



Protocol for Monitoring Aquatic Amphibians in the Mediterranean Coast Network

Santa Monica Mountains National Recreation Area

Natural Resource Report NPS/MEDN/NRR—2011/474



ON THE COVER

(Pacific treefrog, *Pseudacris regilla*)

Photograph by: Katy Semple Delaney, National Park Service, Santa Monica Mountains
National Recreation Area

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Executive Summary

The streams of the Santa Monica Mountains and Simi Hills region of Southern California have been subjected to the impacts of urbanization since the early 20th century. Water quality and quantity changes have been documented, as well as the establishment of exotic plant and animal species. Our monitoring efforts have shown that the percentage of urbanization in the watershed significantly affects the distribution of our native amphibians and invasive species. 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.

This monitoring protocol establishes standardized techniques to annually monitor occupancy and relative abundance of native and non-native species during the amphibian breeding season. Monitoring consists of surveying stream site locations two times each year during the breeding season: one intensive survey where habitat characteristics counts of species are recorded and one presence/absence only survey. The two surveys combined provide us with estimates of occupancy and detectability for four focal native amphibians, as well as non-native species that have invaded the local waterways. In addition, one of the yearly surveys provides information about relative abundance of larval amphibians. There are also two types of monitoring sites: 1) sentinel sites that have been monitored for over 10 years and 2) randomly selected sites that are monitored on a three-year rotation but provide extensive spatial coverage throughout our study region. A wildlife biologist at Santa Monica Mountains National Recreation Area (SAMO), who is partially funded by the Inventory and Monitoring Program, leads the monitoring project and coordinates surveys on a yearly basis. Most surveys are completed by SAMO staff, however partners Pepperdine University and Resource Conservation District of the Santa Monica Mountains (RCDSMM) conduct surveys at some sentinel sites. The protocol and accompanying SOPs provide the strategy, sampling design, field methodologies, and data analysis procedures for monitoring aquatic amphibians within the Santa Monica Mountains National Recreation Area (SAMO).

Long-term and regular monitoring will allow us to detect changes in occupancy and relative abundance in relation to changes in urbanization pressures and climate change. Trends in occupancy and detectability will be analyzed and the results will be presented in a trend report on a three-year cycle. Relative abundances will be used to examine trends in reproductive output that are potentially associated with urbanization and exotic species. The results of our monitoring can be used to inform management decisions in the watersheds of the Santa Monica Mountains.

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Background and Objectives

The purpose of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. As part of the NPS's effort to improve park management through greater reliance on scientific knowledge, the primary role of the I&M Program is to collect, organize, and make available natural resource data and to contribute to the NPS institutional knowledge by transforming data into information through analysis, synthesis, and modeling of specific key vital signs. The I&M Program defines vital signs as a subset of physical, chemical, and biological elements and processes of park ecosystems that is selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

The five goals of the I&M Program are to:

1. Inventory the natural resources and park ecosystems under NPS stewardship to determine their nature and status
2. Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments
3. Establish natural resource inventory and monitoring as a standard practice throughout the NPS system that transcends traditional program, activity, and funding boundaries
4. Integrate natural resource inventory and monitoring information into NPS planning, management, and decision making
5. Share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives

These goals are accomplished through park-wide inventories and a long-term monitoring program. In establishing a Service-wide natural resources I&M Program, the NPS created networks of parks that are linked by geography and shared natural resource characteristics. Working within and across networks improves the efficiency of inventory and monitoring because parks are able to share budgets, staffing, and other resources to plan and implement an integrated program.

The Mediterranean Coast Network (MEDN) is one of 32 monitoring networks across the NPS. The MEDN is comprised of three NPS units: Cabrillo National Monument, Channel Islands National Park, and Santa Monica Mountains National Recreation Area (SAMO).

The MEDN Vital Signs Monitoring Plan (Cameron et al. 2005) provides the foundations for the long-term ecological monitoring programs of the network and describes the rationale and basis for the programs. This protocol provides the strategy, sampling design, field methodologies, and data analysis procedures for monitoring aquatic amphibians within the Santa Monica Mountains National Recreation Area (SAMO).

Rationale for Monitoring Aquatic Amphibians

While much of the Santa Monica Mountains are protected parklands, their proximity to the Los Angeles Metropolitan area, which hosts a regional population of over 17 million people, has subjected them to 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, alteration of 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 (Riley et al. 2005), invertebrates, and fish communities (Paul and Meyer 2001). A reduction in the distribution of native amphibians 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).

Native aquatic amphibian species in the Santa Monica Mountains include California newts (*Taricha torosa*, TATO), Pacific treefrogs (*Pseudacris regilla*, formerly *Hyla regilla*, HYRE), California treefrogs (*P. cadaverina*, formerly *H. cadaverina*, HYCA), western toads (*Bufo boreas*, BUBO), and red-legged frogs (*Rana draytonii*; Appendix A). 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. Exotic aquatic species within the Santa Monica Mountains include red swamp crayfish (*Procambarus clarkia*) from the southeastern United States, bullfrogs (*Rana catesbeiana*), and a number of fish species including bass (*Micropterus* spp.), bluegill (*Lepomis macrochirus*), and mosquitofish (*Gambusia affinis*). In addition, invasive New Zealand mudsnails (*Potamopyrgus antipodarum*) have recently been found in many streams of the Santa Monica Mountains and surrounding areas (Appendix A).

The Santa Monica Mountains ecosystem is experiencing significant changes in water quality and quantity. Historically most streams in southern California were dry in the summer and fall. Continuous flow mingled with sporadic episodes of extreme flow was the norm only during the cool wet winter and spring months. Native species that are dependent on stream ecosystems for their survival, particularly amphibians and invertebrates, are well adapted to the wet/dry pattern of these streams. However, in the last few decades many streams in southern California have seen an increase in flow duration. Streams that once flowed only seasonally now flow year-round. There are several different reasons why this might be true, including increased urban run-off and removal of native riparian vegetation (B. Hibbs and P. Rundel, personal communications). The shift from intermittent to perennial flow in some streams has allowed invasive non-native species that require year-round water, such as crayfish, bass, and bluegill to colonize and thrive.

Negative effects of introduced species have been documented for many species of amphibians (Kats and Ferrer 2003, and references therein). Specifically in the Santa Monica Mountains, the introduction of invasive fish and crayfish has had a negative impact on native amphibians in the park. In lab and field experiments, the survivorship of Pacific tree frog tadpoles from Santa Monica Mountains streams was severely reduced in the presence of non-native mosquitofish, whether mosquito larvae were present or not (Goodsell and Kats 1999). In two surveys done 10 years apart in the same 10 streams, California newts disappeared from 3 of the 10 streams where they were formerly found after the introduction of crayfish, mosquitofish or both (Gamradt and Kats 1996). Also, in field and lab trials survivorship of newt egg masses and larvae was significantly reduced in the presence of crayfish (Gamradt and Kats 1996).

Water quality, in particular the amount of contaminants and pesticides, has been suggested as a possible cause of world-wide amphibian decline (Blaustein and Wake 1990, Kiesecker 2002,

Blaustein et al. 2003, Davidson 2004, BeeBee and Griffiths 2005, Bishop et al. 2010, Westman et al. 2010). Two of these studies were conducted on two of our native species. In British Columbia, a study compared hatching success of Pacific treefrog and Western toad eggs in organic and conventionally sprayed orchard ponds. In the orchard ponds that were sprayed with 17 common pesticides, hatching success was lower in both species (Bishop et al. 2010). In lab tests using 3 of the pesticides at environmentally relevant concentrations, it was observed that Pacific treefrog tadpoles died, behaved differently, and had different tail morphologies than the control group (Westman et al. 2010). Red-legged frogs in California showed that they were significantly less likely to occupy historic sites with increasing upwind pesticide use (Davidson 2004). Although we do not test for specific agricultural chemicals in our streams, we do collect data on many chemical components that can lead to increased toxicity, stream eutrophication, or an increase in acidity (see SOP 4, Table 4.2). Water quality testing of the streams within the Santa Monica Mountains and Simi Hills includes testing for ammonia, nitrite, and nitrates, which are toxic in high doses. Under natural conditions, it is unknown how toxic these chemicals are to our aquatic amphibians. However, anthropogenic inputs of nitrogen (N) and phosphorous (P) from garden or commercial fertilizers can cause eutrophication in streams (Smith et al. 2006, Mann et al. 2009). Eutrophication can cause changes in food web structure by increasing primary productivity (Smith et al. 2006), but can also perturb the natural life cycle of parasites and their hosts, leading to increased pathogenic infection rates of amphibians, which then causes limb deformations (Johnson et al. 2007). Acidification (lowered pH) caused mortality or sublethal effects, such as slow swimming, in salamander larvae (Green and Peloquin 2008). These studies indicate that survival and population persistence may be linked to water quality in amphibians.

Because of their moist and highly permeable skin, unshelled eggs, aquatic and terrestrial life histories, restricted home ranges, and limited dispersal abilities, amphibians generally are considered to be good indicators of ecosystem health (Blaustein et al. 1994, Welsh and Ollivier 1998, Beasley et al. 2002). The life history requirements of species that inhabit both wetland (streams) and upland habitats can provide useful indication of the health or condition of the overall landscape. Additionally, several species of amphibians are known to be sensitive to environmental stressors and are considered good indicators of ecosystem health (cf. Blaustein and Wake 1990). For these reasons, aquatic amphibians (frogs, newts, and toads) were selected as a “vital sign” for Santa Monica Mountains National Recreation Area (SAMO) as part of the Mediterranean Coast Network of the NPS Inventory and Monitoring Program.

History of Amphibian Monitoring in the Santa Monica Mountains

In 2000, prior to the initiation of the Mediterranean Coast Network of the Inventory and Monitoring Program, park staff at SAMO, in consultation with local and regional wildlife experts, implemented an inventory of the reproductive success and population status of amphibians in SAMO. This 5-year inventory was intended to assess the relative abundance, distribution, and reproduction of amphibians that require standing or flowing water for breeding. Streams were selected for sampling by resource managers and other stakeholders for their intrinsic value as amphibian habitat and their potential to provide information on streams from within highly developed or undeveloped watersheds.

The inventory, conducted in 2000-2004 by the NPS in cooperation with Pepperdine University and the Resource Conservation District of the Santa Monica Mountains (RCD), documented the

distribution and relative abundance of aquatic amphibians in streams during their spring and early summer breeding season. Counts of adults, egg masses, larvae, and juveniles were done. Presence and abundance of invasive species was noted, the physical characteristics of these streams were recorded, and basic water quality parameters were measured. The inventory effort provided experience and baseline data that guided development of this long term monitoring plan (cf. Riley et al. 2005).

Monitoring Goals and Objectives

The overall objective of this protocol is to determine the status and long-term trends in the distribution and relative abundance of aquatic amphibians throughout the coastal, mountains and inland resource management zones of SAMO, in addition to the influence on native species of urbanization, water quality, and the presence and abundance of non-native species. In addition, monitoring of stream environmental and physical features that may influence amphibian distribution and abundance can be used as a measure of overall ecosystem health. This protocol complements concurrent monitoring of terrestrial reptiles and amphibians (Busteed et al. 2006) and stream water quality (Hibbs et al. in prep.) in the Santa Monica Mountains.

Specific Monitoring Objectives to be addressed by the protocol include:

- Determine the status and long-term trends in percent area occupied by larvae, juvenile, and adult aquatic amphibians (HYRE, HYCA, TATO, and BUBO) in streams throughout SAMO (excluding the Eastern urban zone) during the breeding season.
- Determine the status and long-term trends in indices of abundance for larvae, juvenile, and adult aquatic amphibians in streams throughout SAMO (excluding the Eastern urban zone) during the breeding season.
- Determine the status and long-term trends in occupancy and abundance of non-native species, including crayfish, non-native fish, and New Zealand mud snails in streams throughout SAMO (excluding the Eastern urban zone) during the breeding season.

Sampling Design

In this section we provide a brief overview of the sampling design. Further information about the sampling design and power analysis is provided in standard operating procedures (SOPs) 1, 2 and 9.

Sampling is the process of selecting some portion of a population to observe so that a state variable may be estimated for the population as a whole. In sampling, the opportunity exists to deliberately select the sample in an attempt to avoid many of the factors that make data unrepresentative of the population. The procedure by which a sample of units is selected from the population is the sampling design (Thompson 2002).

The two critical aspects of sampling animal populations are: spatial variation and detectability. Spatial variation is important because in most studies and monitoring programs, the entire target population cannot be surveyed. Consequently, samples must be drawn in a way that allows statistical inference to the locations not surveyed and therefore the entire area of interest. Probability-based selection procedures (e.g., random sample or systematic sample) are used in natural resource situations because they provide the foundation for valid statistical inference to a larger population of interest and they are necessary for unbiased estimates of the population mean or total and design-unbiased estimates of variability. The key characteristic of probability-based sampling designs is that all locations within the study area have some positive and known chance of being selected.

Another source of variability that is important in sampling design is detectability. Detectability refers to the fact that a species may be present, but not detected during a survey. Few species are so conspicuous that detectability is one, meaning they are always detected at every survey. Instead, a count statistic is obtained (e.g., number of animals seen or heard) and a statistical method is used to estimate the detection probability associated with the count statistic (MacKenzie et al 2002). Most abundance estimators are comprised of count statistics divided by estimated detection probabilities (Seber 1982). Using an index of abundance (a count statistic without accounting for detection probabilities) is not recommended because changes in the count may be the result of random variations or changes in detectability, rather than actual changes in population numbers.

Target Population

While SAMO has a distinct and permanent administrative boundary, more than 50% of the land within the park is privately owned. Some of this private land within the park boundary is developed, and the park is surrounded by intensive urban development. In addition, many SAMO parklands are adjacent to state and local park lands. Land uses within and surrounding the Santa Monica Mountains can have significant influences on protected lands inside the boundaries of the park. With this in mind, the Santa Monica Mountains Resource Management Zone (RMZ) has been identified as an area of significant ecological breadth. Within the RMZ, local, state, and national park managers operate to coordinate management activities to best meet the NPS mandate to maintain the natural resources for future generations. The target population for this protocol is the aquatic amphibians within the Santa Monica Mountains Resource Management Zone, excluding the Eastern Urban section (Figure 1).

Stratification

The estimation of population state variables will be most precise if the population is stratified so that within each stratum, the units are as similar as possible (Thompson 2002). Our sampling design includes stratification of the RMZ into four ecological regions based on physical features, vegetation, coastal influence, elevation, and development. The four regions include: 1) Lower elevation inland Santa Monica Mountains and Simi Hills (Inland, primarily chaparral vegetation); 2) Upper elevation Santa Monica Mountains (Mountains, primarily chaparral vegetation), 3) Immediate coast (Coastal, primarily coastal sage scrub), and 4) Eastern Urban (very fragmented habitat; see Figure 1). The eastern urban region was eliminated from the eventual sites selection process because of access and ownership limitations, small overall size, and its high proportion of development coupled with the logistics associated with working in this area. Therefore, the coastal, mountain, and inland regions are relevant to the status of amphibian populations within the streams of the Santa Monica Mountains RMZ, and provided the basis for stratifying a random selection of monitoring sites across the RMZ. Stratification allowed for a proportion of sites to be selected in locations proportionate to lands within the Santa Monica Mountains and Simi Hills.

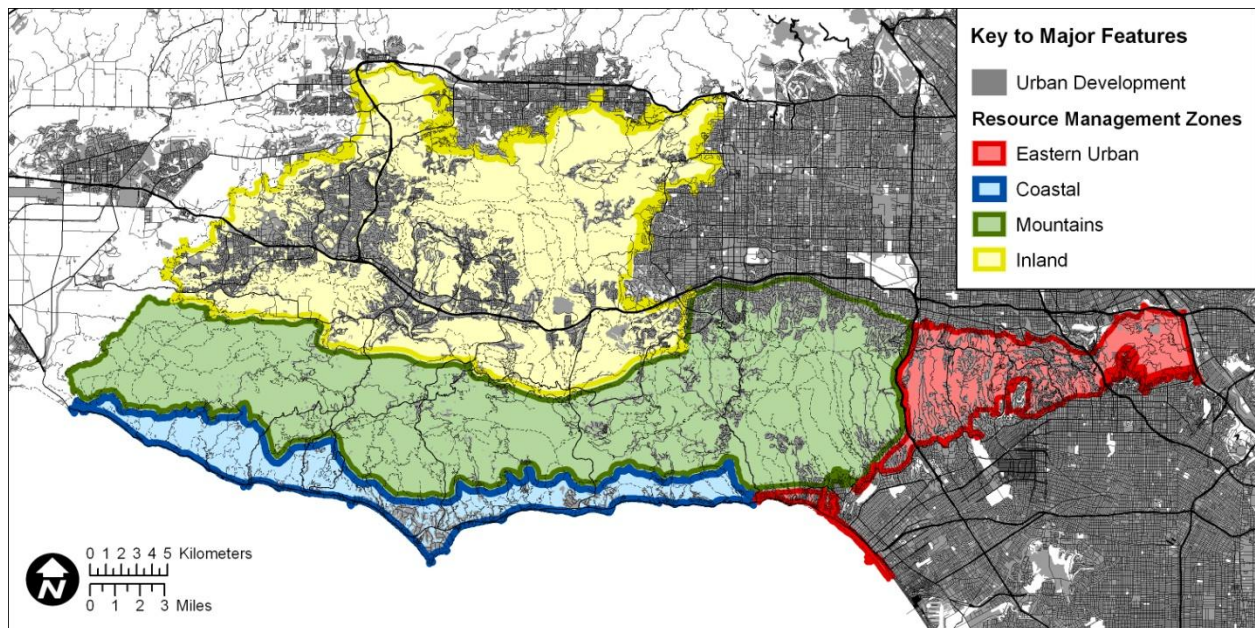


Figure 1. Four ecological regions within the Santa Monica Mountains Resource Management Zone.

Inventory (Sentinel) Sites

Objectives for identifying sampling locations for the 2000-2004 inventories of aquatic amphibians included sampling all of the larger, mostly perennial streams, within the Santa Monica Mountains and Simi Hills. These also included streams with significant development within the watershed, and some larger streams that had survey sites above and below major urban barriers such as freeways or intense development. After selection, the degree of urban development within the upstream watershed of each of the selected streams was determined and streams were categorized as either natural or urban (8-10% or more of the land in the upstream watershed is developed; Riley et al. 2005). Criteria dictating the selection of the specific site along the stream included several factors: all sample locations were located on public lands, had

reasonable and safe access from established roads or trails, and had flowing water between April and August in all but the very driest of years.

Twenty-two of the 37 inventory sites surveyed during 2000-2004 will continue to be monitored annually (sentinel sites, Figure 2); 10 by the NPS, nine by Pepperdine University, and three by the Santa Monica Mountains Resource Conservation District (RCD). Pepperdine University and the RCD will continue to monitor the streams they monitored during the baseline inventory effort. The 10 streams to be sampled by the NPS represent a subset of the streams originally inventoried by the NPS. For the purpose of this protocol, these 10 streams (and the streams monitored by our partners) are called “sentinel” streams. Elimination of some of the original streams in the NPS program was necessary to broaden the inference landscape of monitoring results by incorporating streams from randomly-selected grid cells into the program.

GRTS Selected Sites

Thirty-six additional monitoring sites were selected using generalized random tessellated stratified (GRTS) methods (Stevens and Olsen 1999, 2003, 2004). A map of cells that included stream segments was created by overlaying a grid of 2.25 km² cells (1.5 km on a side) over the RMZ. Cells that had less than 50% protected park lands, contained no intermittent or perennially flowing streams, or already had sentinel monitoring sites located within them were eliminated. After cells were selected, sites were visited and accessibility was assessed. If a site contained geophysical characteristics such as extremely steep banks so that access to the stream was unsafe, it was eliminated after the site visit. Such constraints on the sampling frame composed of stream segment cells was thought necessary because a blind and fully random selection of monitoring sites along streams would result in the majority of sites not meeting the safety, access, and presence of perennial water criteria or because of vegetation and topography would be unreachable or they would be located on private lands. The safety and access restrictions made on the sampling frame reduce the sampled population to a subset of the desired target population, but this is a common and necessary trade-off for long-term monitoring programs, and only reduces our scope of inference based on the probabilistic sites.

A spatially random selection of 36 cells was made from the final sampling frame of cells stratified within the RMZ eco-regions by GRTS methods running on the open source statistical software package R (see the U.S. E.P.A. Aquatic Resources Monitoring web page, <http://www.epa.gov/nheerl/arm/>, accessed July 13, 2006). If the majority of a cell (>50%) contained land within a particular strata, it was named to that strata (mountain, inland, or coastal). The number of cells selected from each eco-region was proportionate to the total number of cells meeting the sampling criteria within each eco-region. A total of 12 cells were identified from the Inland region, 18 from the Mountains region, and six from the Coastal region (Figure 1).

To accommodate the possibility of eliminating one or more cells because of unknown or unexpected conditions in accessing the cell an additional thirty-six “over-sample” (GRTS terminology) cells were identified by the GRTS program. Over-sample cells were selected from each region in the same proportion as the primary sites. Over-sample cells can replace primary cells and maintain spatial randomness if added in the order in which they are generated by the program.

Within each grid cell, starting points were selected for stream segments of 250-meters in length to be surveyed. It was required that each survey start site had to be accessible from a road or trail, and could be safely navigated by the survey team. We assume that the final selected stream segments based on safety and logistical constraints are representative of those stream segments that were not surveyed within a grid cell. Site locations were recorded using a Global Positioning System receiver (GPS). This information is stored in the stream survey database managed by the MEDN data manager. If there was no point within a selected cell where a stream could be sampled, then it was dropped from the panel and the next available over-sample cell within the same region was added. Over-sample sites can be adopted in the future if stream morphology changes for any reason and the stream becomes perennially dry (i.e., climate, development, etc.).

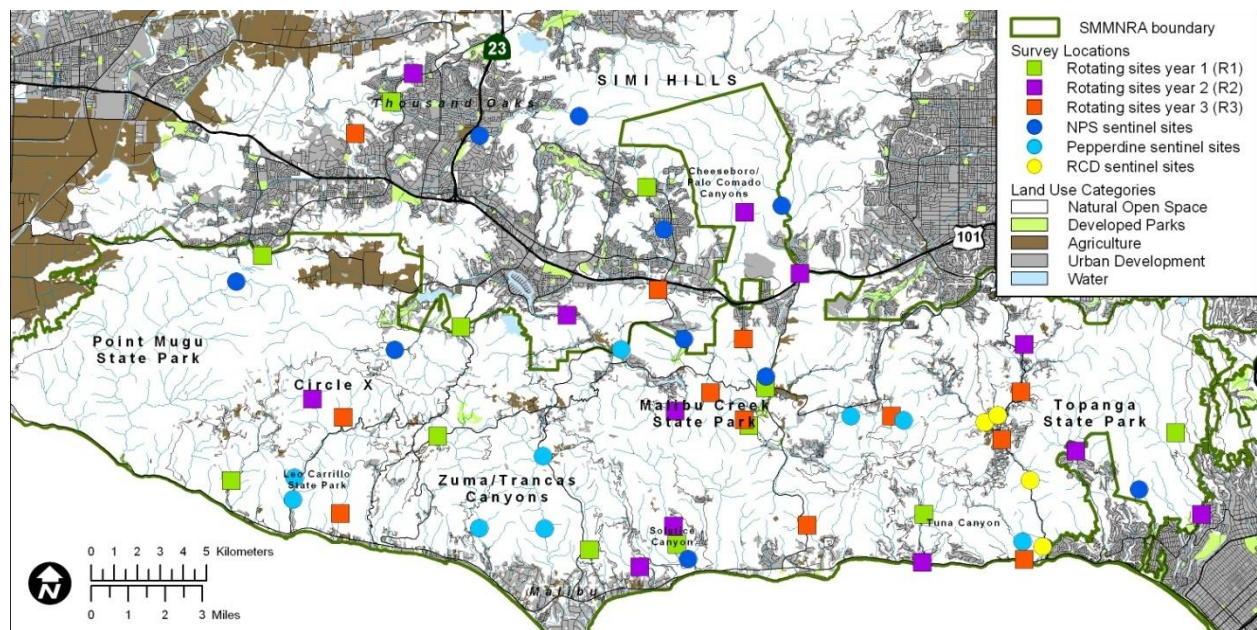


Figure 2. Site locations for stream surveys within the Santa Monica Mountains and Simi Hills. Sentinel sites are surveyed by NPS, Pepperdine University (PEP) and the Resource Conservation District of the Santa Monica Mountains (RCD). Rotating randomly-selected sites are surveyed by NPS.

