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U.S. Department of the Interior



Natural Resource Program Center

Monitoring Aquatic Amphibians and Invasive Species in the Mediterranean Coast Network, 2009 Project Report

Santa Monica Mountains National Recreation Area

Natural Resource Report NPS/MEDN/NRDS—2011/137

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February 2011

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Delaney, K. S., Riley, S. P. D., Ostermann-Kelm, S., and S. Hayes. 2011. Monitoring aquatic amphibians and invasive species in the Mediterranean Coast Network, 2009 project report: Santa Monica Mountains National Recreation Area. Natural Resource Data Series NPS/MEDN/NRDS—2011/137. National Park Service, Fort Collins, Colorado.

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Acknowledgments

We would like to thank the following: Cathy Schoonmaker, Joanne Moriarty, Jeff Sikich, and many wildlife interns for invaluable help with field work; California State Parks, Conejo Open Space Conservation Authority, and many other city and private landholders for land access; and Kathi Irvine for helpful discussions on the data analysis.

Introduction

Because of their proximity to the Los Angeles Metropolitan area, which hosts a regional population of over 17 million people, the Santa Monica Mountains (SMM) and Simi Hills are subjected to the stressors and impacts associated with urban areas. Ecosystem changes that result from urban encroachment include the destruction and fragmentation of breeding habitat for aquatic amphibians, degradation of air and water quality, altered stream discharge regimes, and the introduction and spread of non-native invasive species. Urbanization of as little as 8-10 percent of a watershed can have significant impacts on the distribution and abundance of native amphibians (Paul and Meyer 2001, Riley et al. 2005). A reduction in the distribution of native amphibians in the Santa Monica Mountains in association with increasing levels of urbanization and invasive species has been documented in the Santa Monica Mountains (Gamradt and Kats 1996, Goodsell and Kats 1999, Riley et al. 2005).

Aquatic amphibian species in the SMM include California newts (*Taricha torosa*), Pacific treefrogs (*Pseudacris regilla*), California treefrogs (*P. cadaverina*), western toads (*Bufo boreas*), and red-legged frogs (*Rana draytonii*). Red-legged frogs, formerly common in a number of streams in the region (De Lisle et al. 1987), now occur only in one small population within the park. Non-native species within the SMM include red swamp crayfish (*Procambarus clarkii*) from the southeastern United States, bullfrogs (*R. catesbeiana*), and a number of fish species including bass (*Micropterus spp.*), bluegill (*Lepomis macrochirus*), and mosquitofish (*Gambusia affinis*).

Monitoring of aquatic amphibians in the Mediterranean Coast Inventory and Monitoring Network (Delaney et al. in review) focuses on two metrics: occupancy (MacKenzie et al. 2003) and indices of abundance. Occupancy modeling provides a statistical framework for assessing changes in species occurrence while explicitly accounting for differences in detectability (MacKenzie et al. 2003, MacKenzie et al. 2006). Information from repeated observations at sample units (streams) is used to estimate detectability and adjust occupancy rates for imperfect detection (failure to observe a species that is actually present).

The objectives of our long-term monitoring program are to 1) determine the status and long-term trends in abundance indices and percent area occupied by juvenile and adult aquatic amphibians in streams during the reproductive season, 2) determine the status and long-term trends occupancy and abundance indices of non-native species, and 3) characterize the relationship between urbanization, non-native species and the occupancy and abundance indices of the focal native aquatic amphibians.

Methods

Sampling Design and Site Selection

In all, 58 unique locations have been identified for long-term monitoring (Figure 1). These sites include a mix of sites that have been monitored since 2000 (sentinel sites, N=22) and a suite of sites selected using generalized random tessellation stratified sampling (GRTS; Stevens and Olsen 1999, 2003, 2004) that have been monitored on a rotating basis since 2006 (“R” sites, N=36). The “R” streams are visited following a serially rotating panel design. The 36 sites are divided into 3 panels consisting of 12 monitoring sites (R1, R2, and R3). One panel is visited each year for three years. In the fourth year, R1 panel sites are revisited and so on. In 2009, sentinel sites and the R3 panel of stream sites were surveyed by the National Park Service (Table 1).

