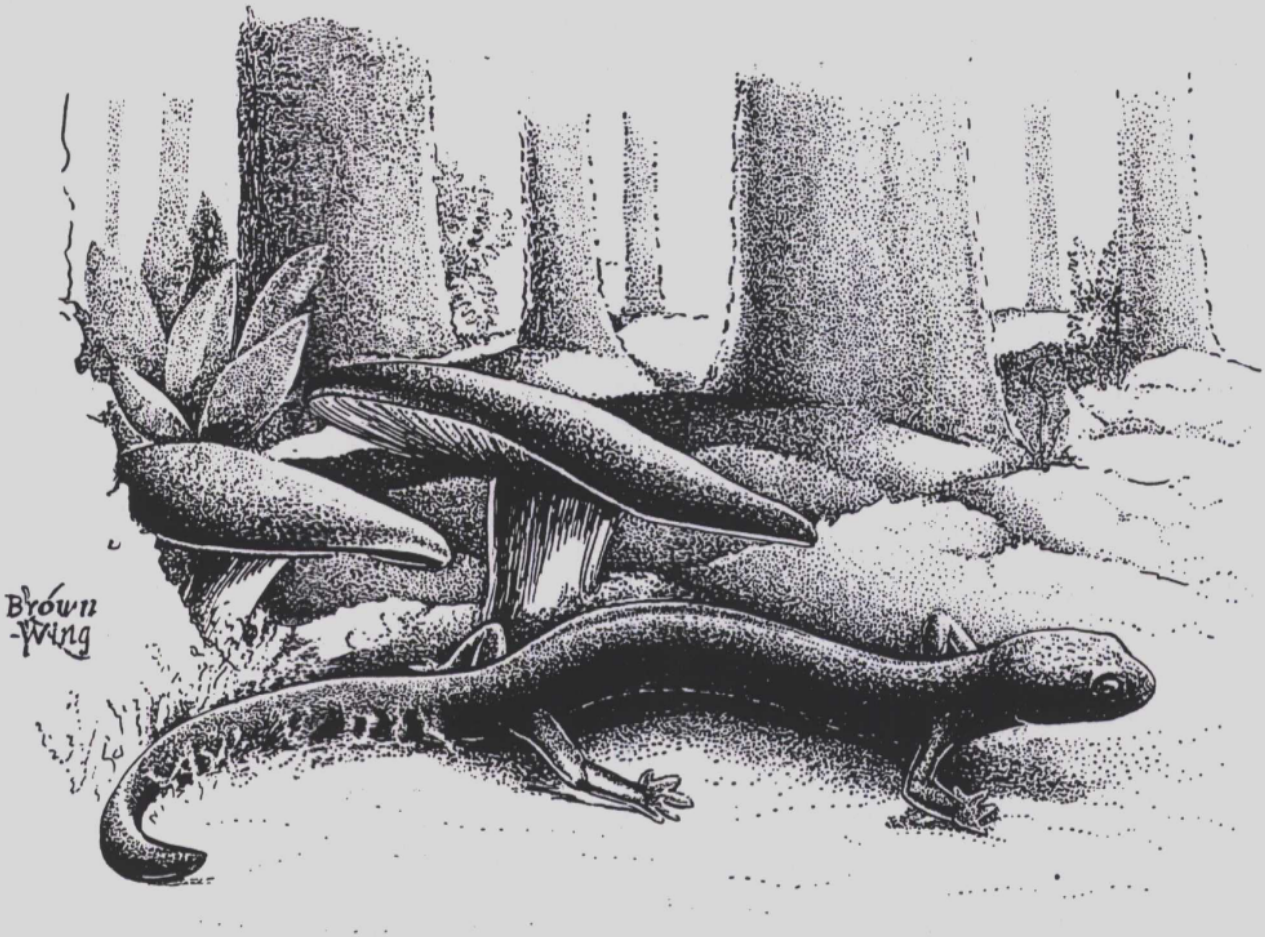
CHEAT MOUNTAIN SALAMANDER

(Plethodon nettingi)

RECOVERY PLAN



Region Five
U.S. Fish and Wildlife Service

CHEAT MOUNTAIN SALAMANDER (*Plethodon nettingi*)

RECOVERY PLAN

Prepared by:

Thomas K. Pauley
Department of Biological Sciences
Marshall University
Huntington, WV 25755

for:

Northeast Region
U.S. Fish and Wildlife Service
Newton Corner, MA 02158

Approved: _____
Regional Director, Northeast Region
U.S. Fish and Wildlife Service

Date: 7-25-91

* * *

This recovery plan delineates reasonable actions needed to recover and/or protect the threatened Cheat Mountain Salamander. The plan does not necessarily represent the views or official position of any particular individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. The proposals in this plan are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks. Objectives will be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints.

Literature citations should read as follows:

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

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
or
1-800-582-3421

Fees vary according to number of pages.

EXECUTIVE SUMMARY
Cheat Mountain Salamander Recovery Plan

Current Species Status: The Cheat Mountain salamander is currently known to exist at 68 sites within an approximately 700 square-mile area in West Virginia. Most of these populations are small, with less than ten salamanders observed. Although historical levels are not known, it is likely that the current population represents only a small portion of the species' former distribution and population levels. *Plethodon nettingi* was listed as a threatened species on September 28, 1989.

Habitat Requirements and Limiting Factors: This small woodland salamander is found in red spruce and mixed deciduous forests above 2,980 feet in microhabitats that have relatively high humidity, moist soils, and cool temperatures. The Cheat Mountain salamander's decline is attributed primarily to extensive loss of and changes to its habitat from colonial days to the present. Extant populations of the species are threatened by removal of the forest canopy and wildfires, as well as by roads and possibly trails which remove forest floor litter, thus affecting the salamander's territory.

Recovery Objective: To remove the Cheat Mountain salamander from the list of Federally endangered and threatened species.

Recovery Criteria: The species can be delisted when: (a) monitoring of ten populations over a period of ten years shows them to be stable or expanding, (b) 100 populations distributed throughout its range are in protected ownership, (c) sufficient life history information exists to assure appropriate management as needed, and (d) monitoring and management programs are implemented on a continuing basis.

