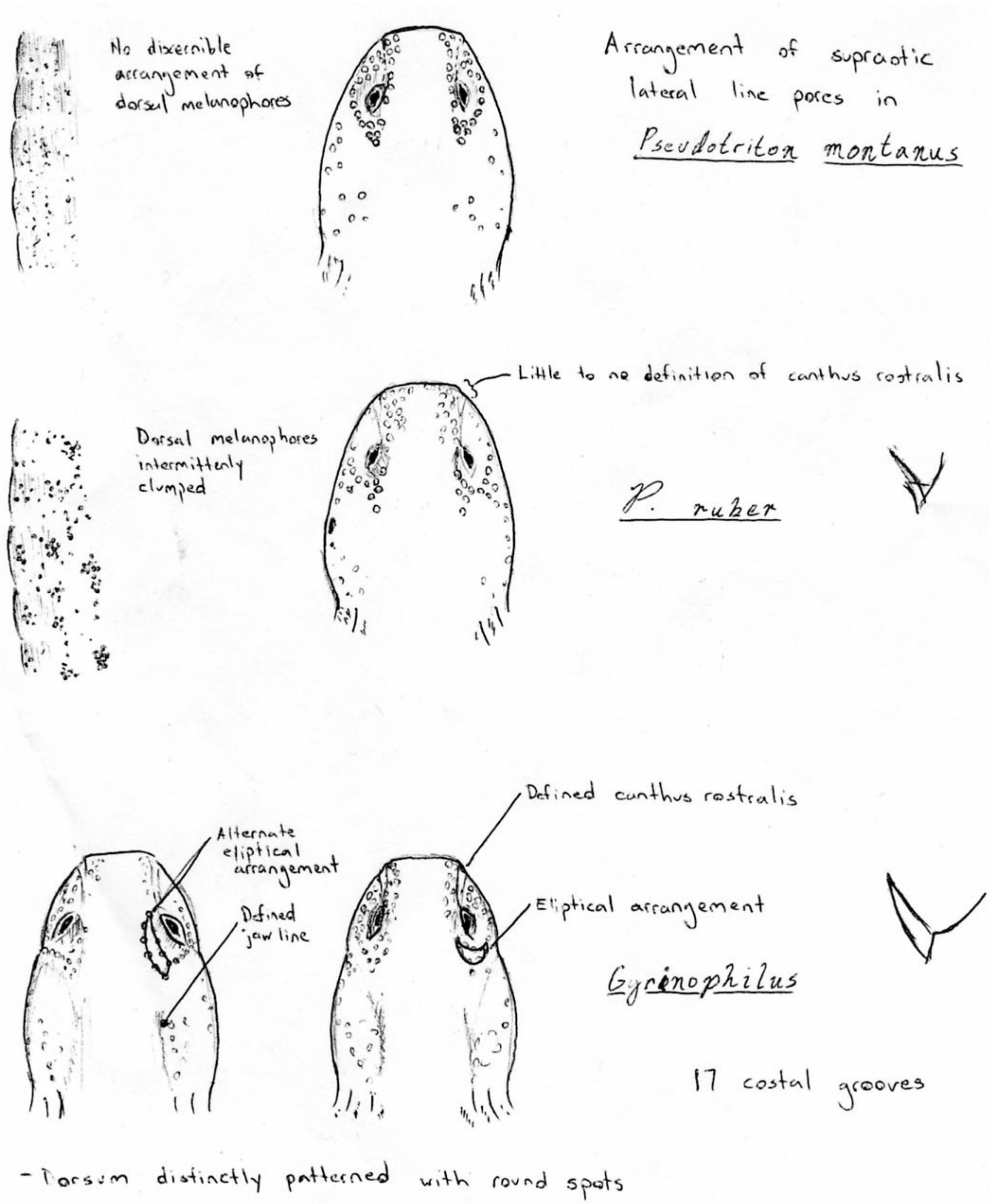


Figure F.5. Illustration of supraotic lateral line pore pattern on *P. montanus* (distinct mask shape around the eyes) and *P. ruber* (messy and extends down the side of the cheek) larvae, used to differentiate the species by Steven Price and students. Illustration by unidentified student



Appendix G. Identification guide for larval eastern mud salamander (*Pseudotriton montanus*) and northern red salamander (*Pseudotriton ruber*).