Revisit Design

The temporal revisit design used is summarized in Figure 3 and Table 1. The GRTS monitoring stations are visited following a rotating panel design (Fuller 1999). Each panel includes four cells from the lower elevation region, six from the upper elevation region and two from the immediate coast region. Using the notation introduced by McDonald (2003) we use a [1-2] revisit design as in Table 1. A panel is visited in one year, rests for two years, and then is revisited in the third year. The sentinel sites are visited every year (always revisit design; [1-0] design).

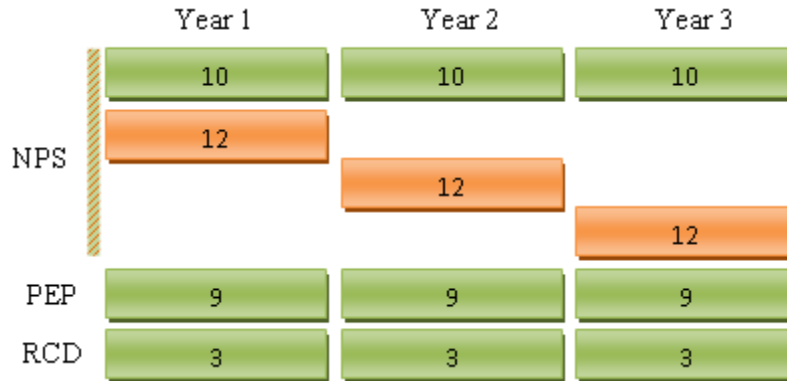


Figure 3. Number of sites surveyed during each year by the National Park Service (NPS), Pepperdine University (PEP) and Resource Conservation District of the Santa Monica Mountains (RCD). Sentinel sites are in green and rotating sites (R1, R2, R3) are in orange.

Table 1. Revisit design for stream sites in the Santa Monica Mountains and Simi Hills. Sentinel sites are surveyed every year by the National Park Service (NPS), Pepperdine University (PEP) and Resource Conservation District of the Santa Monica Mountains (RCD). A stratified random design was used to select 36 streams from three ecological zones, resulting in 3 panels of 12 streams each to be sampled by NPS on a three year rotation (Rotating Sites). The 36 streams were selected using a stratified GRTS draw with proportional allocation.

		Year		
Sentinel Sites		1	2	3
All Years	NPS sites	10	10	10
All Years	PEP sites	9	9	9
All Years	RCD sites	3	3	3
Rotating Sites				
Year 1	Coastal Zone	2		
	Mountains Zone	6		
	Inland Zone	4		
Year 2	Coastal Zone		2	
	Mountains Zone		6	
	Inland Zone		4	
Year 3	Coastal Zone			2
	Mountains Zone			6
	Inland Zone			4

Recommended Seasonal Window for Sampling

Sampling occurs from April to July to capture the breeding seasons of target amphibians. Each sampling location is visited twice in the season: once for an intensive sampling visit, when a full suite of biological and environmental data is collected, and once for observation of occupancy by target species (native amphibians and non-native fauna; see SOP 4).

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 or larvae of *Bufo boreas* 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 *Pseudacris cadaverina* and may be sampled later in the season since this species breeds later in the season. Egg masses of *Taricha torosa* are more likely to be found early in the season, whereas *Pseudacris regilla* will reproduce throughout the entire survey period. In addition, sampling visits are scheduled in response to weather conditions i.e., onset of rainy season.

Response Design

We will monitor the percent area occupied or occupancy (sensu MacKenzie et al. 2002) of native amphibians and non-native species in the Santa Monica Mountains streams to detect changes in the status of our target species. Occupancy uses information about whether the species is present or absent at individual sites to estimate the percent area occupied across the sampling frame.

Occupancy models were designed to overcome the problems created by variation in detectability (MacKenzie et al. 2002, 2003, 2006). Occupancy models use information from repeated observations at the same site to estimate detectability. There are two probabilities incorporated into the models, ψ is the probability a site is occupied by the target species, and p is the probability of detecting the species during a re-visit survey given that it is present.

The response design methodologies proposed herein are designed to assess occupancy and indices of abundance for amphibians in streams of the Santa Monica Mountains. In each sampling season streams are visited twice, once for the “intensive” survey and once for the “occupancy” survey. During the intensive survey, general demographic data are collected on amphibian and non-native fauna abundance (counts of egg masses, larvae, juvenile, and/or adults) in relationship to stream morphology (e.g., riffle, run, or pool) along a 250-meter section of stream. During the occupancy survey, only the presence or absence of target species (amphibians and non-native invasive fauna) is noted along the same 250-meter section of stream.

Data on stream water quality has been collected at each sampling site coincident with amphibian monitoring since 2000 according to the draft fresh water monitoring protocol developed by the MEDN and cooperators at California State University, Los Angeles. The draft MEDN water quality monitoring program incorporated the aquatic amphibian survey sites in its sampling design, providing data three times per year on stream water chemistry, which may help understand the status and trends in selected monitoring criteria for amphibian populations. Although the MEDN water quality monitoring program is currently being revised, a goal of the revised program will be to provide water quality data that complement the amphibian monitoring described in this protocol. Water quality data will be used as covariates in data analysis of site occupancy data.

Field Methods

Field Season Preparations and Equipment Setup

In February or March of each year, staff from the NPS, Pepperdine University, and RCD will meet to plan the coming stream survey season. Coordination of field methods, stream conditions, and a general update of research findings and ideas will be discussed at the meeting. Personnel conducting sampling will need to make field preparations and gather all survey equipment and supplies as described in SOP 3.

At the beginning of each field season, it is essential that all field equipment is in working order and thoroughly cleaned prior to use. Field crews should coordinate their sampling schedule with the water quality monitoring program to insure that one of the 3 annual water sampling events occurs coincidentally with amphibian monitoring.

Sequence of Events during Field Season

Each sampling location is visited twice during the breeding cycle: one “intensive” (formerly called “Apex”) sampling visit and one “occupancy” (formerly called “PAO”) sampling visit. In the occupancy sampling visit, a 250-meter length of the selected stream reach is surveyed (see SOP 4). The occupancy sampling visit is conducted to document the presence or absence of each aquatic breeding amphibian species and relevant invasive species. Intensive visits also survey the same 250-meter length of the selected stream, however, more detailed data for estimating abundance indices are recorded for focal amphibian and non-native species (see SOP 4).

Data Collection

Intensive Sampling

Physical Data

As explained in SOP 4, at each site, personnel identify habitat conditions (e.g., overhead vegetation type, boulders, erosion), and record their observations on the “Stream Survey Field Form” (Appendix B). The field crew then 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 (no standing water). Every change in habitat (e.g., from a riffle to a pool) is considered a “stop” and is recorded as a number sequentially on the field data form. Length and depth of each habitat segment are recorded for the stream segment between stops. Length (m) is measured using a 100-m tape measure, and depth (cm) is taken at the deepest point in the habitat segment using a folding 2-meter stick ruler. Overhead vegetation type and the presence of boulders is also noted at each stop.

Biological Data

For each amphibian species, data is recorded on the “Stream Survey Field Form” (see SOP 4, Appendix B). The following biological data are collected at each stream “stop”:

- Abundance estimates (<5, 5-20, 21-100, >100) for larvae and juvenile *Pseudacris regilla*, *Pseudacris cadaverina*, *Taricha torosa*, and *Bufo boreas*.
- Abundance estimates (<5, 5-20, 21-100, >100) for larvae, juveniles, and adult crayfish, and invasive fish.
- Actual counts of adult *Pseudacris regilla*, *Pseudacris cadaverina*, *Taricha torosa*, and *Bufo boreas*.
- Actual counts of *Taricha torosa* egg masses.

To maximize detection probabilities during intensive surveys, 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.

Occupancy Sampling

Because the primary objective of the occupancy sampling visit is to confirm the presence or absence of target amphibian and non-native focal species, the sampling strategy is less intensive, enabling the field crew to conduct the survey more quickly. As described in SOP 4, once the transect start point in a stream has been located, field crews walk the 250-meter transect, recording the presence of any of the four target amphibian species (*Pseudacris regilla*, *Pseudacris cadaverina*, *Taricha torosa* and *Bufo boreas*), and non-native species including crayfish, fish, and New Zealand mud snails. At the end of the transect, the occupancy sampling visit is complete.

Water Quality Sampling

An assessment of water quality and discharge in streams of the RMZ is currently conducted through the MEDN fresh water quality monitoring program (Hibbs et al. in prep.). Because the MEDN water quality monitoring program incorporates all aquatic amphibian survey sites in its sampling design, stream water chemistry data collected three times per year will be available as covariate data for analyses of trends in amphibian occupancy and abundance. This additional sampling provides NPS managers with greater confidence in correlating water chemistry data with amphibian monitoring data, for evaluating regional and environmental differences among streams, and in evaluating trends that might be observed in amphibian distribution and abundance data. Although the MEDN water quality monitoring program is being reviewed and may be changed, one of the primary objectives of the program will be to provide water quality information to complement aquatic amphibian monitoring.

Water quality sampling is conducted in late winter, late summer, and in early spring so that one sample is taken concurrently with the breeding amphibian monitoring. Field sampling procedures, laboratory methods for water quality assessments, and data products are described in

Hibbs et al. (in prep.). Generally, three independent water samples for laboratory analyses will be collected at each site during each visit. Additionally, three independent determinations of pH, water temperature, dissolved oxygen, and conductivity will be made at each visit to each site. Measurements will be made with hand held instrumentation and will be taken at 10-meter intervals moving up stream from the primary sampling point. Parameters that are sampled include: specific conductance, dissolved oxygen, pH, temperature, turbidity, chloride, nitrate, phosphate, phosphorus, total nitrogen, and others (see SOP 4, Table 4.2).

Data Management

Data and Metadata Procedures

All data collected in the field are entered and maintained in the MEDN stream survey database. Metadata collected include date and time of stream survey, names of participants, and relevant notes or comments. Information about each stream location, physical habitat, amphibian populations, and exotic species abundance is stored in this database. All data storage and preliminary analysis will be facilitated by this database. Please see SOP 5 for detailed data and metadata management procedures.

Overview of Database Design

The SAMO stream survey database was developed in MS Access 2007 and is maintained by the MEDN Data Manager. Interactive computer screen data-entry forms are designed to meet the requirements of project managers and are based on existing field forms used to record data. The data are stored in a format that is consistent with NPS Inventory and Monitoring program guidance for the management of natural resource data (Lee 2005, see SOP 5).

The database is structured to minimize data entry errors by guiding the data entry technician through a simple two-form digital data entry process. Database structure and relationship links among data tables are presented in SOP 6.

Data Entry, Verification and Editing

Upon returning to the office, field staff enters all data from the field data sheets into the MEDN stream survey database. Once the data have been entered and saved, the data manager checks it with QA/QC reports built into the database for apparent outliers, inconsistencies in entry, null values, or any other anomalous data points (see SOP 6). Anomalies are reported to the Monitoring Project Manager for resolution. Pepperdine University and RCD are to deliver data from their stream surveys within 4 weeks of the end of their surveys. As data from monitoring cooperators is received, the MEDN data manager appends those data to the database. Any questions about the data, data entry procedures, or difficulties with the database are to be resolved by the project manager and MEDN data manager.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during quality assurance reviews.

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Monitoring Project Manager is primarily responsible for completing certification. The completed form, certified data, and updated metadata should be delivered to the network Data Manager according to the specified timeline.

Data Archival Procedures

Data entered into the MS Access database are backed up nightly and saved on a tape drive. A complete record of all stream surveys is also kept as a hardcopy at Santa Monica Mountains National Recreation Area headquarters. In addition, hard copies of all data sheets will be stored in the SMMNRA Cultural Museum Building.

Data Analysis and Reporting

Data Analysis

Data Summaries

Queries to the Aquatic Amphibian Database will be made by the Network Data Manager and data will be formatted for analysis to the extent possible before the data is passed to the Monitoring Project Manager. Tables resulting from the queries can be opened and manipulated in Microsoft Excel (see SOP 7). Data used as covariates for occupancy models and trend analysis can be queried in a similar way. Specifically, water quality data that is collected from all sites can be used as covariates. Other effects that can be explored are observer effects, year, month, or day effects, and the presence of invasive species.

Methods to Estimate Single Season Occupancy and Detectability

As described in detail in SOP 7, single season occupancy estimates will be made for each species using intercept-only, zero-inflated binomial mixture models. Only sentinel sites will be used for single-season estimates of occupancy because of the low within-year sample size for GRTS sites. Sentinel sites were selected using judgment sampling, so inference will be limited to the sentinel sites and will not be extended to the sampling population. Occupancy and detection probabilities will be estimated using maximum likelihood (MLE's) and numerical optimization.

Table 2. Occupancy and detection point and interval estimates (CI) for 2009 NPS monitored sentinel and GRTS sites combined. Estimates made from intercept only models using maximum likelihood and assuming asymptotic normality of estimates. Sample size was 22 sites (k=2, 44 surveys) for each species. Note, in future analyses, only GRTS sites will be used for trend analysis.

Species	Parameter	Point Estimate	90% CI
<i>B. boreas</i>	Occupancy	0.1023	0.0299-0.2966
	Detection	0.6667	0.1634-0.9534
<i>P. regilla</i>	Occupancy	0.8700	0.6950-0.9516
	Detection	0.9143	0.7912-0.9678
<i>P. cadaverina</i>	Occupancy	0.2841	0.0754-0.6589
	Detection	0.4000	0.0907-0.8167
<i>T. torosa</i>	Occupancy	0.2301	0.1141-0.4095
	Detection	0.8889	0.5598-0.9805

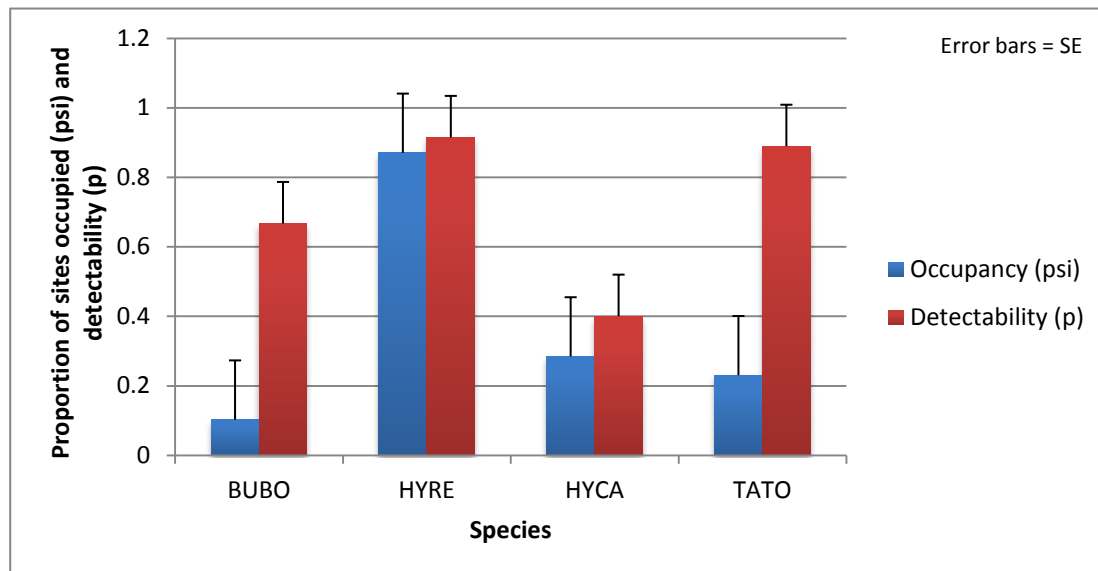


Figure 4. Single season estimation of occupancy and detectability for four target amphibian species as observed in the Santa Monica Mountains and Simi Hills in 2009 NPS monitored sentinel and GRTS sites combined.

Analysis with Abundance Indices

During the intensive stream surveys, abundance indices are taken at each stop for the larvae of the four focal amphibian species (see SOP 4). The number of stops in a stream varies due to differing stream structure. In addition, the abundance indices for any given species will vary because of stream structure, the presence of certain habitat types, the presence of invasive predatory crayfish or fish, and water quality measurements. To analyze abundance data, queries are made by the Network Data Manager to the Aquatic Amphibian Database (SOP 6). Data will be formatted for analysis by the Monitoring Project Manager. Tables resulting from the queries can be opened and manipulated in Microsoft Excel (See SOP 7, e.g., Figure 7.5). Abundance data can be presented in many ways when this type of format is used. For example, abundance data can be compared between sites and years to visualize trends (Figure 7.6).

Analysis to Detect Trend in Occupancy

Occupancy Models

As described in detail in SOP 8, periodic analysis for the trend in occupancy will be conducted at regular 3-year intervals. We will conduct a complete analysis of factors influencing occupancy of amphibians and non-native species. Trend estimates will be made using implicit, zero-inflated binomial mixture models with covariates for occupancy. The zero-inflated mixture model is appropriate because non-detections can occur at occupied sites, and the outcome is a mixture of two random processes (detection and occupancy, Royle and Dorazio 2008). The binomial response is detected/not detected. Models will be fit using maximum likelihood and numerical optimization (Moreno and Lele 2010, Starceovich and Steinhorst 2010). Separate models will be fit for each of the four focal amphibian species with water quality measurements co-located at sampling sites along with other (see above) used as covariates (Hayes and Irvine, personal communication; see SOP 8).

Given limited data availability, we assumed variability of sentinel and GRTS sites was similar, so we pooled data across panels for the initial trend and power analysis (see below). In future estimates of trend, the occupancy model will include a fixed panel effect (sentinel vs. GRTS) and a random effect for sites nested within panels. The estimate of random effect for sites nested within panels will be possible after two replicate samples of GRTS sites have been made (i.e., six years). A global test for trend effect will be conducted first. When the global test is significant, park-wide inferences will be made by testing for trend effects within GRTS sites. Sentinel site inferences will be made by testing for trend effects within sentinel sites.

Cumulative changes in occupancy from sampling period to sampling period may indicate a trend in distribution of target species. Increases in the occupancy distribution of target amphibians could be a positive indicator of species health or habitat value. Decreases in occupancy could indicate the opposite and signal the need for some protective or restorative management action. Increases in the occupancy of invasive crayfish or fishes would raise a red flag indicating again the need for some management action to protect amphibian species that might be displaced or affected by the expansion of these non-native species.

Control Charts

Control chart analysis may also be used to evaluate trends in data over time. Control charts are chronological graphs of process data that are used to help understand and control processes and are frequently used in quality control analyses

(<http://www.itl.nist.gov/div898/handbook/pmc/section3/pmc3.htm> accessed September 24, 2010) Proportions control charts or “P charts” can evaluate the change in proportion based upon presence/absence data (Figure 4).

To analyze data in this way, the proportion of streams occupied by a focal species must be plotted for each year of the analysis. This is then compared to the overall average proportion from all years (± 3 standard deviations, σ , around the average). As an example, we created a P control chart for *T. torosa* from surveys done between 2000-2005 (Figure 5). A review of the control chart analysis indicates that the average number of streams where TATO occurs from year to year is within the limits of natural variation and while a slight upward trend in the number of sites occupied is apparent (blue line, Figure 5), it is not significant within the limits of the data collected between 2000-2005. In general points outside the 3σ limits are “out of statistical control” and indicate that non-random variation may be present and acting on the process or condition being evaluated. A process “in statistical control” is one where only random or natural variation is present.

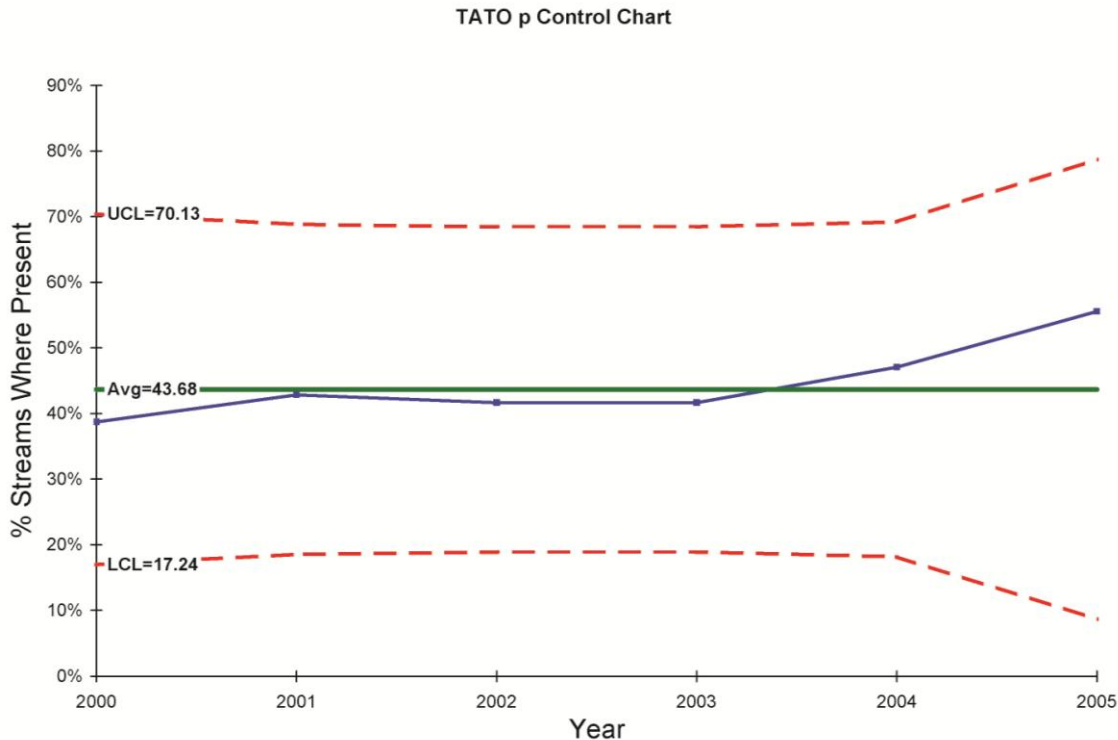


Figure 5. P control chart for *Taricha tarosa* (TATO) across all streams surveyed from 2000 through 2005. Yearly proportion of streams where TATO is present is shown as a blue line. The values for the average (green line), upper confidence limit (UCL) and lower confidence limit (LCL) are based on the average number of stream locations. The dashed red lines are the actual control limits based upon the number of sites actually visited in a given year.

Power analysis to detect trend

As described in detail in SOP 9, a power analysis was performed to determine whether the number of sites and revisits within a year are sufficient to document declines in HYCA and TATO over time (Hayes and Irvine, personal communication). The power analysis was based on data from 4 years, 22 sites per year, with each site visited twice by NPS (described in more detail in SOP 9). The pilot data was used to determine the ‘best’ set of variables for modeling occupancy and detectability. Monte Carlo methods were used to estimate the power of the likelihood ratio test for trend detection. For this analysis, we assumed variability of sentinel and GRTS sites was similar, so we pooled data across panels for the power analysis.

The power to detect a decline in HYCA of 5% annually over 10 years with Type 1 error of 10% was greater than 75% for 22 sites and two revisits within a year. TATO had over 90% power to detect a 5% annual decline over 10 years with 22 sites and two revisits within a year. Power is less for a smaller amount of annual change. However power increases with an increase in number of sites and revisits within a year.

Reporting Schedule

Annual Report

A data summary report is to be completed annually at the end of each field season to correspond with the fiscal funding year for the National Park Service. The report is to be delivered to the MEDN program manager by August 30th of each year with results from the previous year's surveys. The NPS Monitoring Project Manager will coordinate with Pepperdine University and RCD to collect and combine data from each season to be analyzed and included together in an annual report.