Sampling Frequency and Replication

Sampling occurs from April to August to capture the breeding seasons of target amphibians. Each sampling location are visited twice in the season: once for an intensive sampling visit, when a full suite of biological and environmental data is collected, and are revisited some weeks later for observation of occupancy by target species (native amphibians and non-native fauna). The timing of the sampling events are scheduled to coincide with species specific breeding seasons of the target amphibians, and is somewhat dependent upon year-to-year climate patterns. In very wet years the overall season for sampling may be longer than normal or drier years. Inland low elevation, low gradient streams are most likely to harbor the egg masses and/or larvae of Western toads and are sampled early in the season as these often dry up sooner than higher elevation high gradient streams. High gradient or coastal streams are most likely to harbor the larvae of California treefrogs and may be sampled later in the season.

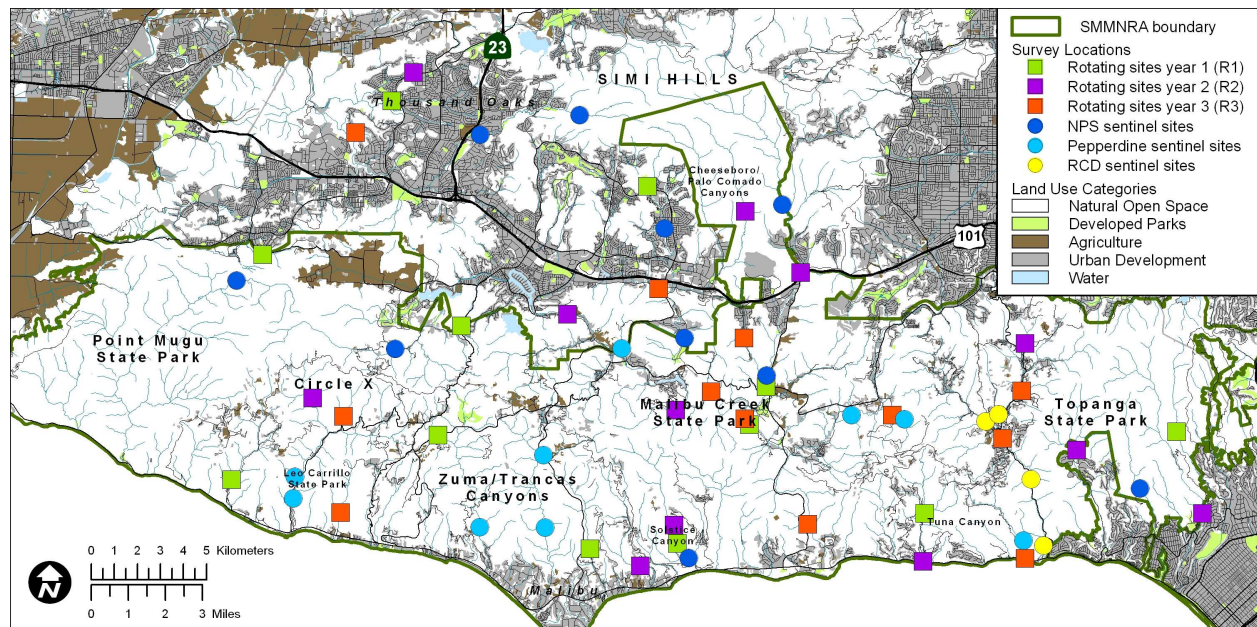


Figure 1. Study area and stream sites for all surveys monitored. Note that in 2009, NPS sentinel and “R3” stream sites were surveyed.

Table 1. Survey site names, stream codes, and dates for the intensive survey visit for 2009.

