Cheat Mountain Salamander
(Plethodon nettingi)

5-Year Review:
Summary and Evaluation

Photo courtesy of Dr. Mark Watson

U.S. Fish and Wildlife Service
West Virginia Field Office
Elkins, West Virginia

September 2009

5-YEAR REVIEW
Cheat Mountain Salamander *(Plethodon nettingi)*

September 2009

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office: Barbara Douglas, West Virginia Field Office, 304-636-6586

Lead Regional Office: Mary Parkin, Region Five, Hadley MA, 617-417-3331

1.2 Methodology Used to Complete the Review

This review was conducted by the U.S. Fish and Wildlife Service's (USFWS) West Virginia Field Office (WVFO). We sought information on the status of the Cheat Mountain salamander (CMS) (*Plethodon nettingi*) from species experts and other individuals familiar with the snail's ecosystem. The new information that has been compiled since listing, in combination with coordination with the species experts, provides the basis for the status assessment. The WVFO appreciates the assistance of the following individuals, who provided information in support of this review:

Dr. Tom Pauley, Marshall University
Craig Stihler, West Virginia Division of Natural Resources
Cathy Johnson, Monongahela National Forest
Dan Arling, Monongahela National Forest
Ken Sturm, Canaan Valley National Wildlife Refuge
Rob Gilligan, Blackwater Falls/Canaan Valley State Parks
Dr. Mark Ford, U.S. Army Engineer Research and Development Center, Vicksburg, MS

1.3 Background

1.3.1 FR Notice announcing initiation of this review:

73 FR 76373-76375 (December 16, 2008)

1.3.2 Listing history:

FR notice: 54 FR 34464-34468
Date listed: August 18, 1989
Entity listed: Species
Classification: Threatened

1.3.3 Review history:

The Cheat Mountain salamander was included in a cursory 5-year review for all species listed before 1991 (56 FR 56882, November 6, 1991).

This review constitutes the first substantive 5-year status review specifically for the CMS. Information that has become available since the time of listing has been used to evaluate the species' status.

1.3.5 Species Recovery Priority Number at start of 5-year review:

8c, indicating an overall moderate degree of threat, high recovery potential, and conflict with construction or other development projects

1.3.6 Recovery plan:

Plan name: Cheat Mountain Salamander (*Plethodon nettingi*) Recovery Plan
Date issued: July 25, 1991

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? Yes.

2.1.2 Is the species under review listed as a DPS? No.

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy? No.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes.

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes, partially. Although new information on the species and its habitat has been gathered since the time the recovery plan was drafted (see section 2.3), this information does not change the adequacy of the recovery criteria in regard to species biology and habitat. However, as described in section 2.2.3 below, there is significant uncertainty regarding how to define a CMS "population," which complicates species status assessments.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No. The recovery criteria do not directly address threats related to Factors C (disease or predation) or E (other factors such as acid precipitation/deposition and climate change). In addition, although the recovery criteria do address long-term protection in the form of public stewardship, this may not be sufficient to minimize threats to existing populations from Factor A (habitat fragmentation) or Factor D (inadequacy of existing regulatory mechanisms). To some extent, however, the recovery criterion requiring ten "stable or expanding" populations over a period of ten years constitutes an indirect measure of the effects of these threats on CMS.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met:

The recovery plan lists the following four recovery criteria that should trigger consideration for delisting:

1. Ten CMS populations, representing both large and small populations and distributed range-wide, are shown to be stable or expanding over a period of ten years.

2. At least 100 extant populations throughout the range are permanently protected. Permanent protection will consist of public stewardship of CMS habitat by the U.S. Forest Service, U.S. Fish and Wildlife Service, State of West Virginia, The Nature Conservancy, etc.

3. Sufficient life history information exists to conduct appropriate management, as needed.

4. Regular monitoring and management programs are established and scheduled over a period that will extend at least five years beyond the time of delisting.

Evaluation as to whether the first two criteria have been met is complicated by lack of clear definition as to what constitutes a CMS "population." At the time the recovery plan was written, the CMS was known to occur at 68 sites, and each of these sites was referred to as a population (USFWS 1991). Currently at least 80 populations have been identified (Pauley 2008a). However, direct comparisons of these numbers may be misleading. Subsequent surveys and habitat delineations determined that some of the sites identified in the recovery plan are actually connected; for example, surveys conducted in 1996 showed that the previously described Stuarts Knob and Middle Point sites are actually one continuous population (WVDNR 1996). A review of current CMS locations indicates that other areas may be shown to be connected if additional survey efforts and habitat delineations are conducted (T. Pauley, pers. comm.; C. Stihler, pers. comm.). Conversely, some formerly contiguous populations are now functionally separate, and there are no clear criteria as to what time period is required to elapse before they are designated as separate populations or how large or potentially unrestorable the barrier must be. As one example, recent surveys in the vicinity of the population near Yokum

Run Headwaters documented that ski slopes constructed in the last 25 years have bisected what was likely once one large population into at least three separate areas (USFWS 2009c). Similarly, the Hoelick North, Hoelick South, and Fishing Hawk Creek East sites are within a few hundred yards of each other but are separated by a large pipeline right-of-way and are thus given separate site name designations (WVDNR 2009). In both of these situations, designating each of these disjunct areas as a "population" under the recovery criteria artificially gives the impression that additional populations have been found and that the species is nearing recovery when, in fact, this is an indication of fragmentation and adverse effects. Resolving how to best define a population is outside the scope of this review, and in order to be consistent with published literature and current CMS recording schemes, this review has not refined any existing CMS population designations. However, future work should focus on determining how to best address this issue.

Recovery Criterion 1: Ten CMS populations, representing both large and small populations and distributed range-wide, are shown to be stable or expanding over a period of ten years.

Evaluating whether this recovery criterion has been met is difficult because very few CMS sites have been consistently monitored over a long period of time or surveyed using methods designed to document population trends. Although designating and monitoring "benchmark" populations was recommended in the recovery plan, this recovery action has not been completed. Nonetheless, monitoring and/or repeated surveys have been conducted at a number of sites.

The site where long-term monitoring has been most regularly conducted is adjacent to Timberline Four Seasons Ski Resort, near the northern extent of the species' range in Tucker County, West Virginia. The population occurs on both private and Monongahela National Forest (MNF) lands, and surveys on MNF lands are required in conjunction with a special use permit that has been granted for construction of a ski slope crossing MNF property. Surveys have been conducted annually for the past 24 years, including one year pre-ski slope construction and 23 years post-construction. Survey methods have been generally consistent and are designed to help assess the impacts associated with construction and maintenance of the ski slope. Salamanders are counted in 43 fixed plots along four transects and information on environmental conditions, including air and soil temperature, relative humidity, and soil and litter moisture, are gathered (Pauley and Watson 2009).

A total of 881 individual CMS have been documented in studies conducted in the Timberline area through 2007. Salamander gender was recorded starting in 1990. Since then, 805 CMS have been observed, including 277 males, 301 females, 124 sub-adults, and 58 juveniles (45 escaped before gender could be determined)[1] (USDA Forest Service 2008a). Over 23 years of post-construction monitoring, the average number of CMS found in plots in the area adjacent to the ski slope (impacted area) was less than the number found in study plots that were farther away (non-impacted area). For 20 out of

[1] These numbers may include some recaptures.

23 years of data, soil and litter moisture were statistically higher in non-impacted plots when compared to impacted plots (Pauley and Watson, 2007). Whereas juveniles, neonates, and gravid females were commonly found in the non-impact area, evidence of reproduction within the impact area has been limited. Throughout the entire monitoring period through 2007, only two gravid females and ten juveniles/subadults have been found in the impact area; both gravid females were found in 2006 (Pauley and Watson 2007). Occupied habitat, which is estimated to have covered 49 acres prior to ski-slope construction, is now estimated to cover 41.4 acres and is fragmented into three areas of 21, 2.6, and 17.8 acres. Approximately 8.2 of these acres are degraded by effects of fragmentation such as reduced canopy cover and decreased soil and leaf litter moisture (USFWS 2009c). Although the data have not been analyzed with respect to long-term population trends across the study area and period, they do appear to indicate some level of population stability based on documented persistence and reproduction in the non-impact area, as well as recovering numbers and gradually increasing evidence of reproduction in the impact area.

One CMS site in Blackwater Falls State Park in Tucker County has been the subject of various studies and surveys since 1992 (Pauley 2009). The results of these efforts provide some insight into the long-term status of CMS in the area. The wooded site is bisected by a heavily traveled trail that lacks leaf litter cover. Surveys conducted in 1995-1996, 1998-1999, and through 2008 (WVDNR 1999, 2000; Pauley 2009a, 2009b) showed a decrease in the number of CMS observed when compared to 1992 when an average of 4.2 CMS were found per individual survey effort (Pauley 2009a). When the site was last surveyed in 2002 and 2008 under the same weather conditions and using the same methods as previous surveys, no CMS were found (Pauley 2009). As a result, data indicate that CMS abundance at this site may be declining.

Since 2000, Canaan Valley National Wildlife Refuge (CVNWR) has been monitoring CMS sites on the Refuge located in Tucker County. Cover board arrays were established on two sites, Cabin Mountain and Bald Knob. Night surveys were also conducted at these two sites, as well as on other tracts near Cabin Mountain. Using the combination of both survey types, consistent occupation has been documented at all areas monitored on the Refuge and information on the presence of different age classes has been gathered. However, data gathered during these surveys are not sufficient to make any predictions on whether numbers of CMS at the sites are stable, increasing, or decreasing (Sturm 2009).

