BIBLIOGRAPHY

JEMEZ MOUNTAINS SALAMANDER

PLETHODON NEOMEXICANUS

BY

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BIBLIOGRAPHY: Plethodon neomexicanus

INTRODUCTION

Plethodon neomexicanus is a species of lungless salamander, family Plethodontidae, subfamily Plethodontinae, found only in Rio Arriba, Sandoval, and Los Alamos Counties in the Jemez Mountains of north-central New Mexico. In areas where it is locally abundant it is the major herpetofaunal ingredient of the ecosystem. Much of the present known range of this salamander has never been published in scientific journals, but is reported in various state and federal agency reports. A relict species with limited physiological tolerance, it has been the topic of much discussion with relation to disturbance of it's habitat, particularly alterations, such as logging, which would cause drying conditions. No concrete evidence has been submitted to support either side of this question. It has been recognized as a candidate for listing under the Endangered Species Act.

Since this salamander's discovery in the early 1900's, taxonomic confusion has been evident in the literature. First thought to be Eurycea multiplicata, it was rediscovered and named as a separate species in 1950. Since that time researchers have endeavored to classify its evolutionary history using more modern techniques as they became available. P. neomexicanus is located far from other species of this genus, the nearest being in eastern Oklahoma and the Northwest. The microhabitat of this species is colder and drier than that of other Plethodon, and differences in its physiology probably reflect this peculiarity. Little is known about its ability to survive under threats of disturbance to its habitat. More research needs to be conducted on this salamander's requirements and/or tolerances.

Confusion also arises when locating new populations of salamanders since their habitat limitations have been narrowly defined in the literature thus causing biases in search technique and selection of study areas. To complicate this, much of their potential range falls on private and Indian lands which have not been adequately surveyed.

This annotated bibliography attempts to collect all known information on this unique salamander and present it in a useable form. The following index will indicate, numerically, articles of specific interest in chosen catagories. Articles omitted from review are those which only paraphrase articles reviewed elsewhere.

ACKNOWLEDGEMENTS

I would like to thank New Mexico Department of Game and Fish and especially Charles W. Painter for making this project possible. Technical assistance and use of libraries were gladly received from Rayann Robino, Norman J. Scott, Jr., and Gerald L. Burton of the United States Fish and Wildlife Service. Special thanks go to past researchers for searching their memory banks and responding to inquiries with helpful information. I would like to thank Barry C. Lauesen for immeasurable support, tolerance, and editing help during this process.

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BIBLIOGRAPHY

1. **Behler, John L. 1979.** The Audubon Society field guide to North American reptiles and amphibians. Chanticleer Press, Inc., New York. 719 p.

A field guide description of Plethodon neomexicanus, based on information available in 1979, notes isolated range.

2. **Blair, W. Frank, A. P. Blair, P. Brodkorb, F. R. Cagle, and G. A. Moore. 1957.** Vertebrates of the United States. McGraw-Hill Book Company, New York. 616 p.

A key to species of Plethodon notes the reduced 5th toe in P. neomexicanus and associates it with P. larselli.

3. **Blair, W. Frank. 1958.** Distributional pattern of vertebrates in the southern United States in relation to past and present environments. P. 433-468. In Carl L. Hubbs, ed., Zoogeography. Amer. Assoc. Advance. Sci. Pub. (51):x + 509 p.

Though I was unable to locate a copy of this book, according to Williams (1974), Blair proposed a late Pleistocene connection between Plethodon neomexicanus and P. cinereus of Oklahoma.

4. **Brattstrom, Bayard H. 1963.** A preliminary review of the thermal requirements of amphibians. Ecology 44(2):241-242.

Plethodon neomexicanus body temperature is reported as 12.8°C. from Bogert (1952) from one specimen, and adjacent soil temperature recordings made by Stebbins (1951) also registered 12.8°C.

5. **Brodie, Edmund D., Jr. 1968.** Observations on the mental hedonic gland-clusters of western salamanders of the genus Plethodon. Herpetologica 24(3):248-251.

Plethodon neomexicanus and P. larselli are the only salamanders in this study that lack visible mental glands.

Mention is made that P. neomexicanus is probably more closely related to eastern small Plethodon.

6. Brodie, Edmund D., Jr. 1970. Western salamanders of the genus Plethodon: systematics and geographic variation. Herpetologica 26:468-516.

The question of whether Plethodon neomexicanus is related to eastern or western species is discussed briefly, but P. neomexicanus is not included in the results.

7. Brodie, Edmund D., Jr., and R. G. Altig. 1967. Morphological variation of the Jemez Mountains salamander, Plethodon neomexicanus. Copeia 1967(3):670-672.

Forty specimens of Plethodon neomexicanus were examined using physical examination and radiographs. The number of vomerine teeth were found to increase with snout-vent length. The radiograph studies revealed the presence of two phalanges in over 50% of specimens and that the fifth toe is always shorter than other Plethodon, with the exception of P. larselli. Other morphological variations are also discussed.

8. Burns, Douglas M. 1962. The taxonomic status of the salamander Plethodon vandykei larselli. Copeia 1962(1):177-181.

In a taxonomic review of Plethodon larselli, P. neomexicanus is compared to this species as being the only other Plethodon with one phalanx in the fifth toe. Differences are also discussed.

9. Burton, Gerald L. 1990. Endangered and threatened wildlife and plants; findings on a petition to list the Jemez Mountains Salamander as threatened or endangered. Federal Register 55(181):38342-38343.

A petition to list Plethodon neomexicanus was submitted by Dr. James L. Dixon February 13, 1990 and received by United States Fish and Wildlife Service (USFWS) on February 21, 1990. The 90 day finding of the USFWS indicated that listing the salamander may be warranted. Before this petition was submitted a status review had been initiated December 30, 1982 (Federal

Register, 1982). Information about the habitat requirements and current status of the salamander are included. The Service will be required to make a finding as to whether or not the petition is warranted within one year from the date the petition was received. A call for information and comments is included.

10. **Carey, Cynthia. 1987.** Microhabitat characteristics and membrane lipids of the Jemez Mountains salamander, Plethodon neomexicanus. Unpubl. report to New Mexico Department of Game and Fish, Contract No. 516.6-74-26. 26 p.