Stream Name	Stream Code	Intensive Survey Date
Arroyo Sequit (Oak Valley)	R3_ARRSEQOV	5/20/2009
Cold Creek (off Stunt Road)	R3_COLD CRK	7/1/2009
Conejo Creek (year 3)	R3_CONCRK	7/22/2009
Malibu Creek (Craggs Road)	R3_CRAGSRD	7/10/2009
Malibu Creek (at Cross Creek)	R3_CROSSCRK	7/23/2009
Ladyface	R3_LADYFACE	6/9/2009
Liberty Canyon	R3_LIBCYN	6/3/2009
Malibu Creek SP (rock pool)	R3_MALICRKSP	7/16/2009
Malibu Nature Preserve	R3_MALINP	5/21/2009
Topanga Creek (at Summit Road)	R3_TOPACRK	7/21/2009
Topanga Creek (off Topanga)	R3_TOPANGA	7/15/2009
Tuna Canyon (from PCH)	R3_TUNACYN	7/6/2009
Big Sycamore Canyon	S_BIGSYC	5/13/2009
Carlisle Canyon	S_CARLISLE	6/25/2009
Lang Ranch (N)	S_LANRNCHN	5/22/2009
Erbes (Lower)	S_LANRNCHS	5/21/2009
Las Virgenes (S)	S_LLASVIR	6/30/2009
Medea Creek (S)	S_LMEDCRK	6/4/2009
Solstice Canyon	S_SOLSCRK	6/17/2009
Temescal Canyon	S_TEMECYN	6/16/2009
Las Virgenes (N)	S_ULASVIR	5/28/2009
Medea Creek (N)	S_UMEDCRK	6/26/2009

Data Collection

There are two types of surveys done each year at each stream site; presence/absence (not detected) or occupancy sampling and intensive sampling. To confirm observations, dip nets, aquascopes, or mask and snorkel are used to find and capture larvae and adults and to verify species identification. Undersides of rocks, submerged logs and floating vegetation are searched for amphibian egg masses. Banks, exposed rocks and floating vegetation are also scanned for juvenile and adult amphibians.

- During occupancy sampling, a team of at least two surveyors begins at the designated starting point and travels upstream 250 m while recording the presence of any native amphibians or non-native target species.
- During intensive sampling, a team of at least two surveyors begins at the designated starting point, travels upstream for 250 m and collects physical and biological stream data as outlined below.

Physical Data

The field crew measures physical variables of each habitat along the length of the 250-meter stream transect. Habitat is categorized into one of four types: pool (slow to non-moving bodies of water); riffle (quick shallow moving water); run (deeper slow moving water); and dry. Every change in habitat is considered a “stop” and is recorded as a number sequentially on the field data form. Length and depth of habitat are recorded for the stream segment between stops. Length (m) is measured using a 100m tape-measure, and depth (cm) is taken at the deepest point in the habitat segment using a meter stick. Habitat conditions (e.g. vegetation type, boulders, erosion) are recorded at each site.

Using GIS, we determined the percent urbanization of the watershed upstream of each of our starting points. Areas that were considered urbanized were roads and areas closely adjacent to roads, and buildings (commercial, residential, and industrial). The urbanization area was laid over on the watershed area to calculate the percentage of the watershed that contained urbanized areas.

Biological Data

For each target amphibian species, the following are determined and recorded at each stop:

- Abundance estimates (<5, 5-20, 21-100, 101-500, >500) for larvae and juveniles; complete counts for adults and egg masses,
- Age class counts (egg, larvae, juvenile, adult).

For each invasive species, the following are determined at each stop and recorded:

- Presence/absence of fish
- Presence/absence of crayfish
- Abundance estimates (<5, 5-20, 21-100, 101-500, >500) of adult and juvenile crayfish

Data Analysis

We used linear regression to investigate the relationship of urbanization percentage in the watershed upstream of our survey sites and the number of stops in the stream survey. In this context, a high number of stops represents a high amount of habitat structure and heterogeneity, and a low number of stops indicates a more homogeneous habitat.

Naïve occupancy for 2009 was simply estimated from presence/absence data taken during the occupancy and intensive surveys conducted at each site. For analysis of occupancy, data from intensive surveys was collapsed to resemble the format of data from occupancy surveys. Single season occupancy estimates were made for each species using intercept-only, zero-inflated binomial mixture models. Occupancy and detection probabilities were estimated using maximum likelihood (MLE's) and numerical optimization. R code, adapted from Royle and Dorazio (2008; p. 117, Panel 3.8), was used to generate the point and 90% confidence interval estimates for occupancy and detection. Single season occupancy and detection did not include co-variates, therefore no model selection was needed.