Finally, although population trend data was not gathered, Pauley (2007b) conducted a study in 2007 to determine whether vertical distribution has changed over the last 28 years at four CMS sites: Stuart Knob and Gaudineer Knob in Randolph County, Dolly Sods in Tucker County, and Spruce Knob in Pendleton County. Vertical distribution at these sites was previously evaluated in 1978-1979, and this study repeated the previous methods in order to evaluate changes. The study found that CMS appears to occupy the same approximate vertical distribution at all sites except Dolly Sods. At that site, vertical distribution of CMS appears to have been reduced by 40 feet with the CMS now only occurring at higher elevations compared with the 1978-79 distribution. The study also

suggests that vertical distributions of two competitive salamander species, the redback salamander (*Plethodon cinereus*) and the mountain dusky salamander (*Desmognathus ochrophaeus*) have been expanding at Spruce Knob, Gaudineer Knob, and Dolly Sods, and, further, that these two species now occur at higher elevations that were previously more exclusively occupied by CMS[2]. In addition, although no definitive determinations of CMS population trends can be made from the limited data, at all four sites the number of individual CMS located during the 2007 study was reduced compared to the 1978-1979 results. This could be due to differences in weather conditions between the two survey periods, as 2007 was noted to be a hot, dry summer (Pauley 2007b).

In summary, insufficient data are available to determine whether ten populations have been stable or expanding over a period of ten years. However, repeated surveys using various methods and at various intervals have been conducted at eight sites. Continued presence was confirmed at seven of the eight sites. One site appears to have some level of population stability over 24 years of monitoring, although adverse impacts in the form of reduced CMS abundance and reproduction are occurring within portions of the overall population area. There are some limited and non-definitive indications that numbers of CMS may be reduced at five sites. As a result, we can not conclude that this recovery criterion has been met.

Recovery Criterion 2: At least 100 extant populations throughout the range are permanently protected. Permanent protection will consist of public stewardship of Cheat Mountain salamander habitat by the U.S. Forest Service, U.S. Fish and Wildlife Service, State of West Virginia, The Nature Conservancy, etc.

When the recovery plan was written, CMS were known to occur at 68 sites. Sixty of these sites (88.2%) occurred on MNF lands. Three (4.4%) were on state park lands and five (7.3 %) were on private lands (USFWS 1991). Since that time, Dr. Pauley, a species expert from Marshall University who has conducted the large majority of CMS surveys, has examined over 1300 sites and found CMS in approximately 135 locations. Geographic extent studies conducted at many of these locations determined that several sites were part of the same population. He estimates that there are now approximately 80 disjunct populations. Of the approximately 80 populations, 60 (75%) are on state or federally-owned lands (Pauley 2008a).

Due to limited funding and staff time, as well as lack of access to some sites on private lands, many of these sites or populations are represented only by capture of a single or limited number of individuals, do not have associated habitat delineations, or have not been revisited in many years. As discussed above, quantification of the number of CMS populations is complicated by the need to further delineate some areas and the absence of a definition of what constitutes a population. The number of populations listed above may be elevated as a result of habitat fragmentation that has created multiple, functionally-separate populations out of what was once a larger contiguous grouping. Even in the absence of these complicating factors, this recovery criterion has not been met.

[2] The effects of increased intra-specific competition are described in section 2.3.2.1.

Recovery Criterion 3: Sufficient life history information exists to conduct appropriate management, as needed.

As described in section 2.3.1, new information on the species biology, life history, and habitat requirements has been developed since the time of the recovery plan. This information has assisted biologists in developing appropriate management recommendations to protect habitat. However, additional information on CMS genetics and the species response to habitat fragmentation and predation is currently being gathered that should improve our ability to develop appropriate habitat restoration measures. Additional information on species dispersal and mobility, minimum population size, population trends, and factors affecting those trends may be required to effectively manage the species over the long-term. As a result, this recovery criterion has been partially, but not fully, met.

Recovery Criterion 4: Regular monitoring and management programs are established and scheduled over a period that will extend at least five years beyond the time of delisting.

As evidenced by the discussion of recovery criteria 1-3 above, although a large amount of research and survey work has been completed, regular monitoring programs have generally not been established in most parts of the species range. CVNWR has established a program to regularly monitor CMS sites that occur on their lands. As further described in section 2.3.2.4, management plans are in place for CMS sites present on CVNWR and MNF lands. These plans are scheduled to remain in effect between 10-15 years from the time of completion. A revision to the CVNWR plan is scheduled to be completed by 2010 and the MNF Forest Plan was completed in 2006. These plans are therefore expected to be in place for at least 10 years from today. As a result, this recovery criterion has been partially, but not fully, met.

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat:

2.3.1.1 New information on the species' biology and life history: Additional studies conducted since the time of listing have clarified and confirmed historical accounts of some aspects of CMS life history, particularly in regard to reproductive patterns and seasonal and daily activities. In one study Pauley (2008c) compared historical observations from Brooks (1948 in Pauley 2008c) with information gained from more recent field studies. CMS show consistent patterns of daily and seasonal activities. CMS take refuge in decayed logs or under logs, rocks, and litter during the day and emerge at night to forage on the forest floor. They generally over-winter under the surface and emerge to the surface to forage and breed in early spring (March-April). Mating probably occurs in late April, May, or early June, but there also may be an abbreviated mating period in late September and early October (Pauley 2008c). In late April or early May, the CMS deposits egg masses containing five to eleven eggs and the

female attends the eggs until they hatch in about four months (late August or September) (Pauley 2008a). Nests are characteristically found under rocks, logs, and bark on logs and are frequently just two or three inches deep into the soil (Pauley 2008a). Timing of mating and egg deposition appears to have remained constant between the two study periods. CMS remain near the surface until mid-October. Their presence on the surface is temperature- and moisture-dependent; thus, dates of emergence and submergence depend on these environmental factors and can vary from year to year (Pauley 1978a, 1978b, Pauley 2005; all *in* Pauley 2008c).

While the typical size of CMS home range is not known, in a preliminary study Pauley (unpubl. data) found that CMS probably did not move more than three feet (USFWS 1991). Several studies have been conducted on the home range of the redback salamander. Home range of that species in Michigan was 32 ft^2 for males, 262 ft^2 for females, and 138 ft^2 for juveniles (Kleeberger and Werner 1982, *in* Pauley 2008a). Since CMS is of a similar size and occupies similar habitat to that species, it likely has a similar home range (Pauley 2008a). However additional species-specific studies should be conducted to confirm this.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends: As described in section 2.2.3 above, very few CMS sites have been consistently monitored over a long period of time or surveyed using methods designed to document population trends. It is also difficult to determine CMS abundance within most of the extant populations using existing survey data, because the objectives of individual survey efforts varied; therefore, standard search times were not used during searches and more than one search has been conducted at some populations (Pauley 2008a). However, most larger populations throughout the range that have been recently surveyed from Blackwater River Canyon (Tucker County) to Snowshoe (Pocahontas County) show some evidence of reproduction such as the presence of nests, neonates, juveniles, and subadults. A number of smaller populations and some populations on private land have not been studied enough to determine if reproduction is occurring (Pauley 2008a).

Because of the difficulty associated with quantifying population numbers or density, determination of relative population size has been tentatively based on habitat area. Pauley (2008a) defined those populations that cover greater than one acre as "large[3]." Sixty-six of the known populations fall into the large category (Pauley 2008a).

Efforts to fully delineate the overall extent of CMS occurrences at some of the largest known sites have been undertaken. Estimated population extent for four of these sites is as follows:

- Spruce Knob, Pendleton County – 2,006 acres (WVDNR 1992)
- Stuart Knob, Randolph County – 1,800 acres (WVDNR 1996).
- Gaudineer Knob, Randolph County – 465 acres (WVDNR 1992)

[3] If we assume that the home range of the CMS is similar to that of the redback salamander (see section 2.3.1.1), it is estimated that one acre would provide adequate space to support the home ranges of approximately 160 female salamanders.

- Mozark Mountain (South of Plantation Trail), Tucker County – 150 acres (WVDNR 1999)

Habitat quality and suitability within the overall extent of these sites is varied, and CMS may not be evenly distributed throughout. Barriers to migration and dispersal may also be present. A major Forest Service road, Stuart Memorial Drive, bisects the Stuart Knob habitat area, and other Forest Service roads bisect the Gaudineer and Spruce Knob areas, often multiple times (WVDNR 1992, 1996, 1999). However, the presence of CMS in habitats areas covering over 1000 acres may indicate that the potential for viable or stable subpopulations in these areas is high. These habitats may provide core conservation areas for the species.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation: No information is currently available on CMS genetics. In order to address this data gap, a study was initiated in 2009 to assess genetic diversity across the species range. The study is being conducted by Dr. Thomas Pauley of Marshall University and Dr. Brian Arbogast of the University of North Carolina. The results of this study may be used to examine relative effective population sizes of disjunct populations, identify genetically unique populations of conservation interest, and identify populations that have been separated recently and would benefit from management efforts aimed at reuniting them (Stihler 2009).