Actions Needed:

1. Population searches and monitoring
2. Delineation and protection of occupied habitat
3. Habitat characterization
4. Other ecological and life history studies
5. Long-term monitoring and management
6. Educational and informational program

Estimated Costs of Recovery ($000's):

	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6
FY 1	17	19	15	8	3	4
FY 2	32	21	25	20	3	4
FY 3	17	16	25	18	5	
FY 4-10	60	64	20	—	10	—
TOTAL	126	120	85	46	21	8

Total Estimated Recovery Cost: $406,000 -- not including possible land acquisition costs, which are unknown at this time.

Date of Recovery: If recovery task timetables are met, delisting should be possible in 2002.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

PART I: INTRODUCTION

The Cheat Mountain salamander (*Plethodon nettingi* Green) was listed as a threatened species by the U.S. Fish and Wildlife Service on September 28, 1989 (Federal Register, Vol. 53, No. 188:37814-37818).

This small woodland salamander was first observed on White Top Mountain in West Virginia in 1935 by M. Graham Netting and Leonard Llewellyn (Brooks 1965). Dr. N. Bayard Green (1938) then described the species from specimens taken at Barton Knob in Randolph County, West Virginia. Although Highton and Grobman (1956) considered the Cheat Mountain salamander a subspecies of the ravine salamander (*P. richmondi)*, Highton and Larson (1979) subsequently conducted electrophoretic studies and assigned it full species status.

Description

Plethodon nettingi reaches a maximum length of 4.0 inches (Conant 1975) and has 17-19 costal grooves (Highton 1971). The dorsal color is blackish, usually with brassy or white flecks. The venter is mly dark gray to black.

Similar Species:

Three salamander species found within its range bear some morphological resemblance to the Cheat Mountain salamander: the redback salamander (*P. cinereus*), Wehrle's salamander (*P. wehrlei*), and the mountain dusky salamander (*Desmognathus ochrophaeus*). Of these, only the redback salamander and

mountain dusky salamander have been found to be associated with the Cheat Mountain salamander in all known populations (Pauley 1980).

While typical specimens of each species are fairly easy to distinguish, there are phase and size variations that can be confusing, including the leadback phase of the redback salamander, and dark phases of the mountain dusky salamander and small Wehrle's salamanders. The leadback phase of the redback salamander can be distinguished from the Cheat Mountain salamander by a mottled (salt and pepper) venter as opposed to the dark gray venter of the latter species. The mountain dusky salamander has a chunkier body, larger hind legs relative to the front, a white line or spot between the eyes and angle of the jaws, and 14 costal grooves. Juvenile Wehrle's salamanders differ from the Cheat Mountain salamander by the presence of small orange spots on the dorsum, white spots along their sides, and a whitish chin and throat.

Species outside but near the range of the Cheat Mountain salamander similar in appearance include the valley and ridge salamander (*P. hoffmani*) and the ravine salamander (*P. richmondi*). Both species have a longer tail (i.e., longer than the body) than *P. nettingi* and more costal grooves (19-22).

Population Status and Distribution

The current known range of the Cheat Mountain salamander is a 696 mi^2 area falling entirely within West Virginia (Figure 1). The northernmost population was discovered in Blackwater Falls State Park (Tucker County) during 1989 field surveys (Pauley unpubl. data). The most southern extant population known is a small population found west of Bald Knob at the headwaters of Oats Run in Pocahontas County.