Abundance data was used by calculating the number of stops in the stream that had the same abundance category. For example, we calculated the number of stops in a stream that had an abundance category of 21-100 divided by the total number of stops in a stream, resulting in a proportion of stops in a stream with an abundance category of 21-100. Also, the average number of larvae per meter was calculated for streams with and without crayfish. This was calculated by taking the lowest number from our abundance categories (e.g. 5-20), adding the numbers together, and dividing by 250m (the length of stream surveyed).

Results

Physical Data

One stream surveyed (Malibu Nature Preserve, R3_MALINP) was dry at the time of the first survey, and was not re-visited as there was no rain after the first visit of 2009. This stream was dropped from the analyses, and when R3 streams will be surveyed again, this site location will be re-visited. If it is dry again, it will be replaced with a new randomly-selected oversample site (from existing GRTS points).

Stream structure in 2009 was inversely related to the percentage of urbanization upstream ($R^2=0.1473$, $y = -0.48 + 36.4$). The number of stops (i.e. pools, riffles, or runs) decreased in streams that had a higher percentage of urbanization in the upstream watershed (Figure 2). A similar result was found previously in the Santa Monica Mountains (Riley et al. 2005).

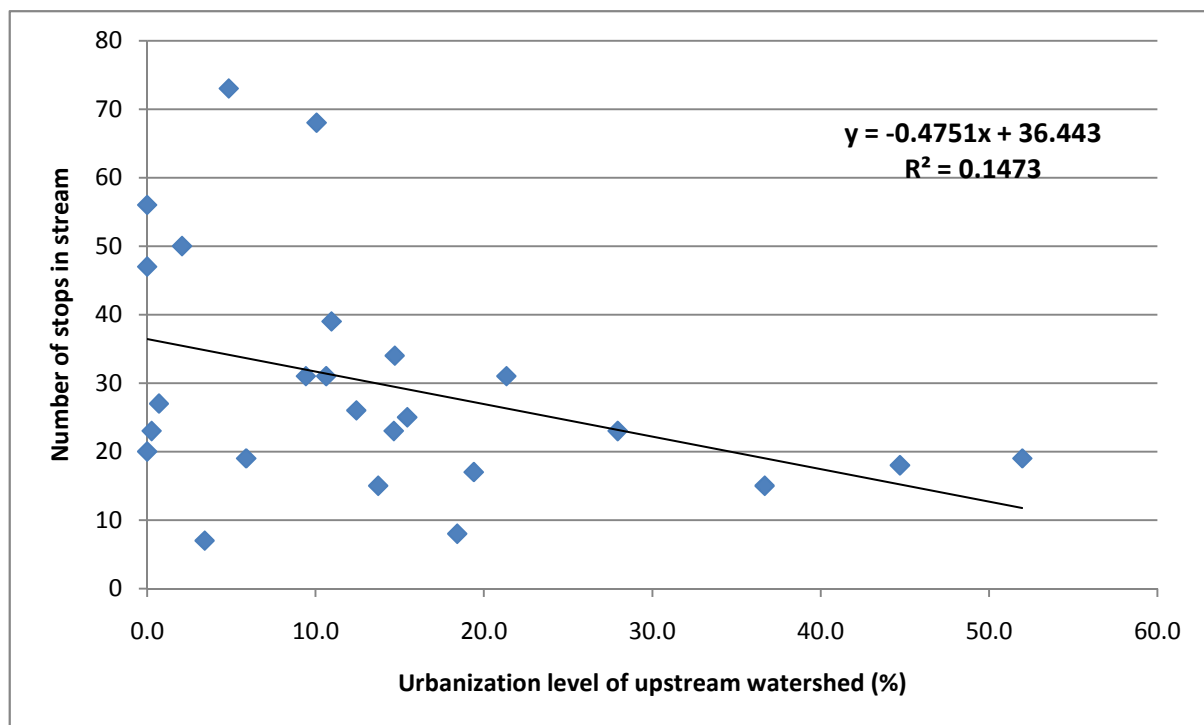


Figure 2. Number of stops in streams during 2009 as a function of the percent of the upstream watershed that was urbanized. As the amount of urbanization upstream increases, streams become less structurally complex (fewer stops per stream survey).