	Eastern Mud Salamander (*Pseudotriton montanus*)	**Northern Red Salamander (*Pseudotriton ruber*)**
Color	Light brown (Birchfield and Bruce 2000). Dorsum brown to reddish-brown (Downs 1989). Hatchling larvae are light brown above and white below (White and White 2002).	Brown (Richard Bruce, pers. comm.). Dorsal ground color pale (Downs 1989). Hatchling larvae are light brown (White and White 2002).
Pigmentation patterns	Two patterns have been observed: 1) Few, conspicuous (Petranka 1998), widely scattered small dark dots (larger than dots of *P. ruber*; Downs 1989) and only faint streaking (Richard Bruce, pers. comm.). Common in North Carolina populations in Coastal Plain and Lower Piedmont (Richard Bruce, pers. comm.). This pattern was observed in a Maryland specimen from the Coastal Plain that was raised to metamorphosis (this study). 2) Dark flecks arranged into longitudinal streaks or reticulated pattern, especially on the posterior of the body and the anterior part of the tail (Wayne Van Devender, pers. comm.; Richard Bruce, pers. comm.). Common in North Carolina populations in Upper Piedmont and Blue Ridge (Richard Bruce, pers. comm.). It is unknown if this pattern is present in Maryland specimens.	No real spots (Petranka 1998). Clumped melanophores (Petranka 1998) described variously as "dark flecks arranged into clumps" (Wayne Van Devender, pers. comm.); "flecked pattern of an irregular array of tiny dark flecks on the back and sides" (Richard Bruce, pers. comm.); and " profusely covered by numerous small dark spots, dots, and flecks or with a reticulated pattern of dark pigment" (Downs 1989).
Stature	Slimmer, more gracile, shorter limbs (Birchfield and Bruce 2000). Slender body form (Altig and Ireland 1984). Thinner (Wayne Van Devender, pers. comm.).	Thicker body, larger limbs, wider head (Birchfield and Bruce 2000). Stout body form (Altig and Ireland 1984). Wider (Wayne Van Devender, pers. comm.).
Gill length	In syntopic populations of larvae, longer gills such that if gills were folded back over head, would overlap considerably (Ralph Pfingsten, pers. comm.). Bushier when syntopic with *P. ruber* (Birchfield and Bruce 2000). Caveat: gill size is a phenotypically plastic character for *Pseudotriton* spp. (Pfingsten, pers. comm).	In syntopic populations of larvae, shorter gills such that if gills were folded back over head, would not overlap or would only slightly overlap (Ralph Pfingsten, pers. comm.). Less bushy when syntopic with *P. ruber* (Birchfield and Bruce 2000). Caveat: gill size is a phenotypically plastic character for *Pseudotriton* spp. (Pfingsten, pers. comm).

Eye diameter	"Slightly larger" (Birchfield and Bruce 2000; dimensions not provided in manuscript)	"Slightly smaller" (Birchfield and Bruce 2000; dimensions not provided in manuscript)
Canthus rostralis-like line from eye to snout	Absent (Powell et al. 1998)	Present (Powell et al. 1998) Present in larvae only (Addison Wynn, pers. comm.)
Costal grooves	16-17 (16 diagnostic; variation may be due to observer count methods; Addison Wynn, pers. comm.)	16-17 (17 diagnostic; variation may be due to observer count methods; Addison Wynn, pers. comm.)
Supraotic lateral line pores	Mask pattern of pores around eye (Steven Price, pers. comm.)	Messier pattern of pores and pattern extends down cheek (Steven Price, pers. comm.)
Habitat	Mucky, deep, seepy springs at the base of steep hills and often with skunk cabbage (Wayne Van Devender, pers. comm.). Slower, muddier streams (Steven Price, pers. comm.). Slow- or non-moving flow in springs, may appear to be pools or puddles and may dry up on surface (Ralph Pfingsten, pers. comm.). Wet pockets of organic matter along swampy creeks and in mucky depressions and seeps in the floodplains of streams of Strahler order 3 or greater (Bruce et al. 2000). Streams with clay or silt (Bruce 2003).	Rocky headwater streams and slow moving muddy streams (Steven Price, pers. comm.). Almost always free flowing, sometimes in large volumes, generally hillside (Ralph Pfingsten, pers. comm.). Streams with sand, leaf packs (Bruce 2003)
Range in MD	Coastal Plain and lower Piedmont	Throughout; uncertain in Lower Eastern Shore

Appendix H. Eastern mud salamander (*Pseudotriton montanus*) larva captured May 3 and raised to metamorphosis October 23, from site SOUT-201-H-2006, Flat Creek, near Davidsonville, Maryland, 2006.

