Assessment of "Nondeclining" Amphibian Populations Using Power Analysis

J. MICHAEL REED* AND ANDREW R. BLAUSTEIN†

*Biological Resources Research Center, and Department of Environmental and Resource Sciences, University of Nevada, Reno, 1000 Valley Road, Reno, NV 89512, U.S.A.

†Department of Zoology, Oregon State University, 3029 Cordley, Corvallis, OR 97331, U.S.A.

One of the most volatile controversies in conservation biology is whether or not amphibian populations are declining (Pechmann et al. 1991; Blausten 1994; Blaustein et al. 1994; Pechmann & Wilbur 1994). There are only two reasons that declines would not be detected in a population study: either there was no decline, or there was inadequate statistical power to detect a decline that actually was present (too few years and/or too much variance) (Cohen 1988). Statistical power is the probability that a test will yield statistically significant results—a significant trend or confidence in a lack of trend (Cohen 1988).

Blaustein et al. (1994) reviewed the available studies lasting four years or longer for amphibian population trends and listed nine populations of different species for which no significant change in population size was found (*Ambystoma opacum* was listed as fluctuating but actually was significantly increasing). Three of the studies reporting population trends used the Kendall partial-rank-order correlation (Pechmann et al. 1991) and one used the Kolmogorov-Smirnov one-sample test (Jaeger 1980); the other four studies used no statistical test (Husting 1965; Hairston 1983, 1987; Berven 1990). We calculated statistical power for these eight studies—that is, we determined if existing data were sufficient to provide statistical confidence in the assertion that there was no change in population size over time.

Statistical power can be a valuable tool for studying amphibian population declines. Power is $1-\beta$, where β is the probability of making a type II error in which the null hypothesis of "no change in population size" is not rejected when it should have been rejected. For studies of population trends, this would be the probability that a true trend is not detected. The type of population dynamics exhibited by amphibians, however (large population fluctuations due largely to environmental stochasticity), mean that many years of data will be required for statistical certainty of nondeclining status (Nicholson & Fryer 1992). This problem has been recognized in other studies of species with strong annual variation in population size (Peterman 1989, 1990). Pechmann and Wilbur (1994) expressed concern that calculating power required knowing the biological significance of a given effect size. That is, they did not want to calculate statistical power until they knew the biological significance of a given rate of decline. This is a philosophical argument regarding power. The alternative viewpoint is that the correlation coefficient is the effect size, and statistical power can be used to determine how many years of data are required to provide statistical confidence in the result (Cohen 1988).

We calculated power for Pearson product-moment correlations done on each study's data. Power tests are not readily available for the nonparametric correlations used in the four studies with statistical tests, but our calculations are an upper bound for the power of those tests. Population data were taken from tables or estimated from figures from the original studies.

Statistical power in these studies ranged from less than 0.06 to 0.45 ($\alpha = 0.05$, two-tailed; Table 1), all well below the 0.8 considered adequate for statistical certainty of protecting the Type II error rate. All studies had at least a 55% or greater chance of making a Type II error (not rejecting H_o when it was false). The low power observed is a result of small sample sizes and/or high yearly variability in population sizes. The fact that four of the eight studies presented lasted longer than 10 years indicates that species with high annual variability in population size will need extremely long studies to be certain a decline does not exist (Reed & Oring 1993). These results do not affect previous conclusions regarding declining amphibian populations. We conclude, however, that arguments for a lack of decline in populations of amphibians cannot be supported statistically.

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Table 1. Statistical power of studies that concluded no trend in population size for eight populations of amphibians.

Species	*Duration of Study (years)*	*Power*[a]	*References*
Rana sylvatica Wood Frog	4[b]	< 0.37	Berven (1990)
Pseudacris ornata Ornate Chorus Frog	12	~ 0.16	Pechmann et al. (1991)
Plethodon jordani Red-cheeked Salamander	8	~ 0.15	Hairston (1983)
Plethodon glutinosus Slimy Salamander	5	< 0.06 - < 0.25[c]	Hairston (1987)
Plethodon cinerius Red-backed Salamander	13	< 0.06	Jaeger (1980)
Ambystoma talpoideum Mole Salamander	12	< 0.06	Pechmann et al. (1991)
Ambystoma tigrinum Tiger Salamander	12	~ 0.45	Pechmann et al. (1991)
Ambystoma maculatum Spotted Salamander	5	< 0.11	Husting (1965)

[a] *Power values below 0.8 are considered inadequate for confidence in concluding that no trend was present.*
[b] *Males and females combined.*
[c] *Range comes from power tests for two study sites, each of two months.*

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