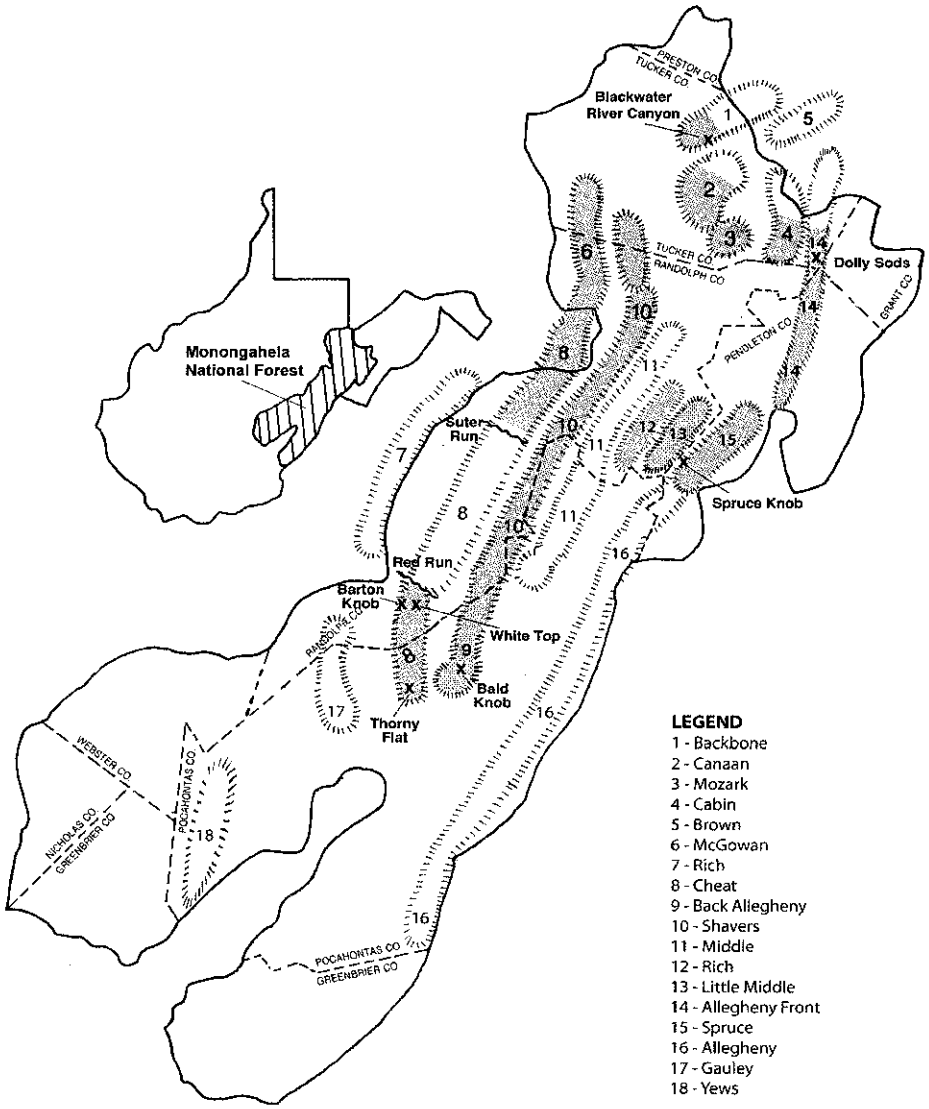
2.3.1.4 Spatial distribution, trends in spatial distribution, or historic range:

Since the time the recovery plan was written (1991), additional work has been done to clarify the vertical and spatial extent of the CMS's range as well as to further define CMS distribution within that range. For example, the recovery plan states that CMS populations were only known to occur at elevations above 2,980 feet in the northern part of the range (i.e., Spruce Knob in Pendleton County and areas north). However, additional surveys have resulted in CMS being documented down to elevations of 2,000 feet in that part of range. No changes in known elevations have been documented in the southern part of the range (i.e., south of Spruce Knob), where CMS are only known to occur at elevations above 3,500 feet (Pauley 2007a).

Surveys conducted or reported since the recovery plan was finalized have also extended the spatial extent of the range slightly into the western-most edge of Grant County along the Allegheny Front. The CMS is now known to occur in five counties in the Allegheny Mountains of eastern West Virginia: Randolph, Pendleton, Pocahontas, Tucker, and Grant counties. The current range of the species is described as extending over approximately 695 square miles from Blackwater River Canyon (Tucker County) in the north, south to Thorny Flat (Pocahontas County) (approximately 57 miles) and from Cheat Mountain in the west, and to Allegheny Front in the east (approximately 19 miles). The west to east range varies in width from less than two miles at the southern tip of the range to approximately 19 miles near the northern end (Pauley 2007a).

As shown in Figure 1, within this overall range, distribution of the CMS is discontinuous and is restricted to the higher elevations of 12 mountains: Allegheny Front, Back

Figure 1 – Range of the CMS (Taken from Pauley 2007a)



Allegheny, Backbone, Cabin, Canaan, Cheat, Little Middle, McGowan, Rich (east), Mozark, Shavers, and Spruce. CMS have not been found on other high elevation mountain ridges within the vicinity including the entire lengths of Middle Mountain, Allegheny Mountain, Brown Mountain, Gauley Mountain, and Yew Mountains, and have only been found on portions of Allegheny Front and Cheat, Backbone, Canaan, and Cabin mountains. The largest and most extensive CMS population groupings occur on

Shavers, Cheat, and Spruce mountains and Allegheny Front. CMS have only been documented to occur on one site on each of Mozark and Rich mountains (west).

The reasons for the disjunct distribution of CMS are not entirely clear, but have been attributed to a number of factors such as the extent of historical disturbances, underlying habitat conditions, the presence of natural barriers, and xeric conditions (Pauley 2007a; 2008b). For example, much of the original red spruce forest in West Virginia was essentially eliminated between 1870 and 1920 by clear-cutting and subsequent large scale fires. These fires burned the remaining vegetation as well as the duff and soil in many places down to the bedrock, thus eliminating salamander habitats. It is hypothesized that these events eradicated CMS throughout much of its range and that populations only persisted in areas were large emergent rocks or boulder fields provided cool, moist refugia where salamanders could survive (Pauley 2008b). In other areas, it is hypothesized that natural conditions have limited historic CMS distributions. Gauley and Yew mountains both have what is considered "typical" CMS habitat at appropriate elevations but do not have CMS. These mountains are separated from populations of CMS on Cheat and Back Allegheny mountains by the presence of a large, low elevation valley that may have been a natural barrier to southern expansion (Pauley 2007a). Finally, CMS may not be present in high elevation red spruce habitats on northern sections of Canaan and Backbone mountains because these areas are more xeric and may not provide microhabitat conditions suitable to support the CMS (Pauley 2008b).

2.3.1.5 Habitat or ecosystem conditions: A number of recent studies have further clarified habitat conditions required to support the CMS. Based on the results of over 34 years of CMS field surveys and examinations of over 1300 sites within the range, Dr. Pauley has described typical CMS habitat as stands of conifers such as red spruce (*Picea rubens*) and occasionally eastern hemlock (*Tsuga canadensis*) or stands of mixed deciduous forests at elevations above 2,000 ft in the northern part of the known range to above 3,500 ft in the southern part of the range. The forest floor is usually covered with the liverwort (*Bazzania trilobata*) and the habitat typically contains rock outcrops, emergent rocks, boulder fields, or narrow ravines lined with great rhododendron (*Rhododendron maximum*) (Pauley 2008a).

In addition, there have been recent attempts to model the distribution of CMS relative to landscape-level and site-level habitat characteristics (Dillard *et al.* 2008b; 2008c). Those studies found that probability of CMS occurrence at a fine spatial scale increased in areas (1) with shallower depth to rocks, (2) proximal to rocky outcrops but distal to seeps, (3) with higher densities of bryophytes, and (4) with high densities of red spruce and eastern hemlock (Dillard *et al.* 2008c). At the landscape level, there was an increased chance of CMS presence in (1) high-elevation areas underlain by sandstone; (2) areas with northeasterly aspects, moderate slopes, and higher relative annual precipitation; and (3) areas further from surface water (Dillard *et al.* 2008c). The results of these field and modeling efforts are generally consistent and clearly indicate a general suite of habitat conditions needed to support CMS populations.

At the site level, geophysical characteristics rather then vegetation composition and structure are often a primary influence on CMS habitat suitability, and CMS generally occur at sites associated with rock at or near the surface (Pauley 2008a, Dillard *et al.* 2008c). This is also consistent with the landscape-level association with areas of sandstone geology, because sandstone parent materials weather to produce abundant emergent rocks. Rocks just below the surface often indicate the presence of extensive colluvium and abundant interstitial spaces. CMS likely use such underground refugia to avoid dry, hot weather during summer and to overwinter (Pauley 2008b, Petranka1998 in Dillard *et al.* 2008b). CMS exit these covered habitats to forage on the surface when moist, cool microclimatic conditions allow for cutaneous respiration (Feder 1983, Owen 1989, Grover 1998, Petranka 1998, Welsh *et al.* 2006; all *in* Dillard *et al.* 2008). These areas also likely provided refugia that allowed CMS to survive historical habitat perturbations as described in section 2.3.1.5 above (Pauley 2008a).