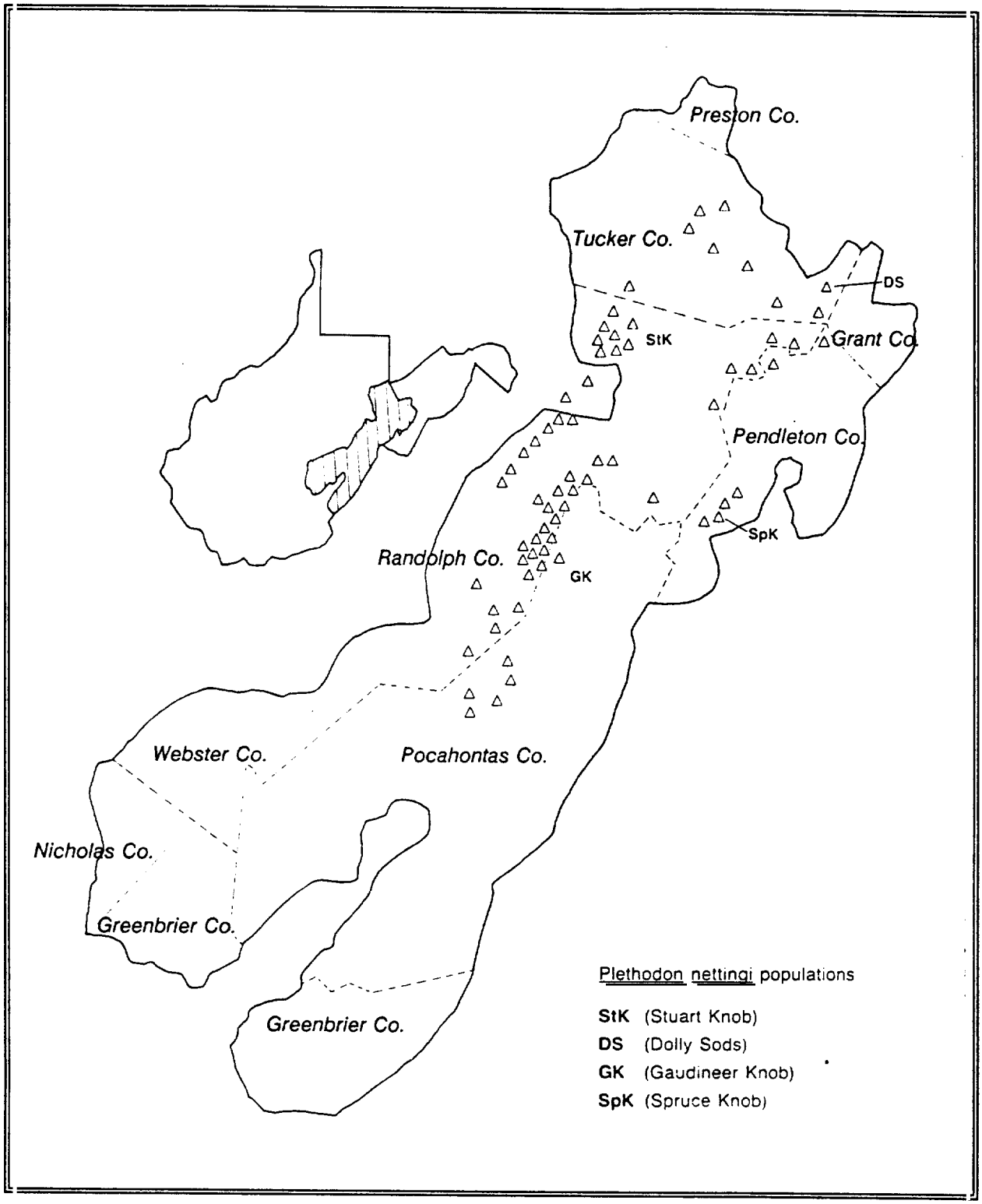


Figure 1. Distribution of *Plethodon nettingi* populations

Surveys conducted over the years have resulted in expansion of the known range since Brooks (1948) originally described it as an area extending from the headwaters of Condon Run in Randolph County south to Thorny Flat in Pocahontas County. Highton (1971) found that the salamander's range extended to the higher elevations of the Allegheny Front in Tucker County, and Pauley (1981) described the range as extending east of McGowan Mountain (Randolph County) to Dolly Sods (Tucker County), south to Spruce Knob (Pendleton and Pocahontas Counties), southwest to Thorny Flat (Pocahontas County), and north to Barton Knob (Randolph County). Prior to the 1989 surveys, a population found on Backbone Mountain just north of Blackwater Canyon in Tucker County extended the range northward by 3.9 miles (Pauley 1987).

Despite this apparent expansion, the known range probably represents only a small portion of the historical distribution of the Cheat Mountain salamander. Vast acreages of forested salamander habitat have been cut and burned since the settlement of West Virginia began, as described in **Factors Affecting the Cheat Mountain Salamander.**

During surveys conducted in 1980 and 1989, two known historical populations (Bald Knob and Thorny Flat) were found to be extirpated; these populations may have been destroyed by timbering activities. A third population located on Shavers Mountain east of Yokum Run was destroyed by the development of a deep coal mine in 1981 (Pauley unpubl. data).

To date, surveys have been conducted at 499 sites within the known range of the Cheat Mountain salamander. *P. nettingi* has been found in 68 sites (Table 1; Pauley unpubl. data), but other populations probably exist. Sixty (88.2%) of the known populations occur on U.S. Forest Service lands (Monongahela National Forest), three (4.4 %) occur within West Virginia state parks, and five (7.3%)

Table 1. **Elevation and number of *Plethodon nettingi* sites.** Sites are listed from north to south.

Site Location (Quadrangle)	Site Location (County)	Elevation Ranges (in Feet)	Number of Sites
Blackwater Falls	Tucker	3,980 - 4,100	2
Blackbird Knob	Tucker	3,840 - 4,140	1
Parsons	Tucker	3,728	1
Mozark Mountain	Tucker	2,980 - 3,843	4
Bowden	Randolph	3,450 - 3,920	12
Harman	Randolph	4,430	1
Laneville	Tucker/ Randolph	4,080 - 4,770	1
Hopeville	Pendleton	3,780 - 4,020	6
Beverly East	Randolph	3,600 - 3,955	9
Whitmer	Randolph	4,445	1
Widell	Randolph/ Pocahontas	3,680 - 4,069	14
Sinks of Gandy	Randolph	4,675	1
Spruce Knob	Pendleton	4,800 - 4,200	4
Snyder Knob	Randolph/ Pocahontas	4,434 - 4,640	3
Durbin	Randolph	4,200 - 4,520	3
Cass	Pocahontas	3,960 - 4,747	5

occur on private lands. Of the 60 populations found on U.S. Forest Service lands, five are in Wilderness Areas, 14 are in areas designated as Management Prescription 6.2 (i.e., semiprimitive, nonmotorized areas for dispersed recreation with a low level of disturbance) in the Monongahela National Forest Land and Resource Management Plan, and two are in National Recreation Areas (since the

Forest Plan allows timber management in NRAs, protection is not necessarily assured by this area designation).

All of the 68 known populations are restricted to elevations above 3,500 feet in the southern part of its range and 2,980 feet in the northern part of its range. Only five populations (at Dolly Sods, Stuart Knob, Gaudineer Knob, Cabin Mountain, and Spruce Knob) have been studied in detail, including examination of vertical and horizontal distribution patterns. Populations extend vertically 200 feet or less in four of these five populations. The fifth population (Spruce Knob) has the greatest vertical distribution (480 feet) as well as the highest elevation (4,800 feet) of any population (Pauley 1980). Studies to determine horizontal distributions were started in 1989 at two sites (Dolly Sods and Stuart Knob). Preliminary results show that the population at Dolly Sods extends more than 2,624 feet. The Stuart Knob population is one of six small populations, each of which has a horizontal distribution of 1,148 feet or less (Pauley unpubl. data).

Detailed population studies, i.e., estimates of the number of individuals per population, are in progress. During initial surveys, Pauley (1980, 1985, and 1989) uncovered fewer than ten specimens in 51 of the 68 populations (75.0%). Population estimate studies of other *Plethodon* species have shown that numbers of individuals range from 571 to 5,535 per hectare (Burger 1935, Test and Bingham 1948, Kleeberger and Werner 1982, Klein 1960, Merchant 1972, Werner 1975). Factors that may limit population sizes of *P. nettingi* include environmental parameters, habitat alterations, and interspecific competition.