The annual report will include the following information (see SOP 7):

- A brief narrative of the year's survey methodology, effort, basic results, noteworthy observations, and any changes in the sampling or analysis procedures.
- A table with the names of personnel that conducted surveys in that year.
- A table and accompanying map with the locations, date, and type of survey visit for each stream surveyed in that year.
- A list of all species observed that year.
- A brief description of field procedures, quality control and data handling, and data analysis methods.
- A table with all raw data gathered in the current year.
- A brief synthesis (graphs, charts, or statistical tests) of occupancy and abundance data taken.
- A short discussion of results.
- A list of references cited.

Trend Report

Periodic analysis for the trend in occupancy will be conducted at regular 3-year intervals. We will conduct a complete analysis of factors influencing the occupancy by the amphibians and non-native species.

The trend report will include the following information (see SOP 8)

- A brief narrative survey methodology, effort, basic results, noteworthy observations, and any changes in the sampling or analysis procedures.
- A list of personnel and training schedule from the time period.
- A table and accompanying map with the locations, date, and type of survey visit for each stream surveyed in the time period.
- A list of all species observed in the time period.
- A brief description of field procedures, quality control and data handling, and data analysis methods.
- A table with all raw data gathered from the survey time period.
- A synthesis (graphs, charts, or statistical tests) of occupancy and abundance data taken, including control chart analysis.

- An extensive discussion of results and trends.
- Recommendations for management actions that may be informed by the results of the periodic report.
- An accounting of time management and fund resources that were needed to collect and analyze data, and complete the written periodic report.

Personnel Requirements and Training

Roles and Responsibilities

One full-time Monitoring Project Manager (Wildlife Biologist or Natural Resource Specialist 0486/0401- GS 11) serves as Monitoring Project Manager, and is responsible for coordination between cooperating agencies, maintenance and calibration of equipment, renewal and holding of all necessary permits, and data entry. The Monitoring Project Manager is also responsible for data analysis, written annual reports, and periodic trend reports. In addition, manager hires and conducts initial and periodic training for wildlife interns and technicians (see SOP 10).

One wildlife technician (0404 – GS 5/6/7) assists the Monitoring Project Manager, and is responsible for amphibian counts and physical habitat data collection from April to July (4 months; full-time).

Two wildlife interns are trained by and assists the Monitoring Project Manager and wildlife technician. Interns are responsible for assisting in amphibian counts and all other data collection.

Qualifications

Qualifications for the project manager and technicians are those applicable to the grade and series at which they are hired; Wildlife Biologist (Series 0486- GS11) or Natural Resource Specialist (Series 0411– GS11), and Wildlife Technician (0404- GS 5/6/7). Experience and familiarity with aquatic herpetofauna is desirable.

Training

Training procedures are conducted at the beginning of the field season each year during the first weeks of April. Using field guides, websites, and discussions with experienced field personnel, new park staff and volunteers are trained to locate and identify local amphibian species at adult and larval phases (see SOP 10, Appendix A). In the field, new staff and wildlife interns are paired with more experienced personnel to learn field identification techniques as well as assist with physical habitat measures.

Operational Requirements

Annual Workload and Field Schedule

Each year, NPS staff will conduct 22 intensive stream surveys and 22 occupancy visits across the Santa Monica Mountains and Simi Hills. This equates to 44 sample events per year conducted between April and July. A two-person crew can conduct one intensive stream survey per day, therefore to complete all intensive surveys requires 22 sampling days. This same two-person field crew can complete one to two occupancy revisits per day depending on the proximity of two sampling locations in any given year. Therefore occupancy sampling averages around 18 sampling days to complete all occupancy sampling visits. All surveys are done between April and mid-July during the normal work week. NPS staff devote 3 to 4 days of every week during the season to stream surveys (Table 3). Note that Pepperdine and RCD coordinate their own field schedule and are not included in this section or Table 3.

Table 3. Annual work cycle to complete aquatic amphibian monitoring by NPS in SMMNRA and the Simi Hills.

Month	Action items	Responsibility
Feb	Advertise wildlife intern positions	Monitoring Project Manager
Mar	Interview and hire wildlife intern(s) Train wildlife intern(s) Meet with collaborators Prepare field equipment Coordinate schedule, vehicles, site visits, and surveyors	Monitoring Project Manager
Apr	6 survey days	Monitoring Project Manager, Technician, Interns
	6 survey days	Monitoring Project Manager, Technician, Interns
May	6 survey days	Monitoring Project Manager, Technician, Interns
	6 survey days	Monitoring Project Manager, Technician, Interns
Jun	6 survey days	Monitoring Project Manager, Technician, Interns
	6 survey days	Monitoring Project Manager, Technician, Interns
Jul	4 survey days	Monitoring Project Manager, Technician, Interns
	Complete any postponed surveys, clean and store field equipment.	Monitoring Project Manager, Technician, Interns
	Enter data, QA/QC, validation, metadata and data certification	Monitoring Project Manager, Technician, Interns
Sep	Compile results Analyze results Prepare written annual report Get internal peer-review for annual report Finalize and submit annual report	Data Manager, Monitoring Project Manager Monitoring Project Manager

Budget

Personnel needed to complete field surveys, data management, and reporting will cost \$39,850 annually. Approximately 26% of the total annual budget (\$10,270) is spent on analysis and reporting, which requires the participation of all staff listed in Table 4. Surveys are conducted with the help of wildlife interns which cost \$1428.57 each per month including housing. Surveys are conducted over 3.5 months for a total intern investment of \$10,000. Equipment for aquatic amphibian monitoring needs to be replaced as needed due to use and wear. Annually, we estimate the cost of equipment replacement will be \$500 (Table 4).

Table 4. MEDN Aquatic Amphibian Monitoring Budget

	Time allotted	% of time spent	Cost (\$)
<i>NPS Personnel</i>			
Monitoring Program Manager (GS12)	1 week report review	100%	\$2,000
Data Manager (GS11)	1 week field season prep; 1 week QA/QC, data archiving and close-out	100%	\$3,400
Projects Manager/Wildlife Ecologist (GS12)	1 week prep for field work and logistics, 4 weeks field training and assistance, 1 week reporting and editing	20%	\$2,450
Monitoring Project Manager/Ecologist (GS11)	2 weeks prep for field work and logistics, 12 weeks field training and sampling, 3 weeks data analysis, reporting, and close-out	80%	\$21,500
Wildlife Interns (2)	1 week training, 12 weeks sampling, 2 weeks QA/QC and close-out	80%	\$5,600
<i>Operations/Equipment</i>			
Housing (interns)			\$4400
Equipment replacement			\$500
Vehicle lease/fuel			\$3,000 (In-kind support)
Years 1 and 2 Total			\$42,850
Trend report every 3 years	Monitoring project manager 100% time for 3 weeks every 3 years		\$5,100
Year 3 Total			\$47,950

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Standard Operating Procedure (SOP) No. 1 – Sampling Design

Version 2.0 (September 2011)

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1.0 Santa Monica Mountains Resource Management Zone

Target Population

While SAMO has a distinct and permanent administrative boundary, more than 50% of the land within the park is privately owned. Some of this private land within the park boundary is developed, and the park is surrounded by intensive urban development. In addition, many SAMO parklands are adjacent to state and local park lands. Land uses within and surrounding the Santa Monica Mountains can have significant influences on protected lands inside the boundaries of the park. With this in mind, the Santa Monica Mountains Resource Management Zone (RMZ) has been identified as an area of significant ecological breadth. Within the RMZ, local, state, and national park managers operate to coordinate management activities to best meet the NPS mandate to maintain the natural resources for future generations. The target population for this protocol is the aquatic amphibians within the Santa Monica Mountains Resource Management Zone (excluding the Eastern Urban section, see Figure 1).

Stratification

The estimation of population state variables will be most precise if the population is stratified so that within each stratum, the units are as similar as possible (Thompson 2002). Our sampling design includes stratification of the RMZ into four ecological regions based on physical features, vegetation, coastal influence, elevation, and development. The four regions include: 1) Lower elevation inland Santa Monica Mountains and Simi Hills (Inland, primarily Chaparral vegetation); 2) Upper elevation Santa Monica Mountains (Mountains, primarily Chaparral vegetation), 3) Immediate coast (Coastal, primarily Coastal Sage Scrub), and 4) Eastern Urban (very fragmented habitat; see Figure 1). The eastern urban region was eliminated from the eventual sites selection process because of access and ownership limitations, small overall size, and its high proportion of development coupled with the logistics associated with working in this area. Therefore, the coastal, mountain, and inland regions are relevant to the status of amphibian populations within the streams of the Santa Monica Mountains RMZ, and provided the basis for stratifying a random selection of monitoring sites across the RMZ. Stratification allowed for a proportion of sites to be selected in locations proportionate to lands within the Santa Monica Mountains and Simi Hills.

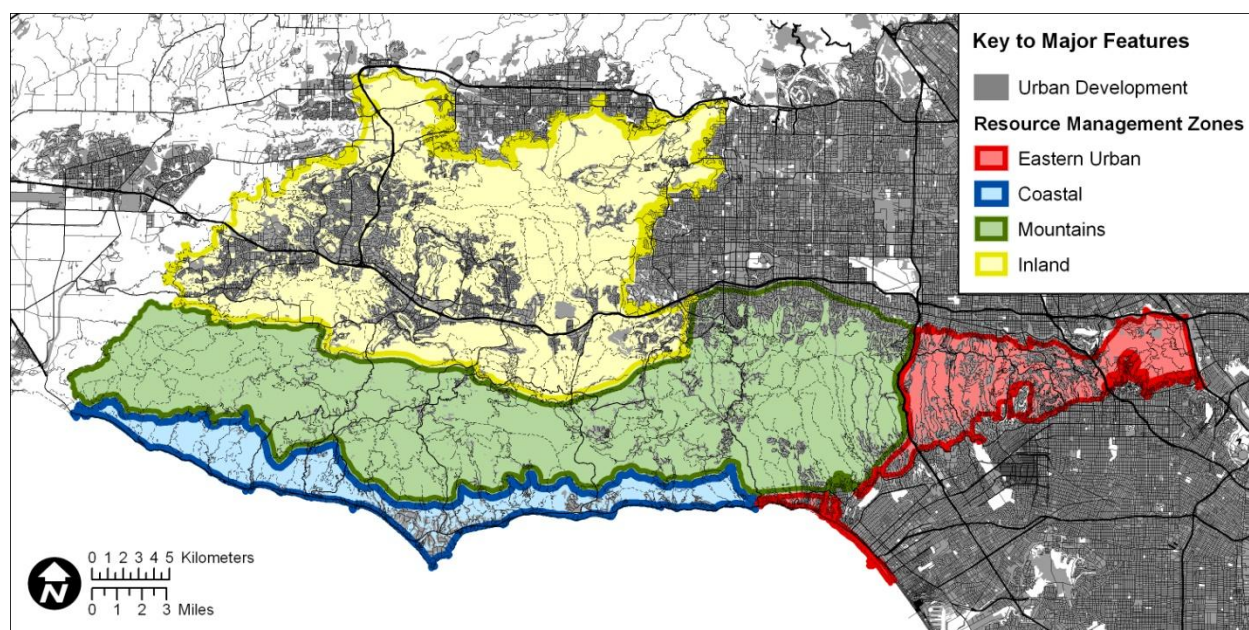


Figure 1.1. Four ecological regions within the Santa Monica Mountains Resource Management Zone.

1.1 Monitoring Objectives

The objectives of the aquatic amphibian monitoring in the SAMO are to monitor stream resources throughout the park. Specifically, we will determine the status and long-term trends in percent area occupied and relative abundance of juvenile and adult native aquatic amphibians and non-native invasive species in streams throughout SAMO during the reproductive season.

1.2 Sampling Frequency and Replication

Field sampling occurs annually from April to July, and is scheduled to begin coincident with the spring breeding cycle of amphibians in southern California (Stebbins 1985). During this period the population demographics and reproductive success of four native amphibian species: California newt (*Taricha tarosa*), Pacific treefrog (*Pseudacris regilla*), California treefrog (*Pseudacris cadaverina*), and western toad (*Bufo boreas*) are monitored. Coincident with this monitoring, data is collected on stream morphology and the occurrence of non-native invasive crayfish (*Procambarus clarkii*), fish (various species), and New Zealand mudsnails (*Potamopyrgus antipodarum*). Stream water quality data are also collected (Hibbs et al. in prep.).

Each year NPS staff monitors 22 sites on streams in the Santa Monica Mountains and Simi Hills (Figure 1.2). Ten of these sites are called sentinel sites, are visited annually, and represent a subset of sites that were sampled during a five year inventory from 2000-2004 (Riley et al. 2005; Figure 1.2 and Table 1.1). An additional 12 individual stream sites are monitored each year on a three-year rotating panel design (Figure 1.2). At the end of each three-year cycle thirty-six sites will have been monitored according to this augmented serially alternating panel design (Fuller 1999; Table 1.2).

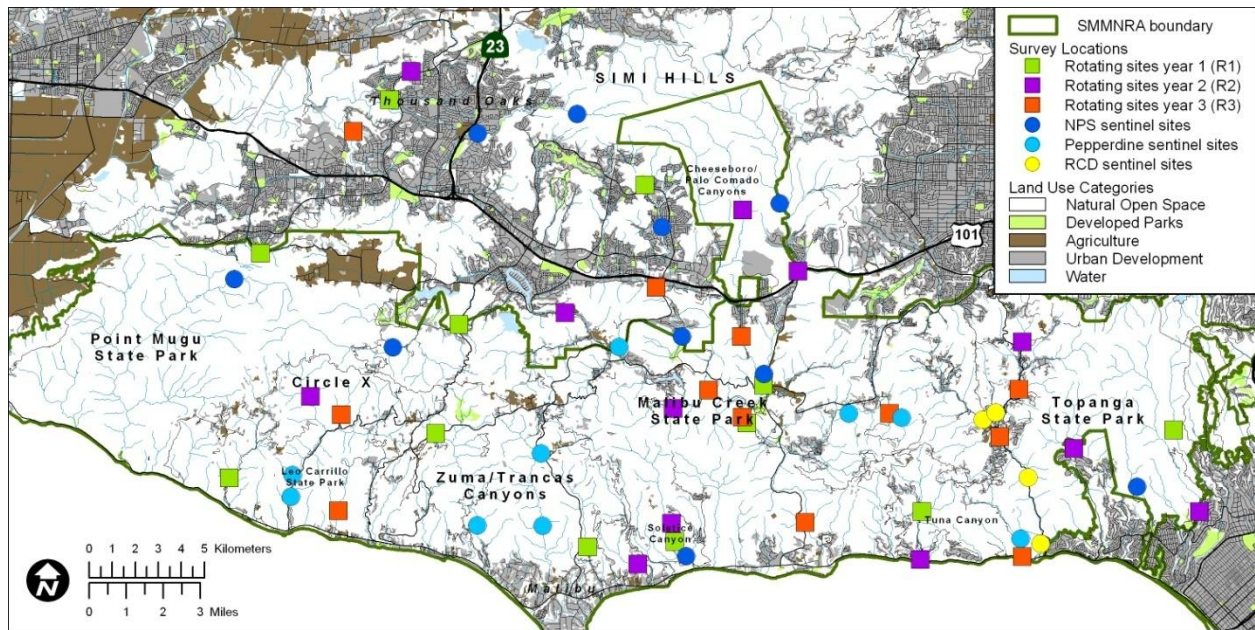


Figure 1.2. Survey locations for aquatic amphibian monitoring in the Santa Monica Mountains RMZ. Streams are monitored annually by NPS, Pepperdine University, and Resource Conservation District of the Santa Monica Mountains (RCD). A panel of 36 randomly-selected sites are surveyed by NPS, 12 per year on a 3-year rotating schedule (R1, R2, and R3 sites).

Coinciding with NPS monitoring, cooperators at Pepperdine University and the Resource Conservation District of the Santa Monica Mountains (RCD) will annually monitor the streams that they sampled during the five-year stream inventory. Pepperdine University and the RCD will monitor nine and three streams respectively (Figure 1.2 and Table 1.1), employing the methods described by Riley et al. (2005). Note that in recent years, RCD has added a fourth stream survey site, which will be incorporated into future protocol revisions. Therefore, currently NPS and its cooperators will monitor amphibian populations at 58 sites across streams in the Santa Monica Mountains and the Simi Hills.

Table 1.1. Coordinate locations (NAD 27) and physical descriptions of start points for streams surveyed during the aquatic amphibian inventory effort (2000-2004) by the National Park Service (NPS), Pepperdine University (PEP), and the Santa Monica Mountains Resource Conservation District (RCD). Sites that will continue to be sampled annually by the NPS are highlighted in green. These sites are termed Sentinel sites for future monitoring, and will be sampled every year. The remaining NPS sites have been dropped from the monitoring program. Sites sampled by Pepperdine University and the RCD will continue to be monitored yearly.

Stream name	Agency	X	Y	Landmarks for stream start point
Arroyo Sequit (Lower)	PEP	321566	3770115	Above second stream crossing and upstream from Leo Carillo campground.
Arroyo Sequit (Upper)	PEP	321638	3771046	Mulholland Highway at first stream culvert.
Big Sycamore Canyon	NPS	319118	3779571	On upper Sycamore Canyon Trail above first bridge crossing from Rancho Sierra Vista.
Carlisle Canyon	NPS	326005	3776606	Westlake Blvd. south to Carlisle Road. Survey begins at end of public road.
Cheeseboro Canyon	—	339661	3779472	Canwood Culvert.
Cold Creek (Lower)	PEP	345808	3773721	Piuma to Cold Creek Road.
Cold Creek (Upper)	PEP	348114	3773551	Cold Creek Road, above UC Reserve.
Corral Canyon	—	339980	3767076	Lagoon at Pacific Coast Highway.
Deer Creek	—	317090	3770572	First culvert from ocean on Deer Creek Road.
Erbes (Lower)	NPS	329684	3785897	Culvert at downstream end of Old Meadows Park.
Erbes (Upper)	—	330635	3786240	Culvert on Erbes Road.
La Jolla Canyon	—	311743	3773801	Above La Jolla campground at first stream crossing on La Jolla Canyon Trail.
Lang Ranch (N)	NPS	334010	3786741	Above Chumash Center at large ten foot boulder before waterfall off of Westlake Blvd.
Lang Ranch (S)	—	332015	3786889	Conejo Creek below Westlake Blvd.
Las Virgenes (N)	NPS	342811	3782854	End of north Las Virgenes Blvd. on Ahmanson Ranch at second stream crossing.
Las Virgenes (S)	NPS	342125	3775434	First bridge on White Oak Farm off of Las Virgenes/Malibu Canyon Road.
Liberty Canyon (S)	—	341756	3775564	Horse Bridge at Liberty Canyon Trail entrance at White Oak Farms.
Lindero Canyon	—	335328	3782947	Culvert on Lindero Canyon and Rockfield roads.
Malibu Canyon (Lower)	—	344612	3767984	Low water crossing in Sierra Retreat on Cross Creek Road.
Medea Creek (N)	NPS	337686	3781820	Kanan to culvert on Conifer.
Medea Creek (S)	NPS	338558	3777073	Paramount Ranch at stream crossing on Bwana Trail.
Newton Canyon	PEP	332437	3771997	Newton Trail.
Old Topanga Canyon	RCD	351631	3773446	Second culvert on Old Topanga Road off of Topanga Road.
Palo Comado Canyon	—	339094	3785089	Palo Camado Canyon Road to China Flat.
Ramirez Canyon	—	334547	3767428	Barbara Streisand Center.
Rustic Canyon	—	361042	3769456	First stream crossing at Will Rogers —on Rustic Canyon Trail.
Serrano Canyon	—	316885	3774414	Deer Creek Road to Serrano Road.
Solstice Canyon	NPS	338744	3767519	Corral Rd to Solstice at second entrance gate above parking lot.
Sullivan Canyon	—	360075	3772493	Mandeville Canyon Road to Westridge to end of Queensferry Road.
Temescal Canyon	NPS	358333	3770551	Upstream of Temescal Gateway Park above bridge on Temescal Canyon Trail.

Table 1.1. (Continued) Coordinate locations (NAD 27) and physical descriptions of start points for streams surveyed during the aquatic amphibian inventory effort (2000-2004) by the National Park Service (NPS), Pepperdine University (PEP), and the Santa Monica Mountains Resource Conservation District (RCD). Sites that will continue to be sampled annually by the NPS are highlighted in green. These sites are termed Sentinel sites for future monitoring, and will be sampled every year. The remaining NPS sites have been dropped from the monitoring program. Sites sampled by Pepperdine University and the RCD will continue to be monitored yearly.

Stream name	Agency	X	Y	Landmarks for stream start point
Topanga Canyon	RCD	353605	3770943	Above first stream crossing from Pacific Coast Highway.
Topanga Canyon (Greenleaf)	RCD	352196	3773767	Topanga Blvd. to Greenleaf.
Trancas Canyon	PEP	329663	3768859	Trancas Road to Principio to end of Paseo Canyon Road.
Triunfo Canyon	PEP	335830	3776617	Culvert on Triunfo Creek at Kanan Road.
Tuna Canyon	PEP	353276	3768279	First culvert from ocean on Tuna Road.
Wood Canyon	—	313812	3776682	Big Sycamore Canyon to Wood Canyon at second stream crossing.
Zuma Canyon	PEP	332500	3768853	End of Bonsall Road.

1.3 Intensive and Occupancy Sampling

The sampling methodologies proposed herein are designed to assess amphibian distribution and abundance during the reproductive season in streams of the Santa Monica Mountains. Sampling generally follows methods described in Riley et al. (2005) and Gamradt and Kats (1996). For all stream surveys, a 250-meter stretch of the selected stream will be sampled. Data to be collected include presence/absence and estimates of abundance of amphibian and non-native fauna in streams. Data on stream morphology and water quality is also collected. Each stream will be visited twice during the breeding cycle: one intensive survey visit and one occupancy survey visit.

1.3.1 Occupancy Sampling Monitoring

Occupancy monitoring visits will be conducted to confirm presence/absence of each aquatic amphibian and target non-native species. This sampling strategy will be less detailed than intensive sampling and will enable park personnel to complete the survey for amphibian and non-native species quickly. Occupancy surveys are efficient, cost-effective metric for determining large-scale patterns in species distribution from which regional trends may be deduced, and has been identified by the U.S.G.S. – ARMI Program as the most promising metric for assessing amphibian populations and detecting declines in these species (Corn et al. 2005).

1.3.2 Intensive Sampling

Intensive sampling will be conducted to collect a suite of physical and biological data from each transect. Methodologies, described in SOP 3, were designed in cooperation with Lee Kats, Ph.D. (Pepperdine University). Intensive sampling yields data on stream morphology as well as abundance estimates for target amphibian and non-native species.

1.3.3 Site Visit Schedule

The biology of target species can dictate when sites are surveyed. For example, inland low elevation, low gradient streams likely to harbor the egg masses and/or larvae of *Bufo boreas* are sampled early in the season because they breed quickly and are more likely to breed earlier in the season. These low elevation streams often dry up sooner than higher elevation high gradient

streams. High gradient or coastal streams likely to harbor the larvae of *Pseudacris cadaverina* are sampled later in the season, since they breed later in the season. Egg masses of *Taricha torosa* are more likely to be found early in the season, whereas *Pseudacris regilla* will reproduce throughout the entire survey period. In addition, sampling visits are scheduled in response to weather conditions, such as the onset of the rainy season.

Table 1.2. Sampling panel for stream sites in the Santa Monica Mountains and Simi Hills. Sentinel sites are surveyed every year by the National Park Service (NPS), Pepperdine University (PEP) and Resource Conservation District of the Santa Monica Mountains (RCD). A stratified random design was used to select 36 streams from three ecological zones, resulting in a sampling panel of three groups of 12 streams to be sampled by NPS on a three year rotation (Rotating Sites).

