

Status of the Green Salamander in South Carolina

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Abstract: In 1989 and 1990 a green salamander (*Aneides aeneus*) habitat study was conducted in the mountains of Oconee, Pickens, and Greenville counties, South Carolina. Based upon the topographic characteristics of 14 known green salamander sites in South Carolina, a list of criteria was developed to identify areas of potential habitat in the state. Twenty-four 7.5' topographic maps containing areas with possible habitat were subdivided into 0.16-km² sections and evaluated to determine the number of potential green salamander habitat areas. Of 15,789 sections in the study area, 670 grids (107.20 km²) had a high probability of potential green salamander habitat. Another 33% of the moderate probability sites contained potential habitat, totalling 2,631 grids (420.96 km²) of green salamander habitat in South Carolina.

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The Southern Blue Ridge population of the green salamander (*Aneides aeneus*) is currently listed as a Category 2 species (U.S. Fish and Wildl. Serv. 1989), and its status is being reviewed by the U.S. Fish and Wildlife Service to determine if it qualifies for federal protection under the 1973 Endangered Species Act, as amended. Nine counties in North Carolina, South Carolina, and Georgia make up the disjunct Blue Ridge portion of the green salamanders' range. These counties historically contained 37 populations of green salamanders, but in the past 15 years this species has apparently disappeared from 78% of its known localities (U.S. Fish and Wildl. Serv. 1987). The green salamander is primarily restricted to small crevices that are moist but not wet in rock outcrops that are shaded at least partially during the day. The spotty and limited distribution of this habitat results in localized green salamander populations throughout its range (Bishop 1943; Gordon and Smith 1949; Gordon 1952, 1967; Schwartz 1954; Cochran 1961; Woods 1969; Snyder 1971; Mount 1975; Cupp 1980). Due to apparent population

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decline or limited distribution, this salamander was listed as endangered in North Carolina (A. Boynton, pers. commun.) and Maryland (Thompson and Taylor 1985). Thompson and Taylor (1985) suggested that the green salamander should be down-listed from endangered to threatened, however, because they identified 41 new localities in western Maryland. In South Carolina suitable habitat conditions are found only in the mountainous regions of Greenville, Pickens, and Oconee counties. Therefore, the South Carolina Wildlife and Marine Resources Department has listed the salamander as a "species of concern" in the state (Gaddy 1985). To determine the status of a species, systematic surveys must be conducted to locate potential habitat and then verify population distribution. However, no standardized procedures for such surveys currently exist. Standardized techniques can be used to identify potential salamander habitat and to monitor the impact of future resource management on green salamander habitats.

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Methods

Twenty-four topographic maps (7.5') of the mountainous regions of Greenville, Pickens, and Oconee counties were each divided into 952 squares by superimposing a 0.16-km² grid over the study area. Each grid square was ranked as having high, moderate, or low probability of containing suitable green salamander habitat, based on an evaluation of key topographic features. High probability grid squares possessed all of the following characteristics: (1) midpoint elevation was greater than 366 m, (2) change in elevation was greater than or equal to 110 m, (3) aspect was northerly (northwest to northeast), (4) a drainage was present, and (5) the site was less than 0.4 km from water (permanent or intermittent creek or seep). Moderate probability grid squares did not possess all the high probability site characteristics and did not have any low probability site characteristics. Grid squares that we defined as having a low probability of containing suitable green salamander habitat had a least one of the following characteristics: (1) midpoint elevation was less than 275 m, (2) change in elevation was less than 61 m, or (3) no obvious drainage was present. These criteria were derived from a compilation of topographic characteristics of 14 known green salamander sites in South Carolina. These sites have midpoint elevations ranging from 293 m to 1,024 m, and change in elevation varies from 61 m to 207 m. Ten of these sites have northerly aspects, and all sites have drainages present and are less than 0.4 km from a water source. At least 70% of the sites containing known green salamander populations possessed all of the topographic features we defined for high probability sites, and none had topographic features that we outlined for low probability sites.