Biological Data

Naïve Occupancy

Pacific treefrogs had the widest distribution of all of the target amphibian species, and were present in 19 of 21 (90%) streams surveyed in 2009 (Table 2). California treefrogs were found in 4 (19%) and California newts were found in 5 (24%) of the 21 streams. The rarest species, western toads, were only found in 2 of the 21 (9%) streams surveyed. Invasive crayfish and fish

were found in about half of the streams (Table 2). Crayfish were present in 10 (47%) streams and fish were present in 11 (52%).

Occupancy appeared to be related to the presence of non-native species in our stream surveys. California newts, California treefrogs, and Western toads were not present in streams that had invasive crayfish (Table 2). However, newts and California treefrogs were found in one stream where an invasive fish was seen at one of the surveys (S_TEMECYN, Table 2). Pacific treefrog tadpoles were not found in 2 of the streams, where one had invasive crayfish and fish, and the other had only invasive fish (Table 2).

Table 2. Presence (1) or absence/not detected (0) of each target species at each stream site during the intensive (INT) or occupancy (OC) survey in 2009. The following codes were used for each species: BUBO (Western toad), HYRE (Pacific treefrog), HYCA (California treefrog), TATO (California newt), CRAY (crayfish), and FISH (any non-native fish species).

Stream Code	BUBO		HYRE		HYCA		TATO		CRAY		FISH	
	OC	INT	OC	INT	OC	INT	OC	INT	OC	INT	OC	INT
R3_ARRSEQOV	0	0	1	0	1	0	0	0	0	0	0	0
R3_COLD CRK	0	0	1	1	1	0	0	1	0	0	0	0
R3_CONCRK	0	0	1	1	0	0	0	0	1	1	1	1
R3_CRAGSRD	0	0	0	0	0	0	0	0	1	1	1	1
R3_CROSSCRK	0	0	0	1	0	0	0	0	1	0	1	1
R3_LADYFACE	0	0	0	1	0	0	0	0	1	1	0	1
R3_LIBCYN	0	0	1	1	0	0	0	0	0	0	0	0
R3_MALICRKSP	0	0	1	1	0	0	0	0	1	1	1	0
R3_TOPACRK	0	0	1	1	0	0	0	0	0	0	0	0
R3_TOPANGA	0	0	1	1	0	0	0	0	1	0	1	1
R3_TUNACYN	0	0	1	1	0	0	0	0	0	0	0	0
S_BIGSYC	0	0	1	1	0	0	1	1	0	0	0	0
S_CARLISLE	1	0	1	1	1	1	1	1	0	0	0	0
S_LANRNCHN	0	0	1	1	0	0	0	0	0	0	0	0
S_LANRNCHS	0	0	1	1	0	0	0	0	1	1	0	1
S_LLASVIR	0	0	1	1	0	0	0	0	1	1	1	0
S_LMEDCRK	0	0	1	1	0	0	0	0	1	1	1	1
S_SOLSCRK	0	0	1	1	0	0	1	1	0	0	0	0
S_TEMECYN	0	0	0	0	0	1	1	1	0	0	1	0
S_ULASVIR	1	1	1	1	0	0	0	0	0	0	0	0
S_UMEDCRK	0	0	1	1	0	0	0	0	1	1	1	1

Two other notable species were detected during the 2009 surveys. Non-native bullfrogs were found in Conejo creek (R3_CONCRK). Most notable, however, was the discovery of an adult red-legged frog (*Rana draytonii*) in North Las Virgenes creek.

Occupancy and Detectability

Estimated occupancy was high for Pacific treefrogs (HYRE), and lower for the other three species. Detectability was high for two of the four native species, with California treefrogs (HYCA) and toads (BUBO) having lower detectabilities (Figure 3).