Based on 25 specimens, and having taken various microhabitat measurements on the moisture available and the temperature, the author concludes that the salamander has a greater range of tolerances than previously reported, but that lethal temperatures may exist under some cover objects under some conditions. This temperature alarm was not aimed exclusively at logging.

11. **Cochran, Doris M., and C. J. Goin. 1970.** The new field book of reptiles and amphibians. G. P. Putnam's Sons, New York. 359 p.

A description of Plethodon neomexicanus as an eastern woodland salamander points out the reduced fifth toe.

12. **Crippen, Robert G. 1962.** Holotype specimens of amphibians and reptiles in the Museum of Vertebrate Zoology, University of California, Berkeley. Herpetologica 18(3):189.

The holotype specimen was collected by Robert C. Stebbins on Aug. 14th, 1949 and is held in this museum (MVZ 49033).

13. **Degenhardt, William G. 1975.** Herpetofaunal survey of Bandelier National Monument. (P.O. PX7000-3-0530). Unpubl. final report to the National Park Service. November 1975. 13 p.

In a survey for the National Park Service one juvenile Plethodon neomexicanus was observed in the Apache Spring gulley at 8200'. Habitat indicates a larger population exists.

14. Dunn, E. R. 1926. Salamanders of the family Plethodontidae. Society for the Study of Amphibians and Reptiles (SSAR) Publication, 1972. 446 p.

Doubt is thrown on the identification of two salamanders from New Mexico, Jemez Mountains as Eurycea multiplicata due to the poor condition of the specimens and the disjunct range.

15. Feder, M. E., J. F. Lynch, H. B. Shaffer, and D. B. Wake. 1982. Field body temperatures of tropical and temperate zone salamanders. Smithsonian Herpetological Information Service, No. 52. 23 p.

Three records of body temperatures, one by Stebbins (1951) and two by Reagan (1972) are included in this database. The range is from 10.5 C. to 13.0 C.

16. Federal Register. 1982. Notice of Review. Federal Register 47:58454-58457.

In Region 2 of the United States Fish and Wildlife Service, Plethodon neomexicanus is listed as a species under review, category 2, which indicates that not enough is known about the species to determine listing status under the Endangered Species Act, but that such listing is possibly appropriate.

17. Federal Register. 1991. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species. 56(225):58804-836.

In Region 2 of the United States Fish and Wildlife Service, Plethodon neomexicanus is listed as a species under review, category 1, which means "taxa for which the Service has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species".

18. Guthrie, Daniel A. 1978. Small mammal studies and evaluation of the status of the Jemez Mountains salamander in Bandelier National Monument. Unpubl. From the Superintendents Annual Research Report to the National Parks Service PX7079-7-

0807.

A year low in precipitation in 1978 resulted in few salamander sightings.

19. Guthrie, Daniel A. 1979. Status of the Jemez Mountains salamander (Plethodon neomexicanus) within Bandelier National Monument. Unpubl. National Parks Service Report PX7029-7-0807. 7 p.

During the summmers of 1978 and 1979 salamander searches were conducted on Bandelier National Monument under optimal conditions, i.e. following heavy rains. Reservations about the suitability of habitat include distance from permanent water sources, the availability of rock and/or rotten log cover and disturbance to the canopy, which could be caused by wildfire or fire suppression tactics. A table of localities is included. Seven salamanders were found on south facing slopes, 3 on north facing slopes, and 1 on an east facing slope.

20. Hagerty, Scott. 1989. 1988/1989 soil monitoring for the Jemez Mountains salamander, Plethodon neomexicanus, Barley Timber Sale, Jemez Ranger District, Santa Fe National Forest. Unpubl. United States Forest Service Report. 16 p.

Baseline soil temperatures at 10" and 20" depth were collected from five cutting units with salamanders which are scheduled to be harvested. Temperatures recorded in summers of 1988 and 1989 showed that 20" readings were normally lower than 10" readings. The range was 9.5-13.5° C at the 10" level and 9.0-13.75° C at the 20" level. Although some soil structure, moisture content, and pH data were collected, they were not discussed. Graphs are included for each cutting unit showing temperature and soil moisture over time.

21. Herrington, Robert E., and J. H. Larsen. 1985. Current status, habitat requirements and management of the Larch Mountain salamander Plethodon larselli Burns. Biological Conservation 34:169-179.

Similarities between Plethodon larselli and P. neomexicanus are cited from other studies and the fact that they are both relict species in disjunct populations is noted.

22. Highton, Richard. 1962. Revision of North American salamanders of the genus Plethodon. Bulletin of the Florida State Museum in Biological Sciences 6(3):235-367.

A description of Plethodon neomexicanus as an eastern branch of salamander emphasises the pigmentation which is so reduced on the belly as to make internal organs visible. Lateral iridosphores and brassy flecking seem to make young specimens appear to have a brassy dorsal stripe. The author suggests that some Plethodon species are in need of further taxonomic study.

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

An extensive electrophoretic study of Plethodon genetic relationships reveals P. neomexicanus and P. larselli to be most closely associated as a branch of the western salamanders (P. neomexicanus group), but distinct from the P. vandykei, P. vehiculum, P., and P. elongatus groups. This concurs with morphological and albumin immunological studies with a high rate of correlation (r=.86). Genetic divergence times are assessed using a combination of genetic distance and albumin immunological distance. Plethodon has a slow divergence using these criteria, diverging over 40 million years ago (in the late Eocene).

24. Hubbard, John P., M. C. Conway, H. Campbell, G. Schmitt, and M. D. Hatch. 1979. Handbook of species endangered in New Mexico. New Mexico Department of Game and Fish. D-101:1-2

Pointing out that Plethodon neomexicanus was first listed by the State of New Mexico on Jan. 24, 1975, this account has a detailed description of the salamander to make field identification very easy. The threat to salamander distribution, which may include locally abundant populations, is thought to be any activity which creates drier conditions in the salamander's habitat. This could be caused by logging, fire, tree disease, overgrazing, or other types of clearing of vegetation. Spraying toxic chemicals to control tree disease may be equally detrimental. Conservation of the salamander should be aimed at protecting and restoring cool, moist conditions of their habitat and protecting known populations. A map of distribution is

included.

25. **Leviton, A. E., and B. H. Banta. 1956.** Catalogue of the amphibian and reptile types in the Natural History Museum of Stanford University supplement Number 1. Herpetologica 12:213-214.