In addition to providing habitat structure, emergent rocks likely more favorable temperature and moisture regimes for CMS (Pauley 1998). Because CMS are lungless, sufficient moisture must be present for respiratory exchange to occur directly through the skin (USFWS 1991). As a result, CMS require microhabitats with high relative humidity or moisture and acceptable temperatures (Feder and Pough 1975, Feder 1983; *in* USDA Forest Service 2008a); in fact, most CMS habitat characteristics described reflect the species' need for specific temperature, moisture, and humidity regimes.

For example, higher elevations generally have greater annual average precipitation and cooler average annual temperatures when compared to lower elevations (Dillard *et al.* 2008b). Similarly, the positive association found with north facing slopes is reflective of the lower level of solar radiation received at this aspect which helps to maintain cool, moist conditions (Dillard *et al.* 2008b). Warmer more xeric slopes may limit distribution of CMS (Pauley 2007a).

The vegetation composition and structure associated with typical CMS habitat also combine to provide similar microclimate regimes. Although typically present in areas with red spruce, the CMS also occur in areas with eastern hemlock and overall high canopy closure associated with mature forests (Pauley 2008a). Mature red spruce and eastern hemlock stands typically have dense canopies and this type of vegetative structure is known to affect salamander populations. Moist old growth stands have greater salamander abundance and species richness than dry old growth or younger stands of various moisture levels (Welsh and Lind 1988). This is probably due to the complex structure of older stands and resulting amenable microclimates. Old stands provide dense litter layers, abundant woody debris, and stratified canopies, which all enhance moisture retention and limit moisture and temperature variations in the forest floor (Petranka *et al.* 1994, Petranka 1998; *in* USDA Forest Service 2008b). Similarly, the presence and density of bryophytes such as liverwort generally indicates a site has high soil moisture and site-level humidity and thus, provides suitable microhabitat conditions for CMS (Pauley and Pauley 1997).

Positive trends have been noted in the age and composition of high elevation forests that may benefit CMS. The reduced level of forest clearing in recent years has resulted in forest regeneration and succession, producing older forest stands and improved forest structure when compared to conditions at the time of listing (Adams *et al.* 1999, Audley *et al.* 1999, Schuler *et al.* 2002, Rollins 2005). However, as noted above, vegetation composition and structure represent only one component of several CMS habitat requirements, and many of these regenerated forests do not have the geophysical characteristics that the CMS require or have not acquired the "old growth" characteristics such as high levels of downed woody debris and dense litter layers that would make them more likely to support CMS populations.

2.3.2 Five-factor analysis (threats, conservation measures, and regulatory mechanisms):

2.3.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range: Habitat destruction and modification were the primary threats that led to listing the CMS. Historically, the large-scale timbering and burning that occurred throughout the CMS range in the last 100 years resulted in significant change and loss of CMS habitat (USFWS 1991). Habitat modifications continue to be the major factor affecting CMS today, and can affect the CMS by (1) completely removing suitable habitat; (2) altering remaining habitat conditions and making the area less suitable to support the species; or (3) by fragmenting populations (Pauley 2008a, 2008c).

Direct Habitat Loss – Federal Lands
As a result of land use management plans that are in place on federally-owned lands within the MNF and CVNWR, direct removal of CMS habitat occurs infrequently in these areas. These plans provide CMS populations within these areas with substantial protections from new habitat-based disturbances and contribute to the recovery of the species.

In 2006, the MNF finalized a new Land and Resource Management Plan (Forest Plan) that guides how projects are conducted on MNF lands (USDA Forest Service 2006). The Forest Plan incorporated numerous measures designed to avoid adverse effects and enhance recovery of CMS including:

- Management Prescription 4.1 emphasizes active and passive ecosystem restoration and management of red spruce and spruce-hardwood communities, research or administrative studies on spruce restoration, and recovery of threatened or endangered species and other species of concern associated with these communities.

- Goal TE04 states "within watershed-level planning units, identify threatened, endangered, or proposed (TEP) species habitat and opportunities to maintain, restore, or enhance habitat conditions. Design and implement management actions at the project level to address opportunities and provide for ecological conditions, population viability, reproductive needs, and habitat components for TEP species."

- Goal TE57 states "identify opportunities to reduce fragmentation of (CMS) populations and habitat."

- Standard TE58 states "prior to proposed vegetation or ground disturbance in known or potential (CMS) habitat, field surveys must be conducted and occupied habitat must be delineated."

- Standard TE59 states "ground and vegetation-disturbing activities shall be avoided within occupied (CMS) habitat and a 300-foot buffer zone around occupied habitat, unless analysis can show that the activities would not have an adverse effect on populations or habitat."

As a result of these measures, it is generally anticipated that populations of CMS on MNF lands will not be subject to new habitat-disturbing projects that have adverse impacts. However, these measures may be modified in the future when the Forest Plan is revised (anticipated to occur every 15 years). In addition, the measures listed above may be modified on a project-by-project basis. For example, in 2009 the MNF issued a project-specific amendment to the Forest Plan in order to reissue a Special Use Permit (SUP) for a ski trail through CMS habitat being used by a private entity, Timberline Four Seasons Resort. The project-specific Forest Plan amendment, which did not comply with some of the standards listed above, allowed a project to proceed that had previously documented adverse effects to CMS populations (USDA Forest Service 2009, USFWS 2008).

Nonetheless, it is anticipated that situations like this will be extremely rare, and in the case cited above there were extenuating circumstances that allowed the project to proceed (USFWS 2008b): The project was a renewal of an existing SUP that was in place prior to enactment of the current Forest Plan, and the ski-slope was originally constructed while the CMS was being considered for listing under the ESA but had not yet been officially listed. No new loss or direct removal of CMS habitat occurred as a result of SUP renewal; furthermore, prior to issuing the SUP, the project was modified to incorporate red spruce and CMS habitat restoration measures that would reduce the level of existing impacts, contribute to CMS recovery efforts, and make the project more consistent with the overall objectives, standards, and goals of the Forest Plan. The USFWS is not aware of any additional projects with similar extenuating circumstances that would result in project-specific forest plan amendments to allow take of CMS.

A management plan is also in place for CMS populations within CVNWR (USFWS 2009b). Current management strategies are designed to "conserve and manage spruce forest habitat for threatened CMS populations to prevent disturbance, habitat fragmentation and promote population viability." The following activities are included:

- Monitoring known populations to document persistence and reproductive success.

- Inventorying suitable habitat to document new populations.

- Restoring red spruce in and adjacent to occupied CMS habitat.

- Working with partners to research habitat limitations, habitat improvement and mitigation options, and the impacts of current management on CMS populations as identified in the recovery plan.

CVNWR is also in the process of revising their Comprehensive Conservation Plan (CCP) and a final CCP is scheduled to be released in 2010. All management alternatives described in the draft plan include the measures listed above. Some of the alternatives include additional measures to increase the level of red spruce restoration and CMS threats abatement. As a result, it is generally anticipated that populations of CMS on CVNWR lands will not be subject to new habitat-disturbing projects with adverse impacts. However, as with the Forest Plan, these measures may be modified or deleted in the future when the CCP is revised (anticipated to occur every 15 years).

Direct Habitat Loss – Private Lands

CMS populations on private land are subject to direct habitat loss and alteration due to logging and development. For example, CMS are known to occur throughout the West Ridge subdivision near Snowshoe Resort in Pocahontas County, which encompasses 140 lots of one acre or more each. Houses have already been built on 46% of the lots, fragmenting much of the CMS habitat present in the area, and development continues on the remaining lots. Although Snowshoe Resort is aware of the presence of CMS in this area and does refer potential developers to the USFWS, reviewing each individual lot restricts managers from developing larger-scale avoidance and mitigation options (USFWS 2008a). As a result of threats such as these on private lands, plans are underway to develop a CMS habitat mitigation bank (L. Hill, pers. comm.).

Similarly, CMS populations are known to occur within 2,700 acres of privately-owned lands in Blackwater Canyon in Tucker County. Although the extent of CMS habitat in the area has not been fully quantified, approximately 1,600 acres are potentially slated for logging, and an additional unquantified but smaller acreage is proposed for development. Discussions with the landowner regarding development of a habitat conservation plan are ongoing (L. Hill, pers. comm.).

Finally, in some cases, private entities may own the mineral rights beneath both privately- and federally-owned lands. Private entities may seek to develop their mineral rights, and it is possible that these activities could be proposed within CMS habitats. In most cases on federal lands, the federal agencies will work with developers to make sure the projects are consistent with existing management plans. However, the threat of habitat loss and alterations from these types of activities is ongoing.