Sentinel Sites		Year		
		1	2	3
1	NPS sites	10	10	10
2	PEP sites	9	9	9
3	RCD sites	4	4	4

Rotating Sites				
1	Coastal Zone	2		
	Mountains Zone	6		
	Inland Zone	4		
2	Coastal Zone		2	
	Mountains Zone		6	
	Inland Zone		4	
3	Coastal Zone			2
	Mountains Zone			6
	Inland Zone			4

1.3.4 Time Commitment

The time commitment for each stream survey varies and depends upon the diversity of the habitat and the accessibility of the site. The intensive stream survey requires a time commitment of approximately six hours, which includes drive time to and from the site and completion of the field survey. Streams that are dry or have reduced habitat complexity can be completed more rapidly. Two people are required, one recording data and the other measuring habitat characteristics or searching for amphibians. Stream surveys for occupancy estimation require one or two people and take significantly less time than intensive surveys.

1.4 Water Quality Sampling

In addition to biological and physical data collected, the MEDN fresh water quality monitoring program will conduct assessments of stream water quality in streams where amphibian monitoring is conducted (Hibbs et al. in prep.). Fresh water quality sampling occurs three times a year in the SMM RMZ with one sampling event scheduled concurrently with the intensive amphibian surveys. The other two visits are in late summer, and right after the first rain in winter. This additional sampling provides NPS managers with greater confidence in correlating water chemistry data with amphibian monitoring data, for evaluating regional and environmental

differences among streams, and in evaluating trends that might be observed in amphibian distribution and abundance data.

Field sampling procedures and laboratory methods for water quality assessments are described in SOP 4 and the draft fresh water monitoring protocol, currently under development by the MEDN (B Hibbs, in prep.).

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Standard Operating Procedure (SOP) No. 2 - Selection of Sampling Sites

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2.0 Inventory

Streams in the Santa Monica Mountains (SMM) vary in terms of water availability, stream gradient, aspect, and urban impact. It is important that a variety of streams are monitored to ascertain changes to local amphibian populations due to urbanization, fluctuating environmental conditions, or long-term ecological changes. However, the number of streams and sampling locations along streams that can be visited annually is limited by personnel, the amount of data being collected, and seasonal occurrence of water in park streams.

Inventory sampling sites were selected based on water availability, gradient, and aspect of surrounding topography, including sampling all of the larger, mostly perennial streams, within the Santa Monica Mountains and Simi Hills. These also included streams with significant development within the watershed, and some larger streams that had survey sites above and below major urban barriers such as freeways or intense development. After selection, streams at the sampling sites were categorized as either natural or urban based upon the degree of upstream watershed urbanization. Streams where more than 8-10% of the upstream watershed was developed were identified as urban streams (Riley et al. 2005). Criteria dictating the selection of specific sites for sampling included several factors: all sampling locations were located on public lands or on lands where continual access was guaranteed, all had reasonable and safe access from established roads or trails, and all had flowing water between April and July in all but the very driest of years.

From 2000 to 2004, 37 streams across the Santa Monica Mountains and Simi Hills were sampled once each year as part of an amphibian inventory program conducted by Santa Monica Mountains NRA, Resource Conservation District of the Santa Monica Mountains (RCD), and Pepperdine University (Figure 2.1 and Table 1.1, see SOP 1). Inventory sites were selected using a Geographic Information Systems (GIS) that evaluated aerial photographs and digital geographic information on land ownership, roads, trails, and topography of the Santa Monica Mountains and surrounding area. Field visits to potential sites were conducted to confirm accessibility and adequacy of each site for the proposed inventory before sampling was begun. The goal of this program was to inventory permanent and intermittently flowing streams (expected to flow each year between April and July) in the Santa Monica Mountains and adjacent area where continuous access was assured, that were considered to be of special management significance, or met specific research objectives (Riley et al. 2005). Sampling locations outside the boundary of the Santa Monica Mountains NRA were included because of

the significant fragmentation of natural open space by development, and because several of the major streams within the mountains originate outside of the park and are exposed to a wide variety of stressors as they make their way to and through the park to the Pacific ocean. Once sample sites were selected the percentage of developed land within the upstream drainage of each sample site was determined.

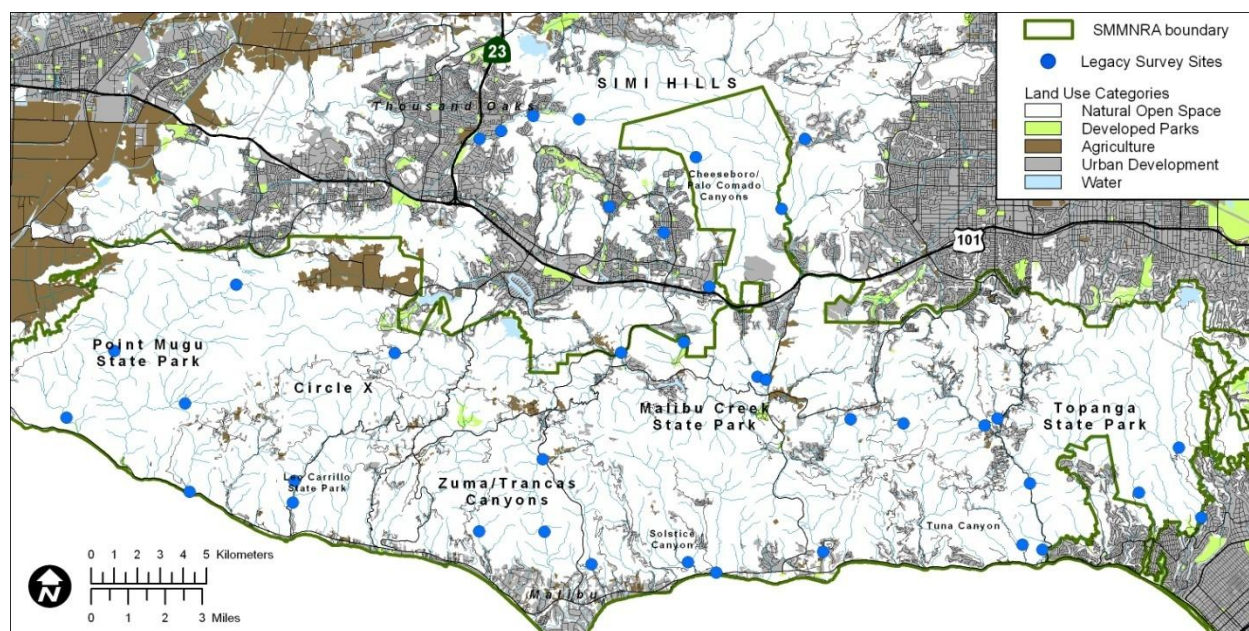


Figure 2.1. Original locations of 37 stream survey sites, called “legacy sites”, used to inventory native amphibians and non-native species from 2000-2004. Surveys were conducted by the National Park Service (NPS), Pepperdine University (PEP), and the Resource Conservation District of the Santa Monica Mountains (RCD).

The NPS conducted sampling in 25 of the 37 stream sites inventoried. Pepperdine University (PEP) sampled 9 stream sites and the Resource Conservation District of the Santa Monica Mountains (RCD) sampled three stream sites. After five years of inventory data collection the amphibian sampling program was evaluated and redesigned to better meet the needs of long-term monitoring.

2.1 Long-term Monitoring

Information from the amphibian inventory conducted between 2000-2004 was used to develop a long-term monitoring program for SMMNRA. The change from inventory to monitoring included the elimination of some inventory or “legacy” sites sampled by the NPS, and the addition of a suite of monitoring sites selected randomly across the landscape of the Santa Monica Mountains Resource management Zone (SMM RMZ; Figure 2.2).

To organize the sampling effort across the park and surrounding region an extended resource management zone (RMZ) that includes the Santa Monica Mountains, Simi Hills and some surrounding areas were identified and divided into four ecological regions based on distinguishing vegetation zones, coastal influence, elevation, and development (Figure 2.2).

Initial sampling regions were identified as follows:

1. Lower Elevation Inland Santa Monica Mountains and Simi Hills. Vegetation type is dominated by Chaparral.
2. Upper Elevation Santa Monica Mountains. Vegetation type is dominated by Chaparral
3. Immediate Coast. Vegetation type dominated by Coastal Sage Scrub.
4. Eastern Urban. Vegetation is a mix of Coastal Sage Scrub and Chaparral.

Eventually, the eastern urban region was eliminated from the selection process because of access and ownership limitations, small overall size, and its high proportion of development coupled with the logistics (distance from headquarters) associated with working in this area (Figure 2.2). The remaining three eco-regions (mountain, inland, and coastal) provide the basis for stratifying the amphibian monitoring sampling framework, and are designed to facilitate comparisons of breeding amphibian distribution and abundance across the landscape of the RMZ. The number of sampling sites within each zone is proportionate to the area within each zone that meets the conditions required for sampling as described below. Sampling frameworks for the terrestrial herpetology and fresh water quality monitoring programs also rely on this eco-zonation for selecting sampling sites and grouping data for analysis and comparison.

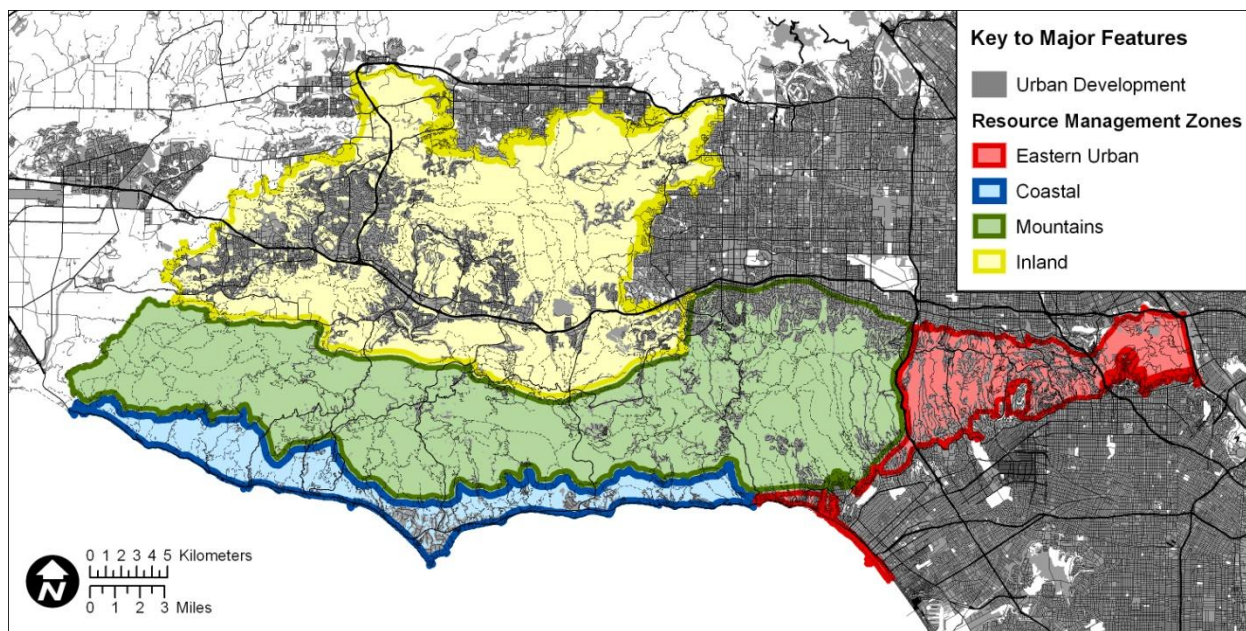


Figure 2.2. Stream Survey Study Regions for the Santa Monica Mountains and Simi Hills. Study regions are based on distinguishing vegetation zones, coastal influence and elevation. Sampling regions are: 1) Lower Elevation Inland Santa Monica Mountains and Simi Hills (Inland; primarily chaparral); 2) Upper Elevation Santa Monica Mountains (Mountains; primarily chaparral), 3) Immediate Coast (Coastal, primarily coastal sage scrub), and 4) Eastern Urban (very fragmented habitat). These sampling regions will be also used for the MEDN Terrestrial Herpetology, Vegetation, and Fresh Water Quality monitoring projects (occurs as Figure 1 in the Protocol).

Twenty-two of the 37 original inventory sites surveyed during 2000-2004 will continue to be monitored annually; 10 by the NPS, 9 by Pepperdine University, and three by the RCD (Figure 2.3 and Table 1.1, see SOP 1). Pepperdine University and the RCD will continue to sample the inventory sites they sampled during the baseline inventory effort. Note that RCD has added a fourth survey site in recent years. Data gathered from these surveys will be incorporated in the analysis and reporting in the future, and will be included in a future protocol revision. The 10 sites to be sampled by the NPS represent a subset of the stream sites originally inventoried by the NPS and will be called “sentinel” sites (Figure 2.3 and Table 1.1, see SOP 1). Elimination of some of the original sites in the NPS program was necessary to broaden the inference landscape of monitoring results by incorporating a suite of randomly selected sampling locations into the monitoring program (see below).

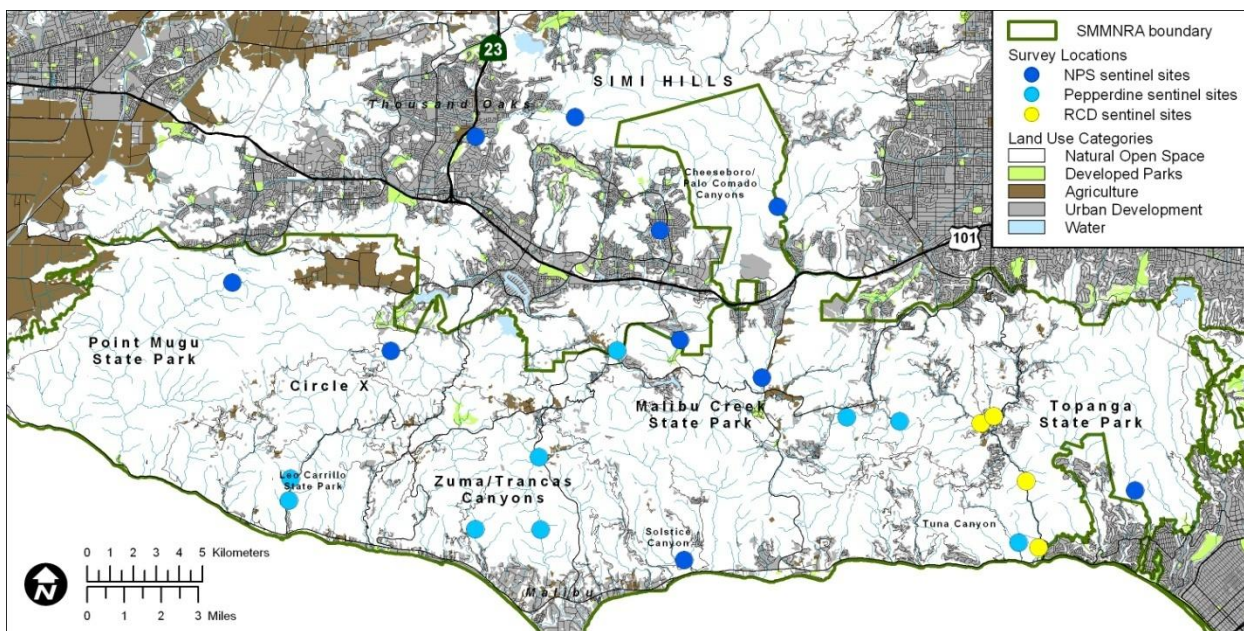


Figure 2.3. Sentinel survey sites kept for long-term monitoring of aquatic amphibian in Santa Monica Mountains National Recreation Area.

2.1.1 Selection of Sites for Long-term Monitoring

2.1.1.1 Sentinel and Randomly-selected Sites

Stream sites sampled during the inventory program that will continue to be monitored are referenced as “Sentinel” sampling sites to differentiate them from the randomly selected “GRTS” sampling sites. GRTS refers to the method of selecting these sites using Generalize Random Tessellated Stratified methodology. GRTS methodology selects a spatial random sample from within the constraints of landscape- or feature-based strata.

Thirty-six additional monitoring sites were selected using generalized random tessellated stratified (GRTS) methods (Stevens and Olsen 1999, 2003, 2004). A map of cells that included stream segments was created by overlaying a grid of 2.25 km² cells (1.5 km on a side) over the RMZ. Cells that had less than 50% protected park lands, contained no intermittent or perennially flowing streams, or already had sentinel monitoring sites located within them were eliminated.

Safe access to a site was also taken into consideration. If a site contained geophysical characteristics, such as extremely steep banks, so that access to the start point was unsafe, those sites were eliminated. Such constraints on the sampling frame composed of stream segment cells was thought necessary because a blind and fully random selection of monitoring sites along streams would result in the majority of sites not meeting the safety, access, and presence of perennial water criteria (mentioned above), and because of vegetation and topography would be unreachable or they would be located on private lands. The safety and access restrictions made on the sampling frame reduce the sampled population to a subset of the desired target population, but this is a common and necessary trade-off for long-term monitoring programs, and only reduces our scope of inference based on the probabilistic sites.

A spatially random selection of 36 cells was made from the final sampling frame of cells stratified within the RMZ eco-regions by GRTS methods running on the open source statistical software package R (see the U.S. E.P.A. Aquatic Resources Monitoring web page, <http://www.epa.gov/nheerl/arm/>, accessed July 13, 2006). If the majority of a cell (>50%) contained land within a particular strata, it was named to that strata (mountain, inland, or coastal). The number of cells selected from each eco-region was proportionate to the total number of cells meeting the sampling criteria within each eco-region. A total of 12 cells were identified from the Inland region, 18 from the Mountains region, and six from the Coastal region (Figure 2.5). To accommodate the possibility of eliminating one or more cells because of unknown or unexpected conditions in accessing the cell an additional thirty-six “over-sample” (GRTS terminology) cells were identified by the GRTS program. Over-sample cells were selected from each region in the same proportion as the primary sites. Over-sample cells can replace primary cells and maintain spatial randomness if added in the order in which they are generated by the program. Over-sample sites can be adopted in the future if stream morphology changes for any reason and the stream becomes perennially dry (i.e., climate, development, etc.).

The GRTS monitoring stations are visited following an augmented, serially alternating panel design (Fuller 1999). Each panel in the sampling frame consists of 12 monitoring stations. One panel of 12 sites is visited each year for three years. In the fourth year “panel one” stations are revisited and so on (see SOP 1, Table 1.2). Each sampling panel includes 4 sites from the lower elevation region, six from the upper elevation region, and 2 from the immediate coast region (see SOP 1, Table 1.2).

```

# File: SAMO_AQ_Herps_1.R
# Purpose: Example GRTS survey designs for SAMO Eco Regions.
# Grid locations are given by their centroid.
# Programmer: Lane Cameron after Tony Olsen's NE Lakes Example
# Date: March 23, 2006
#
# Load sp library
# Load psurvey.design library
#####
#File SAMO_AQ_Herps_1.R
#Selects stratified sampling sites based on proportion of cells in each
#      of three vegetation/climate zones
#      from the area of the SAMO vegetation map
#
# Read in attribute table from shapefile saved as tab delimited file
att <- read.dbf("centroid_no_start_point")

names(att) <- tolower(names(att))
# Tony Olson likes lower case names
tail(att)

##### Proportioned Stratified GRTS design for all grid cells
# stratify by ZONE
# proportioned by cell number ratio 6:18:12 in strata
# sites selected on rotating panel: Inland = 4-4-4, Mountain = 6-6-6, & Coastal = 2-2-2
# each stratum is oversampled equal to the total number of stations in each stratum
table(att$zone)
Stratdsgn <- list(COASTAL=list(panel=c(Year1=2, Year2=2, Year3=2),
                               seltype='Equal', over=6),
                 INLAND=list(panel=c(Year1=4, Year2=4, Year3=4),
                              seltype='Equal', over=12),
                 MOUNTAINS=list(panel=c(Year1=6, Year2=6, Year3=6),
                                 seltype='Equal', over=18))

### select sample
sample(10000000,1) # run to get random seed
dsgntime <- proc.time()

Stratsites <- grts(design=Stratdsgn,
                  DesignID='EQUAL',
                  type.frame='finite',
                  src.frame='shapefile',
                  in.shape='centroid_no_start_point',
                  att.frame=att,
                  stratum='zone',
                  prjfilename='centroid_no_start_point',
                  out.shape='Stratified Sites')

dsgntime <- ( proc.time() - dsgntime )/60 # time in minutes to complete design
dsgntime

# Write out design file
options(digits=11)
write.table(Stratsites,'Stratsites.tab',sep='\t',row.names=FALSE)
options(digits=7)

##### Site Summaries
addmargins( table(Stratsites$stratum,Stratsites$mdcaty) )

```

Figure 2.4. “R” script to perform GRTS selection of 36 primary and 36 over sample sites for monitoring of aquatic amphibian populations in the resource management zone of the Santa Monica Mountains.

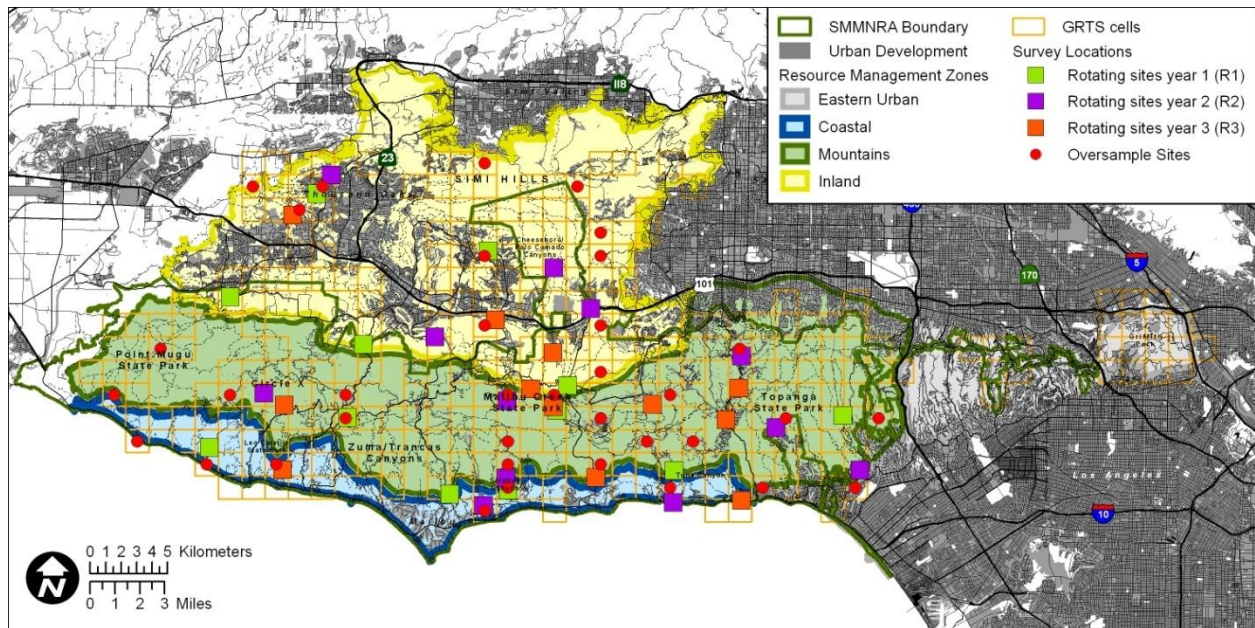


Figure 2.5. Survey locations within the randomly-selected cells chosen by the GRTS draw including rotating stream survey sites (Years 1, 2 and 3) and over-sample sites for the aquatic amphibian monitoring program.

2.1.1.2 Identifying Sampling Points within Grid Cells

Within each grid cell, starting points were selected for stream segments of 250-meters in length to be surveyed. It was required that each survey start site had to be accessible from a road or trail, and could be safely navigated by the survey team. We assume that the final selected stream segments based on safety and logistical constraints are representative of those stream segments that were not surveyed within a grid cell. Site locations were recorded using a Global Positioning System receiver (GPS). This information is stored in the stream survey database managed by the MEDN data manager. If there was no point within a selected cell where a stream could be sampled, then it was dropped from the panel and the next available over-sample cell within the same region was added. GRTS selected sites for monitoring in each of three years are shown in Figures 2.6, 2.7 & 2.8.