Catalogue for this museum lists paratypes (2) of Plethodon neomexicanus collected by R. C. Stebbins Aug. 14, 1949, 12 mi west and 4 mi south of Los Alamos, Sandoval Co., New Mexico.

26. **MacGregor, H. C., and M. H. Walker. 1973.** The arrangement of chromosomes in nuclei of sperm from plethodontid salamanders. Chromosoma (Berl.) 40:243-262.

Chromosomes from 10 Plethodon neomexicanus sperm were studied along with other plethodontid species. In comparisons, this salamander falls between eastern and western salamanders in the amount of DNA per haploid chromosome set and in nuclear length of the sperm nucleus.

27. **Maxson, L. R., R. Highton, and D. B. Wake. 1979.** Albumin evolution and its phylogenetic implications in the Plethodontid salamander genera Plethodon and Ensatina. Copeia 1979(3):502-508.

This paper addresses the ambiguous phylogenetic background of Plethodon neomexicanus and other plethodontids based on the quantitive technique of micro-complement fixation (MC'F) of serum albumins. P. neomexicanus was closest to western plethodontids, though considered separately. P. elongatus and P. larselli were more similar to P. neomexicanus than to P. vehiculum.

28. **Mizuno, S. and H. C. MacGregor. 1974.** Chromosomes, DNA sequences and evolution in salamanders of the genus Plethodon. Chromosoma (Berl.) 48:239-296.

The aim in this molecular cytogenetics study of the genus Plethodon is to draw some evolutionary and taxonomic conclusions about this genus from determining the amount of DNA per haploid chromosome set (C value), the size of the genome, the

characteristics of the chromosome set, and "the degree of commonness and conservation from species to species with respect to DNA sequences". In C value analysis P. neomexicanus, P. larselli, and P. vandykei are distinct from other eastern and western species. P. neomexicanus was not considered in the genome size portion of this study. The DNA sequence portion of the study showed P. neomexicanus has little in common with eastern species and has more in common with western species, though it is still unusual. The lowest level of homologous reassociation is found in western species and P. neomexicanus using P. cinereus, an eastern species, as a baseline. In conclusion, though P. neomexicanus has little in common with other Plethodon it is more similar to western species, deducing that western species and P. neomexicanus diverged after being separated from eastern species. This judgement may be in question if inbreeding in P. neomexicanus increased because of isolation at an earlier time.

29. New Mexico Department of Game and Fish. 1988. A final report on the investigations into the distribution and habitat requirements of the Jemez Mountains salamander (Plethodon neomexicanus). Unpubl. report to the U.S. Forest Service, Contract No. 40-8379-8-0379. 49 p.

Plethodon neomexicanus surveys were conducted in the Jemez Mountains for the United States Forest Service by Charles W. Painter (New Mexico Department of Game and Fish), Ronald L. Gallegos, and Marikay Ramsey. The areas emphasized were Barley, Bonito, Mesa del Medio, Calaveras, and Mesita timber sale areas and the Copar/East Fork pumice mine site.

Microhabitat/ecological transects were conducted on five permanent transects established in 1987 by the United States Forest Service on cutting units in the Barley timber sale with similar numbers of salamanders being captured, adding to prelogging baseline data. An additional four permanent transects were established in cutting units due to be logged. Low numbers of salamanders were captured on these transects.

Twenty-six time constrained high-grade searches were conducted with salamanders found on Calaveras, Bonito, and Copar/East Fork areas. Mesita was found to have unsuitable habitat. The other areas deserve more investigation. Detailed maps are enclosed, a list of major tree and shrub species found in salamander habitat is included, and a list of P. neomexicanus museum holdings is added as an appendix.

30. Painter, Charles W. 1989. A final report on the investigations into the distribution and habitat requirements of the Jemez Mountains salamander (Plethodon neomexicanus). Unpubl. report to the U.S. Forest Service, Contract No. 43-8379-9-0311. 36 p.

Plethodon neomexicanus surveys and research were conducted in 1989 in the Jemez Mountains for the United States Forest Service by Charles W. Painter (New Mexico Department of Game and Fish), Marilyn J. Altenbach (USFS), et al. The areas emphasized in surveys were Bales, Barley, Calaveras, Canoncito, Cerro Pavo, Dome, Lake Fork, Mesa del Medio, Negras, Ojitos, Oso, Paliza, Trail, and Virgin diversity units of the Jemez, Coyote, Cuba, and Espanola Ranger Districts.

In addition to the nine permanent microhabitat/ ecological transects already established in 1986-1988 as per Scott, et al. (1987), three more permanent transects were established. The existing permanent transects were not resurveyed because no major changes in habitat had occurred, that is, the plots had not been logged. Dry weather restricted the field season and limited salamander detection.

Sixty-one time constrained, high-grade searches were conducted. Four new localities were found in the Calaveras, Dome, Lake Fork, and Negras diversity units. Detailed maps are enclosed.

Using data from all permanent transect high-grades (1986-1989) a chi-square test was conducted on numbers of salamanders detected and showed no significant differences over the years at a particular transect. A table of results is included.

31. Painter, Charles W. 1991. A final report on the investigations into the distribution and habitat requirements of the Jemez Mountains salamander (Plethodon neomexicanus). Unpubl. report to the U.S. Forest Service, Contract No. 40-8379-0-0714. 23 p.

Plethodon neomexicanus surveys and research were conducted in 1990 in the Jemez Mountains for the United States Forest Service by Charles W. Painter (New Mexico Department of Game and Fish), and Marilyn J. Altenbach, Ron L. Gallegos, Aileen C. Abeyta, Linda L. West, Benjamin D. Cunningham, Gabriel A. Stryker, and John C. Casey (USFS). The areas emphasized were Negras/Bluebird, Bonito, Virgin, Calaveras, Oso/Canoncito, Los

Griegos, Dome, and Barley.

In addition to the twelve permanent transects established 1987-1989, two transects were established on the Dome area. Transect summaries are included. Only one of the previous permanent transects was repeated on the Barley timber sale since it was the only unit that had been logged. No salamanders were found.

Three activity plots (1/4 hectare marked in 10m squares) were established. No actual data was collected. Nocturnal surveys of above ground salamander activity was attempted as an alternate search method with poor results, e.g. 2 salamanders nocturnal / 25 diurnal.

