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Spatially explicit population viability analysis: a novel model applied to Mojave desert tortoises in the eastern Mojave desert

Mojave desert tortoises (Gopherus agassizii) are long-lived reptiles whose populations are threatened by numerous threats that vary markedly over the species' range. We developed a spatially explicit population viability analysis for the species across a >25 000 km2 area in the eastern Mojave desert. We used a novel technique for population viability analysis, a hierarchical mixed-regressive spatial autoregressive model, to estimate demographic rates and obtain rates of population change and then we forecasted probabilities of quasi-extirpation across the analysis area. Mean estimates of annual survival for juvenile tortoises varied geographically from 0.49 to 0.98 (overall 0.79, 95% CrI 0.39-0.97), whereas annual survival of adults was generally higher and less variable, ranging from 0.70 to 0.97 (0.86, 0.74-0.94). The rate at which juveniles transitioned to adults ranged from 0.09 to 0.11 (overall 0.09, 0.06-0.14). Juvenile survival increased as distance to the nearest city increased (standardized β = 0.30, -0.18 – 0.87), but there was no evidence of a similar pattern in adult survival (-0.04, -0.20–0.13) or juvenile-to-adult transition rate (0.03, -0.23–0.27). There was appreciable geographic variation in the estimated rate of population change (λ), which ranged from 0.89 to 1.18 (mean 1.02). Population viability of Mojave desert tortoise populations was bimodal, with most southern areas of the distribution having low (< 0.1) and most central areas having high (> 0.9) probabilities of quasi-extirpation. Independent line-distance and telemetry studies following the end of our sampling period corroborated our predictions of local population increases or declines. For desert tortoises, conservation actions are needed across much of the analysis area, and would be most beneficial when directed to improve juvenile survival, especially from the central portion of the analysis area extending to the northwest.