Habitat Fragmentation

Anthropogenic habitat fragmentation and alteration continue to affect almost all of the known CMS populations, including those that are on public lands and are protected by management plans addressing direct habitat removal (Pauley 2008a). For example, threats such as roads, ski trails, powerline rights-of-way, and adjacent logging or development were noted for 86% of the CMS areas that have been surveyed since the species was listed (WVDNR 2009). In addition, in 2008 a formal consultation for

continued maintenance of a ski slope project adjacent to CMS habitat on the MNF was completed. These types of activities reduce the suitability of the remaining areas to CMS (USFWS 1991, Pauley 2008a). Habitat fragmentation and tree removal open the interior of the forest floor to increased amounts of sunlight and wind, resulting in an increase in soil temperature and a decrease in soil moisture and changing the microclimatic conditions on the forest floor from mesic to xeric (USFWS 1991, Pauley 2008a). Since the CMS requires moist, cool habitats, any alteration of the habitat that reduces soil moisture and/or relative humidity can lead to adverse effects such as reduced reproductive success through nest desiccation (USFWS 1991, Pauley 2008a). Pauley and Watson (2003) conducted a study of the effects of habitat alterations on CMS populations. This study found that the loss of soil and litter moisture and increased soil temperatures observed at the edges of disturbances may contribute to the loss of salamanders. Few CMS were observed along the edges of disturbed areas and in general, the number of salamanders increased as the distance from the disturbance increased. In addition, juvenile salamanders were not found within 98 feet of the edge of the disturbance.

Disruptions of habitat may also lead to fragmentation or dissection of single, large populations into smaller subunits and create barriers to dispersal and gene flow (Pauley and Watson 2003, Pauley 2008a). The loss of genetic material in a population can reduce genetic variability and could be costly to populations if diseases are introduced or other ecosystem changes should occur (Pauley 2008a). Fragmented, smaller populations may also be more susceptible to extirpation due to natural pressures such as periods of drought and interspecific competition (USFWS 1991, Vos and Chardon 1998 *in* Pauley and Watson 2003). This is especially true if there is no possibility of recolonization from adjacent populations (Pauley and Watson 2003).

Pauley (unpubl. data *in* USFWS 1991) found that roads, and potentially some trails, serve as barriers that prevent territories of different individuals from overlapping, thus fragmenting populations and gene pools. Heavily traveled trails can result in removal of leaves and other forest litter, leaving bare trail treads (USFWS 1991; WVDNR 1999, 2000). Preliminary data suggest that CMS rarely cross trails and other openings that lack sufficient leaf litter cover (Pauley 2005 *in* Pauley and Waldron 2008). CMS use forest floor litter as foraging cover and refugia, especially during the day. Removal of this litter can create a barrier to these activities and render them unsuitable for territories (USFWS 1991; WVDNR 1998, 2000; Pauley and Waldron 2008). Such barriers could also interfere with reproduction, since mating apparently occurs where territories overlap (Horne 1988 *in* USFWS 1991). However, CMS have also been documented to occur and breed within relatively narrow trails that have greater than 75% canopy cover, abundant surficial rocks, leaf litter, and woody debris (Dillard *et al.* 2008a). Therefore, the extent to which these features serve as a barrier to CMS most likely depends on site-specific characteristics such as width, canopy cover, substrate material, compaction, and level/type of use.

In 2009, the MNF initiated a study to further quantify these types of effects and to design more effective road and trail maintenance activities to minimize adverse effects (Johnson 2009). Although results of this effort are not yet available, both the MNF and CVNWR have begun to initiate efforts to address this threat. Activities have included identifying priority areas for red spruce restoration in order to connect or expand existing CMS populations. Options such as increasing shading, placing of rocks, cover boards or leaf litter packs to reduce barriers to movement across trails and roads, or decommissioning unused roads and relocating trails are also being considered. Finally, collaborative partnerships among federal, state, and private entities have been formed in order to encourage landscape-level planning and restoration of high elevation red spruce forests. These efforts are reflected in the creation of the "High Elevation Working Group" and the signing of the "Memorandum of Understanding for the Conservation of the Red Spruce – Northern Hardwood Ecosystem" by partners such as the USFWS, the MNF, the U.S. Department of Agriculture Northern Research Station, the West Virginia Division of Forestry, the West Virginia Division of Natural Resources, and The Nature Conservancy (USFWS *et al.* 2006).

Inter-specific Competition

Habitat alterations and fragmentation may also increase the threat of inter-specific competition. The recovery plan noted that inter-specific competition with species such as the redback salamander and the mountain dusky salamander may limit the ability of the CMS to retain populations within its range or re-populate previously occupied areas (54 FR 34464-34468). Pauley (Pauley and Watson 2003) describes a three-way interaction among these species that influences their microdistribution. He determined that CMS and the mountain dusky salamander require moister soils than the redback salamander and, therefore, compete for moist spots. CMS and the redback salamander have the same body size, consume the same primary and secondary prey items, and deposit eggs at the same time of the year and in the same nesting sites, and they thus compete for food and nesting sites. Dehydration rate studies have demonstrated that CMS loses body moisture faster than the redback salamander (Pauley 2005, Pauley 2008a). Studies also suggest that CMS is not as keen a competitor for limited resources as the other two species and that competition among these three species is probably very keen (USFWS 1991, Pauley 2005). Fragmentation of forests and removal of the forest canopy create gradients of environmental factors from the edge into the forest that may increase the natural level of inter-specific competition (Pauley and Watson 2003). Smaller CMS populations could be more susceptible to inter-specific competition, and competitive stress may place these populations at further risk (Pauley 2008a).

Other studies have reported similar results regarding the effects of changing environmental gradients and inter-specific competition among salamanders. In one study, Grover and Wilbur (2002) evaluated factors that define boundaries between assemblages of streamside and terrestrial plethodontid salamanders by manipulating the moisture gradient in the ecotone between headwater streams and upland forests in the Allegheny Mountains of Virginia. They conducted two experiments that created seeps (continuously moist patches) 9.8 to 49 feet from streams and greater than 98 feet from the nearest stream or seep and then evaluated the response of streamside and terrestrial

salamanders in the area. In the experiment closer to the streams, larger streamside salamanders such as the northern dusky salamander (*Desmognathus fuscus)* increased in density and eventually displaced smaller more terrestrial species such as the redback salamander. At experimental sites farther from streams, and in the absence of streamside salamanders, redback salamander abundance increased in response to the presence of seeps. Finally, Dillard *et al.* (2008b) indicated a negative correlation between CMS occurrence and the presence of seeps, corroborating early CMS habitat descriptions by Brooks (1948 in Pauley 2008c) and indicating that CMS-occupied sites were farther from water sources when compared to random locations (Dillard *et al.* 2008b). Their findings provide support to the prevailing hypothesis that both red-backed and mountain dusky salamanders competitively dominate CMS and potentially restrict its local distribution (Dillard *et al.* 2008b, 2008c).

2.3.2.2 Over-utilization for commercial, recreational, scientific, or educational purposes: There is little evidence that the CMS is being adversely affected by over-use for commercial, recreational, scientific, or educational purposes. The State of West Virginia requires that a scientific collecting permit be obtained before any collections, surveys, or research on the species is conducted, which minimizes the risk of over-utilization for scientific or educational purposes. One incidence of illegal collection of two CMS by a scientist has been recorded since the species was listed. However, law enforcement action was taken in this case, and it appears to have been an isolated instance. The CMS has no known commercial utility, and there is no recent evidence that the species is targeted for recreational uses such as the pet trade.

2.3.2.3 Disease or predation:

Predation
The CMS is susceptible to increased predation from snakes and other predators that access CMS habitat through forest openings created by roads, ski slopes, and utility rights-of-way. Typically, snake species such as gartersnakes (*Thamnophis sirtalis*), ring-necked snakes (*Diadophis punctatus edwardsii*), and red-bellied snakes (*Storeria occipitomaculata*) that prey on salamanders are less common in cool, moist forests where CMS are commonly found (Pauley 2008a). Features that fragment CMS habitat and create forest openings can create habitat conditions that are more conducive for predators. In order to better quantify this threat, a study was initiated in 2009 at a CMS population adjacent to a ski slope and two roads (Bradshaw and Pauley 2009). Objectives of this study were to: (1) determine species richness and relative abundance of snake communities on the ski slope and roads and how far these species move from the edge habitat into the forest, (2) perform mark/recapture to quantify individual numbers of different snake species, and (3) determine whether these snakes are a predatory threat to CMS.

Chytridiomycosis
A newly emergent pathogenic disease, Chytridiomycosis, has recently been linked to multiple amphibian mass mortality and extinction events (Cummer *et al.* 2005, Greathouse and Pauley 2008). The disease is a result of infection from the chytrid fungus

(*Batrachochytrium dendrobatidis*) (Bd); it causes mortality by disturbing cutaneous respiration and the balance of oxygen, water, and electrolytes across the amphibian's skin (Cummer *et al.* 2005; Bakal *et al.* 2007 *in* Greathouse and Pauley 2008). Although the fungus has currently not been documented to occur within the range of the CMS, it is spreading rapidly across regions and through amphibian populations (Vredenburg *et al.* 2007, Greathouse and Pauley 2008), and has been recently documented to occur in Marshall, Brooke, and Fayette counties, West Virginia (Bartkus 2009). Amphibian declines or extinctions linked to this disease have already been noted in North and South America, Europe, and Australia. In the United States, sites of infection include Wyoming, Minnesota, Wisconsin, Missouri, Indiana, Georgia, and Virginia (Bradley *et al.* 2002, Ouellet *et al.* 2005, Fellers *et al.* 2007, Longcore *et a*l. 2007; all *in* Greathouse and Pauley 2008).