Twenty-two soil pits (1 cubic m) were excavated in the Jemez, Cuba, and Espanola Ranger Districts, and examined closely by USFS soil scientists. Twelve of the pits are in known salamander habitat and 10 are in areas deemed unsuitable. More information on subterranean habitat is expected from future studies on this data. Thermocouples were installed in 5 of the pits at depths of 20, 50, and 100 cm to monitor temperature throughout the year.

Recommendations for future research, detailed transect information, and detailed maps are included. Forty-seven time constrained high-grade searches were conducted with a table of results. New salamander localities include upper Capulin Canyon, in forests with predominantly pine overstory, and the west and south side of Las Conchas Peak. More salamanders were found in flat areas than before.

32. Panitz, Eric. 1967. Thelandros salamandrae (Oxyuroidea) Schad 1960, in Plethodon neomexicanus from the Jemez Mountains, New Mexico. Canadian J. Zool. 45:1296-1297.

In parasitological examinations of 31 Plethodon neomexicanus, 17 were positive for the nematode Thelandros salamandrae. This parasite has been found in other populations of plethodontids far removed geographically from P. neomexicanus, leading to a speculation that the salamander became a host in the past through association with other plethodontid populations.

33. Peacock, Robert L., and R. A. Nussbaum. 1973. Reproductive biology and population structures of the Western red-backed salamander, Plethodon vehiculum (Cooper). J. Herp. 7(3):215-224.

Citing Plethodon neomexicanus as a probable eastern small Plethodon, Peacock and Nussbaum state that no detailed reproductive studies have heretofore been conducted on western salamanders. More investigative reproductive biology is encouraged. No taxonomic conclusions are included.

34. Pilz, Wayne R. 1988. The revised biological impact assessment of Public Service Company of New Mexico's proposed Ojo line extension 345 kV project on the Jemez Mountains salamander. Unpubl. report submitted to: New Mexico Department of Game and Fish. 31 p.

In a comprehensive impact study of the proposed Ojo Line Extension (OLE) project, the right-of-way clearing for the project was searched in 1985 and 1987 for salamander occupation in areas of "suitable" habitat. The greatest number of salamanders were found in stabilized talus slopes with decayed conifer logs. Suitable habitat was identified by aerial photo, helicopter reconnaissance, and ground surveillance. Repeat surveys were done in areas of suitable habitat to decrease chances of salamanders going undetected because of environmental conditions. Ten salamanders were found on public land sections of the proposed corridor and 2 were found on the Baca Location #1. Findings are that the project will have little impact on the salamander, and mitigations, including re-routing areas of impact, are considered.

35. Ramotnik, Cynthia A. 1985. Final report: Effects of forest management practices on the endemic Jemez Mountains salamander, Plethodon neomexicanus. Unpubl. report to the U.S. Forest Service, Contract No. 43-8379-4-591. 33 p.

Four logged and 5 unlogged sites were surveyed to determine effects of logging on salamander habitat. Site evaluation included air, litter, and soil temperatures; pH; soil moisture; overstory; slope; aspect; elevation; and litter depth. Lacking in site analysis was soil structure and subterranean habitat features. On three paired, logged/unlogged, sites, salamanders were found in two unlogged and no logged sites. No salamanders were found in logged sites in toto and 47 were found in unlogged sites.

Two methods of salamander survey were employed: pitfall traps and active search. Only 3 salamanders out of 15,480 trap

nights were captured. In smaller arthropod pitfalls 5 salamanders were captured, suggesting pitfall design improvements may increase capture rate.

Other results include: pH, litter depth, and log size were significantly affected by logging; unlogged sites were steeper, drier, and less acidic with smaller logs, closer together and more decayed; unlogged sites had a higher moss/lichen cover, smaller herbaceous vegetation cover, and greater needle or bare ground cover with a greater percent overstory; logs with salamanders were significantly wetter, more decayed, and had greater herbaceous ground cover than those without salamanders; logs with salamanders had greater percent overstory and less needle or bare ground cover.

Preliminary management recommendations, maps, and tables are included.

36. Ramotnik, Cynthia A. 1986. Status report: Plethodon neomexicanus Stebbins and Riemer, Jemez Mountains salamander. Unpubl. report prepared for the Office of Endangered Species, U.S. Fish and Wildlife Service, P.O. Box 1306, Albuquerque, New Mexico 87103. 55 p.

A literature review and summary of past salamander references is included to establish present knowledge of salamander biology.

Microhabitat characteristics were gathered on 20 sites differing in aspect, elevation, and slope. These included cover, air, litter, and soil temperature; soil pH; and moisture. Aspect, elevation, and slope, and date were also recorded. Seven of these sights revealed salamanders (n=29). All were located in logs. Statistical analysis showed salamanders were more likely to be found early in the field season, between 2251-2500 m and 2751-3000 m elevation, and on slopes > 37%. Moisture was positively correlated with salamander detection.

Since no salamanders were found after 14 July, only 10 sites were used for the other analyses. Some of the results of these analyses are as follows: salamanders were found in larger logs, wetter logs, higher surrounding needle cover, and greater soil pH. Log decay class was not significant through class 3-5 decay class. The following microhabitat variables were positively correlated with each other: size of logs and moisture; steep slopes and sparse moss/lichen cover; steep slopes and dry, warm logs; steep slopes and high pH; elevation and moisture; overstory and moss/lichen cover; overstory and moisture in logs; overstory

and temperature of logs. These were negatively correlated: size of logs and temperature; size of logs and decay class; elevation and cover temperature. Regression analysis shows salamander occurrence to be most closely related to log size. Additional comparisons are made between microhabitat variables on salamander vs no salamander sites.

Five new locality records were added from 1984-85 field season with map and table included. Previous known localities are mapped and arranged in tables. The first salamander was detected on 20 May 1985, an early season record.

Twelve salamanders were implanted with Tantalum-182 wire for a movement and homing study. Of eight salamanders used in movement studies, the salamanders on south-facing slopes disappeared first, presumably because they were juveniles dispersing from birth sites. The greatest distance a salamander moved was 13 m in 1.5 hr. Females were tracked longer than males, with the longest period being 6 weeks on a south-facing slope. Four salamanders were implanted, removed from their point of capture and shown to lack an ability for homing.

Question is raised as to the feasibility of estimating populations without more knowledge of underground and aboveground activities, and relative abundance is suggested as a reasonable method of comparing numbers.