Figure H.1. May 3, 2006, date of capture.

Figure H.2. Larva on 3 June 28, 2006, view of head and supra otic lateral line pores.

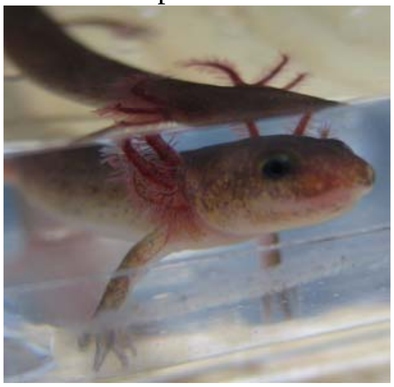


Figure H.3. Larva on October 18, 2006, three days before metamorphosis.

Appendix I. Northern red salamander (*Pseudotriton ruber*) larvae (*N*=9) observed at site SENE-104-H-2006 in Montgomery County, Maryland, 2006. Earlier records of *P. montanus* at this site were likely *P. ruber* specimens. We identified these *P. ruber* larvae by their yellow eyes, transverse bar on eyes of some specimens, lack of round black spots, and presence of many mottled spots that completely covered the dorsum. The site was located in a sandy stream in an open field; there was no muck.

Appendix J. Small (<50mm total length) *Pseudotriton* spp. larva that we were unable to definitely identify to species, but we believe to be *P. ruber* because of mottling and lack of few, clear spots, were collected in Maryland, 2006.

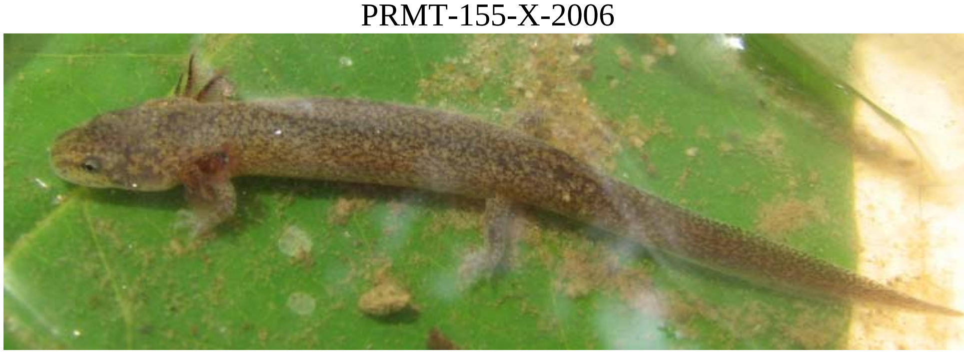
SOUT-201-H-2006, collected in stream approximately 50m from hillside seep.

PRMT-154-X-2006

STMA-101-H-2006

BRET-101-H-2006

PRMT-155-X-2006



Appendix K. Habitat (A, C) and microhabitat (B, D) of eastern mud salamanders (*Pseudotriton montanus*) observed in Nanjemoy (site PRMT-151-X-2006; photographs A, B) and near Davidsonville (site SOUT-201-H-2006; photographs C, D) in Maryland, 2006.

A

B

C

D

Appendix L. Amphibian and Reptile species of Greatest Conservation Need (GCN) observed by Maryland Biological Stream Survey during field surveys, 2006. Coordinates: 1) geographic and 2) state plane NAD83 meters, decimal degrees.