Habitat

Brooks (1948) described the habitat of the Cheat Mountain salamander as nearly pure stands of red spruce, or forests in which red spruce is a predominant species. However, Clovis (1979) found no correlation between the presence of the Cheat Mountain salamander and the occurrence of particular tree species. Further, Calise (1978) found no differences in bryophyte species at sites where *P. nettingi* occurred compared with sites where it did not occur, and Pauley (1980) observed the Cheat Mountain salamander in mixed deciduous forest (predominantly yellow birch, red maple, and black cherry) where few or no red spruce occur. Nevertheless, red spruce may have been the prevalent species in these areas prior to lumbering activities in the early 1900's (Bartgis 1988).

Pauley (1980) found no significant difference in environmental factors (e.g., soil moisture, soil temperature, air relative humidity, air temperature, and insolation) between spruce and non-spruce populations of the Cheat Mountain salamander. He did, however, find that the Cheat Mountain salamander occurred in microhabitats that have higher relative humidities and lower temperatures than microhabitats of sympatric species (*P. cinereus* and *D. ochrophaeus*).

Laboratory dehydration and temperature tolerance experiments demonstrated that the Cheat Mountain salamander requires a more moist habitat, but can tolerate warmer temperatures than montane, sympatric species (Pauley 1980). This suggests that *P. nettingi* could survive at lower elevations, but interactions with *D. ochrophaeus* prevent expansion of its vertical distribution. Experiments conducted to determine the importance of soil chemistry, soil structure, soil types, and soil pH factors in limiting the Cheat Mountain salamander's range showed no significant differences (Pauley 1980).

Life History

Reproduction:

Little is known about the reproductive biology of the Cheat Mountain salamander. Brooks (1948) observed nests from May 28 to August 25 with four to 17 eggs. Pauley observed a female with ten eggs on July 23, 1976 and a female with eight eggs on June 29, 1990. The eggs observed on July 23 hatched between August 21 and 23, and the hatchlings ranged from 1.7 to 1.8 cm. Pauley also observed a female tending eight hatchlings (1.8 cm average length) on September 24, 1976 (Green and Pauley 1987).

The age at which *P. nettingi* becomes sexually mature has not been determined. Its growth patterns are probably similar to its sympatric congener *P. cinereus.* Sayler (1966), in a study in Maryland, found that *P. cinereus* males become sexually mature at age three and females at age four. While the life span of *P. nettingi* has not been studied, most small *Plethodon* live approximately 20 years. Since eggs are probably laid in alternate years, females can potentially rear eight broods.

Food:

The diet of the Cheat Mountain salamander has been studied by Pauley (1980). He examined the digestive tract of 42 specimens and found the major food items to be mites, springtails, beetles, flies, and ants.

Behavioral Studies:

In a preliminary study, Pauley (unpubl. data) found that *P. nettingi* probably did not move more than one linear meter. This is well within the home ranges found in studies of other *Plethodon* species; for example, Kleeberger and Werner (1982) found the home range of *P. cinereus* to be from 12.97 m^2 to 24.34 m^2. Further studies, including night observations, are needed to validate Pauley's preliminary findings.

Preliminary behavioral laboratory experiments by Pauley and Pauley (1990) showed that the Cheat Mountain salamander defends its territory against other species. They found that when a congener (redback salamander) was introduced into its territory, the Cheat Mountain salamander was the aggressor 89% of the time, but the redback salamander won 75.% of confrontations because it bit more frequently and bit the head of the Cheat Mountain salamander. Jaeger *et al.* (1982) determined that salamanders that bite the head of a competitor are the winners in confrontations. Pauley and Pauley concluded that the redback salamander is probably more successful when in competition for resources such as space and food.

Factors Affecting the Cheat Mountain Salamander

Most of the forest within the range of *P. nettingi* has been completely cut at some time during the last 100 years. Mielke *et al.* (1986) estimate that when the first European settlers entered what is now West Virginia, there were nearly 1.5 million acres of red spruce (*Picea rubens*), and that spruce was reduced to approximately 750,000 acres by 1865 due to natural and human-caused factors. Hopkins (1899) stated that red spruce acreage had been reduced to 225,000 acres

acres by 1895, and Clarkson (1964) stated that virtually all spruce had been cut over by 1920. Today it is estimated that there are 110,685 acres left (Mielke *et al.* 1986), representing a loss of approximately 93% of the original acreage.

Wildfires during the early part of the 20th century were probably devastating to woodland salamanders including *P. nettingi*. Clarkson (1964) stated that in 1908 there were wildfires in every county in the state and many of these lasted for three months. He further stated that wildfires in the spruce forest were particularly damaging because deep humus was burned to the bedrock. Salamanders could only survive such heat intensity if they could find deep, cool refugia beneath the ground. While it is speculative, these events could have extirpated some *P. nettingi* populations.

Habitat modifications that remove the forest canopy are probably the primary factors affecting the habitat of the Cheat Mountain salamander. Activities that remove the forest canopy include road development, ski slopes, various methods of timber harvesting, wildlife openings, utility rights-of-way, mining activities, insect infestations such as the gypsy moth, and some wildfires. Since *Plethodon nettingi* requires moist cool habitats above 2,980 feet, any alteration of the habitat that reduces soil moisture and/or relative humidity may have detrimental effects on Cheat Mountain salamander populations. Removal of the forest canopy permits a greater percentage of sunlight to reach the forest floor, resulting in an increase in soil temperature and a decrease in soil moisture.

Habitat alterations could also act to divide populations into subpopulations, thus preventing complete gene flow through original populations. For example, Pauley (unpubl. data) found that roads, and probably trails, serve as barriers that prevent territories of different individuals from overlapping, thus fragmenting populations (gene pools). While roads are more obviously detrimental, limited data suggest

that heavily travelled trails can result in removal of leaves and other forest litter, leaving bare trail treads. Salamanders 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. Such barriers could also interfere with reproduction, since mating apparently occurs where territories overlap (Horne 1988).