Since greater than 90% of known salamander localities are on federal land, management responsibilities should be borne by these agencies. For example, more study and thought should be given to activities such as cable logging which may increase the number of clear cut areas; thus increasing runoff, insolation, and wind which cause drier soils. Increases in logging have been proposed in the Jemez Mountains by the USFS. A list of management recommendations is included.

Other threats to salamanders include the danger of parasitism or predation by shrews, garter snakes, or ground-feeding birds. Also, if pockets of salamanders are increasingly isolated, genetic diversity will be reduced. Drought conditions could jeopardize aboveground activity.

A third population center is recognized in the canyons east of the Valle Grande, and with the other previously identified centers could be set aside as a salamander refugium.

37. **Ramotnik, Cynthia A. 1988.** Habitat requirements and movements of Jemez Mountains salamanders, Plethodon neomexicanus. M.S. thesis, Colorado State University, Fort Collins. 84 p.

BIBLIOGRAPHY: Plethodon neomexicanus

This thesis is basically an elucidation on research conducted by Ramotnik in 1984 and 1985 (Ramotnik, 1985 & 1986) incorporating some information from 1986 and 1987 surveys conducted by USFWS and Scott, et al. More mention is made of rock cover than in previous reports and some biases and limitations are placed on research techniques. A complete list of geographic distribution, localities, to date, and maps are included. Since 1978, thirty-one additional localities have been added. One-way analysis of variance was used to compare habitat components on 25 sites (11 with salamanders) and indicated that sites with salamanders were steeper in slope and had higher soil pH. Aspect had no significant effect. Movement data (Ramotnik, 1986) show salamanders on south-facing slopes spent more time underground, but they were not absent. Much more specific movement data is discussed than in previous reports. The main hypothesis, based on these studies, is that P. neomexicanus moves both vertically and horizontally in periods of dry weather. A call is made to initiate logging effect studies before logging occurs. The abundance of salamanders may be limited by soil pH, but future studies should be conducted over a long period of time.

38. Ramotnik, Cynthia A., and N. J. Scott, Jr. 1988. Habitat requirements of New Mexico's endangered salamanders. Proceedings of the symposium: Management of amphibians, reptiles, and small mammals in North America. July 19-21, 1988. Flagstaff, Arizona. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO 80526. General Technical Report RM-166:30-39.

Based on habitat components collected in the Jemez Mountains by United States Fish and Wildlife Service (1986) and Scott, et al. (1987) discriminant analysis was used to assess predictive value for determining salamander presence/absence. Steep slope and high elevation variables were most useful in predicting salamander presence. Due to low density of salamanders (3/100 m^2) and low discriminant model predictive values, the best method of detection is to ground-proof in wet weather. Other variables, not yet measured, such as soil compaction, past logging and fire history, may have more predictive power.

Interim management guidelines for the USFS include the following: surveys for salamanders should be conducted early in the timber harvest planning process; intensive logging should not be conducted in occupied habitat; soil drying operations like

slash removal should be avoided; and a mix of young and old downed logs should be maintained for future and present habitat preservation.

39. Reagan, Douglas P. 1967. Aspects of the life history and distribution of the Jemez Mountains salamander, Plethodon neomexicanus. M.S. thesis, University of New Mexico, Albuquerque. 38 p.

The information in this thesis is the same as Reagan (1972) with few differences. P. neomexicanus is considered in this paper to be a member of eastern small Plethodon.

40. Reagan, Douglas P. 1972. Ecology and distribution of the Jemez Mountains salamander, Plethodon neomexicanus. Copeia 1972(3):486-492.

Reagan's own abstract reads as follows: "Field studies involving Plethodon neomexicanus were made from September, 1965 to March, 1967. This species is limited to north facing slopes and steep canyons within the upper montane forest (2420-2800 m) of the Jemez Mountains, Sandoval County, New Mexico. P. neomexicanus maintains burrows among the rocks of talus slopes and moves easily through them. Salamanders are active at the surface at temperatures from 10.5 to 13.0 C with the surface dripping wet. Gut analysis revealed that they eat a variety of invertebrates including large numbers of ants. Intestinal nematodes Thelandros salamandrae, were found in 41% of the specimens examined. Salamanders reach sexual maturity at a total length of 98 mm in males and 104 mm in females. Total and S-V length are significantly greater in females than in males. Mean clutch size was estimated at 7.7, range 5-12. P. neomexicanus appears to deposit eggs during late July and early August. Testes weights increase from June to September while salamanders are active at the surface. Salamanders were not accessible at other times. Collections from five new localities extended the known geographic range 19 km."

41. Scott, Norman J., Jr., C. A. Ramotnik, M. J. Altenbach, and B. E. Smith. 1987. Distribution and ecological requirements of endemic salamanders in relation to forestry management: Summary of 1987 activities, Part 2: Santa Fe National Forest. Unpubl.

U.S. Forest Service Report. 33 p.

Based on field studies in 1987 by the authors and Colin Campbell, the objectives were to assess distribution and relative abundance of Plethodon neomexicanus in areas that will be logged (Barley, Bonito, Mesa del Medio, and Tusas Sales), validate high-grade survey techniques, characterize salamander microhabitat variables using ecological transects, establish permanent transects to study logging effects, and visit areas that may harbor salamander populations but have thus far not been surveyed or have not produced positive results.

Using a time constrained search technique called high-grade, sale areas were surveyed at sites determined by ground assessment and aerial photos. Detailed maps are enclosed. Fifteen of 39 high-grades contained salamanders. The following information was collected for each salamander: snout-vent length (SVL), reproductive condition, and dimensions and type of cover object. Aspect, slope, and general description were recorded for each site. To validate the high-grade technique four sites were revisited during varying weather conditions. When populations of salamanders are high they can be detected in a two work-hour high-grade even if conditions are not optimal, but for low density sites salamanders may not be found.

Microhabitat assessments of sites were obtained by conducting 50 m x 2 m transects collecting the following information for each 10 m x 2 m segment: canopy closure; aspect (taken 3 times for each transect); percent slope; estimates of square meters covered by rock, bark, fine woody debris, and coarse woody debris; and ground cover rankings were made for litter, moss, herbs, exposed soil, shrubs, and cover. Coarse woody debris was assessed in three decay classifications. Other ecological data collected were the number and type of trees over six feet tall found in a plot 10 m to each side of the transect midline making each segment 20 m x 10 m (200 m^2). Tree types recorded were fir, spruce, aspen, oak, and non-oak deciduous such as maple, cliff bush, and locust. Diameter at breast height (DBH) was recorded in three catagories: small (0-20 cm), medium (20-50 cm), and large (>50 cm). Each 10 m x 2 m segment was searched thoroughly for salamanders using hands and potato rakes and when detected, SVL was taken, reproductive activity noted, and cover objects were measured and identified. Summaries and maps are included for transects. This transect information was also collected by USFWS (1986), New Mexico Dept. Game and Fish (1988), Painter (1989, 1990).