MBSS SITE NAME	LATITUDE	LONGITUDE	NORTHING83	EASTING83	GCN HERP SPP	S RANK
SAVA-276-S-2006	39.54139	79.21417	210418.2	209680.1	ALLEGHENY MTN DUSKY SAL.	S5
PRMT-156-X-2006	38.43645	77.25236	85480.0	377967.0	BROAD-HEADED SKINK	S4
FURN-101-S-2006	39.61055	76.04611	216217.5	481918.2	EASTERN BOX TURTLE	S5
JONE-109-S-2006	39.43951	76.69843	196842.2	425961.3	EASTERN BOX TURTLE	S5
MACK-122-H-2006	38.71736	75.74854	117377.1	508831.0	EASTERN BOX TURTLE	S5
PAXL-216-H-2006	38.59394	76.74190	102962.7	422484.6	EASTERN BOX TURTLE	S5
PAXL-224-H-2006	38.49411	76.59394	91928.3	435423.5	EASTERN BOX TURTLE	S5
PAXM-109-X-2006	38.77083	76.71667	122605.1	424621.9	EASTERN BOX TURTLE	S5
PAXM-110-X-2006	38.76500	76.72722	121954.8	423706.5	EASTERN BOX TURTLE	S5
PAXU-106-H-2006	39.02666	76.78838	150987.0	418324.1	EASTERN BOX TURTLE	S5
PRMT-157-X-2006	38.43009	77.25079	84773.0	378102.0	EASTERN BOX TURTLE	S5
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	EASTERN BOX TURTLE	S5
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	EASTERN BOX TURTLE	S5
WEBR-101-H-2006	38.93613	76.75470	140944.6	421267.5	EASTERN BOX TURTLE	S5
PRMT-151-X-2006	38.47495	77.25717	89754.0	377559.6	EASTERN MUD SALAMANDER	S2?
PRMT-151-X-2006	38.47495	77.25717	89754.0	377559.6	EASTERN MUD SALAMANDER	S2?
PRMT-155-X-2006	38.44280	77.25719	86186.0	377547.0	EASTERN MUD SALAMANDER	S2?
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	EASTERN MUD SALAMANDER	S2?
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	EASTERN MUD SALAMANDER	S2?
STMA-101-H-2006	38.26389	76.47835	66425.0	445653.2	EASTERN MUD SALAMANDER	S2?
MACK-120-H-2006	38.72965	75.76071	118726.8	507754.2	EASTERN SPADEFOOT	S4
MACK-121-H-2006	38.73525	75.73525	119378.7	509959.2	EASTERN SPADEFOOT	S4
NANT-102-H-2006	38.38758	75.69908	80834.6	513653.4	NEW JERSEY CHORUS FROG	S4
ATKI-105-X-2006	39.53098	76.37824	207136.1	453456.6	NORTHERN RED SALAMANDER	S5
BRET-101-H-2006	38.26196	76.58836	66161.6	436026.5	NORTHERN RED SALAMANDER	S5
PATL-102-H-2006	39.23152	76.72798	173743.0	423486.0	NORTHERN RED SALAMANDER	S5
PAXL-102-H-2006	38.36674	76.57256	77798.6	437354.8	NORTHERN RED SALAMANDER	S5
PRMT-154-X-2006	38.45426	77.25465	87457.0	377773.0	NORTHERN RED SALAMANDER	S5
PRMT-154-X-2006	38.45426	77.25465	87457.0	377773.0	NORTHERN RED SALAMANDER	S5
PRMT-156-X-2006	38.43645	77.25236	85480.0	377967.0	NORTHERN RED SALAMANDER	S5
SENE-104-H-2006	39.21528	77.15774	171916.8	386377.5	NORTHERN RED SALAMANDER	S5
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	NORTHERN RED SALAMANDER	S5
SOUT-201-H-2006	38.94369	76.60881	141827.9	433912.3	NORTHERN RED SALAMANDER	S5
BRIG-101-H-2006	39.30610	77.04889	181988.8	395783.2	PSEUDOTRITON SP. larva	
PRMT-154-X-2006	38.45426	77.25465	87457.0	377773.0	PSEUDOTRITON SP. larva	
PRMT-155-X-2006	38.44280	77.25719	86186.0	377547.0	PSEUDOTRITON SP. larva	
STMA-101-H-2006	38.26389	76.47835	66425.0	445653.2	PSEUDOTRITON SP. larva	
SAVA-276-S-2006	39.54139	79.21417	210418.2	209680.1	SEAL SALAMANDER	S5