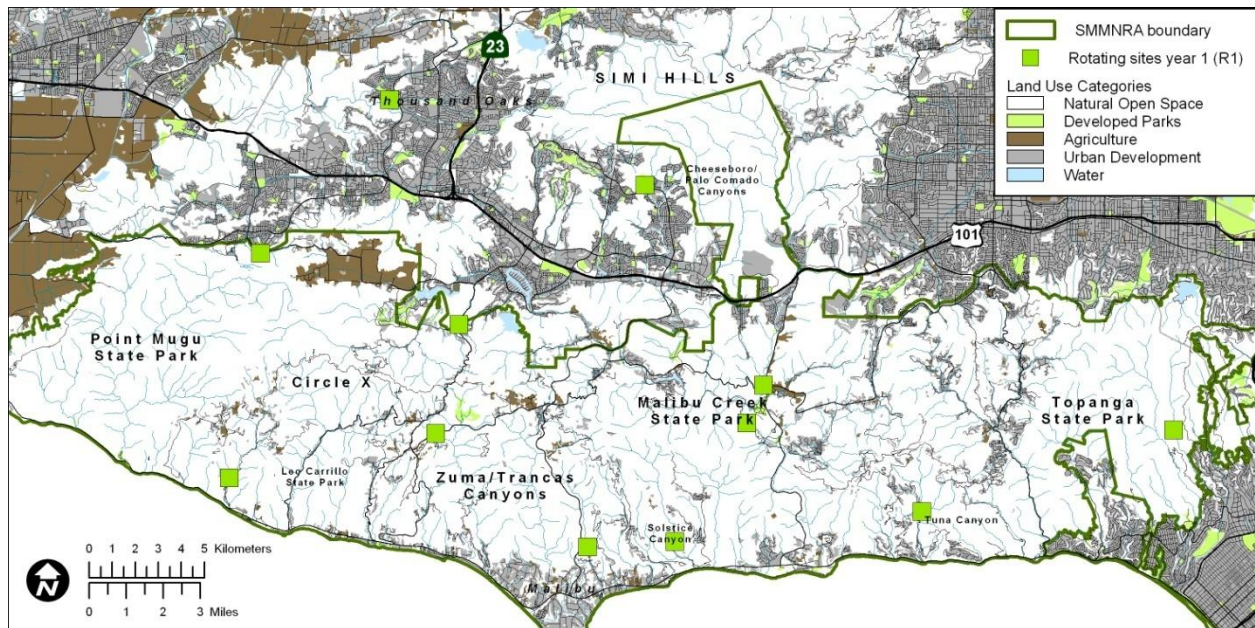


Figure 2.6. Year 1 GRTS sites for rotating stream surveys for the aquatic amphibian monitoring program.

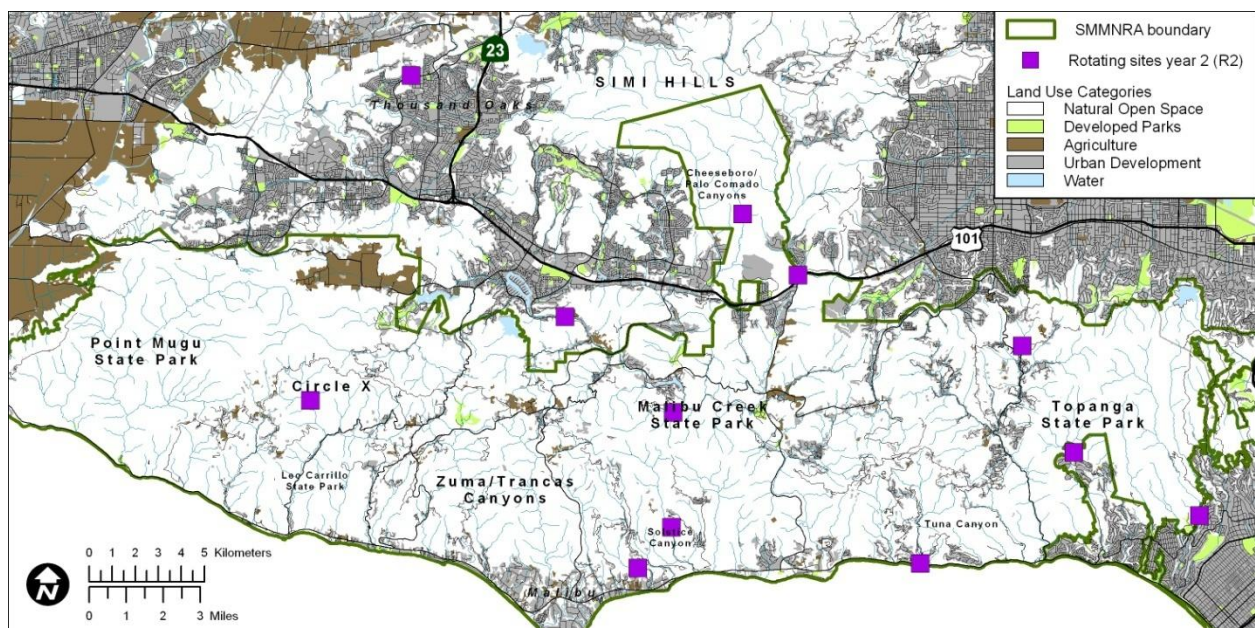


Figure 2.7. Year 2 GRTS sites for rotating stream surveys for the aquatic amphibian monitoring program.

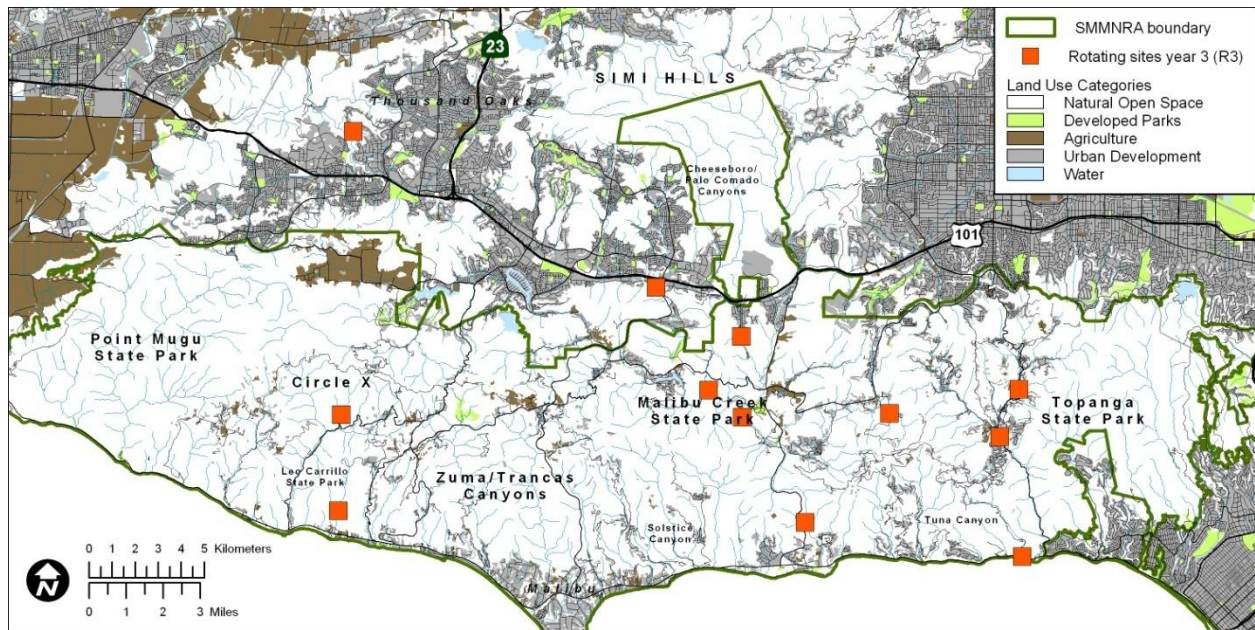


Figure 2.8. Year 3 GRTS sites for rotating stream surveys for the aquatic amphibian monitoring program.

References

- Fuller, W. A. 1999. Environmental surveys over time. *Journal of Agricultural, Biological, and Environmental Statistics* **4**:331-345.
- Riley, S. P. D., G. Busteed, L. B. Kats, T. L. Vandergon, L. F. S. Lee, R. G. Dagit, J. L. Kerby, R. N. Fisher, and R. M. Sauvajot. 2005. Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. *Conservation Biology* **19**:1894-1907.

Standard Operating Procedure (SOP) No. 3 - Field Equipment Preparation and Post-processing

Version 2.0 (September 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

3.0 Field Gear Preparation

3.0.1 Facility and Equipment Needs

Sampling crews deployed in the field should carry NPS two-way radios for both routine and emergency communications. Each sampling crew requires a field vehicle for the full day of each stream survey. A personal computer must be available to each crew for data entry for each day of sampling.

3.0.2 Field Equipment and Supplies

Clipboards with data sheets are stored in the offices of the Monitoring Project Manager, located at the SAMO National Recreation Area headquarters building.

All other field equipment for stream surveys is stored in the Planning Science and Resource Management storage room at the SAMO headquarters building.

Generally, surveyors will wear quick-drying nylon pants and neoprene water slippers with rubber soles. The program maintains many pairs of these shoes and pants so that they may be cleaned properly before they are worn again.

The following equipment and supplies should be taken into the field for each stream survey:

1. Aquascope
2. 100 meter measuring tape (stream length)
3. Aquarium Nets (2)
4. Clipboard with datasheets, calculator, maps & driving directions (if needed).
5. GPS unit (+ 2 AA batteries)
6. NPS two-way radio
7. Nylon pants
8. Water shoes
9. Hand brushes for cleaning shoes and equipment.
10. Small heavy duty trash bags for transporting field gear to the vehicle for cleaning.

3.0.3 Datasheets

Field datasheets are provided in Appendix B. Data sheets and clipboards are to be returned to the Monitoring Project Manager after each stream visit.

3.1 Cleaning Instruments and Field Equipment

3.1.1 Background

Recent identification of the New Zealand mudsnail (*Potamopyrgus antipodarum*) in streams within the study area significantly increases the need for vigilance in cleaning of field equipment and personnel clothing to prevent the spread of this significant invasive mollusk. New Zealand mud snails are very small, easily overlooked, and reproduce parthenogenetically (most individuals in the U.S. are female, males are very rare). They brood their young releasing extremely small juveniles that are essentially invisible to the unaided eye. A single juvenile transported to an uncontaminated stream could be enough to permanently alter the macroinvertebrate community of that stream. In addition, chytrid fungus (*Batrachochytrium dendrobatidis*), which increases mortality of amphibians (e.g., Berger et al. 1998), has been found in the study area streams.

Potentially harmful infections and spread of the chytrid fungus and New Zealand mud snails can be prevented by proper cleaning and care of field equipment, field gear, personal wardrobe items, and field equipment. It is essential that all field equipment be in working order and thoroughly cleaned prior to use in the field.

3.1.2 Cleaning Procedures

Procedures for cleaning field equipment exposed to stream water during intensive and occupancy sampling visits are the same. Clean up procedures for field equipment should begin immediately after leaving the stream. All field equipment that has come in contact with stream water, including clothing and footwear, must be cleaned and disinfected before being introduced into another stream in order to prevent the spread of fungus, disease, or non-native species.

Wetted and presumably contaminated footwear must be removed at the stream bank and scrubbed clean of mud or other debris upon completion of sampling and placed in a heavy duty plastic garbage bag for the walk back to the field vehicle. Field crews must carry a hand-sized scrub brush for this purpose. Equipment in the heavy duty garbage bag is then frozen at -20°C as a treatment for New Zealand mud snails for at least 36 hours. Freezers are located at Diamond X Ranch (need BC-1 key; Mulholland Dr., Calabasas, CA) and Rancho Sierra Vista barn (need BC-1 key; Via Goleta and Potrero Road, Newbury Park, CA, 91320). After freezing, all equipment is rinsed and washed with either a 10% bleach solution or in a regular hot-cycle washer with detergent before re-use.

Sampling equipment that must be disinfected includes (but is not limited to) the following:

- Meter stick
- Aquascope
- measuring tape
- aquarium nets
- water shoes
- nylon pants

3.1.3 Storing Equipment

Once field equipment is frozen, rinsed, and dry, it can be stored in the PSRM storage closet, located in the Santa Monica Mountains National Recreation Area headquarters building.

Data sheets and clipboards are stored in the offices of the Reptile and Amphibian Monitoring Project Manager, in the Santa Monica Mountains National Recreation Area headquarters building.

3.2 End of Season Procedures

For long-term storage and to prevent the spread of chytrid fungus, disease, or New Zealand mud snails all field sampling equipment, including footwear, must be cleaned and disinfected.

Equipment should be thoroughly air-dried prior to storing. All equipment will be stored in large plastic bins at Diamond X Ranch until needed for the next field season.

3.3 References Cited

Berger, L., R. Speare, P. Daszak, E. Green, A. A. Cunningham, C. L. Goggin, R. Slocombe, M. A. Ragan, A. D. Hyatt, K. R. McDonald, H. B. Hines, K. R. Lips, G. Marantellit, and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Sciences U.S.A.* 95:9031-9036.

Standard Operating Procedure (SOP) No. 4 - Survey Methods

Version 2.0 (September 2011)

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Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

4.0 Survey Methods

Each year, two surveys (occupancy surveys and intensive surveys) are conducted on each stream segment being sampled. The purpose of conducting two surveys is to allow estimation of species-specific detection rates (MacKenzie et al. 2002). Surveys may be done in either order with two to six weeks between surveys.

4.1 Occupancy Survey

Note that this survey type was called “PAO” in previous versions of this protocol. The purpose of these surveys is simply to determine the presence or absence of the four aquatic breeding amphibian species (*Taricha torosa*, *Pseudacris regilla*, *Pseudacris cadaverina* and *Bufo boreas*), and the predatory non-native species, such as crayfish, bass, carp, or bluegill in stream segments by walking the entire length of a 250 m transect. Species codes are provided in Table 4.1.

Although species names can change over time, we will consistently use the same species codes we have used in the past. This is to avoid confusion when looking at raw data across many years. Species names, lists, and codes are maintained in the NPSpecies database by the Network Data Manager.

Table 4.1. Common name, species name, and species code for focal amphibian and non-native species.

Common name	Species	Species Code
Pacific tree frog	<i>Pseudacris regilla</i>	HYRE
California tree frog	<i>Pseudacris cadaverina</i>	HYCA
California newt	<i>Taricha torosa</i>	TATO
Western toad	<i>Bufo boreas</i>	BUFO
Red swamp crayfish	<i>Procambarus clarkia</i>	CRAY
Fish	various	FISH
Bullfrog	<i>Rana catesbeiana</i>	RACA

4.1.1 Occupancy Survey Field Sampling Procedures

Navigate to the start point in each stream reach using GPS and physical features of the landscape. GPS coordinates for each stream start point, as well as descriptions of corresponding landmarks, are located in SOP 9. Start sampling at the established GPS coordinates for the start point regardless if there is water in the stream at the starting point.

The sampling crew consists of at least one person, and preferably two people. The crew proceeds from the start point upstream to avoid creating turbidity in front of their progress along the transect, and to limit the potential for disturbance to target species that may be caused by walking in the stream. Dip nets are used to capture larvae and adult amphibians to verify species identification. In deep pools, an aquascope or mask and snorkel can be used to improve

detection. The undersides of rocks, submerged logs, and floating vegetation are examined for egg masses deposited by *Taricha tarosa*. The occurrence of an egg mass is counted as an occurrence of that species within a stream. Surveys are conducted for the entire 250 meters of the stream segment to document the presence or absence of all native and non-native species of interest.

Occurrence data is recorded on the “Stream Survey Field Form” (Appendix B).

4.2 Intensive Field Sampling Procedures

Note that this survey type was called “APEX” in previous versions of the protocol. Once at the general location of each sampling site field crews can navigate to the monitoring start point in each stream reach using GPS and by observing the physical features of the landscape. GPS coordinates for each stream start point, as well as descriptions of corresponding landmarks, may be found in SOP 9. Start sampling at the established start point whether or not there is water in the stream at the starting point.

Sampling proceeds upstream from the start point to avoid creating turbidity in front of sampling personnel, and to minimize disturbance to target species that may be caused by walking in the stream. After entering the stream at the start point, dominant overhead vegetation type and the presence or absence of boulders is noted on the field data form (Appendix B). Sampling personnel measure length and depth of each habitat section (i.e., run, riffle, pool) as described below.

Dip nets are used capture larvae and adult amphibians to verify species identification. In deep pools, an aquascope or mask and snorkel can be used to improve detection. Estimating larval abundance is done by slowly walking upstream and counting all larvae detected within a habitat stop. Because it can be difficult to count every larva in some habitat types, we estimate abundances in categories. We examine the undersides of rocks, submerged logs and floating vegetation for egg masses deposited by *Taricha tarosa*. At each habitat stop, banks, exposed rocks, and floating vegetation should be scanned for adult and juvenile amphibians.

4.2.1 Stream Habitat

Habitat is categorized into one of four types:

- Pool – Slow to non-moving bodies of water; surface of water is relatively motionless.
- Riffle – Quick shallow moving water; surface of water is broken or churning.
- Run – Deeper slow moving water; surface of water usually smooth but debris moves on the surface.
- Dry – No standing or flowing water. Stream bed may be damp.

Every change in habitat is considered a “stop” and is recorded as a sequential number on the “Stream Survey Field Form” (Appendix B). If side pools, runs, or riffles run parallel to the main stream, all of the same data is collected. These are considered secondary habitat stops and are noted as such in the box called “habitat” by indicating if the stop is a side pool, a side run, or a side riffle. The length of secondary habitats is not counted towards the 250 meter survey length.

Length and maximum depth are measured for each habitat section and recorded on the field form. Length is measured in meters using a 100-m tape measure. Depth is measured in centimeters at the deepest point in the habitat segment using a folding 2-m stick.

4.2.2 Abundance Categories and Life Stages

Numbers of tadpoles by species and larval newts are estimated in each habitat segment according to one of 4 abundance categories (<5, 5 – 20, 21 – 100, 101-500, and >500). Abundance of non-native invasive species (crayfish, bass, carp, and bluegill) are estimated in the same manner.

Amphibians, fish, and crayfish are found at various life history stages during our spring stream surveys. Because of visibility differences, egg masses can be found for *Taricha torosa* and *Pseudacris regilla*, but not for *Bufo boreas*, which lays eggs in thin string, and *Pseudacris cadaverina*, which lays single eggs. Larvae, juveniles, and adults from all species can be found, including fish and crayfish. Larvae and juveniles are usually counted using abundance categories, and actual counts for adults are taken for all 4 focal amphibian species.

4.2.3 Species Abundance Indices and Actual Counts

The following biological data are collected at each stream “stop”:

- Abundance estimates as indices (<5, 5-20, 21-100, >100) for larvae and juvenile HYRE, HYCA, TATO, and BUBO.
- Abundance estimates as indices (<5, 5-20, 21-100, >100) for larvae, juveniles, and adult CRAY and FISH.
- Actual counts of adult HYRE, HYCA, TATO, and BUBO.
- Actual counts of TATO egg masses.

Data are recorded on the “Stream Survey Field Form” (Appendix B).

4.3 Water Quality Sampling

In addition to biological and physical data collected, the MEDN fresh water quality monitoring program will conduct assessments of stream water quality in streams where amphibian monitoring is conducted (Hibbs et al. in prep.). Fresh water quality sampling occurs three times a year in the SMM RMZ with one sampling event scheduled concurrently with the intensive amphibian surveys. The other two visits are in late summer, and right after the first rain in winter. This additional sampling provides NPS managers with greater confidence in correlating water chemistry data with amphibian monitoring data, for evaluating regional and environmental differences among streams, and in evaluating trends in amphibian distribution and abundance data that might be observed.

Water quality sampling is conducted in late winter, late summer, and in early spring so that one sample is taken concurrently with the breeding amphibian monitoring. Field sampling procedures, laboratory methods for water quality assessments, and data products are described in Hibbs et al. (in prep.). Generally, three independent water samples for laboratory analyses will be collected at each site during each visit. Additionally, three independent determinations of pH, water temperature, dissolved oxygen, and conductivity will be made at each visit to each site. Measurements will be made with hand held instrumentation and will be taken at 10-meter intervals moving up stream from the primary sampling point. Parameters that are sampled

include: specific conductance, dissolved oxygen, pH, temperature, turbidity, chloride, nitrate, phosphate, phosphorus, total nitrogen, and others (Table 4.2).

Field sampling procedures and laboratory methods for water quality assessments are described in the draft fresh water monitoring protocol, currently under development by the MEDN (Hibbs et. al., in prep.).

Table 4.2. Water quality parameters and methods of analysis as proposed in the MEDN freshwater quality monitoring protocol. These constituents of stream water quality will be measured 3 times a year at all amphibian monitoring locations sampled in a given year.

Measurement	Method	Method Title
Conductivity ¹	E120.1	Conductance
Dissolved Oxygen ¹	SM4500-O G	Membrane Electrode Method
pH ¹	SM4500-H ⁺ B	pH Value
Temperature ¹	SM2550B	Temperature
Turbidity	SM2130	Turbidity
Flow ¹		Flow
Chloride	SM4110B	Ion Chromatography with Chemical Suppression of Eluent Conductivity
N-Nitrate	SM4110B	Ion Chromatography with Chemical Suppression of Eluent Conductivity
Phosphate	SM4110B	Ion Chromatography with Chemical Suppression of Eluent Conductivity
Phosphorus	SM4500-P B(5), E	Persulfate Digestion Method, Ascorbic Acid Method
Total Nitrogen	4500-N C, -NO ₃ ⁻ E	Persulfate Method, Cadmium Reduction Method
Ammonia-N	4500 -NO ₃ D	Ammonia-Selective Electrode Method
Chemical Oxygen Demand	5200D	Closed Reflux, Colorimetric Method
Copper	3500-Cu B	Neocuproine Method
Zinc	3500-Zn B	Zincon Method
Total Coliform	9221 B	Standard Total Coliform Fermentation Technique
Fecal Coliform	9221 E	Fecal Coliform Procedure
<i>Escherichia coli</i>	9221 F	<i>Escherichia coli</i> Procedure

¹field test

Method Sources:

SM = Standard Methods for the Examination of Water and Wastewater 20th Edition, published by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation

E = EPA methods available of the CD-ROM "Methods and Guidance for Analysis of Water, 2.0, June 1999, EPA 821-C-99-004.

Literature Cited

Hibbs, B., J. L. Cameron, S. Hollinger, and M. Merino. in prep. Stream water quality monitoring in the Mediterranean Coast Network (MEDN), Version 2.0. NPS/MEDN/NRTR.

Standard Operating Procedure (SOP) No. 5 - Data Management

Version 2.0 (September 2011)

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Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

5.0 Data Management

This Standard Operating Procedure documents data management organization and procedures specific to the Aquatic Amphibian Monitoring Protocol for the Mediterranean Coast Network (MEDN), Santa Monica Mountains National Recreation Area (SAMO). General procedures on data management procedures are detailed in the network Data Management Plan (<http://science.nature.nps.gov/im/units/medn/data/index.cfm>).

5.0.1 Administration

Administration of all data files and folders associated with the Aquatic Amphibian Monitoring Protocol are carried out by the park Monitoring Project Manager(s), Network Data Manager and Inventory and Monitoring Program Manager.

5.1 Analog File Organization

5.1.1 Field Forms

Field forms are kept in a file cabinet outside the Resource Integration and Analysis (GIS and Data Management) offices at SAMO headquarters. There is one folder for each survey location.

5.1.2 QA/QC Reports

QA/QC Reports are generated from the database after data entry. Reports are used to verify entered data with the actual data (field form). Final QA/QC reports represent a physical hard copy of the entered data and are filed behind the original field form.

5.3.4 Archives

Original field forms and final QA/QC reports are archived in the park's museum once data has been entered and verified. A copy of the field form and QA/QC report is kept in their respective folder.