All 68 known populations have been disturbed by habitat alterations due either to the activities described above or to natural events. The Monongahela National Forest recognizes the threats to this salamander and is contributing to its protection by assessing the impacts of management activities on the salamander and its habitat as described in the Forest's Land and Resource Management Plan.

Smaller populations could be more susceptible to extirpation due to natural pressures such as periods of drought, natural reduction of the canopy by storms, and particularly by interspecific competition.

Hairston (1980) found that narrow population overlaps (less than 400 feet) between *Plethodon glutinosus* and *P. jordani* resulted in keen interspecific competition, whereas broad population overlaps (over 400 feet) resulted in reduced competition. In populations studied for vertical distribution, populations overlaps between *P. nettingi* and *P. cinereus* were 300 feet or less and overlaps between *P. nettingi* and *D. ochrophaeus* were 320 feet. Considering Hairston's results and the narrow vertical overlap between the Cheat Mountain salamander and the redback and mountain dusky salamanders, competition among these three species is probably very keen. In addition, laboratory studies by Pauley (1980) and Pauley and Pauley (1990) demonstrated that *P. nettingi* is not as keen a competitor for limited resources as *P. cinereus* and *D. ochrophaeus*.

Pollution factors such as acid precipitation may also affect the survival of the Cheat Mountain salamander. While it is not known what the soil pH tolerance limits are for the Cheat Mountain salamander, Wyman and Hawksley-Lescault (1987) found that the density of a congener, the redback salamander, declined when soil pH was below 3.7. It would appear that if soil pH in Cheat Mountain salamander sites decreases, there may be a negative impact on the salamander.

Conservation Measures

Since its listing as a threatened species, the U.S. Forest Service and the U.S. Fish and Wildlife Service, in accordance with Section 7 of the Endangered Species Act, have required on-site surveys for *P. nettingi* on Federal lands in areas being considered for development or where Federal permits, licenses, or grants are being sought. Such surveys are conducted in areas proposed for pipelines, ski slopes, and coal mines. Also, in accordance with Monongahela National Forest's Land and Resource Management Plan, the U.S. Forest Service has conducted surveys in areas proposed for projects such as timber sales and roads.

The West Virginia Division of Natural Resources has designated *P. nettingi* as a Species of Special Concern. While West Virginia lacks legislation to protect species so listed, the Division of Natural Resources and the U.S. Fish and Wildlife Service have attempted to make landowners aware of potential *P. nettingi* sites and encouraged them to protect *P. nettingi* populations.

Previous studies funded by the U.S. Forest Service and U.S. Fish and Wildlife Service have determined, to a large extent, the known range and distribution within the range, vertical distribution of four populations, horizontal distribution of two populations, effects of roads and hiking trails on two populations, and habitat characteristics. Studies supported by Section 6 funds through the

U.S. Fish and Wildlife Service during 1990-91 are being conducted to examine the effects of hiking trails, make population estimates, and determine horizontal distribution of two populations. In addition, a study funded by the Timberline Four Season Resort (through a special use permit with the U.S. Forest Service) is attempting to determine the effects of a ski slope on an adjacent *P. nettingi* population.

A Recovery Group consisting of species experts, endangered species biologists, and land managers has been established to carry the recovery program forward. This group will remain involved in a number of the tasks described in **Part II: Recovery.**

Recovery Strategy

The limited range and distribution of *P. nettingi* dictate that habitat protection and knowledge of the species' biology are essential for recovery. The initial recovery strategy for the Cheat Mountain salamander thus consists of ascertaining an accurate overview of the species by determining its total range and searching for additional populations. With intensive surveying, it is felt that at least 100 populations can be located. The viability of current known populations also needs to be ascertained through monitoring.

Concurrent with defining the species' status, protection of occupied habitat and determination of management needs will be a continuing effort. Protection of known and newly discovered populations should lead to a secure enough total population level to consider delisting. Life history and ecological information will be used to determine the need and appropriate means for site-specific management.

Specifically, the following recovery actions need to be undertaken:

1. Define the total range of the species. (While the northern, eastern, and western limits of the range are generally known, there is still some question as to its southern extent.)

2. Survey additional areas within the known range to gain additional information about the species' distribution and abundance.

3. Monitor known populations to determine their status, territoriality, home range, environmental changes, and competitive pressures.

4. Assess population characteristics.

5. Determine the effects of human-induced habitat alterations.

6. Determine biological factors such as reproductive biology, growth rates, and genetic variability among populations.

It is likely that eggs and/or juveniles are more vulnerable to habitat stress than adults. Since it probably takes three to four years for sexual maturity to be attained, some of these conservation methods may be time consuming and require significant funding.

PART II: RECOVERY

Recovery Objective

The objective of this recovery plan is to remove the Cheat Mountain salamander from the list of threatened species. The species can be delisted when:

(a) Ten *P. nettingi* populations, representing both large and small populations and distributed range-wide, are shown to be stable or expanding over a period of ten years.

(b) 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.

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

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

Recovery Tasks

1.0 Monitor Populations.

1.1 Determine the quality and extent of each population. Characterize each population as large or small in terms of area and density, based on numbers observed at the first visit and correlated with numbers observed at later visits. This will provide a relative estimate of observed population density. It will also be useful for establishing correlations with certain habitat features (e.g., spruce vs. non-spruce habitats), other population characteristics (e.g., extent of vertical and horizontal distributions), and perhaps even provide information on interspecific competition.

Areas in terms of horizontal and vertical distributions of each population need to be determined. To determine what factors regulate the size of demes and to properly establish buffer zones, environmental factors and salamander species compositions need to be quantified.

1.2 Monitor benchmark populations. Ten "benchmark" populations will be monitored every year for ten years. These populations should be distributed throughout the species' range and should include at least one "small" (as defined through Task 1.1) population. A one-year monitoring schedule is more appropriate than less frequent time periods due to habitat threats such as acid precipitation, droughts, gypsy moth infestations, and other environmental perturbations, as well as competitive interactions with other salamanders. Guidelines for monitoring are presented in the appendix. Field data should be collected to determine population status (including sex ratio, adult/young ratio, and size classes), snout-vent length measurements,

soil and air temperatures, soil and air relative humidities, and insolation.