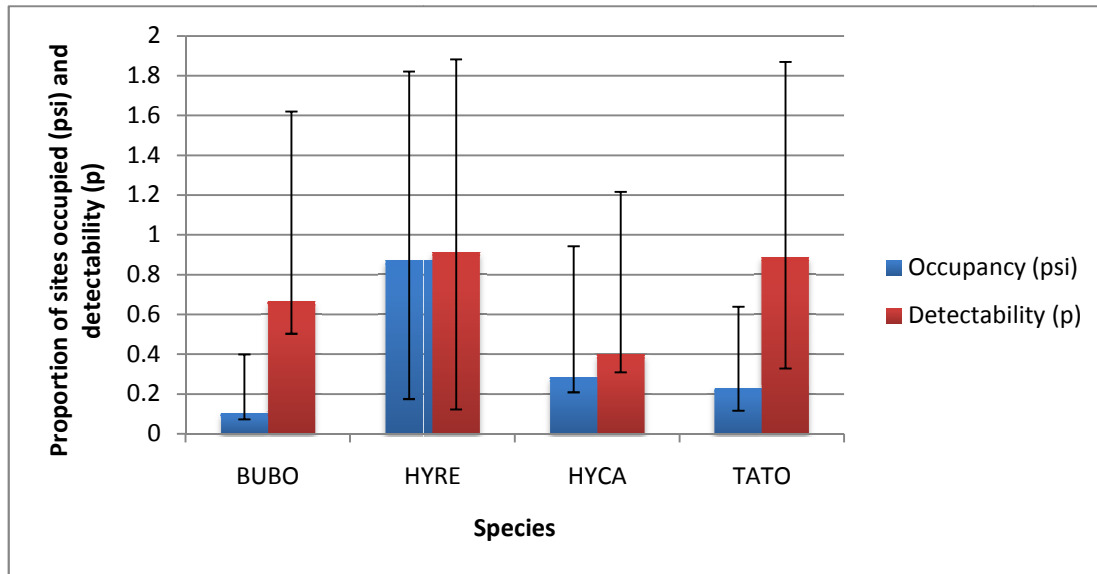


Figure 3. Single season (2009) estimate of occupancy (psi) and detectability (p) and 90% confidence intervals for native amphibians in 22 streams. The following codes were used for each species: BUBO (Western toad), HYRE (Pacific treefrog), HYCA (California treefrog), and TATO (California newt).

Abundance

The average number of Pacific treefrog tadpoles was 0.45 per meter for streams with crayfish and 1.75 per meter for streams without crayfish. Similar data was not calculated for the other three amphibian species because of their relative rarity and low abundances in 2009 surveys.

Categorical abundance data was recorded at each stream “stop” during the intensive surveys. With these data, we examined how the presence of crayfish affected abundance of Pacific treefrog tadpoles. In streams with crayfish, there were more stops with zero Pacific treefrog tadpoles than in streams without crayfish (Figure 4). In general, there were fewer tadpoles in streams with crayfish (Figure 4).