5.2 Digital File Organization

5.2.1 Documents and Non-GIS Files

All digital documents and non-GIS files associated with the Aquatic Amphibian Monitoring Protocol are located on SAMO's "G" drive. The G drive is a mapped directory (\users\psrm\shared) on the park's server (\\inpsamo-homehq\)) and is only accessible to staff

within the park's Planning, Science, and Resource Management division. There are several directories within the G drive where files can be located.

Protocol and annual report documents and data summaries are located in G:\Inventory_and_Monitoring\Vital_Signs\Aquatic_Amphibians.

The Aquatic Amphibian Database is located in G:\Animal_Ecology\SAMO_Natural_Resource_Databases. The latest front-end user interface (MEDN_AquaticAmphibianDatabase_v1.0.mdb) is located in this directory. The directory has four subdirectories: Archive, Data, Manuals, Working. Previous versions of the front-end databases are located in the 'Archive' subdirectory. Back-end data tables (MEDN_AquaticAmphibianDATA_be.mdb) are located in the 'Data' subdirectory. Manuals and SOPs on how to use the database are stored in the 'Manuals' subdirectory. Lastly, versions of the front-end database for users to manipulate are located in the 'Working' subdirectory. It is assumed work done in this folder is temporary.

Field and other documents are located in G:\Animal_Ecology\Reptiles and Amphibians\StreamSurvey.

5.2.2 GIS Data

All GIS data associated with the Aquatic Amphibian Monitoring Protocol are located on SAMO's "J" drive. The J drive is a mapped directory (\gis\data) on the park's server (\\inpsamo-trmsrv2\)) and houses the park's GIS data. This drive is only accessible to staff within the park's Planning, Science, and Resource Management division. GIS data for this protocol are located in J:\data\animal_eco\herps\amphibians.

5.2.3 Maintenance

All files on the park's server are backed up nightly. The server is maintained by the park's Information Technology specialist.

5.3 Data Workflow

It is the responsibility of the Monitoring Project Manager(s) to make sure data are collected, entered, reviewed and verified in a timely manner.

5.3.1 Data collection

Data is collected on a field datasheet (Figure 5.1). A digital copy of the datasheet can be found in G:\Animal_Ecology\Reptiles and Amphibians\StreamSurvey\documents\Forms.

Santa Monica Mountains National Recreation Area
Stream Survey Field Form

STREAM NAME _____		DATE ____/____/____		Start Time ____:____	
Field Crew _____					
Coordinates: X _____		Y _____		Datum _____	
		Accuracy ____ m		Elevation ____ m	
Flow _____ m ³ /s = W _____ m x Avg D _____ m x Flow _____ m/s					
Notes / Comments _____					

Occupancy Sampling

☐ BUFO (western toad)	☐ CRAY (crayfish)	Notes / Comments _____ _____ _____ _____
☐ HYRE (giant tree frog)	☐ FISH _____ species	
☐ HYCA (california tree frog)	☐ OTHER _____ species	
☐ TATO (california newt)		

Intensive Sampling: Habitat and Species Observations

HABITAT: Pool, Riffle, Run, Dry L= length (m), D= depth (m)		POPULATION CLASS: <5, 5-20, 21-100, 101-500, >500	
BOULDERS: Yes / No VEGETATION: oak (o), willow (w), mulefat (mf), chaparral (ch), coastal sage (cs)			
SPECIES:	Adult (A)	Juvenile (J)	Larvae (L)
			Egg (E)
All Frogs and Toads (BUBO, HYCA, HYRE, RAAU, RACA*)	Exact	Popn Class	Popn Class
TATO	Exact	Exact	Exact
CRAY* and FISH (native and nonnative)	Popn Class	Popn Class	NA

Stop #	Habitat	L	D	Species	Popn Class / # of Ind.	Age	Boulders	Vegetation	Notes / Comments

Figure 5.1. Partial view of the Aquatic Amphibian Field Datasheet.

5.3.2 Data Entry

Data is to be entered into the Aquatic Amphibian Database as soon as possible after returning from the field or when field datasheets are received from partnering agencies (Pepperdine University and Resource Conservation District of the Santa Monica Mountains), typically within 4 weeks of survey completion. The database (MEDN_AquaticAmphibianDatabase_v1.0.mdb) can be found at G:\Animal_Ecology\SAMO_Natural_Resource_Databases.

5.3.3 Data Review and Verification

Once the data has been entered and saved, it must be checked for inconsistencies or errors. To do so, the user may either review the data on-screen immediately after data entry or print a QA/QC report of the data for verification at a later date.

To review on-screen, the user should cross-check the data in the database with the actual field data sheet immediately after data entry. Any inconsistencies and errors should be resolved at this time by navigating to the incorrect data.

To print out QA/QC reports for verification at a later date, the user should print out the QA/QC report (see Standard Operating Procedure No. 6) and cross-check the entered data with the actual field data sheet. Any inconsistencies and errors on the report should be noted for correction. Once the reports have been reviewed, it is the responsibility of the Monitoring Project Manager(s) to ensure that the errors are resolved in the database.

Following review of the data, the Network Data Manager will check for apparent outliers, null values, or any other anomalous data points and report any errors or inconsistencies to the

Monitoring Project Manager for resolution. Anomalous data points will be reviewed and re-verified by referring to field notes or partnering agencies as appropriate.

Changes to any record in the Aquatic Amphibian Database are documented in the record itself and must include a description of pre- and post-edit changes, especially changes made to the data post-verification.

5.3.4 Data Certification

Once data has been checked and verified, the data can be certified for distribution. Data certification assumes all unflagged records have been collected according to the methods stated in the protocol, have been verified by the Monitoring Project Manager and MEDN Data Manager, and are approved to be used for analysis.

5.3.4 Data Archive

Once data has been entered and verified the original field form and final QA/QC reports are archived with the park curator. A copy of the field form and QA/QC report should be made and kept in their respective folder.

5.4 Metadata Procedures

Data documentation is a critical step toward ensuring that datasets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog datasets within intranet and internet systems, making data more accessible to a broad range of potential users. Metadata for all MEDN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the MEDN Data Management Plan. For GIS files and databases, metadata will be completed at the onset of implementing the protocol. The Monitoring Project Manager and MEDN Data Manager will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. Metadata will be created using Environmental Systems Research Institute (ESRI) tools, the NPS Metadata tools and Editor, and the NPS Database Metadata Extractor. The Monitoring Project Manager should update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Edits within the document should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. The MEDN Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to the NPS IRMA (Integrated Resource Management Applications) data system where they will be available to the public.

5.5 Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Manager and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to MEDN Data Manager. At this time, we do not anticipate that sensitive information will be present in the aquatic herpetofauna monitoring program.

Standard Operating Procedure (SOP) No. 6 - Aquatic Amphibian Database – Structure and Organization

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6.0 Aquatic Amphibian Database

The MEDN Aquatic Amphibian Database is modeled after the Natural Resource Database Template (NRDT) developed by the Natural Resource Inventory and Monitoring Program. The NRDT is a set of relational database tables in Microsoft Access (MS Access, Access) that parks and networks can use as a standardized yet flexible database core for developing natural resource-related applications (National Park Service, 2007). This database complies with NRDT standards for core mandatory tables, fields, relations and naming conventions where applicable.

The database consists of two linked files, a front-end user interface (MEDN_AquaticAmphibianDatabase_v1.0.mdb) and a back-end database (MEDN_AquaticAmphibianDATA_be.mdb). Monitoring Project Manager and wildlife interns that regularly enter data will access the front-end user interface on the SAMO network “G-drive” at the following path - G:\Animal_Ecology\SAMO_Natural_Resource_Databases. The database will automatically open in Microsoft Access 2007 when opened from this folder. The front-end user interface contains forms, queries and visual basic code for the database itself, whereas the backend database contains the data tables. This configuration makes it easier to make changes to the database application without altering the actual data structure or data records. The linked tables are managed by the Linked Table Manager wizard included in the application.

The database is primarily managed by the Network Data Manager. Changes to the design or structure of the database can only be made by the Network Data Manager or with the approval of the Network Data Manager. Changes to the database, such as species lists and file naming conventions are made 2-4 weeks prior to the start of the field season. Changes are documented in the tbl_Db_Meta and tbl_Db_Revisions tables within the database.

Prior to any structural changes to the database, a copy with the most recent version number is stored in the ‘Archive’ subdirectory. Each new version of the database is assigned a sequentially higher number. Version numbers allow project and data managers to track changes to the database over time. Changes to any record in the database are documented in the record itself and must include a description of pre- and post-edit changes, especially changes made to the data post-verification.

Information on data management organization and procedures can be found in Standard Operating Procedure No. 5.

6.1 Forms

Forms are located in the front-end database (MEDN_AquaticAmphibian_v1.0.mdb). The data entry user, usually the Monitoring Project Manager or wildlife intern, interfaces with the database through a series of custom-built forms. The forms have been designed in a way to (1) mimic existing field recording methodology, (2) minimize transcription error (i.e., look-up tables, drop-down menus, auto-filled fields, range limits), and (3) allow users not familiar with MS Access to query the database and export datasets for analysis. Instructional steps are also provided on each form, where applicable, to help guide the user in making the correct selections.

When the database is first opened, the Main Menu ([frm_MainMenu]) window appears (Figure 6.1). Three options are available: Data Entry, Reports, and Data Analysis.



Figure 6.1. Screen shot of the “Main Menu” window in the Aquatic Amphibian Database.

6.1.1 Data Entry

After selecting Data Entry from the Main Menu window, the Data Entry Menu ([frm_StreamSurvey_DataEntryMenu]) appears (Figure 6.2). Users are prompted to select (1) a stream by their code, (2) the survey type (either Occupancy or Intensive), and (3) survey date. There are two options at the third prompt. To enter data for a new survey, users should enter the date in the left field. To view data for an existing survey, the user should select the date from the drop-down list on the right.

Figure 6.2. Screen shot of the “Data Entry Menu” window in the Aquatic Amphibian Database.

When all parameters have been filled in, hit the ‘Enter/Edit Stream Data’ button to open the Stream Survey Field Form window. For new surveys (i.e., new date), a new event record will be added to the database.

6.1.1.1 Stream Survey Field Form

The stream code/name, survey type and survey date corresponding to the parameters selected in the Data Entry Menu will display in the Stream Survey Field Form ([frm_StreamSurvey_DataEntry]) window (Figure 6.3 for Occupancy visits, and Figure 6.4 for Intensive visits). Users should verify that the stream code/name and survey date shown are correct and that the correct survey type is displayed.

Users should enter the start time of the survey ([Time]), all participants involved ([Field Crew]), coordinate locations (if taken) ([X], [Y], [Datum]), and any relevant notes ([Notes/Comments]) associated with the survey event. Time should be entered in 24-hour clock format. Names of participants can be entered manually or selected from a pop-up list (“Select Names”). Datum is required if coordinate locations are entered.

Occupancy and Intensive sampling data are located on subforms within the survey event form ([fsub_PAO_SpeciesData], [fsub_APEX_StopData], [fsub_APEX_SpeciesData]).

SAMO Aquatic Amphibian Database

Mediterranean Coast Network | Santa Monica Mountains National Recreation Area | Aquatic Amphibian Database

Stream Survey Field Form

Print Report **Return to Main**

Stream Code/Name: R1 MEDCRK / MEDEA CREEK **Date:** 7/3/2007 **Time:**

Field Crew: Select Names

Coordinates: X Y **Datum:**

Notes / Comments:

Survey Type: PAO **Water Quality Data**

PAO Sampling

☐ BUBO	☐ FISH	☐ OTHER	Notes/Comments:
☐ HYRE	BASS largemouth bass	AMPH amphibian (unknown)	
☐ HYCA	BLGL bluegill	RAAU California red-legged frog	
☐ TATO	CARP carp	RACA bullfrog	
☐ CRAY	CHUB arroyo chub	INVR invertebrate (unknown)	
	FAMI fathead minnow	ODON Order: Odonata	
	FISH fish (generic)	TOEB toe biter	
	GOLD goldfish	MOLL mollusk (unknown)	
	MOSQ mosquitofish	NZMS New Zealand mud snails	
	STEE steelhead trout	CLMA Southwestern pond turtle	
	SUNF green sunfish	CRVI Southern Pacific rattlesnake	
		ELMU alligator lizard	
		EUSK western skink	

Search for a survey: Stream name Survey date **Find Survey**

Record: 1 of 1 (Filtered)

Figure 6.3. Screen shot of the “Stream Survey Field Form” window in the Aquatic Amphibian Database. The database has been filtered to show a PAO/occupancy sampling event.

For Occupancy sampling ([fsub_PAO_SpeciesData]), users should mark/select the species detected ([BUBO], [HYRE], [HYCA], [TATO], [CRAY], [FISH] and [OTHER]) and enter any relevant notes ([Notes/Comments]) pertaining to species detection during the visit. Species lists for FISH and OTHER are enabled if they are marked. More than one species in the list may be selected.

SAMO Aquatic Amphibian Database

Mediterranean Coast Network | Santa Monica Mountains National Recreation Area | Aquatic Amphibian Database

Stream Survey Field Form

Print Report **Return to Main**

Stream Code/Name: R1 MEDCRK / MEDEA CREEK **Date:** 5/10/2007 **Time:** 3:00

Field Crew: Select Names | lauren constancio, catherine preese, gary busteed

Coordinates: X Y **Datum:**

Notes / Comments: lots of snails

Survey Type: apex **Water Quality Data**

Apex Sampling: Habitat and Species Observations

Total Length = 257.90 m

STOP	TYPE	HABITAT	L	D	Boulders?	Vegetation	Notes / Comments:
1	Primary	Pool	2.00	16	no		high density of snails

Species Information

Species	Popn Class	# of Ind.	Age	Notes / Comments
	<5		Larvae	

Total Number of stops: 21 **Previous STOP** **Next STOP**

Record: 1 of 21

Search for a survey: **Find Survey**

Stream name *Survey date*

Record: 1 of 1 (Filtered)

Figure 6.4. Screen shot of the “Stream Survey Field Form” window in the Aquatic Amphibian Database. The database has been filtered to show an intensive sampling event.

For Intensive sampling ([fsub_APEX_StopData]), users first enter habitat/stop data then species data observed at that habitat/stop. Habitat/stop data include the stop number ([Stop]), segment type [Type], habitat ([Habitat]), length of the habitat ([L]), depth of the habitat ([D]), whether boulders were present ([Boulders?]), general overstory vegetation class ([Vegetation]), and any relevant notes ([Notes/Comments]) associated with the habitat/stop. Stop numbers begin at one and increase sequentially. Primary segment types increase by whole numbers; secondary and tertiary segment types increase by one-tenth decimal increments from the primary segment stop number.

Species data ([fsub_APEX_SpeciesData]) include species name ([Species]), the number observed as a population category ([Popn Class]) or as an exact number ([Exact no]) depending on the protocol, age ([Age]), and any relevant notes ([Notes/Comments]) associated with the species observation.

For convenience, users may either enter all habitat/stop first then navigate back to the associated habitat/stop number to enter species data, or enter species data at the time the habitat/stop data is entered.

Though not collected under this monitoring protocol, cooperating agencies occasionally collect water quality data. To enter this data, hit the “Water Quality” button located above the habitat/stop data section.

To print out a QA/QC report of the current survey event, hit the “Print Report” button located at the top of the form. QA/QC reports should be printed out once data entry is completed and compared to the original field form for errors or inconsistencies. QA/QC reports serves as a hardcopy of the data within the database.

To go to another survey event, select the survey location and date at the bottom of the form and hit “Find Survey”.

6.1.2 Reports

The Reports Menu is currently under construction. Upon completion, the Reports Menu will allow the user to print out QA/QC reports and data summary tables for annual reports.

6.1.3 Extracting Data for Analysis

After selecting Data Analysis from the Main Menu window, the Data Entry Menu appears (Figure 6.5). The Data Analysis Menu creates a query based on user-defined parameters. The queried dataset can be exported to format that can be easily imported into Excel, R, Systat, or other statistical programs. for analysis. It should be noted that queries and query parameters are not saved to the database. The functions that currently exist are to format data for analysis of abundance and occupancy. Plans to include other data analysis functions are in progress and are expected to be completed by the end of fiscal year 2012.

The screenshot shows a software window titled "SAMO Aquatic Amphibian Database". The window has a menu bar with "Mediterranean Coast Network", "Santa Monica Mountains National Recreation Area", and "Aquatic Herpetofauna Database". Below the menu bar is a header "Data Analysis Menu". The main content area is titled "Queries for Analysis" and contains a note: "Note: Data will be exported to an Excel." Below the note is a section titled "Abundance and Occupancy Data". This section contains five numbered parameters for a query: 1. Query by: Sentinel Streams (dropdown), Use: Code Name (dropdown), 2. Species: (dropdown) (Age: (dropdown)), 3. Between Jan 1, (dropdown) and December 31, (dropdown), 4. Analysis: PresenceAbsence (dropdown), 5. Type: COMBINED (dropdown). Below these parameters is a "QUERY" button. At the bottom of the window are two buttons: "Reset Values" and "Return to Main Menu".

Figure 6.5. Screen shot of the “Data Analysis Menu” window in the Aquatic Amphibian Database.

To extract data from the database for analysis, users must first enter a series of parameters. The first parameter queries a specific group of streams (All Streams, Sentinel Streams, Random Year 1 streams, etc.) and displays it by its stream code or full location name. The second parameter queries a specific target species by an age class. The third parameter specifies a date range for the dataset. The fourth parameter specifies the type of analysis the query is for. The last parameter specifies whether to use Occupancy data or Intensive data or both survey type data.

6.2 Tables

Data tables are located in a back-end database (MEDN_AquaticAmphibianDATA_be.mdb). Figure 6.6 shows the relationships among the primary tables.

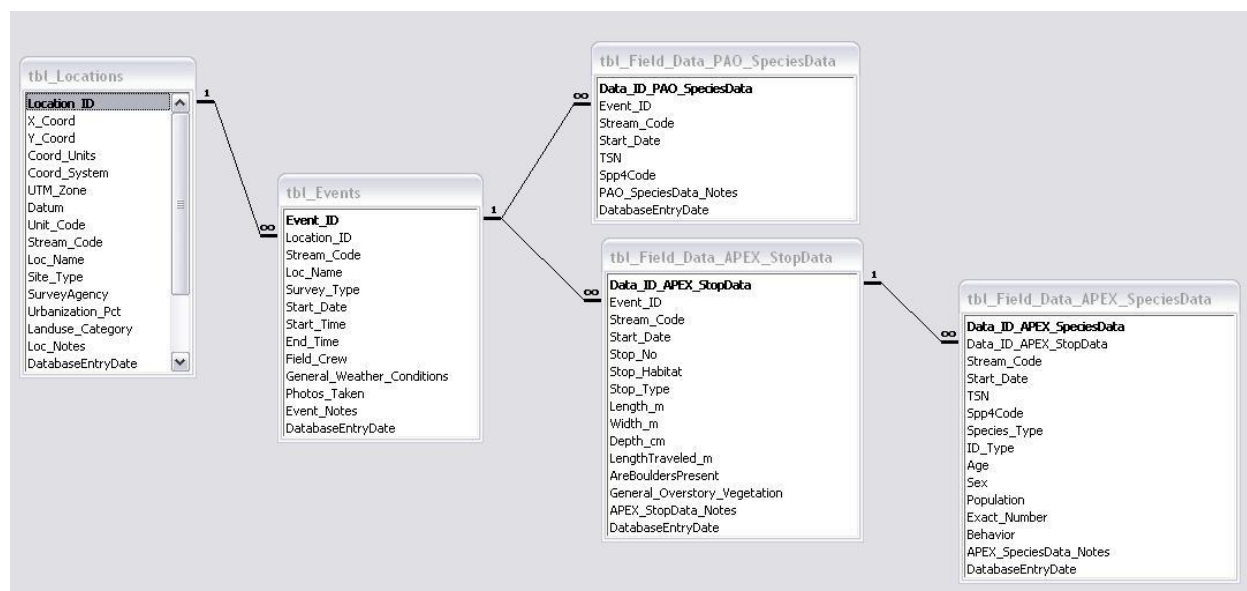


Figure 6.6. Table relationship among the primary tables in the Aquatic Amphibian Database.

The primary table for storing location information is **tbl_Locations** (Table 6.1). This is a core mandatory table under the NRDT standard. The table contains one record for each location that is monitored and includes data on the location, such as coordinate points, and other stream attributes such as the site type, agency responsible for the survey, and percent of urbanization of the watershed upstream of the survey location.

Table 6.1. tbl_Locations is the primary table for storing site information including location name, x- and y-coordinates, agency responsible for the survey, and general land use category. There is one record for each survey location.

Field Name	Field Type	Size	Field Description
Location_ID	Long Integer	4	Location identifier (autonumber)
XCoord	Double	8	X coordinate
YCoord	Double	8	Y coordinate
Coord_Units	Text	50	Coordinate distance units (meters)
Coord_System	Text	50	Coordinate system (UTM)
UTM_Zone	Text	50	UTM Zone (11N)
Datum	Text	50	Geographic datum (Nad 27)
Unit_Code	Text	12	Park code (SAMO)
Stream_Code	Text	20	Location (stream) code
Loc_Name	Text	75	Location (stream) name
Site_Type	Text	20	Site type: Legacy, Sentinel, Random1, Random2, Random3, NPS, Pepperdine, RCD
SurveyAgency	Text	20	Agency responsible for location stream survey (NPS, RCD, Pepperdine)
Urbanization_Pct	Long Integer	4	Percent of watershed upstream of survey location that is urbanized
Landuse_Category	Text	20	General land use category (natural, urban)
Loc_Notes	Memo		Additional comments
DatabaseEntryDate	Date/Time	8	Date data was entered into the database

The primary table for storing information on survey event is tbl_Events (Table 6.2). This is a core mandatory table under the NRDT standard. The table is linked to tbl_Locations by the Location_ID field. The table contains one record for each visit made and includes data on the visit such as the date and time, type of survey (Intensive or Occupancy), names of the field crew and general weather conditions.

Table 6.2. tbl_Events is the primary table for storing event (visit) information including date and time, field crew and weather. The table contains one record for each survey visit.

Field Name	Field Type	Size	Field Description
Event_ID	Long Integer	4	Event identifier
Location_ID	Long Integer	4	Link to tbl_Locations
Stream_Code	Text	10	Stream code
Loc_Name	Text	50	Stream name
Survey_Type	Text	5	Survey type (PAO, Apex)
Start_Date	Date/Time	8	Starting date for the event
Start_Time	Date/Time	8	Starting time for the event
End_Time	Date/Time	8	Ending time for the event
Field_Crew	Memo		Field crew
General_Weather_Conditions	Text	25	Description of weather
Photos_Taken	Text	5	Were photos taken during this visit?
Event_Notes	Text	255	Additional comments on event data
DatabaseEntryDate	Date/Time	8	Date data was entered into the database

There are three main primary tables for storing survey field data collected during a survey event (tbl_Field_Data_PAO_SpeciesData, tbl_Field_Data_APEX_StopData, tbl_Field_Data_APEX_SpeciesData). These are core mandatory tables (tbl_Field_Data) under the NRDT standard.

The primary table for storing species detection data on PAO/occupancy visits is tbl_Field_Data_PAO_SpeciesData (Table 6.3). The table is linked to tbl_Events by the Event_ID field. The table contains one record for each target species (BUBO, HYCA, HYRE, TATO, CRAY, and FISH) detected at the stream during the PAO/Occupancy visit. If a record does not exist for a target species it is assumed that the species was not detected during the visit.

Table 6.3. tbl_Field_Data_PAO_SpeciesData is the primary table for storing species detection data during a PAO/Occupancy visit. There is one record for each species detected at the given site.

Field Name	Field Type	Size	Field Description
Data_ID_PAO_SpeciesData	Long Integer	4	Field data table row identifier
Event_ID	Long Integer	4	Link to tbl_Events
Stream_Code	Text	10	Stream code
Start_Date	Date/Time	8	Starting date for the event
TSN	Text	4	ITIS Taxonomic Serial Number
Spp4Code	Text	4	4-letter species code
PAO_SpeciesData_Notes	Text	255	Additional comments on species data
DatabaseEntryDate	Date/Time	8	Date data was entered into the database

Two primary tables are used for storing species detection data on an Intensive visit. The first table, tbl_Field_Data_APEX_StopData (Table 6.4), stores data on the stream survey segment. The table is linked to tbl_Events by the Event_ID field. The table contains one record for each stop made during the survey. Stops are made at each stream habitat and information on the length and depth of the habitat and other characteristics are recorded.