Should Bd enter the range of the CMS, it is not known how populations will respond. Research has shown that species which inhabit montane, stream-associated habitats are the most likely to become infected with and potentially become extinct due to Bd (Greathouse and Pauley 2008). The fungus is considered an aquatic pathogen because it requires water for zoospore transmission, cannot survive desiccation, and in the wild is associated only with aquatic habitats (Cummer *et al.* 2005). Since CMS are terrestrial salamanders, they may be less susceptible to Bd than other more aquatic species. In addition, studies have demonstrated that the skin of two other species of *Plethodon* salamanders, the redback salamander and the southern zigzag salamander (*Plethodon ventralis*) contains bacteria that have antifungal properties (Lauer *et al.* 2007). Researchers hypothesize that when these species come into contact with Bd, they will be less likely to succumb than species not supporting these antifungal bacteria on their skin (Lauer *et al.* 2007). However, other studies have documented cases of chytridiomycosis in the Jemez Mountain salamander (*Plethodon neomexicanus*), a species endemic to the dry slopes of the Jemez Mountains of New Mexico (Cummer *et al.* 2005). The discovery of chyridiomycosis in a wild-caught, terrestrial amphibian may indicate that terrestrial salamanders, including *Plethodon* species, are in fact susceptible to Bd (Cummer *et al.* 2005). Although there is uncertainty regarding the potential susceptibility of CMS, if the disease enters the species' range, Bd could present a significant threat to CMS populations, particularly given the restricted range of the species.

2.3.2.4 Inadequacy of existing regulatory mechanisms: Although non-regulatory management plans are in place for the MNF and CVNWR, there are no other regulatory protections in place for CMS populations occurring outside of those federal lands. There are no particular documents or regulations governing development at West Virginia state parks (Gilligan 2009). West Virginia has no state threatened and endangered species legislation, and there are few if any other county zoning or planning ordinances that would preclude development. The State of West Virginia requires that a scientific collecting permit be obtained before any collections, research, or surveys on the species are conducted, which minimizes the risk of over-utilization for scientific purposes but does not provide any protection against other forms of take or to the species' habitat. Therefore, in the absence of the ESA, most forms of take of CMS would not be regulated.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Climate Change

Climate change is a rapidly emerging threat to biodiversity (NatureServe 2009) that has the potential to significantly restrict the range and viability of the CMS over time. Numerous studies suggest that some species' ranges may shift or become restricted in response to the effects of climate change (Sekercioglu *et al.* 2008, Swanson 2009). This is particularly true for montane species that have existing habitat and elevational limitations (Harris and Pimm 2007 *in* Sekercioglu *et al.* 2008). Species such as the CMS are confined to specific elevational bands as a result of microclimatic requirements and their preferred vegetation types (Weathers 1997, Martin 2001, McNab 2003, all *in* Sekercioglu *et al.* 2008; Pauley 2008a, 2007a, 2007b). Consequently, even when they occupy intact habitats, highland species are now facing the threat of warming temperatures that increasingly push these species toward higher portions of mountain tops and further restrict their range (Williams *et al.* 2003, Pimm *et al.* 2006; *in* Sekercioglu *et al.* 2008).

Most models are unable to predict with reasonable certainty habitat changes at scales as small as that of the range of the CMS, and there is significant uncertainty regarding anticipated effects to vegetation that may occur in high elevation forests in West Virginia (73 FR 50226). However, existing climate change models for the region predict slight increases in winter temperatures and an overall increase in annual precipitation, with associated seasonal changes such as a slight decrease in summer and winter precipitation and increases in fall and spring precipitation (Janoiak 2009). Given the CMS's restricted microhabitat requirements in regard to seasonal temperature and moisture, as well as their limited mobility, these predicted changes could more significantly affect the CMS than other species with more habitat plasticity and adaptability. Climate changes may also promote the expansion of competitor species that may be able to better adapt to changed microhabitat conditions.

In order to evaluate CMS's vulnerability to these types of changes, we applied NatureServe's Climate Change Vulnerability Index (Index). The Index uses a scoring system that considers a species' predicted exposure to climate change within its range along with factors associated with climate change sensitivity, such as (1) indirect exposure to climate change; (2) species-specific factors (including dispersal ability, temperature and precipitation sensitivity, physical habitat specificity, interspecific interactions, and genetic factors); and (3) documented response to climate change. In order to avoid duplicating factors that affect both conservation status and vulnerability to climate change, the Index does not consider population size, range size, and demographic factors (Young *et al.* 2009). Based on our species-specific inputs to the Index, the CMS was determined to be "extremely vulnerable" to the effects of climate change (USFWS 2009a), indicating that the species' abundance and/or range extent is highly likely to become substantially decreased as a result of the effects of climate change over time (Young *et al.* 2009). Factors that contributed to this result included the CMS's limited dispersal ability, sensitivity to changes in precipitation and temperature, and reliance on inter-specific relationships and habitat types (USFWS 2009a).

Drought
Drought decreases soil moisture and thus has similar effects to those discussed under habitat modifications. Drought conditions in recent years may have had a severe and negative effect on the success of nests throughout the range of CMS (Pauley 2008a). Nests are characteristically found under rocks (frequently just two or three inches deep in the soil), logs, and bark on logs. These nesting sites are susceptible to desiccation during drought events (Pauley 2008a).

Acid Precipitation/Deposition
Pollution factors such as acid precipitation may also affect the survival of the CMS. The range of the CMS has been, and continues to be, the recipient of some of the highest acid (sulfate and nitrate) deposition in the nation, mainly due to its location downwind of many old coal-fired power plants that have had minimal or no pollution controls. Historically high sulfate (SO42) deposition from sources in the Ohio River Valley has contributed to acidification of streams and may have affected soil quality and productivity on parts of the MNF and other high elevation areas of West Virginia. Although acid precipitation/deposition continues to occur, recent trends suggest a reduction in the historic rate of these events. Sulphate deposition in the Central Appalachians has dropped by at least 25 % in the last 10 years, pH of deposition has increased, and the rate of nitrogen deposition has leveled off or may be slightly increasing (Johnson *et al.* 1992, Adams *et al.* 2006, Adams and Kochenderfer 2007).

Although the effects of acid precipitation/deposition on regional vegetation is unclear, research scientists have found evidence of nutrient depletion in certain soils on the MNF (Jenkins 2002 and Sponaugle 2005 *in* USDA Forest Service 2008b; Adams *et al.* 2006). The combination of high emissions and limited buffering capacity of certain geology and soil types found on the MNF has led to increased acidity in stream water and possible changes in soil chemistry. Although over time MNF soils acidify naturally, the rates of acidification are accelerated due to the continued inputs of the deposition. Forest management activities such as trail maintenance and construction, timber harvests, and other types of soil disturbance could also alter soil chemistry over time (S. Connolly, pers. comm.). Since CMS directly inhabit the soil, they are likely to be susceptible to changes in soil chemistry due to acid deposition, and this could, therefore, ultimately affect the ability of habitats to support the CMS (USDA Forest Service 2008b).

For example, acid deposition has been implicated in the build up of heavy metals in the soil and the release of aluminum into soil solutions (Ulrich *et al.* 1980, Gibson and Linhurst 1982; *in* Wyman and Hawksley-Lescault 1987). These factors may result in the exclusion of young or adult *Plethodons* from affected soils (Wyman and Hawksley-Lescault 1987). In addition, although it is not known what the soil pH tolerance limits are for CMS, it appears that negative impacts may occur if soil pH in CMS sites decreases (USFWS 1991). Wyman and Hawksley-Lescault (1987) found that the density of the redback salamander declined when soil pH was below 3.7. In other studies, no young of the year were found on soils below 3.7, and adult survival, respiration, and growth were reduced on substrates of pH 3 and 4 (Wyman 1988). Low soil pH has also been shown to affect sodium balance in other *Plethodon* species. Disruption of sodium

balance can cause death, dehydration, and slowed growth in salamanders (Frisbie and Wyman 1992).

Other studies evaluating the effects of artificially acidified soils and watersheds failed to document differences in surface densities of terrestrial salamanders between treatment and control areas but did document differences in the size of salamander eggs between treatments (Adams *et al.* 2006; however, the relatively short duration of this field study may have been "too brief for acidification effects to be detected in long-lived, high trophic level animals"). In sum, the effects of acid precipitation/deposition on the CMS are unclear. Nonetheless, some concern exists about consequent long-term changes in soil chemistry and the associated effects that this may have on the CMS that live within those soils.

2.4 Synthesis

Overall population trends for the CMS are unclear. At the time the recovery plan was written, CMS were known to occur at 68 sites, and each of these sites was referred to as a population. Currently at least 80 disjunct populations have been identified. However, direct comparisons of these numbers are complicated because what constitutes a CMS "population" has not been clearly defined. Although additional populations have been found, habitat delineations have determined that some previously identified sites are actually one larger continuous site. Conversely, some formerly contiguous populations are now functionally separate, and there are no clear criteria as to what time period is required to elapse before they are designated as separate populations or how large or potentially restorable the barrier must be. Furthermore, insufficient data are available to determine trends for most populations and long-term monitoring has only been conducted at eight sites. Continued presence was confirmed at seven of the eight sites. One site appears to have some level of population stability over 24 years of monitoring, although adverse impacts, in the form of reduced CMS abundance and reproduction, are occurring within portions of the overall population area. There are some limited and non-definitive indications that numbers of CMS may be reduced at five sites. However, most larger populations throughout the range that have been recently surveyed show some evidence of reproduction, e.g., presence of nests, neonates, juveniles, and subadults. A number of smaller populations and populations on some private land have not been studied enough to determine if reproduction is occurring (Pauley 2008a). Efforts to fully delineate the overall extent of CMS occurrences at some of the largest known sites have been undertaken.