Permanent transects were established in the Barley timber

sale, in areas scheduled to be logged to assess effects on salamander populations and ecological variables. Maps and transect summaries are included.

As a result of salamander high-grade searches in areas outside known distribution, P. neomexicanus was recorded from two sites in the Mesa del Medio area, six localities in Los Alamos County, and several sites in the Barley timber sale area. Maps and high-grade summaries are included.

42. Shaw, J. W. 1971. Our pint-sized relic of the age of dinosaurs. New Mexico 49(9-10):34-35.

A natural history story of Plethodon neomexicanus, based on field work by Steve Williams, this article's main point is the need to determine logging effects on this species.

43. Shaw, J. W. 1972. To save a salamander. Animal Kingdom 75(6):25-27.

This article stresses the fragility of Plethodon neomexicanus's habitat, and, based on the research of Steve Williams, covers many aspects of the salamander's natural history.

44. Smith, Hobart M. 1978. A guide to field identification, amphibians of North America. Golden Press, New York. 160 p.

In this field guide Plethodon neomexicanus is described as a single species of salamanders belonging to the New Mexican group between eastern and western groups but more closely resembling the western group.

45. Smith, Phillip W. Date unknown. A naturalist in the environmental crisis. Carlton Press, Inc., New York. p. 63.

During a collecting trip to New Mexico in the early spring to attempt to find Jemez Mountains salamanders, none were collected as the season was very cold.

46. Stebbins, Robert C., and W. J. Riemer. 1950. A new species

of Plethodontid salamander from the Jemez Mountains of New Mexico. Copeia 1950(2):73-80.

Because of the occurrence of Plethodon hardii (Aneides hardii) in the southern Rockies, the supposition that this mountain range was instrumental in salamander distribution, and the records of Eurycea multiplicata from the Jemez Mountains, Stebbins and Riemer searched for and found what is described here as a new species, Plethodon neomexicanus. Holotype and 17 paratypes were collected 14 August 1949 and deposited in the Museum of Vertebrate Zoology. Description was made from a living, anesthetized specimen and many measurements are included. Specimens of Eurycea multiplicata identified by Dunn (1926: 316) were reexamined and determined to be this new species. Coloration, anatomical details, and juvenile differences are discussed in detail. Pictures and description of type locality habitat show a spruce-fir forest in the Transition Zone of a geographically isolated range of volcanic mountains on a west to northwest facing slope with no flowing water and almost no exposed rock. Pseudotsuga, Douglas fir, is the predominant tree, and salamanders are found most commonly in and under downed, rotted logs of this species. Herbaceous plants 2" to 6" high form an almost continuous ground cover with some small shrubs and small clumps of grasses. A humus layer of dead leaves and needles forms a 1.5" mat which covers the soil. Moisture is high in sites with salamanders, and none were found in nearby, drier sites.

When compared to other plethodontids, P. neomexicanus is described as close to P. cinereus except for larger size, reduced fifth toe, absence of dorsal band in adults, and in lacking contrasting light and dark reticulations on the ventral surface of the body. Similarities and differences between other species of plethodontids are discussed.

47. **Stebbins, Robert C. 1954. Amphibians and reptiles of western North America. McGraw-Hill Book Company, Inc., New York. 536 p.**

This field guide description of Plethodon neomexicanus lists two localities: the type locality and Jemez Creek, 6 miles northwest of Bland. Adults and juveniles are described briefly and compared to western species P. elongatus and P. vandykei noting reduction in fifth toe. Habitat is described as coniferous forest consisting largely of Douglas fir, white fir,

and spruce, with scattered maples and clumps of aspen. Breeding habits are unknown and activity period is supposed to be the rainy summer months.

48. Stebbins, Robert C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston, Massachusetts. 279 p.

Plethodon neomexicanus is described in this field guide as the slimmest western plethodon with usually 19 costal grooves, short legs, 7.5 to 8.5 costal folds between tips of toes of adpressed limbs, fifth toe absent or with only 1 segment, brown above with fine brassy-colored stippling, sooty below with lightening on throat and tail. Habitat is moss-covered rockslides especially on north-facing slopes in mixed conifer forests above 8000 ft. Usually subterranean, this salamander is active on the surface during periods of summer rains. The salamander may be locally abundant but is reported from only 3 localities. Locality map and plate are included.

49. Thurow, G. R. 1957. A new Plethodon from Virginia. Herpetologica 13:64.

Plethodon neomexicanus is mentioned briefly as being larger than P. hubrichti, having a shorter tail, shorter legs relative to body length, lighter pigmentation, and lacking one phalanx on the fifth toe.

50. Thurow, G. R. 1968. On the small black Plethodon problem. Western Illinois University, Series in the Biological Sciences, No.6. 42 p.

Though I was unable to obtain this article, according to Brodie (1970) Thurow believes Plethodon neomexicanus to be more closely related to P. elongatus than to eastern Plethodon.

51. U. S. Fish and Wildlife Service. 1986. Report on the distribution and ecological requirements of endemic salamanders in relation to forestry management: Part 2: Santa Fe National Forest. Unpubl. report submitted to the U.S. Forest Service by the National Ecology Center, U.S. Fish and Wildlife Service,

Museum of Southwestern Biology, University of New Mexico, Albuquerque, New Mexico 87131. 40 p.

In field work conducted in the summmer of 1986 by Marilyn J. Altenbach, Robert R. Beatson, Thomas H. Fritts, and Cynthia A. Ramotnik using methods described in Scott, et al. (1987), salamanders were detected in 14 of 23 sites. Transect summaries and maps are included. The lowest elevation with salamanders was in Medio Dia Canyon at 7,650' and the highest number of salamanders, seven, were detected in Medio Dia Canyon on a west southwest facing slope with above average rock cover and predominantly oak canopy. Each area surveyed has a brief synopsis with recommendations for future study.