Monitoring should be implemented immediately upon approval of this plan. Only biologists with knowledge of salamander biology and ecology should conduct monitoring studies. All data collected by biologists should be sent to and compiled by a data coordinator designated by the Recovery Group and released to appropriate Federal and state agencies.

1.3 Periodically survey all known populations. In addition, each of the remaining 58 known populations, as well as any newly discovered populations, should be monitored at least once every five years to assess surface abundance and determine any potential threats. Small populations need to be studied to determine factors that may limit their sizes and to determine if populations have declined in size and density or perhaps become extirpated. Surveys should include surface density, population estimates, and vertical distribution.

1.4 Search for additional populations. Several areas within the known range have not been surveyed. In order to fill in distributional gaps within the range, eight potential Cheat Mountain salamander geographic areas that have been identified need to be surveyed (Table 2). Surveys should be conducted according to guidelines presented in the appendix.

1.5 Determine range boundaries. Based on the information obtained through the preceding task, the southern extent of the salamander's range will be delineated and other distributional gaps will be remedied.

Table 2. Potential *Plethodon nettingi* areas needing additional surveys.

1. Rich Mountain between Whitmer and Sinks of Gandy
2. Rich Mountain west of Harman
3. Beech Mountain
4. Grassy Mountain
5. Elk Mountain
6. Spruce Mountain between Onego and Judy Springs
7. Middle Mountain between Laurel Fork and Otter Creek Wilderness Area.
8. Green Mountain

2.0 Protect occupied habitats. Owners of private lands with *P. nettingi* populations should be made aware of the species' presence and encouraged to protect these populations. Further, since 92.6% (63 of 68) of the known populations occur on public land, there is an excellent opportunity to monitor and protect a large proportion of the known populations of *P. nettingi*.

2.1 Delineate occupied habitats. Location and habitat area of all known populations should be provided to state and Federal agencies.

2.2 Monitor threats. Potential threats to any Cheat Mountain salamander occupied habitat will be monitored on a regular basis.

2.3 Protect occupied habitats and *P. nettingi* populations on public lands. In addition to controlling collection of specimens through permit procedures by state and Federal agencies, the following subtasks will be implemented to protect known occupied habitats on public lands.

2.31 Develop interim management guidelines and revise as necessary. Management guidelines will apply to habitats on public lands, and should include (1) avoidance of known sites, (2) on-site surveys when ground or vegetation-disturbing projects are proposed in high potential areas for *P. nettingi* or near known populations, (3) establishment of a buffer zone of at least 300 feet around known *P. nettingi* populations within which trees and other vegetation should not be removed, and (4) re-routing of trails or other barriers to go around rather than through known populations (or, alternatively, replacement of trail segments with boardwalks). Until additional knowledge relating to management of this species is obtained through research and studies, interim protection measures should be applied in both known and high potential habitats.

2.32 Ensure that Federal actions do not adversely affect the Cheat Mountain salamander. Section 7 of the Endangered Species Act requires the U.S. Fish and Wildlife Service to review all Federal actions to ensure that endangered and threatened species and their habitat are not adversely affected. This is done routinely by maintaining close interagency contact. These activities will continue.

2.4 Protect occupied habitats and *P. nettingi* populations on private lands.

2.41 Develop cooperative agreements with private landowners. Cooperative agreements between landowners and government agencies should be developed to assist in surveying for *P. nettingi* in potential habitats and in protecting known populations on private lands from habitat alterations. State and Federal agencies should assist in delineating the extent of the population and reviewing management options.

2.42 Where feasible, consider placing privately-owned habitat under public ownership, on a willing seller basis only. Appropriate agencies such as the U.S. Forest Service, U.S. Fish and Wildlife Service, West Virginia Division of Natural Resources, or possibly The Nature Conservancy will consider either purchasing private sites or establishing deed restrictions.

3.0 Characterize habitat parameters. Habitat alterations and fragmentations of populations may limit salamander movements and, therefore, gene flow. Smaller populations are more prone to extirpation. Habitat parameters are of key importance for *P. nettingi* due to the apparently narrow range of habitat tolerance.

3.1 Ascertain variables associated with "quality" habitats. Habitat characteristics associated with each population should be identified and quantified. Habitat characteristics to be assessed include dominant overstory species (spruce vs. non-spruce), percent canopy cover, major vegetation types, and availability and types of cover objects. Information gained might be used to improve habitats of "poor" populations.

3.2 Determine effects of habitat alterations. It has been shown that certain land activities such as roads, clear-cutting, ski slopes, utility rights-of-way, deep mines, and surface mines are definitely detrimental to *P. nettingi* habitats and need not be studied further. However, other activities such as hiking trails, temporary roads, and various types of timber harvesting (e.g., thinnings, seed tree cuts, shelterwood cuts, selection cuts) need to be assessed. Assessments should determine if particular habitat alterations separate populations into subpopulations, decrease surface densities, affect reproductive success, and influence growth rates.

3.3 Determine habitat parameters common to large populations. Parameters that should be considered include vegetation types and timber size-classes, air relative humidity, soil relative humidity, air temperature, soil temperature, quantity and quality of forest litter, and cover objects.

3.4 Compare elevation disparity between northern and southern populations. Investigations should be conducted to determine why there is more than a 500-foot disparity in elevation between the northern and more southern limits of the range. These investigations should include effects of environmental factors such as soil and air temperatures, soil and air moisture, insolation, aspect, and soil characteristics, as well as competitive interactions with other salamander species. Results may provide information about ecological factors that influence vertical distribution of the Cheat Mountain salamander.

4.0 Conduct other studies of ecology and life history.

4.1 Determine food items. Additional studies need to be considered in terms of dietary activities. Studies should be done seasonally to compare spruce/nonspruce habitats and northern/southern populations.

4.2 Identify significance of interspecific competition. Additional territorial studies between the redback salamander and Cheat Mountain salamander need to be conducted. Interactions between the Cheat Mountain salamander and mountain dusky salamander and Wehrle's salamander (especially immatures about the same size as the Cheat Mountain salamander) also need to be investigated.