Returning to the 24 topographic maps of the mountainous regions of South Carolina, we randomly selected 20 grid squares that possessed those topographic

features we defined for sites that had a high probability of containing suitable green salamander habitat. Similarly we chose 20 grid squares with topographic features that defined them as moderate probability sites and 20 grid squares with topographic features that defined them as low probability sites. Ground surveys of these areas were conducted to determine if suitable habitat existed within the selected grid squares. Based on the variance of these initial samples, 25 additional samples of the moderate probability sites were randomly taken to obtain a 15% bound on the error of estimation in a sample size determination. A Chi-square goodness-of-fit test was run on the final sample to determine if the observed topographic characteristics fit the expected criteria. These criteria were then applied to the original grid-square maps to describe the potential distribution of green salamander habitat in South Carolina.

Results and Discussion

High Probability Sites

Of the 20 high probability sites randomly sampled, 19 contained potential green salamander habitat and 1 was found of marginal quality (too wet). Of the 19 potential sites, 4 supported green salamander populations. These new sites extended the green salamanders' range approximately 32 km eastward in South Carolina. These sites fit the criteria that were based on the topographic features of 14 known green salamander sites ($\chi^2 = 0.723$, d.f. = 2). Using these criteria, 107.20 km² (670 grid squares) in the mountains of Pickens, Greenville, and Oconee counties may have suitable green salamander habitat.

Low Probability Sites

Of the 20 low probability sites randomly sampled, 2 had potential habitat, 2 had habitat of marginal quality, and 16 lacked habitat. These locations fit the defined criteria for low probability sites ($\chi^2 = 4.89$, d.f. = 2). Based on these criteria, 1,454.88 km² (9,093 grid squares) of the mountains of Pickens, Greenville, and Oconee counties have no suitable green salamander habitat. The criteria for high and low probability sites appeared to be accurate and exclusively defined potential habitat value for the green salamander, but the moderate sites were much more variable.

Moderate Probability Sites

Of the 45 moderate sites sampled, 16 had potential habitat, 14 had marginal habitat, and 15 lacked habitat. These moderate sites did not fit the expected ratio of 1:2:1 (potential, marginal and no habitat types, respectively) based on Chi-square ($\chi^2 = 6.47$, d.f. = 2). When evaluating the characteristics of the 45 moderate sites, we found no features that could predict which location contained potential, marginal, or no habitat. Some of the characteristics that were found in moderate sites containing no habitat were also found in those containing potential and marginal habitat. The sampled sites followed a categorical breakdown into thirds (33.3% potential, 33.3% marginal, 33.3% no habitat) ($\chi^2 = 0.13$, d.f. = 2).

A total of 5,883 grid squares fell into the moderate probability category. Since one-third of these may likely contain potential green salamander habitat, 1,961 grid squares representing 313.76 km² of habitat can be added to the 107.20 km² of high probability area to total 420.96 km² of potential green salamander habitat in South Carolina.

Potential Populations

Out of a sample of 20 high probability sites, 4 (20%) contained green salamanders. Using this ratio, 134 out of 670 high sites may contain green salamanders; and if the additional 1,961 moderate sites that probably contain potential green salamander habitat are included, an additional 392 grid squares may contain green salamanders. Only a small percentage (usually <20%) of the potential habitat in the 20 sampled high probability grid squares was examined (especially the more inaccessible ones). Also, these green salamanders were observed during one-time site visits in May and July, which are not the best months for viewing green salamanders (Hafer 1992a). This estimate, therefore, should be considered a conservative estimate of the population in South Carolina.

Searching in suitable rocky habitat may reveal that this species is more abundant than supposed (Schwartz 1954). Using the criteria and the topographic approach described in this study should enable investigators to predict locations of suitable green salamander habitat more efficiently. Systematic searches of these areas should reveal potential populations.

This approach to locating potential green salamander habitat does not take into account changes in land use. For example, Hafer (1992b) used this method to plot potential habitat in a section of Transylvania County, North Carolina, and found that many of the sites were located in areas of recent residential development. Therefore, regular re-evaluation based on changes in land use should be made.

Since the Blue Ridge population of the green salamander has a C2 Federal status, this information should be helpful in determining whether to list this species as threatened or endangered according to the 1973 Endangered Species Act, as amended. Because of its affinity for such a specific and relatively limited habitat as moist crevices in rock outcrops in mesophytic forests (Bishop 1943; Gordon and Smith 1949; Gordon 1952, 1967; Cochran 1961; Woods 1969; Mount 1975; Thompson and Taylor 1985), this species should remain as a species of concern in South Carolina due to the potential for habitat destruction.

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