New information on the species' life history and habitat requirements has been developed. The geophysical, topographical, vegetative, and microclimatic conditions required to support the species have been described. The vertical and spatial range of the species has also been further defined and clarified. Within the overall range, distribution of the CMS is discontinuous and is restricted to the higher elevations of 12 mountains. Additional information on CMS genetics and the species' response to habitat fragmentation and predation is currently being gathered and should improve our ability to develop appropriate management and habitat restoration measures. Additional

information on dispersal and mobility, minimum population size, population trends, and factors affecting those trends may be required to effectively manage the species over the long term.

Approximately 75% of known CMS sites are on state or federally-owned lands. Management plans are in place for CMS sites on CVNWR and MNF lands. There are no other regulatory protections in place for CMS populations that are not within these areas. Habitat fragmentation and alteration continue to affect almost all of the known CMS populations, including those on private lands and public lands protected by management plans. The presence of features such as roads and ski slopes reduce the suitability of the remaining areas to CMS by changing microclimatic conditions, increasing susceptibility to predation and inter-specific competition, and by creating barriers to dispersal and gene flow.

A newly emergent and rapidly spreading pathogenic disease, Chytridiomycosis (Bd), has recently been linked to multiple amphibian mass mortality and extinction events throughout North and South America. Although there is uncertainty regarding the potential susceptibility of CMS, given the restricted range of the species, Bd could present a significant threat to CMS populations. The CMS also appears to be potentially susceptible to the effects of climate change, drought, and acid precipitation/deposition.

Given the uncertainties regarding population status in conjunction with ongoing and emerging threats – some of which are severe – to the CMS and its habitat, the species continues to meet the definition of threatened, i.e., "is likely to become endangered species within the foreseeable future throughout all or a significant portion of its range."

3.0 RESULTS

3.1 **Recommended Classification:** Retain as threatened.

Rationale: Gains in habitat protection from development of land-use management plans do not offset continuing and emerging threats to the species. Therefore, we cannot conclude that the species is not likely to become an endangered species in the foreseeable future.

3.2 **Appropriate Recovery Priority Number:** Retain as 8c.

Rationale: The threats to CMS are considered moderate, that is, they will not cause immediate endangerment if abatement is temporarily postponed, although prolonged delays in taking action could result in a serious decline. The recovery potential is considered high based on continuing cooperative efforts to manage and restore CMS habitat. The RPN is also based on continuing conflicts between CMS conservation and development.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The following list of immediate recovery needs was generated based on the results of this five-year review and discussions with experts familiar with the species and its habitats. These proposed actions are not presented in any order of priority. If the proposed action was identified in the recovery plan, the action number from the plan is listed.

- Additional work needs to be done to define what constitutes a CMS population and to evaluate existing data in relation to that definition.

- A monitoring program should be developed using consistent methods. Monitoring protocols should be designed to evaluate long-term population trends and changes in density, abundance, and distribution. Existing survey data should be systematically reviewed and analyzed to help determine appropriate monitoring strategies and overall population viability (Recovery Action 1.0).

- Benchmark populations should be established and monitored using the developed protocol on a regular basis (Recovery Action 1.2).

- Additional monitoring and evaluation should occur at apparently declining populations (e.g., Dolly Sods-Fisher Spring Run, Gaudineer Knob, Stuart Knob, and Blackwater Falls State Park Elakala Trail) to determine the extent and causes of decline. Restoration measures should be developed and implemented (Recovery Actions 1.3 and 5.0).

- Large, stable populations should be designated and core conservation areas for long-term CMS survival established. Areas that provide for resiliency to climate change should be considered when designating these core areas (Recovery Actions 2.0 and 3.2).

- Additional habitat delineations should be conducted where known populations occur. Many sites are known from a single location and the extent of the population has not been examined (Recovery Action 1.1).

- Searches for new populations should be continued. Surveys should be conducted at areas within the known range that have previously not been surveyed in order to determine whether they are occupied and the extent of any potential populations. Surveys should be prioritized in areas with apparently suitable habitat conditions (Recovery Action 1.4).

- Genetic studies should be completed that look at genetic diversity across the species' range and connectedness of existing populations. Populations that are genetically unique and important in the long-term conservation of the species should be identified (Recovery Action 4.4).

- Efforts to address habitat fragmentation (e.g. from roads, trails, rights-of-way) should be undertaken and methods to restore and reconnect CMS populations should be evaluated and implemented (Recovery Actions 2.0, 3.2 and 5.2).

- Landscape-level habitat evaluation and restoration of red spruce and spruce-northern hardwood habitats should be continued and enhanced. CMS distribution and habitat requirements should be considered as part of these efforts (Recovery Actions 2.0 and 5.2).

- Efforts to work with private landowners to address potential habitat loss should be continued and, where possible, opportunities to develop conservation easements or purchase occupied habitats from willing sellers should be pursued (Recovery Action 2.3).

- The threats posed by Chytridiomycosis, climate change, and acid precipitation/deposition should be monitored and long-term management plans and response efforts to address these threats should be developed and implemented (Recovery Actions 2.2 and 5.2).

In most cases, these actions will require the participation of the USFWS, WVDNR, federal and state land managers, species experts, and other researchers. Formation of a CMS working group or formal recovery team would help facilitate enhanced cooperation, consistency, and the timely initiation and successful completion of these recovery actions. Formation of a team would also serve to encourage additional partners to participate in collaborative, landscape-level recovery efforts. The Recovery Team or working group could also review the existing recovery criteria and make recommendations as to how to best up-date the criteria to address all relevant threats and overall population biology of the species.

5.0 REFERENCES

Adams, M.B., D.R. DeWalle, and J.L. Hom. 2006. The Fernow Watershed acidification study. Springer-Verlag, New York. 279 pp.

Adams, M.B. and J.N. Kochenderfer. 2007. Long-term stream chemistry monitoring on the Fernow Experimental Forest: Implications for sustainable management of hardwood forests. Pp. 97-106 *in* Buckley, D.S. and W.K. Clatterhbuck (eds.), Proceedings of the 15th Central Hardwood Forest Conference. E-General Technical Report SRS-101. U.S. Department of Agriculture, Forest Service, Southern Research Station. Available online at www.treesearch.fs.fed.us.

Adams H.S., S.L. Stephenson, M.B. Adams, and D.H. Lawrence. 1999. Ecological status of mid-Appalachian red spruce communities. P. 235 in R.P. Eckerlin (ed.), Proceedings of the Appalachian Biogeography Symposium, Special publication No. 7, Virginia Museum of Natural History, Martinsville.

Audley, D.E., J.M. Skelly, L.H. McCormick, and W.A. Jackson. 1998. Crown condition and nutrient status of red spruce (*Picea rubrens* Sarg.) in West Virginia. Water, Air, and Soil Pollution 102:177-199.

Bartkus, C.J. 2009. The occurrence of *Batrachochytrium dendrobatidis* in salamander populations in West Virginia. M.S. Thesis, Marshall University, Huntington, WV.

Bradshaw, C. R. and T.K. Pauley. 2009. Study Proposal: Identifying snake species and densities at forest edge habitats on ski slopes in Canaan Valley, West Virginia.

Cummer, M., D.E. Green, and E.O. O'Neil. 2005. Aquatic Chytrid pathogen detected in terrestrial Plethodontid salamander. Journal of Herpetology 36(3): 248-249.

Dillard, L.O., K.R. Russell, and W.M. Ford. 2008a. *Plethodon nettingi* habitat use and ovoposition. Herpetological Review 39(3):335-336.

Dillard, L.O., K.R. Russell, and W.M. Ford. 2008b. Macrohabitat models of occurrence for the threatened Cheat Mountain salamanders *Plethodon nettingi*. Applied Herpetology 5:201-224.

Dillard, L.O., K.R. Russell, and W.M. Ford. 2008c. Site-level habitat models for the endemic, threatened Cheat Mountain salamander (*Plethodon nettingi*): the importance of geophysical and biotic attributes for predicting occurrence. Biodiversity and Conservation 17:1475-1492.

Frisbie, M.P. and R.L. Wyman. 1992. The effect of soil chemistry on sodium balance in the red-backed salamander: A comparison of two forest types. Journal of Herpetology. 26(4): 434-442.

Greathouse, J. and T.K. Pauley. 2008. Development of an amphibian Chytrid fungus surveillance and response protocol for West Virginia. Report prepared for the West Virginia Division of Natural Resources. 19 pp.

Grover, M. C. and H. M. Wilbur. 2002. Ecology of ecotones: Interactions between salamanders on a complex environmental gradient. Ecology 83(8):2112-2123.

Janowiak, M. 2009. Overview of climate change. Presentation at the Climate Change Training Seminar, Monongahela National Forest, Elkins, WV. 28 April, 2009.

Johnson, D.W., and I.J. Fernandez. 1992. Soil-mediated effects of atmospheric deposition on eastern U.S. spruce-fir forests. Pp. 235- 270 *in* Eager, C. and M.B. Adams (eds.), Ecological Studies 96: Ecology and decline of red spruce in the eastern United States. Springer-Verlag, New York.