4.3 Determine reproductive biology. This research should include time of mating, time of egg deposition, activity of female during brooding, energy expenditure by females during brooding, period of egg gestation, frequency of female reproductive activity (annual or biennial), rate of growth, and age of sexual maturity of males and females.

4.4 Identify any phenotypic variability among populations. Populations with greatest phenotypic variability and separated by greatest distance should be analyzed for genetic variability using gel electrophoresis. Such studies need to identify inter-population variability, north-south genotypes, and possible genetic "bottlenecks".

4.5 Conduct other ecological studies. Times of activity (annual and diel) need to be determined, as do home range, homing ability, and

territoriality. These data should be recorded during and outside the breeding season.

5.0 Develop a monitoring program and establish long-term, site-specific management strategies. In order to protect *P. nettingi*, a program to monitor known populations as well as a long-term management plan need to be developed by state and Federal agencies.

5.1 Implement a monitoring program. State and Federal agencies should develop and implement a program to monitor habitat conditions and status of the populations of all known *P. nettingi* colonies. The monitoring plan should include techniques described in the appendix.

5.2. Implement a long-term management program. In addition, government agencies should establish a long-term, site-specific management program designed to protect all populations and to enhance populations considered to be the most fragile. If certain habitat alterations are found to have a detrimental effect on Cheat Mountain salamander populations, as determined in Task 3.2, either methods for habitat mitigation should be designed and implemented, or the activity should be prohibited within any known site and its buffer. For instance, barriers such as roads and trails should be removed as needed to unite split populations, and research to determine timber harvesting practices that will not damage salamander populations should be pursued. Habitat parameters that are found to be common among large populations (see Task 3.3) should be emulated in smaller populations.

6.0 Develop an education and information program. Educational and informational programs should be developed to inform pertinent audiences of the fragile existence and protection needs of *P. nettingi*.

6.1 Develop training and awareness programs for government agencies. Training and awareness programs should be developed to teach government biologists and land managers (non-biologists) the field techniques necessary to survey for potential populations as well as how to monitor and protect known populations. Such sessions should be conducted by field biologists familiar with the ecology of *P. nettingi*.

6.2 Release educational information to the general public. Announcements and presentations should be prepared and disseminated to the general public describing the precarious existence of *P. nettingi* and the ecological significance of protecting its habitat. Announcements could be in the form of brochures and/or news releases. Materials should be prepared for school-aged children, possibly in conjunction with the West Virginia Nongame Program.

Literature Cited

Bartgis, R. 1988. The wild west of the east. The Nature Conservancy Magazine 38(2):23-27.

Brooks, M. 1948. Notes on the Cheat Mountain salamander. Copeia 1948:65.

Brooks, M. 1965. The Appalachians. Houghton Mifflin Co., Boston. 346 pp.

Burger, J. 1935. *Plethodon cinereus* (Green) in eastern Pennsylvania and New Jersey. Amer. Nat. 69:578-586.

Calise, C. 1978. Bryophyte ecology in high elevation forest of West Virginia. Unpubl. master's thesis. West Virginia University.

Clarkson, R. 1964. Tumult on the mountains. McClain Printing Co., Parsons, WV. 410 pp.

Clovis, J. 1979. Tree importance values in West Virginia red spruce forest inhabited by the Cheat Mountain salamander. Proc. W. Virginia Acad. Sci. 41(2):58-64.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Co., Boston. 429 pp.

Green, N. 1938. A new salamander, *Plethodon nettingi*, from West Virginia. Ann. Carnegie Mus. 27:295-99.

Green, N. and T. Pauley. 1987. Amphibians and reptiles in West Virginia. Univ. Pitt. Press. 241 pp.

Harriston, N. 1980. Evolution under interspecific competition: field experiments on terrestrial salamanders. Evolution 34(3):409-420.

Highton, R. 1971. Distributional interactions among eastern North American salamanders of the genus *Plethodon*. In *The distributional history of the biota of the Southern Appalachians*, Perry C. Holt, ed., pp. 139-88. Res. Div. Monogr. 4. Blacksburgh: Virginia Polytechnic Institute.

Highton, R. and A. Grobman. 1956. Two new salamanders of the genus *Plethodon* from the southeastern United States. Herpetologica 12:185-188.

Highton, R. and A. Larson. 1979. The genetic relationships of the salamanders of the genus *Plethodon*. Systematic Zoology 28:579-599.

Hopkins, A. 1899. Report on investigations to determine the cause of unhealthy conditions of spruce and pine from 1880-1893. W. Va. Agricultural Experiment Station, Bulletin 56, 270 pp.

Horne, E. A. 1988. Aggressive behavior of female red-backed salamanders. Herpetologica 44(2):203-209.

Jaeger, R., D. Kalvarsky and N. Shimizu. 1982. Territorial behavior of the red-backed salamander: expulsion of intruders. Animal Behavior 30:490-496.

Klein, H. 1960. Population estimate of the red-backed salamander. Herpetologica 16:52-54.

Kleeberger, S. and J. Werner. 1982 Home range and homing behavior of *Plethodon cinereus* in northern Michigan. Copeia 1982(2):409-415.

Merchant, H. 1972. Estimated population size and home range of the salamanders *Plethodon jordani* and *Plethodon glutinosus*. J. Wash. Acad. Sci. 62(3):248-257.

Mielke, M., D. Soctomah, M. Marsden, and W. Ciesla. 1986. Decline and mortality of red spruce in West Virginia. U.S. Forest Service Report No. 86-4. Fort Collins, Co. 26 pp.

Pauley, T. 1980. The ecological status of the Cheat Mountain salamander (*Plethodon nettingi*). Unpublished report to U.S. Forest Service. 160 pp.

Pauley, T. 1981. The range and distribution of the Cheat Mountain salamander, *Plethodon nettingi*. Proc. W. Virginia Acad. Sci. 53:31-35.