Table 6.4. tbl_Field_Data_APEX_StopData is the primary table for storing stream segment data including habitat type, and length and depth of the segment (stop). There is one record for each segment visited at a survey location.

Field Name	Field Type	Size	Field Description
Data_ID_APEX_StopData	Long Integer	4	Field data table row identifier
Event_ID	Long Integer	4	Link to tbl_Events
Stream_Code	Text	10	Stream code
Start_Date	Date/Time	8	Starting date for the event
Stop_No	Long Integer	4	Stop number
Stop_Habitat	Text	50	Habitat at stop (run, riffle, pool, dry)
Stop_Type	Text	50	Level of stop (primary, secondary, tertiary)
Length_m	Single	4	Length of habitat (meters)
Width_m	Single	4	Width of habitat (meters) - LEGACY
Depth_cm	Single	4	Depth of habitat (meters)
LengthTraveled_m	Long Integer	4	Sum of distance traveled
AreBouldersPresent	Text	5	Are boulders present in the habitat?
General_Overstory_Vegetation	Text	20	General overstory vegetation class
APEX_StopData_Notes	Text	255	Additional comments on stop data
DatabaseEntryDate	Date/Time	8	Date data was entered into the database

The second table, tbl_Field_Data_APEX_StopData (Table 6.5) stores species detection and abundance information. tbl_Field_Data_APEX_SpeciesData is linked to tbl_Field_Data_APEX_StopData by the Data_ID_APEX_StopData field. The table contains one record for each species observed within the stream segment along with age, sex, abundance category or exact count of the number of individuals seen.

Table 6.5. tbl_Field_Data_APEX_SpeciesData is the primary table for storing species data including species, age, and abundance. There is one record for each species observed at a given stream segment.

Field Name	Field Type	Size	Field Description
Data_ID_APEX_SpeciesData	Long Integer	4	Field data table row identifier
Data_ID_APEX_StopData	Long Integer	4	Link to tbl_Field_Data_APEX_StopData
Stream_Code	Text	10	Stream code
Start_Date	Date/Time	8	Starting date for the event
TSN	Text	4	ITIS Taxonomic Serial Number
Spp4Code	Text		4-letter species code
Species_Type	Text	20	Species type (reptile, amphibian, fish, invertebrate)
ID_Type	Text	10	Identification type (visual or audio)
Age	Text	10	Age of species (A dult, J uvenile, L arvae, E gg, U nknown)
Sex	Text	7	Sex of animals observed (M/F)
Population	Text	10	Estimated number of animals observed (<5, 5-20, 21-100, 101-500, >500, NA)
Exact_No	Double	8	Exact number of animals observed, if known
Behavior	Text	20	Behavior observed (WCP, breeding, vocal)
APEX_SpeciesData_Notes	Text	255	Additional comments on species data
DatabaseEntryDate	Date/Time	8	Date data was entered into the database

Regardless of whether or not water exists or animals were observed during a survey visit, data in the tbl_Events and tbl_FieldData_APEX_StopData (if the survey type is Intensive) tables is always collected. So, for example, if a stream is dry during a survey visit, an event is entered, as well as a corresponding record in the stop data table with the following values: stop number = 1, habitat = dry, length = 250 m, depth = 0 cm.

Supporting tables include several lookup tables such as tlu_SpeciesList and tlu_PopnClass, as well as database metadata and revision history (tbl_DB_Meta and tbl_DB_Revision, respectively). tlu_SpeciesList contains a list of species (reptiles, amphibians and fish) that are likely to be observed during a survey. The table also includes ITIS Taxonomic Serial Numbers for each species. tlu_PopnClass Contains a list of all the possible population categories that have been used since monitoring began. tbl_Db_Meta and tbl_DB_Revisions are core tables under the NRDT standard.

Users not familiar with MS Access or the Monitoring Protocol are prohibited from working in the back-end database. Any questions about data entry procedures or difficulties should be directed to Monitoring Project or Network Data Managers.

6.3 Reports

Reports are located in the front-end database (MEDN_AquaticAmphibian_v1.0.mdb). Reports generated by the database are currently under construction. At present, only one report exists in the database. This report generates a QA/QC report for the survey event, which is generated by the data entry user immediately following data entry. Plans to include various summary reports are in progress and are expected to be completed by the end of fiscal year 2011.

Standard Operating Procedure (SOP) No. 7 - Data Analysis for Annual Status Reports

Version 2.0 (September 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

7.0 Annual Status Reports

This Standard Operating Procedure documents the general format and contents of the annual status report for monitoring data associated with the Protocol for Monitoring Aquatic Amphibians in the Mediterranean Coast Network. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the Mediterranean Coast Network monitoring program are detailed in the program's Data Management Plan.

7.0.1 Annual Report General Contents

A data summary report is to be completed annually at the end of each field season to correspond with the fiscal funding year for the National Park Service. The report is to be delivered to the MEDN program manager by August 30th of each year with results from the previous year's surveys. The program manager will work to combine and analyze data collected by NPS, Pepperdine University and Resource Conservation District of the Santa Monica Mountains (RCD) to complete the annual report.

The annual report will include the following information:

- A brief narrative of the year's survey methodology, effort, basic results, noteworthy observations, and any changes in the sampling or analysis procedures.
- A table with the names of personnel that conducted surveys in that year.
- A table and accompanying map with the locations, date, and type of survey visit for each stream surveyed in that year.
- A list of all species observed that year.
- A brief description of field procedures, quality control and data handling, and data analysis methods.
- A table with all raw data gathered in the current year.
- A brief synthesis (graphs, charts, or statistical tests) of occupancy and abundance data taken
- A short discussion of results
- A list of any references cited.

7.1 Data Analysis for Annual Status Reports

Queries to the Aquatic Amphibian Database will be made by the Network Data Manager and data will be formatted for analysis by the Monitoring Project Manager. Tables resulting from the

queries can be opened and manipulated in Microsoft Excel (e.g., Figure 7.1). Data that can be used as covariates for occupancy models and trend analysis (see SOP 8) can be queried in a similar way. Specifically, water quality data that is collected from all sites can be used as covariates. Other effects that can be explored are observer effects, year, month, or day effects, and the presence of invasive species.

7.1.1 Methods to estimate single season occupancy and detectability

Single season occupancy estimates will be made for each species using intercept-only, zero-inflated binomial mixture models. Only sentinel sites will be used for single-season estimates of occupancy because of the low within-year sample size for GRTS sites. Sentinel sites were selected using judgment sampling, so inference will be limited to the sentinel sites and will not be extended to the sampling population. Occupancy and detection probabilities will be estimated using maximum likelihood (MLE's) and numerical optimization. R code, adapted from Royle and Dorazio (Royle and Dorazio 2008), page 117, Panel 3.8), will be used generate the point and 90% interval estimates for occupancy and detection. Variance of parameter estimates will be determined by assuming asymptotic normality of the MLE. Confidence limits will be estimated for the logit of occupancy and detection and then transformed to probabilities. Confidence intervals will be asymmetric, but will range within the 0-1.0 interval.

7.1.2 Example results, infiles, and R code for estimation of single season occupancy and detectability

As an example, we are presenting the results of this type of analysis for 2009 stream survey data. Data were provided by MEDN staff (Excel file name "CombinedPAO_SAMO_06to09_corrected.xls"). Manipulations were conducted in Excel to prepare the data for the R code. Missing observations were converted from "-" characters to "NA" and data from years 2006-2008 were removed since this is an analysis of single season occupancy and detection from 2009. Data were saved in *.csv format. Input data files produced by the Excel manipulations were: "bubo_2009.csv", "hyre_2009.csv", "hyca_2009.csv", and "tato_2009.csv" (Figure 7.2). The R files "bubo_2009.r", "hyre_2009.r", "hyca_2009.r", and "tato_2009.r" input each species *.csv data files and conduct the analysis (Figure 7.3).

The results of this analysis found that occupancy point estimates for 2009 ranged from 0.102 for BUBO to 0.870 for HYRE (Table 7.1). Detection was less variable, ranging from 0.400 to 0.914. A bar graph was made in Microsoft Excel using data from Table 7.1 (Figure 7.4). For demonstration purposes, sentinel and GRTS sites were combined in 2009 (Table 7.1, Figure 7.4), however in the future only sentinel sites will be used for single-season estimates of occupancy because of the low within-year sample size for GRTS sites. However, inferences for trends (over several years) in occupancy and detectability in our study area will be made using only the GRTS data (see SOP 8).

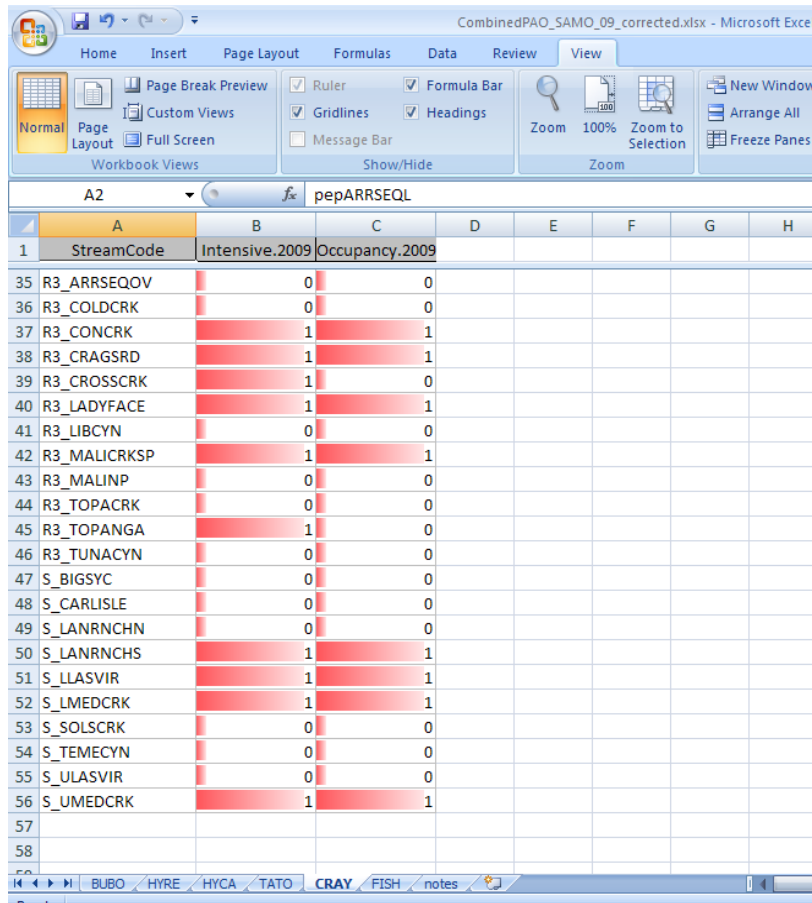


Figure 7.1. Screen shot of Microsoft excel file showing detection data for crayfish in 2009 streams surveyed by NPS.

	A	B	C	D	E	F	G	H	I
1	StreamCode	y.1	y.2						
35	R3_ARRSEQOV	0	0						
36	R3_COLDCKR	0	1						
37	R3_CONCRK	0	0						
38	R3_CRAGSRD	0	0						
39	R3_CROSSCRK	0	0						
40	R3_LADYFACE	0	0						
41	R3_LIBCYN	0	0						
42	R3_MALICRKSP	0	0						
43	R3_MALINP	0	0						
44	R3_TOPACRK	0	0						
45	R3_TOPANGA	0	0						
46	R3_TUNACYN	0	0						
47	S_BIGSYC	1	1						
48	S_CARLISLE	1	1						
49	S_LANRNCHN	0	0						
50	S_LANRNCHS	0	0						
51	S_LLASVIR	0	0						
52	S_LMEDCRK	0	0						
53	S_SOLSCRK	1	1						
54	S_TEMECYN	1	1						
55	S_ULASVIR	0	0						
56	S_UMEDCRK	0	0						
57									
58									

Figure 7.2. Comma-separated file opened in Microsoft Excel for 2009 presence or absence data for California newts (TATO, *Taricha torosa*). This file named “tato_2009.csv” is used as the input file for use with the R code (Figure 7.3) to estimate single-season occupancy and detection, where y.1 and y.2 are the two survey visits during that year.

```

# Filename:      tato_2009.r
# Date:         8/27/10

# Notes:        Code calculates 2009 occupancy and detection point and interval
#               estimates, then uses the estimates to determine the % of sites
#               to sample (for an optimum k) to achieve a SE = 0.05 on occupancy.
#               Code modified from Panel 3.8 of Royle and Dorazio, page 117.
# Contact:      Steve Hayes (a-tc-g@comcast.net)

# Define the path to the single season data.
setwd("C:/Consulting/NPS/MEDN/Aquatic Herps/data/single season data/2009")

expit <-function(x){exp(x)/(1+exp(x))}
logit <-function(x){log(x/(1-x))}

# Read data into an R object.
data<-read.table("tato_2009.csv",sep=',',header=T)
# Examine the data
names(data)
head(data)
data

# Define the response object.
ymat<-data[,c("y.1","y.2")]
M<-nrow(ymat)
ones<-rep(1,M)

# Define the function that calculates the likelihood for the no intercept model.
lik<-function(parms,vars){
  tmp<-rep(0,2)
  names(tmp)<-c("pconst","psiconst")
  tmp[vars]<-parms
  ones<-rep(1,M)
  pmat<-expit(tmp[1]*ones)
  psi<-expit(tmp[2]*ones)
  loglik<-rep(NA,M)
  for(i in 1:M){
    yvec<-ymat[i,]
    navec<-is.na(yvec)
    nd<-sum(yvec[!navec])
    pvec<-pmat[i]
    cp<- (pvec^yvec)*((1-pvec)^(1-yvec))
    cp[navec]<-1
    loglik[i]<-log(prod(cp)*psi[i] + ifelse(nd==0,1,0)*(1-psi[i]))
  }
  sum(-1*loglik)
}

nam<-c("pconst","psiconst","-2l", "aic")
out<-matrix(NA,nrow=1,ncol=length(nam))
dimnames(out)<-list(1:1,nam)

v<-c("pconst","psiconst")
x<-nlm(lik,c(0,0),vars=v,hessian=TRUE)
alarm()
out[1,v]<-x$estimate
out[1,3]<-x$minimum*2
out[1,"aic"]<-2*x$minimum + 2*length(v)
# Print the model estimates, -2ln(likelihood), and AIC
out

# Choose the column from the beta-hat vector that contain the occupancy intercept:
Beta.Occ<- data.matrix(x$estimate[2])
# Invert the Hessian (Information) matrix to obtain the variance/covariance
# matrix for beta-hat:
Var.Beta.Occ<-solve(x$hessian)
yhat<- Beta.Occ
SE.yhat<-sqrt(Var.Beta.Occ[2,2])

# Estimate a 90% CI on yhat.
alpha<-0.10
Z.alpha<- qnorm(1-alpha/2)

```

Figure 7.3. Example of R code used to estimate single season occupancy and detection for California newts in 2009.

Table 7.1. Occupancy and detection point and interval estimates (CI) for 2009 (NPS sites only – sentinel and GRTS sites combined). Estimates made from intercept only models using maximum likelihood and assuming asymptotic normality of estimates. Sample size was 22 sites (k=2, 44 surveys) for each species.

Species Code	Parameter	Point Estimate	90% CI
BUBO	Occupancy	0.1023	0.0299-0.2966
	Detection	0.6667	0.1634-0.9534
HYRE	Occupancy	0.8700	0.6950-0.9516
	Detection	0.9143	0.7912-0.9678
HYCA	Occupancy	0.2841	0.0754-0.6589
	Detection	0.4000	0.0907-0.8167
TATO	Occupancy	0.2301	0.1141-0.4095
	Detection	0.8889	0.5598-0.9805

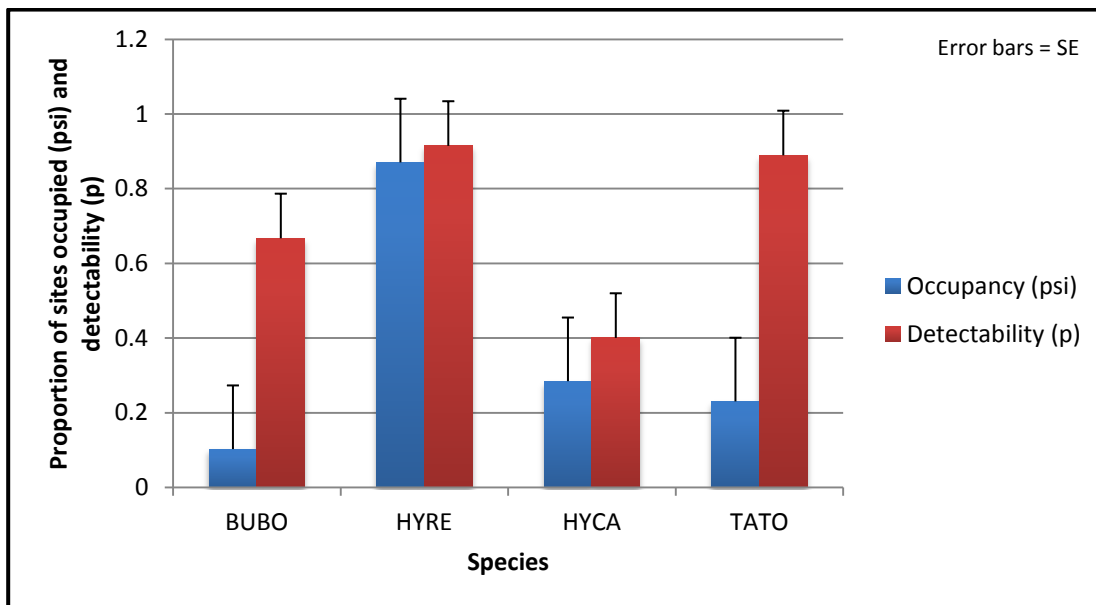


Figure 7.4. Bar graph showing the data presented in Table 7.1 for occupancy, detectability, and standard error bars.

7.1.3 Analysis with abundance indices

During the intensive stream surveys, abundance indices are taken at each stop for the larvae of the four focal amphibian species and invasive species (see SOP 4). The number of stops in a stream varies due to differing stream structure. In addition, the abundance indices for any given species will vary because of stream structure, the presence of certain habitat types, the presence of invasive predatory crayfish or fish, and water quality measurements. To analyze abundance data, queries are made by the Network Data Manager to the Aquatic Amphibian Database. Data will be formatted for analysis by the Monitoring Project Manager. Tables resulting from the queries can be opened and manipulated in Microsoft Excel (e.g., Figure 7.5).

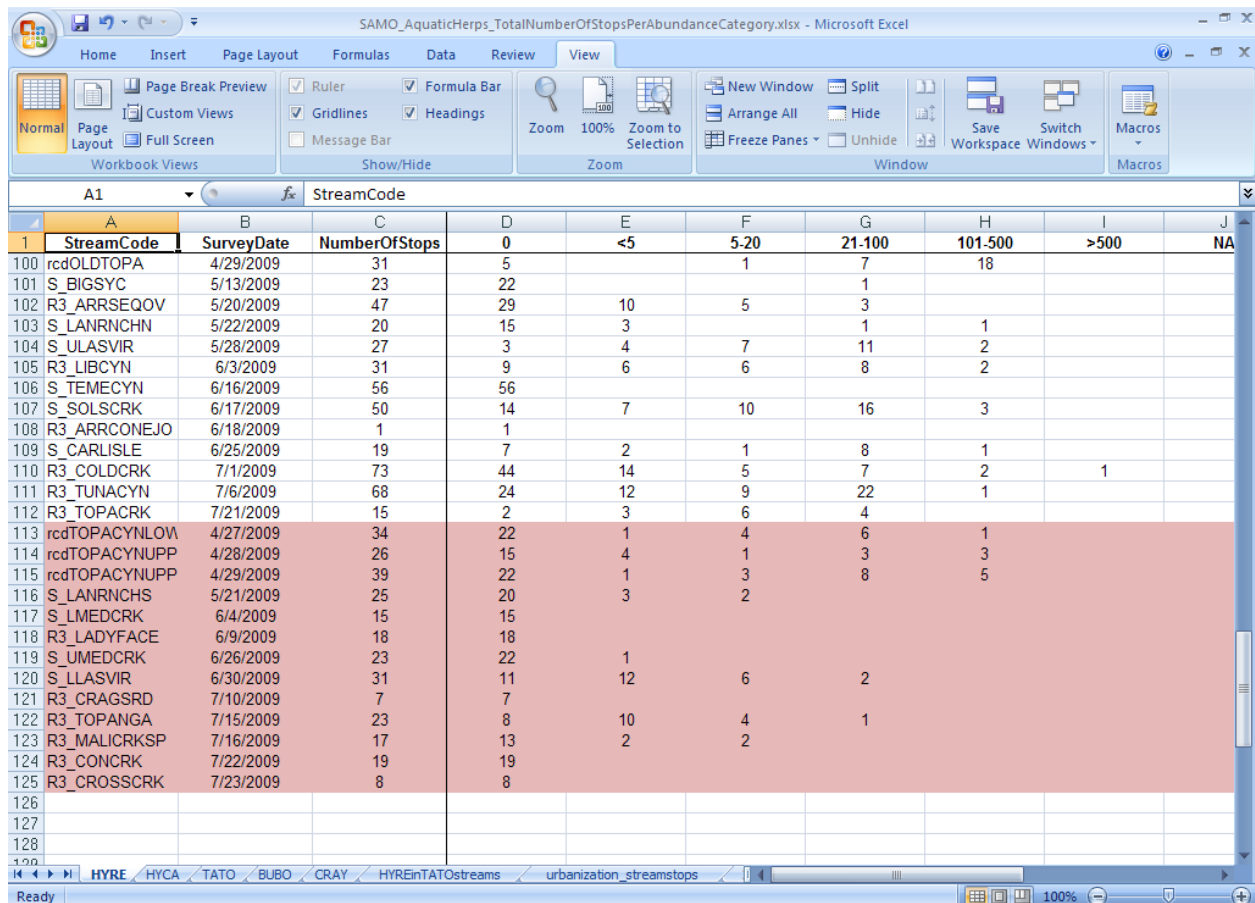


Figure 7.5. Screen shot of Pacific tree frog (HYRE, *P. regilla*) abundance data from 2009 intensive stream surveys in Microsoft Excel. Shown here is the name (code) of the stream, the number of stops in the stream, and the number of stops that contained HYRE tadpoles at an abundance index of 0, less than 5 (<5), 5 to 20, 21 to 100, 101 to 500, or greater than 500 (>500).

Abundance data can be presented in many ways when this type of format is used. For example, abundance data can be compared between streams with invasive crayfish (highlighted in pink, Figure 7.5) and those without crayfish (not highlighted, Figure 7.5). Another example is shown in Figure 7.6, where trends in abundance and years can be visualized for each site.