Lauer, A., M.A. Simon, J.L. Banning, E. Andre, K. Duncan, and R. N. Harris. 2007. Common cutaneous bacteria from the Eastern red-backed salamander can inhibit pathogenic fungi. Copeia (3):630-640.

NatureServe. 2009. Confronting Climate Change. Accessed at http://www.natureserve.org/prodServices/climatechange/ClimateChange.jsp.

Pauley, B.A. 1998. The use of emergent rocks as refugia for the Cheat Mountain salamander, *Plethodon nettingi* Green. M.S. Thesis, Marshall University, Huntington, WV.

Pauley, T. K. 2008a. Natural History and Status of the Cheat Mountain Salamander, *Plethodon nettingi*. Unpublished Report to the U.S. Fish and Wildlife Service, West Virginia Field Office. 8pp.

Pauley, T. K. 2008b. The Appalachian Inferno: Historical Causes for for the Disjunct Distribution of *Plethodon nettingi* (Cheat Mountain Salamander). Northeastern Naturalist. 15(4): 595-606.

Pauley, T.K. 2008c. Status of the Federally Threatened Cheat Mountain Salamander, *Plethodon nettingi*, (Amphibia: Caudata): Sixty years later. Proceedings of the West Virginia Academy of Science 80(2):26-29.

Pauley, T. K. 2007a. Revised notes on the range of the Cheat Mountain Salamander, *Plethodon nettingi*, (Amphibia: Caudata). Proceedings of the WV Academy of Science. 79(2):16-21

Pauley, T. K. 2007b. Status of four *Plethodon nettingi* populations after a 28 year hiatus. Unpublished Report to the U.S. Fish and Wildlife Service, West Virginia Field Office. 16pp.

Pauley, T. K. 2005. Reflections Upon Amphibian Conservation. *In* Amphibian Declines: The Conservation Status of United States Species. M. J. Lannoo, Editor. University of California Press, Berkeley, California. Chapter 40, pp 277-281.

Pauley, T. K and B.A. Pauley. 1997. Range and Distribution of the Cheat Mountain salamander, Plethodon nettingi: An update. Proc. West Va. Acad. Sci. 69:3.

Pauley, T. K. and J. L. Waldron. 2008. The effects of trails and gated roads on movement patterns and relative abundance of the federally threatened Cheat Mountain Salamander (*Plethodon nettingi*). Study proposal to the Monongahela National Forest.

Pauley, T. K., and M. B. Watson. 2009. Annual Report: 2008 Timberline Four Season Resort Report, Cheat Mountain Salamander. Unpublished Report to the U.S. Forest Service, Monongahela National Forest. 6pp.

Pauley, T. K., and M. B. Watson. 2007. Annual Report: 2006 Timberline Four Season Resort Report, Cheat Mountain Salamander. Unpublished Report to the U.S. Forest Service, Monongahela National Forest. 5pp.

Pauley, T. K., and M. B. Watson. 2003. Determination of the Size of Buffer Zones to Prevent Detrimental Effects on the Cheat Mountain Salamander *(Plethodon nettingi)*. Unpublished Report to the U.S. Fish and Wildlife Service, West Virginia Field Office. 35pp.

Petranka, J.W., M.P. Brannon, M.E. Hopey, and C.K. Smith. 1994. Effects of timber harvesting on low elevation populations of southern Appalachian salamanders. Forest Ecology and Management 67:135-147.

Rollins, Adam R. 2005. Analysis of red spruce (*Picea rubens)* regeneration in Pocahontas, Randolph, and Tucker Counties, West Virginia. Unpublished M.S. Thesis, West Virginia University, Morgantown, WV. 83 pp. Available on-line at www.wvu.edu/~thesis.

Sekercioglu, C.H., S.H. Schneider, J.P. Fay and S.R. Loarie. 2008. Climate change, elevational range shifts, and bird extinctions. Conservation Biology. 22(1): 140-150.

Schuler, T.M., W.M. Ford, and R.J. Collins. 2002. Successional dynamics and restoration implications of a montane coniferous forest in the central Appalachians, USA. Natural Areas Journal 22: 88-98.

Swanson, C. 2009. Interactions between forests, carbon, and climate change. Presentation at the Climate Change Training Seminar, Monongahela National Forest, Elkins, WV. 28 April, 2009.

USDA Forest Service. 2009. Authorization of Timberline Special Use Permit
Decision Notice & Finding of No Significant Impact, Monongahela National Forest, Cheat Potomac Ranger District, Tucker County, West Virginia. March 2009

USDA Forest Service. 2008a. Biological Assessment and Evaluation: Timberline Four Seasons Resort Special Use Permit Renewal; Cheat/Potomac Ranger District, Monongahela National Forest. 39 pp.

USDA Forest Service. 2008b. Timberline SUP - Draft Environmental Assessment; Cheat/Potomac Ranger District, Monongahela National Forest.

USDA Forest Service. 2006. Land and Resource Management Plan, Monongahela National Forest.

U.S. Fish and Wildlife Service. 2009a. Results of Climate Change Vulnerability Index for the entire range of the Cheat Mountain Salamander. 29 June, 2009.

U.S. Fish and Wildlife Service. 2009b. Draft Comprehensive Conservation Plan and Environmental Assessment for Canaan Valley National Wildlife Refuge.

U.S. Fish and Wildlife Service 2009c. Final Biological Opinion, Special Use Permit for Timberline Four Seasons Resort, March 10, 2009.

U.S. Fish and Wildlife Service. 2008. Letter to Clyde Thompson RE: Comments on draft Environmental Assessment on the Special Use Permit, Timberline Four Seasons Resort; Cheat Potomac Ranger District. 6 June 2008.

U.S. Fish and Wildlife Service. 1991. Cheat Mountain Salamander Recovery Plan. Newton Corner, Massachusetts. 35 pp.

U.S. Fish and Wildlife Service, U. S. Department of Agriculture – Monongahela National Forest, U.S. Department of Agriculture Northern Research Station, West Virginia Division of Forestry, West Virginia Division of Natural Resources, and The Nature Conservancy. 2006. Memorandum of Understanding for the Conservation of the Red Spruce – Northern Hardwood Ecosystem.

Vredenburg, V. T., R. Knapp, and C. Briggs. 2007. Rapid spread of *Batrachochytrium dendrobatidis* causes chytridiomycosis outbreaks and extinctions in yellow-legged frogs of the Sierra Nevada. Presentation of the Amphibian Declines and Chytridiomycosis: Translating Science into Urgent Action Conference at Tempe, Arizona 5-7 November, 2007.

Welsh, H. H. and A. J. Lind. 1988. Old Growth Forests and the Distribution of Terrestrial Herpetofauna in General Technical Report RM- Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service., no. 166, pp 439-458.

West Virginia Division of Natural Resources. 2009. Unpublished database on surveys of state tracked species.

West Virginia Division of Natural Resources. 2000. Performance Report: West Virginia Endangered Animal Species. Project E-1-17 (1 July 1999 through 30 June 2000).

West Virginia Division of Natural Resources. 1999. Performance Report: West Virginia Endangered Animal Species. Project E-1-16 (1 July 1998 through 30 June 1999).

West Virginia Division of Natural Resources. 1996. Performance Report: West Virginia Endangered Animal Species. Project E-1, Segment 13 (1 July 1995 through 30 June 1996).

West Virginia Division of Natural Resources. 1992. Performance Report: West Virginia Endangered Animal Species. Project E-1, Segment 8 (1 July 1990 through 30 June 1991).

Wyman, R. L. 1988. Soil acidity and moisture and the distribution of amphibians in five forests of southcentral New York. Copeia 1988(2):394-399.

Wyman, R. L & D. S. Hawksley-Lescault. 1987. Soil acidity affects distribution, behaviour, and physiology of the salamander *Plethodon cinereus*. Ecology 68(6): 1819-1827 Young, B., E. Byers, K. Gravuer, K. Hall, G. Hammerson, A. Redder. 2009.

Guidelines for Using the Climate Change Vulnerability Index. NatureServe. Accessed online at http://www.natureserve.org/prodServices/climatechange/pdfs/Guidelines_NatureServeClimateChangeVulnerabilityIndex_v1_Aug09.pdf.

Electronic Communications

Gilligan, R. "Cheat Mountain salamander info needed." E-mail to Barbara Douglas, 1 September, 2009.

Johnson, C. M. "Re: CMS 5-year review – recommendations for future actions". E-mail to Barbara Douglas, 3 September, 2009.

Pauley, T. K. "Re: reminder - comments needed on CMS 5-yr review." E-mail to Barbara Douglas, with attachments, 23 September, 2009.

Pauley, T. K. "Trails." E-mail to Barbara Douglas, 28 August, 2009.

Stihler, C. "Genetics Proposal." E-mail to Barbara Douglas, 23 March, 2009.

Sturm, K. "CMS." E-mail to Barbara Douglas, 28 August, 2009.

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF THE CHEAT MOUNTAIN SALAMANDER

Current Classification: Threatened

Recommendation resulting from the 5-Year Review: No change needed

Review Conducted By: Barbara Douglas, West Virginia Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Deborah Carter Date 9/28/2009

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Acting

Approve Sheryl R. Morgan Date 8/12/2010