52. Van Denburgh, John 1924. Notes on the herpetology of New Mexico, with a list of species known from that state. California Academy of Sciences, Proc. 4th Ser. Vol.XIII(12):191.

In an early review of the herpetofauna of New Mexico, one specimen of Eurycea multiplicata (later Plethodon neomexicanus) is mentioned from the National Museum collection.

53. Wake, David B. 1966. Comparative osteology and evolution of the lungless salamanders, family Plethodontidae. Memoirs of the Southern California Academy of Sciences 4:1-111.

By analyzing skeletal variation, the plethodontid salamanders are reanalyzed for evolutionary relationships. Within the genus Plethodon, only P. neomexicanus and P. vandykei have populations in the Rocky Mountain chain. P. neomexicanus exhibits calcifications in the distal carpals, based on one specimen, which shows an evolutionary bifurcation from other plethodontids from both eastern and western populations. Though primitive plethodontids have four fingers and five toes, this salamander and P. larselli have lost single phalanges from the fifth toes of most individuals. The Arcto-Tertiary flora suggest that habitats for plethodontid dispersal are now unsuitable, and further suggest that some time from middle Miocene to early Pliocene, this habitat became inhospitable to plethodontid populations. Also, the rain shadow effect of the Sierran uplift and severe cooling of Pleistocene glacial periods would have contributed to toe disappearance of plethodontids over most of the Rocky Mountains. P. neomexicanus is described as a relict

population of the mid-Tertiary Rocky Mountain fauna, but final isolation may have occurred as late as late Pleistocene. Though Blair (1958) has suggested that P. neomexicanus has arisen from eastern populations in Wisconsin times, the evidence of New Mexican highland flora being derived from the West American Element of the Arcto-Tertiary Geoflora suggests that these salamanders may be derived from ancient Rocky Mountain fauna and are displaced southern relict populations.

54. Whitford, Walter G. 1968. Physiological responses to temperature and dessication in the endemic New Mexico plethodontids, Plethodon neomexicanus and Aneides hardii. Copeia 1968(2):247-251.

The low microhabitat temperatures found for these two species probably accounts for their relatively low critical thermal maximum (CTM), 33.3° C for Aneides hardii and 33.5° C for Plethodon neomexicanus. The ability to obtain oxygen being partly a function of surface area per unit weight, it is not surprising that the metabolic-temperature (MT) curve for P. neomexicanus with a lower surface area per unit weight is lower than A. hardii which has a relatively high surface area per unit weight. This means A. hardii has a better capability of supplying oxygen to body tissues at increased temperatures. An optimum temperature metabolically for both species is around 15° C. P. neomexicanus has a higher resistance to dessication than the eastern plethodon group and is more like the western group. However, the resistance to dessication and the requirement of low ambient temperatures might suggest a dispersal from the eastern forms during Pleistocene when the climate in that area was cooler and wetter.

55. Whitford, Walter G., and J. Ludwig. 1975. The biota of the Baca geothermal site. Unpubl. report for Union Oil Co. - Geothermal Div. 140 p.

I was unable to obtain a copy of this document.

56. Whitford, Walter G. 1977. The biota of the Baca geothermal site. Unpubl. report. Whitford Ecological Consultants. p 117-121.

During surveys for an environmental impact study for Union Geothermal on the Baca Land and Cattle Company land in the Redondo Border/Redondo Peak area, salamanders were found to be locally abundant in three distinct areas. On Redondo Peak populations were discovered as high as 11,250' under rocks and surface debris. Some areas with "good" salamander habitat did not yield specimens and none were found in clear cut areas on north facing slopes, suggesting that the species requires either virgin timber or at least closed canopy to modify the climate of the surface. One salamander was captured in a mammal trap on an open talus slope. Mitigation includes avoiding known populations when planning drilling and road building activities. Map is enclosed.

57. Williams, Stephen R. 1972a. Reproduction and ecology of the Jemez Mountains salamander, Plethodon neomexicanus. M.S. thesis, University of New Mexico, Albuquerque. 98 pp.

The reproductive biology section of this thesis is repeated in Williams (1978) but is based on a slightly smaller sample size. These results are not discussed here.

Population estimates of study areas were made for two consecutive summers under the premise that most salamanders are underground at a given time. Twenty-six of 165 marked salamanders were recaptured in 1970 and 14 of 127 marked animals were recaptured in 1971. Using the Lincoln Index method for estimates of population, 1970 had 1 salamander / 9.5 m^2 and 1971 had 1 salamander / 10.9 m^2.

Mature female salamanders are larger than males, with a mean snout-vent length of 55.5 mm compared to 54.4 mm. The sex ratio over the entire season was 1.03. More males were detected early in the activity period and more females were found at the end of the season. This is presumably because female Plethodon tend to brood their eggs and are not as active during this period.

Based on size classes of 659 salamanders, sexual maturity is probably reached in 2 to 3 years in males and 3 years in females. Three juvenile classes probably exist, though few hatchlings were represented. They were first found in late July and August.

Habitat temperatures ranged from 6.0 to 17.0° C. with a mean of 12.7° C. Sixty-seven percent of the salamanders were found under logs, 19% under rocks, and 14% in logs. Little correlation was found between habitat temperature and air temperature.

Since the groupings of the genus Plethodon have raised questions about P. neomexicanus' origins, comparisons are made

with some other species from this genus. In snout-vent length P. neomexicanus is closest to P. elongatus of the western group and P. glutinosus of the eastern large group. In gaining sexual maturity P. neomexicanus at 2 to 3 years is probably between P. cinereus, 2 years, and P. glutinosus, 4 to 5 years. Eggs of P. neomexicanus are larger than most, except P. elongatus, and clutch size is closest to P. dunni and P. elongatus. Mating period is probably different from other species, occurring in the rainy, summer months instead of winter.

58. Williams, Stephen R. 1972b. The Jemez Mountains salamander, Plethodon neomexicanus. Pp. 118-127 in Symposium on rare and endangered wildlife of the southwestern United States. New Mexico Department of Game and Fish. vii+167 pp.

This report is a rehash of Williams (1972a) but emphasizes also the salamander's fragility and inability to flee predators, poor prey capture mechanisms, and susceptibility to environmental changes aboveground. They also have low reproductive potential, recorded at about 8 offspring per female every other year. Mortality rates are supposed to be high when the animals are young and decrease with age.