Pauley, T. 1985. Additional field surveys for the Cheat Mountain salamander (*Plethodon nettingi*). Unpublished report to the U.S. Fish and Wildlife Service. 35 pp.

Pauley, T. 1987. Range expansion of the Cheat Mountain salamander. Herpetological Review 18(2):39.

Pauley, T. 1989. Mower Tract Report: The Cheat Mountain salamander (*Plethodon nettingi*). Unpublished report to the West Virginia Department of Natural Resources. 22 pp.

Pauley, B. and T. Pauley. 1990. Competitive interactions between two sympatric *Plethodon* species. Proc. W. Virginia Acad. Sci. 62(1):19.

Sayler, A. 1966. The reproductive ecology of the redback salamander, *Plethodon cinereus*, in Maryland. Copeia 1966:183-193.

Test, F. and B. Bingham. 1948. Census of a population of the red-backed salamander (*Plethodon cinereus*). Amer. Mid. Nat. 39(2):362-371.

Werner, J. 1975. Vertebrate animal populations of the McCormick Forest. II. Amphibians and Reptiles. USDA Forest Serv. Res. Pap. NC-118:18-25.

Wyman, R.L. and D. Hawksley-Lescault. 1987. Soil acidity affects distribution, behavior and physiology of the salamander *Plethodon cinereus*. Ecology 68:1819-1827.

Part III: IMPLEMENTATION

The Implementation Schedule lists and ranks tasks that should be undertaken within the next three years in order to implement recovery of *Plethodon nettingi*. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in order of priority.

Key to Implementation Schedule Column 1

Task priorities are set according to the following standards:

Priority 1: Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: Those actions that must be taken to prevent a significant decline in species population, or some other significant impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Agency Designations in Column 5

USFWS = U.S. Fish and Wildlife Service
R5 FWE = Region 5, Division of Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service
USFS = U.S. Forest Service
WVDNR = West Virginia Division of Natural Resources
PO = Private organizations and institutions, e.g., Marshall University, The Nature Conservancy

IMPLEMENTATION SCHEDULE
Cheat Mountain Salamander

July 1991

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimates ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
1	Ensure that Federal actions do not adversely affect *P. nettingi*.	2.32	Ongoing	R5 FWE	USFS	5	5	5	Plus an additional 5,000/yr over 7 more years
2	Determine quality and extent of each population.	1.1	3 years	R5 FWE	WVDNR, USFS, PO	7	7	7	
2	Monitor ten benchmark populations on an annual basis.	1.2	10 years	R5 FWE	WVDNR, USFS, PO	5	5	5	Plus an additional 5,000/yr over 7 more years
2	Search for additional populations and determine range boundaries.	1.4, 1.5	5 years	R5 FWE	WVDNR, USFS, PO	5	5	5	Plus an additional 5,000/yr over 2 more years
2	Delineate occupied habitats.	2.1	5 years	R5 FWE	USFS, WVDNR	4	4	4	Plus an additional 4,000/yr over 2 more years
2	Monitor threats to populations/ habitat.	2.2	Ongoing	R5 FWE	USFS, WVDNR	7	7	5	Plus an additional 3,000/yr over 7 more years
2	Develop management guidelines and revise as necessary.	2.31	2 years	R5 FWE	USFS, WVDNR	3	3		
2	Develop cooperative agreements with private landowners.	2.41	2 years	R5 FWE	WVDNR, PO		2	2	
2	Ascertain variables associated with quality habitats.	3.1	3 years	R5 FWE	WVDNR, PO	7	7	7	
2	Determine effects of habitat alterations.	3.2	5 years	R5 FWE	WVDNR, USFS, PO	5	5	5	Plus an additional 5,000/yr over 2 more years
2	Implement habitat improvements as appropriate.	3.3	3 years	R5 FWE	WVDNR, USFS		10	10	Plus an additional 10,000 over 1 more year

Cheat Mountain Salamander Implementation Schedule (continued) July 1991

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimates ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
2	Determine reproductive biology.	4.3	3 years	R5 FWE	PO	2	2	2	
2	Identify phenotypic variability among populations.	4.4	2 years	R5 FWE	PO		5	5	
2	Develop a program to monitor habitat conditions and population status.	5.1	2 years	R5 FWE	WVDNR, USFS	3	3		
2	Establish a long-term management plan.	5.2	3 years	R5 FWE	WVDNR, USFS, PO			5	Plus an additional 5,000/yr over 2 more years
3	Survey all known populations.	1.3	Once every 5 years	R5 FWE	WVDNR, USFS, PO		15		Plus an additional 15,000 within 10 years
3	Where feasible, place habitats on private lands under public ownership, on a welling seller basis only.	2.42	5 years	R5 FWE	WVDNR, USFS, PO				
3	Compare elevation disparity between northern and southern population.	3.4	3 years	R5 FWE	PO	3	3	3	
3	Determine food items.	4.1	2 years	R5 FWE	PO	2	2		
3	Identify significance of interspecific competition.	4.2	3 years	R5 FWE	PO	4	4	4	
3	Conduct other ecological studies.	4.5	2 years	R5 FWE	PO		7	7	
3	Develop a training and awareness program for government agencies.	6.1	2 years	R5 FWE	WVDNR, USFS	2	2		
3	Release educational information to the general public.	6.2	2 years	R5 FWE	WVDNR, USFS	2	2		

APPENDIX: Methodology for Salamander Surveys

1. Surveys should be conducted by biologists or persons properly trained in salamander identification.

2. Surveys should be conducted during spring through fall providing nighttime temperatures are above 55 °F and within 48 hours following rain, or preferably, during rain.

3. The amount of time/person spent searching will vary according to the size of area and should be carefully noted as well as species and numbers of salamanders found.

4. In performing ground surveys, all rocks and downed woody debris should be turned in a systematic pattern. Cover moved should be replaced to its original position.

5. In areas that appear to be favorable habitats for *P. nettingi* but day surveys do not produce specimens, night surveys should be conducted if possible.

6. Survey data should be given to the data coordinator to maintain a log of all sites surveyed for this species.