

Long-term occupancy monitoring of the endangered Arroyo toad in southern California: Findings, feedback loop to management, and implications of climate change.

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Since 2003, we have monitored the endangered arroyo toad (*Anaxyrus californicus*) across 87 km of habitat in three watersheds on Marine Corps Base Camp Pendleton (MCBCP), California. The multi-year species occupancy design originated as part of the Amphibian Research and Monitoring Initiative (ARMI) within the USGS and incorporates imperfect detection of the species. In this program, we monitor the presence of arroyo toad breeding populations by documenting the presence of eggs and larvae. Multi-year occupancy models show that arroyo toad population dynamics differ according to hydrology. Population dynamics within ephemeral systems are highly variable and driven by stochastic processes (i.e. amount of rainfall), while those in perennial systems are more stable and likely driven by deterministic processes (i.e. predation, competition, habitat alteration). In the perennial systems, detection of toad larvae is consistently negatively associated with the presence of non-native aquatic species, including bullfrogs, predatory fish, and crayfish. Species interaction models show that after drought years, these non-natives are temporarily extirpated from ephemeral systems, and are slower than arroyo toads in recolonizing suitable habitat. However, without drying, the non-native predators have zero probability of extinction. Additional occupancy monitoring across San Diego County has also shown a negative association between arroyo toads and the presence of bullfrogs. Therefore, long term persistence of the toads in perennial watersheds will require non-native species management. In addition, we have found that fire and scouring events with subsequent sediment deposition result in expansion of suitable breeding habitat and colonization by the arroyo toad. Finally, climate change scenarios of long term drought present a concern for persistence of the short-lived toad in ephemeral watersheds.