The main pressures on populations can be predation, which is a reduced threat due to their secretive habits, and man-made threats consisting mainly of logging and over-collecting. Logging may deplete essential mineral elements of the microhabitat necessary for salamander diet and/or reduce moisture on logged hillsides by lowering the canopy closure. Collectors not only take large numbers of these salamanders, but they also destroy aboveground habitat by breaking apart decaying logs and moving other cover to a less propitious site for salamander habitation. This information suggests that Plethodon neomexicanus may be a likely candidate for placement on the endangered species list.

59. Williams, Stephen R. 1973a. Comparison of the reproduction and ecology of the Jemez Mountains salamander, Plethodon neomexicanus, and the Sacramento mountain salamander, Aneides hardii. Unpubl. report to the Resources Development Internship Program: Western Interstate Commission for Higher Education. 14 p.

Much of this report is devoted to descriptions of ongoing

and future projects, the results of which do not appear in the literature.

One of these projects is a field study using enclosures of 3 ft square by 4 ft deep with thermistor probes to monitor temperature. Twenty salamanders of varying age will be marked by toe-clipping, measured and placed in enclosures. Information collected will include soil moisture, soil pH, air and soil temperature at various depths, number and depth of animals present, and size of animals. This would entail excavation of the enclosures, and excavations will be conducted every other month to achieve maximum results. The expected data include growth rates, male and female reproductive cycles, information on existing cavities for egg deposition, and information about possible underground foraging habits. Temperature data should provide clues about hibernation tolerances in a natural setting. Soil data and moisture will be compared to depth of salamanders and their condition, and compared to dessication tolerances supplied by Whitford (1968).

Electrophoretic taxonomic techniques are being employed to compare P. neomexicanus to other Plethodon species by Dr. Ronald Lucchino of Syracuse University.

Tantalum-182 wire implants for movement studies has been delayed by the Atomic Energy Commission, but hope to reveal activity patterns on a daily, weekly, monthly, and seasonal basis. This study was conducted by Ramotnik in the summer of 1985, with results discussed in Ramotnik (1986, 1988).

A possible inclusion of P. neomexicanus in a forthcoming book on vanishing wildlife by the National Geographic Society is also mentioned.

Distribution of the salamander and the effects of logging are two more areas of study to be included in the future.

60. Williams, Stephen R. 1973b. Plethodon neomexicanus Stebbins and Riemer, Jemez Mountains salamander. SSAR Cat. Amer. Amphib. Rept. 131.1-131.2.

This species account is based on information from Stebbins and Riemer (1950), description; Brodie and Altig (1967), morphological variation; Wake (1963, 1966), osteology; Brodie (1968), absence of mental glands; Highton (1962); Stebbins (1951, 1954); and Williams (1972a, 1972b), reproductive biology and distribution. An additional literature review is provided and a map of known distribution included.

61. Williams, Stephen R. 1976. Comparative ecology and reproduction of the endemic New Mexico plethodontid salamanders, Plethodon neomexicanus and Aneides hardii. Ph.D. thesis, University of New Mexico, Albuquerque. 152 p.

New information contained in this thesis is mainly for Aneides hardii, and much of the information on Plethodon neomexicanus has been taken from Williams' previous work (1972a, 1974) and presented by Williams (1978). Only additional information will be reviewed here.

Main differences between P. neomexicanus and A. hardii are as follows: males are smaller than females in P. neomexicanus and larger in A. hardii; A. hardii is a smaller animal; A. hardii was found most commonly under rocks and P. neomexicanus under logs; average habitat temperature is lower for A. hardii; sperm are present in the vas deferens of A. hardii in early fall while in P. neomexicanus this happens in late fall or winter; and in electrophoresis banding, patterns showed that A. hardii resembles A. lugubris more than P. neomexicanus, which resembles the western plethodons more than A. hardii. Neither resembles eastern species representatives as much as western species.

62. Williams, Stephen R. 1978. Comparative reproduction of the endemic New Mexico plethodontid salamanders, Plethodon neomexicanus and Aneides hardii (Amphibia, Urodela, Plethodontidae). J. Herp. 12(4):471-476.

In a histological, reproductive study comparing the two New Mexico plethodontids, it appears that Plethodon neomexicanus males (n=33) are sexually active throughout the active season (June-August) because sperm-packed vasa deferentia were noted at collection dates throughout the season. Females (n=41) probably brood underground in fall or early spring every other year because no gravid female was collected after 20 August, a gravid female collected in August and kept in the lab deposited her clutch in early June the following spring, and less than 50% (39%) of the females collected were gravid. Clutch size agrees with Reagan (1972), since the one female clutch contained 7 eggs. These eggs had a range of 6.8 - 7.3 mm in diameter which is unusually large for Plethodon.

High precipitation levels measured by the United States Forest Service correspond with periods in which P. neomexicanus are active above ground. Their activity period is longer than that of Aneides hardii.

63. Williams, Stephen R., and W. G. Degenhardt. 1974. Distribution, reproduction, and ecology of the two New Mexican plethodontids: the Jemez Mountains salamander, Plethodon neomexicanus, and the Sacramento mountain salamander, Aneides hardyi. Unpubl. report for the United States Forest Service and the Western Interstate Commission for Higher Education. 92 p.

This study added new locality records for Plethodon neomexicanus, 10 in Sandoval County and 4 in Los Alamos County. Maps and locality descriptions are included.

Two main centers of distribution are identified: one near the type locality south of the Valle Grande, and one along the Rio Cebolla and it's drainages. In the Los Alamos County localities, no sites produced an abundance of salamanders. No salamanders were found in three collecting trips to the San Pedro Parks Wilderness.

In heavily logged areas at the head of Peralta Canyon, no salamanders were found in 12 hours of search. According to known habitat preferences, salamanders should have been found, but the slopes were dry as a result of logging. Recommendation is to limit or exclude logging in the two main centers of distribution.

Two enzymes, esterase and lactate dehydrogenase, were analyzed using electrophoresis to help determine relationships between some species of eastern and western groups of Plethodon and P. neomexicanus. The banding patterns suggest this salamander is more closely related to western plethodons than either eastern plethodons or Aneides hardii.

Other information in this report such as habitat description, size groups, activity period, habitat temperatures, and reproductive cycles are taken from Williams (1972a) and also reported in Williams (1978). These are not discussed here.