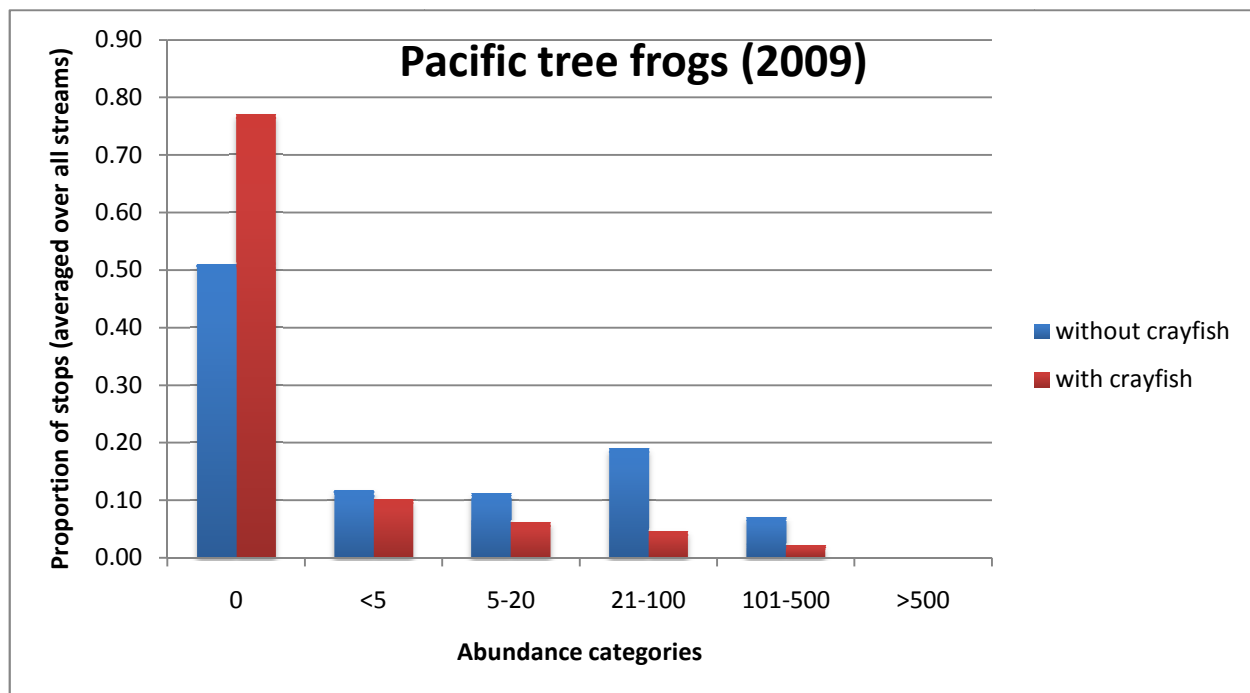


Figure 4. The proportion of stops averaged over streams with or without crayfish that contained the various categories of Pacific treefrogs.

Discussion

Results from 2009 monitoring indicate that urbanization and the introduction of exotic species may be negatively affecting amphibians in the SMM. Streams with high percentages of upstream urbanization tended to have less habitat structure in 2009 (Figure 2). Therefore, there were fewer stops or habitat changes within the surveyed segments. Past work in the SMM streams found a similar result, and found that the length of the stream that was a “run” was significantly associated with urbanization (Riley et al. 2005). Urban streams also have more permanent water (data not shown) which allows non-native crayfish and fish to persist, given that these species would die-off if streams became dry.

The naïve occupancy data clearly show that native California newts and California treefrogs are almost never found in streams with crayfish or fish (Table 2). A similar result was found for newts in SMM streams where crayfish and mosquitofish were introduced (Gamradt and Kats 1996). In that study, predation of newt larvae by the invasive species had a huge negative effect on survival. Goodsell and Kats (1999) found that mosquitofish preferred to eat Pacific treefrog tadpoles, even when mosquito larvae were present. Interestingly, Pacific treefrogs persist in almost all of our streams, suggesting that non-native predators do not severely affect the distribution of this species (Table 2). However, the presence of non-native crayfish appears to affect abundance (Figure 4). Almost four times the amount of Pacific treefrog tadpoles were found in streams without crayfish than those with crayfish (0.45 vs. 1.75 larva/m). Furthermore, only 50% of stops in streams without crayfish had zero tadpoles, whereas 80% stops in streams with crayfish had zero tadpoles (Figure 4).

Perhaps the most exciting new result from this year’s stream surveys occurred at North Las Virgenes creek, where we have been monitoring the same stretch of stream for almost 10 years. This year, we detected and reliably identified an adult red-legged frog in one of the deeper pools. This federally threatened species was once widespread throughout the region, but in recent times the only known population in or near the park was a small population of about 25 adults in East Las Virgenes creek, a tributary of Las Virgenes. This is the first new detection of this rare species in the park since the stream surveys began. The detection and location were reported to the U.S. Fish and Wildlife Service (USFWS) and the California Natural Diversity Database.

Future directions

The draft monitoring protocol for aquatic amphibian monitoring (Delaney et al., in review) is anticipated to be finalized and published in FY2011. The draft protocol incorporates models to evaluate annual status and long-term trends in occupancy. Additionally, New Zealand mudsnails (*Potamopyrgus antipodarum*) will be added to our data sheets and used as a new covariate in occupancy modeling.

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