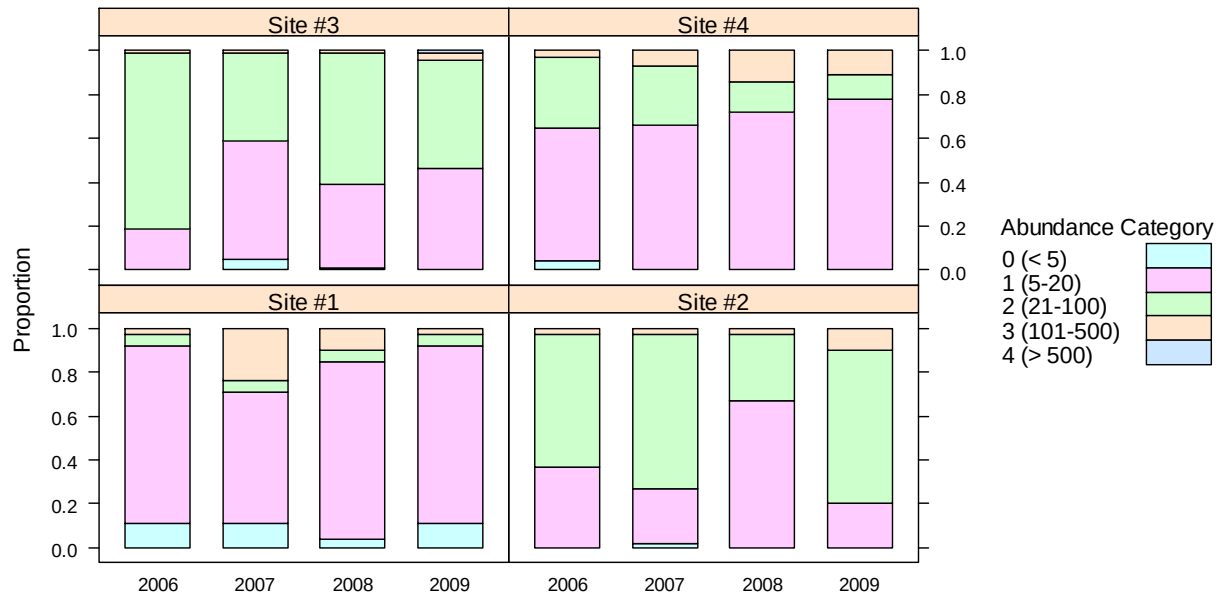


Figure 7.6. Example plot of trend in abundance categories for 4 hypothetical sites.

Literature Cited

Royle, J. A., and R. M. Dorazio. 2008. Hierarchical Modeling and Inference in Ecology. Academic Press, New York.

Standard Operating Procedure (SOP) No. 8 - Data Analysis for Periodic Trend Status Reports

Version 2.0 (September 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

8.0 Periodic Trend Status Reports

This Standard Operating Procedure documents the general format and contents of the periodic trend status report for monitoring data associated with the Breeding Aquatic Amphibian Monitoring Protocol for the Santa Monica Mountains National Recreation Area. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the Mediterranean Coast Network monitoring program are detailed in the program's Data Management Plan.

8.0.1 General Contents of Periodic Trend Status Reports

A trend report is to be completed every 3 years. This time frame allows for all 36 rotating sites to be visited. The report is to be delivered to the MEDN network Program Manager by December 30th of the required year with results analyzed up to the previous year's surveys. National Park Service, Pepperdine University, and Resource Conservation District of the Santa Monica Mountains (RCD) will combine data from each season to be analyzed together and included together in periodic reports.

The periodic report will include the following information:

- A brief narrative survey methodology, effort, basic results, noteworthy observations, and any changes in the sampling or analysis procedures.
- A list of personnel and training schedule from the time period.
- A table and accompanying map with the locations, date, and type of survey visit for each stream surveyed in the time period.
- A list of all species observed in the time period.
- A brief description of field procedures, quality control and data handling, and data analysis methods.
- A table with all raw data gathered from the survey time period.
- A synthesis (graphs, charts, or statistical tests) of occupancy and abundance data taken.
- An extensive discussion of results and trends.
- Recommendations for management actions that may be informed by the results of the periodic report.
- An accounting of time management and fund resources that were needed to collect and analyze data, and complete the written periodic report.

8.0.2 Trend Estimation Model

Trend estimates will be made using implicit, zero-inflated binomial mixture models with covariates for occupancy. The zero-inflated mixture model is appropriate because non-detections occur at occupied sites, and the outcome is a mixture of two random processes, detection and occupancy (Royle and Dorazio 2008). The binomial response is detected/not detected. Models will be fit using maximum likelihood and numerical optimization (Moreno and Lele 2010, Starcevich and Steinhorst 2010).

Separate models will be fit for each of the 4 species (BUBO, HYCA, HYRE, TATO). Sentinel and GRTS selected sites will be analyzed separately for trend analysis. Park-wide inference in the trend in occupancy and detectability will be made only using the GRTS selected sites.

A set of candidate models (per species) will be identified by considering combinations of the occupancy covariates (Table 8.1). Initially, occupancy covariates will be year, watershed development (developed/not developed), crayfish presence/absence, and fish presence/absence. Watersheds will be classified as “developed” if 8-10% or more of the watershed was urbanized, and as “not developed” otherwise. Other covariates will include habitat characteristics that affect stream structure (boulders presence/absence, overstory vegetation, amount of submerged vegetation) and water quality measurements (e.g., pH, phosphates, nitrates, flow, conductivity, etc.) The AIC criterion and model stability will be used to select the optimal model (Burnham and Anderson 2002).

Model stability can be problematic when numerical methods are used to obtain parameter estimates from likelihoods such as the zero-inflated binomial mixture (Lele et al. 2007, Polansky et al. 2009, Moreno and Lele 2010). Stability depends in part on data structure, parameter starting values used to begin the optimization, and sample size (number of sites and number of revisits). Starting values are determined using logistic regression on the naïve occupancy and detection responses. Stability will be assessed by examining the structure of the Hessian (Information) matrix and the parameter estimates (Moreno and Lele 2010). Models that produce Hessian matrices that cannot be inverted or models that produce very large or small values may be deemed unstable. In addition, models that produce extremely large or biologically implausible parameter estimates will also not be considered (Polansky et al. 2009, Moreno and Lele 2010).

Once an optimal model is selected, 90% confidence intervals will be estimated for parameter estimates and odds ratios. A likelihood ratio test ($\alpha=0.10$) will be performed to test for a significant year effect on occupancy, which would indicate a significant trend upward or downward in occupancy. R code, adapted from Starcevich and Steinhorst (2010), will be used to fit the models, estimate confidence intervals, and perform the likelihood ratio test.

8.1 Example using data from 2006-2009

Data were provided by MEDN staff (Microsoft Excel file name “CombinedPAO_SAMO_06to09_corrected.xls”). Given the limited data availability, we assumed that variability of sentinel and GRTS sites was similar, so we pooled data across panels for the demonstration of the method. Before models could be fit using R, data had to be manipulated so each row represented an individual sampling event, i.e., data from each season with k=2 sampling events had to be represented in 2 rows. SAS (Proc Transpose) was used to

create the appropriate data sets for analysis in R. The SAS programs (“bubo merge final.sas”, “hyre merge final.sas”, “hyca merge final.sas”, and “tato merge final.sas”) were used to create transposed data sets that were exported to Excel. In Excel, missing values were changed from “.” to “NA”, then saved as *.csv files (Figure 8.1).

Table 8.1. Candidate models that can be considered for estimating occupancy trend over time for each of 4 amphibian species. Whether a watershed was considered developed (urbanized) or not (DEV), the presence of crayfish (CRAY), and the presence of invasive fish (FISH) can be used as covariates for occupancy.

Model	Occupancy Covariates			
	Year	DEV	CRAY	FISH
1				
2	X			
3	X	X		
4	X		X	
5	X			X
6	X	X	X	
7	X	X		X
8	X		X	X
9	X	X	X	X

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	strm_code	year	occ	name	response	c	cray_samp	f	fish_samp	urban					
1	S_BIGSY	0	1	f11	1	0	0	0	0	0.26					
2	S_BIGSY	0	1	f12	1	0	0	0	0	0.26					
3	S_CARLISLE	0	1	f11	1	0	0	0	0	5.88					
4	S_CARLISLE	0	1	f12	1	0	0	0	0	5.88					
5	S_LANRNCHN	0	1	f11	1	0	0	0	0	0					
6	S_LANRNCHN	0	1	f12	0	0	0	0	0	0					
7	S_LANRNCHS	0	0	f11	0	1	1	1	1	15.44					
8	S_LANRNCHS	0	0	f12	0	1	1	1	1	15.44					
9	S_LLASVIR	0	0	f11	0	1	1	1	1	10.63					
10	S_LLASVIR	0	0	f12	0	1	1	1	1	10.63					
11	S_LMEDCRK	0	0	f11	0	1	1	1	1	36.67					
12	S_LMEDCRK	0	0	f12	0	1	1	1	1	36.67					
13	S_SOLSCRK	0	1	f11	1	0	0	0	0	2.07					
14	S_SOLSCRK	0	1	f12	1	0	0	0	0	2.07					
15	S_TEMECYN	0	1	f11	1	0	0	0	0	0					
16	S_TEMECYN	0	1	f12	1	0	0	0	0	0					
17	S_ULASVIR	0	0	f11	0	0	0	0	0	0.7					
18	S_ULASVIR	0	0	f12	0	0	0	0	0	0.7					
19	S_UMEDCRK	0	0	f11	0	1	1	1	1	27.94					
20	S_UMEDCRK	0	0	f12	0	1	1	1	1	27.94					
21	pepCOLDCKRU	0	1	f11	1	0	0	0	0	2.55					
22	pepCOLDCKRU	0	1	f12	1	0	0	0	0	2.55					
23	R1_ARRCONEJO	1	0	f21	0	0	0	0	0	6.722					
24	R1_ARRCONEJO	1	0	f22	0	0	0	0	0	6.722					
25	R1_CONCRK	1	0	f21	0	1	1	1	1	86.198					

Figure 8.1. Screen shot of the Microsoft Excel comma-separated input file (“tato_full.csv”), input to R for estimating trend in occupancy in California newts (TATO, *Taricha torosa*)

Two sets of R programs were used to fit and evaluate models. The first set (“bubo_occ_SAMO_las.r”, “hyre_occ_SAMO_las.r”, “hyca_occ_SAMO_las.r”, and “tato_occ_SAMO_las.r”) was used to fit all nine models (Table 8.1) to determine starting values, stability, and AIC. The second set (“hyca_occ_m4_SAMO_las.r”, “tato_occ_m5_SAMO_las.r”) was used to estimate confidence intervals and conduct the likelihood ratio tests for trend effects.

Example of R code in Figure 8.2.

```
# Filename:  tato_occ_m5_SAMO_las.r
# Date:      8/25/10

# Notes:     This code estimates occupancy and detection for 'tato' pilot data,
#            2006-2009, generates 90% CI's of occupancy for each unique
#            occupancy covariate pattern, and performs a likelihood ratio
#            test for trend (year effect) for the pilot data. "Model 5",
#            containing no detection covariates and occupancy covariates
#            year and fish, is fit. Model 5 is used because it produced
#            the lowest AIC values from the set of stable candidate models.

#            Adapted from code obtained from Leigh Ann Starcevich in the document
#            "DataAnalysis_SOP_LAS_032110.doc"

# Contact:   Steve Hayes (a-tc-g@comcast.net)

##### NOTE: You will need to change the setwd statement to access pilot
##### data location on your local computer.
setwd("C:/Consulting/NPS/MEDN/Aquatic Herps/data")
tato<-read.table("tato_full.csv",sep=',',header=T)

names(tato)
head(tato)
summary(tato)
tato

# Copy and paste these general functions into R for summarizing results:

expit<-function(x) ifelse(x>700,1,exp(x)/(1+exp(x)))
logit<-function(x) log(x/(1-x))

# The following defines the amphi.implicit function. Use this function to
# fit a zero-inflated binomial model to the pilot data. Occupancy covariate
# choices are year, cray, fish, and urban. Detection covariate choices are
# cray_samp and fish_samp. Due to collinearity concerns, cray and cray_samp
# should not be modeled together; nor should fish and fish_samp.

amphi.implicit <-function(parms,vars, data){

# Create a vector to hold the estimated parameters.
tmp<-rep(0,8)
# Parameter names:
```

Figure 8.2. R code for TATO example.

```

names(tmp)<-c("pconst","psiconst", "year", "cray", "fish", "urban", "cray_samp", "fish_samp")
# First, the starting values are held here, then they are updated with each
# iteration of the nlm function.
tmp[vars]<-parms

# Obtain the occupancy data:
OccData<-data.frame(unique(cbind(data$year, data$cray, data$fish, data$urban)))
names(OccData)<-c("year", "cray", "fish", "urban")
M<-dim(OccData)[1]

# Obtain the detection data:
DetData<-data.frame(unique(cbind(data$cray_samp, data$fish_samp)))
names(DetData)<-c("cray_samp", "fish_samp")
T<-dim(DetData)[1]

# Pick off the covariates for occupancy and detection models.
Rows<- dim(data)[1]
ones.Occ<-rep(1,M)
ones.Det<-rep(1,T)
year<- OccData$year
cray<- OccData$cray
fish<- OccData$fish
urban<-OccData$urban

cray_samp<-DetData$cray_samp
fish_samp<- DetData$fish_samp

# Model detection probs:
pmat<-expit(tmp[1]*ones.Det + tmp[7]*cray_samp + tmp[8]*fish_samp)
# Model occupancy rates
psi<-expit(tmp[2]*ones.Occ + tmp[3]*year + tmp[4]*cray + tmp[5]*fish + tmp[6]*urban)

# Create a vector to hold the log-likelihoods:
LogLik<-rep(NA,M)
# The response vector:
ymat<-data$response

for(i in 1:M){
# Unique occupancy covariate pattern loop
prob<-rep(1,T)
for (t in 1:T) {
# Unique detection covariate pattern loop
index<-(1:Rows)*as.numeric((data$year==OccData[i,1]) & (data$cray==OccData[i,2]) & (data$fish==OccData[i,3]) &
(data$urban==OccData[i,4]) & (data$cray_samp==DetData[t,1]) & (data$fish_samp==DetData[t,2]))
length_index<-length(index)

index<-index[index!=0]
m<-length(index)
if(m>0) {
yvec<-ymat[index]
ysum<-sum(yvec)
nodet<-as.numeric(ysum==0)

```

Figure 8.2. R code for TATO example (continued).

```

# Calculate the likelihood:

prob[t]<- ((psi[i]* pmat[t])^ysum)*((1- (psi[i]*pmat[t]))^(m-ysum))

    }                                # end if

    }                                # End t loop
    LogLik[i]<-log(prod(prob))

}                                    # End i loop
sum(-1*LogLik)
}

# Determine optimal starting values using naive logistic regression.

# Model 10
fit.some.logreg<-glm(response~ 1, family = binomial, data=tato)
summary(fit.some.logreg)
fit.occ.logreg<-glm(occ~ year + f, family = binomial, data=tato)
summary(fit.occ.logreg)

# Obtain the MLE for the model using numerical optimization:
# Model 10
v= c("pconst", "psiconst", "year", "fish")
x<-nlm(amphi.implicit, p=c(-0.60, 0.85, -0.22, -3.84), vars=v, data=tato, hessian=TRUE)
alarm()
x

nam<-c("pconst", "psiconst", "year", "fish", "-2l", "aic")
out<-matrix(NA,nrow=1,ncol=length(nam))
dimnames(out)<-list(1:1,nam)
out[1,v]<-x$estimate
out[1,"-2l"]<-x$minimum*2
out[1,"aic"]<-2*x$minimum + 2*length(v)

out

# Estimate 90% CI for occupancy parameters:

# Produce a table of predicted occupancy with 90% CI's for each occupancy
# covariate pattern:

# Choose the columns from data that contain year and urban covariates:
X.Occ<- data.matrix(cbind(1, tato[,c(2,8)]))
# Choose the columns from the beta-hat vector that contain the occupancy estimates:
Beta.Occ<- data.matrix(x$estimate[2:4])
# Invert the Hessian (Information) matrix to obtain the variance/covariance
# matrix for beta-hat:
Var.Beta.Occ<-solve(x$hessian)
yhat<- X.Occ%*% Beta.Occ
SE.yhat<-sqrt(diag( X.Occ%*% Var.Beta.Occ[2:4,2:4] %*% t(X.Occ)))

```

Figure 8.2. R code for TATO example (continued).

```

alpha<-0.10
Z.alpha<- qnorm(1-alpha/2)
OccCILow.Untrans<- yhat - Z.alpha* SE.yhat
OccCIHigh.Untrans<- yhat + Z.alpha* SE.yhat

OccCILow <-expit(OccCILow.Untrans)
OccCIHigh <-expit(OccCIHigh.Untrans)
# Note that pihat is obtained by the inverse of the logit:
Occ.Ests<-data.frame(round(cbind(Year=tato$year+2006, Fish=tato$fish, pihat= expit(yhat), OccCILow,
OccCIHigh),4))
names(Occ.Ests)<-c("Year", "Fish", "pihat", "pihat.Cl.Low", "pihat.Cl.High")
unique(Occ.Ests[order(Occ.Ests$Year, Occ.Ests$Fish),])

# Estimate CI's on paramter estimates:

Beta.year.lower<-x$estimate[3] - Z.alpha*sqrt(Var.Beta.Occ[3,3])
Beta.year.upper<-x$estimate[3] + Z.alpha*sqrt(Var.Beta.Occ[3,3])
Beta.fish.lower<-x$estimate[4] - Z.alpha*sqrt(Var.Beta.Occ[4,4])
Beta.fish.upper<-x$estimate[4] + Z.alpha*sqrt(Var.Beta.Occ[4,4])
Occ.Parm.Ests<-data.frame(Beta.year.lower, Beta.year.upper, Beta.fish.lower, Beta.fish.upper)
Occ.Parm.Ests
# Odds Ratio CI's
OR.year<-exp(x$estimate[3])
OR.year.lower<-exp(Beta.year.lower)
OR.year.upper<-exp(Beta.year.upper)
OR.fish<-exp(x$estimate[4])
OR.fish.lower<-exp(Beta.fish.lower)
OR.fish.upper<-exp(Beta.fish.upper)
Occ.OddsRatio.Ests<-data.frame(OR.year.lower, OR.year.upper, OR.fish.lower, OR.fish.upper)
Occ.OddsRatio.Ests
#### Print the OR for year and fish
OR.year
OR.fish

# Test for trend with a likelihood ratio test (LRT).
# Fit a second model without the year term, then form the LRT:

# First, obtain starting values:
# Model 3
fit.some.logreg<-glm(response~ 1, family = binomial, data=tato)
summary(fit.some.logreg)
fit.occ.logreg<-glm(occ~ f, family = binomial, data=tato)
summary(fit.occ.logreg)

```

Figure 8.2. R code for TATO example (continued).

```

# Fit the model:
# Model 3-- same as Model 17 but without the year term.
v= c("pconst","psiconst", "fish")
x3<-nlm(amphi.implicit, p=c(-0.63, 0.47, -3.84), vars=v, data=tato, hessian=TRUE)
alarm()
x3

# Perform the LRT
# Conclude that there is a significant declining trend if the parameter estimate
# for year is negative and the P-value is less than your specified alpha level.
chisq.test<- 2*( x3$minimum-x$minimum)
p.value<-pchisq(chisq.test, 1, lower.tail=FALSE)
LRTyear<-c(chisq.test, p.value)
names(LRTyear)<-c("Chi-square statistic", "P-value")
LRTyear

```

Figure 8.2. R code for TATO example (continued).

No stable models could be estimated for the BUBO or HYRE species groups. Instability may have occurred because naïve occupancy estimates were less than 0.10 for BUBO and greater than 0.75 for HYRE. Maximum likelihood estimates can be problematic near parameter boundaries (i.e., the likelihood surface is multimodal, (Polansky et al. 2009). Stable models were fit for HYCA and TATO (Tables 8.2-8.6). Additional data from 2009 collaborators and 2010 sampling may allow us to fit stable models for BUBO and HYRE species groups.

Table 8.2. AIC values for stable models in the candidate model sets (2 of 4 amphibian species, HYCA and TATO). Models with missing AIC values were deemed unstable because of problematic Hessian matrices, extremely large parameter estimates, or biologically implausible estimates.

Model	HYCA	TATO
1	188.45	217.10
2	183.76	-
3	-	-
4	176.14	182.66
5	-	174.87
6	-	180.64
7	-	-
8	-	-
9	-	-

Table 8.3. Parameter estimates for stable occupancy models with lowest AIC scores.

Species Code	Occupancy					Detection Intercept
	Intercept	Year	Develop	Cray	Fish	
HYCA	0.906	-0.420	-	-2.078	-	0.520
TATO	0.510	-0.297	-	-	-3.924	13.761

Table 8.4. Occupancy estimates and 90% confidence intervals for HYCA model.

Year	Crayfish	Occupancy (90% CI limits)
2006	Absent	0.712 (0.003, 1.000)
2006	Present	0.237 (0.004, 0.956)
2007	Absent	0.619 (0.005, 0.998)
2007	Present	0.169 (0.008, 0.840)
2008	Absent	0.517 (0.008, 0.993)
2008	Present	0.118 (0.013, 0.579)
2009	Absent	0.413 (0.014, 0.973)
2009	Present	0.081 (0.017, 0.309)

Table 8.5. Occupancy estimates and 90% confidence intervals for TATO model.

Year	Fish	Occupancy (90% CI limits)
2006	Absent	0.625 (0.464, 0.762)
2006	Present	0.032 (0.006, 0.156)
2007	Absent	0.553 (0.453, 0.649)
2007	Present	0.024 (0.005, 0.115)
2008	Absent	0.479 (0.401, 0.558)
2008	Present	0.018 (0.003, 0.089)
2009	Absent	0.406 (0.292, 0.531)
2009	Present	0.013 (0.002, 0.072)

Table 8.6. Detection estimates and 90% confidence intervals for HYCA and TATO models.

Species	Detection (90% CI limits)
HYCA	0.627 (0.004, 0.999)
TATO	1.000 (0.000, 1.000)

Trend was not a significant ($\alpha = 0.10$) effect in either of the 2 amphibian species models (Table 8.7). The odds ratio confidence interval for crayfish presence/absence contained 1.0 and was not significant effect on HYCA occupancy. However, fish presence/absence did have a significant effect on TATO occupancy (Table 8.8).

Table 8.7. Likelihood ratio test results of trend (2006-2009) effects in HYCA and TATO model; P-values $< \alpha$ indicate significant trend effect on occupancy for the 2 species.

Species Code	Likelihood Ratio χ^2 (df=1)	P-value
HYCA	2.418	0.120
TATO	2.307	0.129

Table 8.8. Odds ratios and 90% confidence intervals for occupancy covariates in stable models with lowest AIC scores. Intervals that do not contain 1.0 (**in bold**) indicate significant ($\alpha=0.10$) covariate effect on occupancy.

Species Code	Year	Cray	Fish
HYCA	0.657 (0.223-1.940)	0.125 (0.007-2.219)	-
TATO	0.743 (0.537-1.029)	-	0.020 (0.004-0.108)

8.3 Control Charts - Example using data from 2000-2005

Control chart analysis may also be used to evaluate trends in data over time. Control charts are a method of partitioning variation between inherent or natural variation in the response variable and variation caused by a specific cause or stressor. A control chart may indicate an out-of-control (stressor or special cause variation present) condition when one or more points fall beyond the control limits, or when the plotted points exhibit some nonrandom pattern of behavior. Proportions control charts (P-charts) can evaluate the change in proportion based upon presence/absence data (Figure 5).

To analyze data in this way, the proportion of streams occupied by a focal species must be plotted for each year of the analysis. This is then compared to the overall average proportion from all years (± 3 standard deviations, σ , around the average). As an example, we created a P-chart for *T. torosa* from surveys done between 2000-2005 (see Protocol, Figure 5). In general points outside the 3σ limits are “out of statistical control” and indicate that non-random variation may be present and acting on the process or condition being evaluated. A process “in statistical control” is one where only random or natural variation is present.

8.4 Trend Analysis of Abundance Indices

Statistically, the abundance indices are an example of ordered categorical data. Because not all the different life stages of the native and non-native species are counted at a stop but, instead, are estimated to be within one of 4 categories (<5, 5-20, 20-100, >100). This type of data collection was motivated by the large time cost for more intensive types of sampling and the concern over inducing counting errors. This type of data is discrete in nature and should be modeled using a generalized linear mixed model which accounts for this type of response structure (Agresti 2010). The added complication in this sampling design is that an abundance category is recorded at each stop within the 250-m segment. The habitat also varies at the stop-level. Because of this nested or hierarchical structure a multi-level or hierarchical model should be explored for trend analysis that includes a random effect for stream segment. This approach is also suggested for a model-based approach for analyzing one-stage cluster samples (Lohr 2010). Parameter estimation for generalized mixed models can be difficult, thus Bayesian methods should be explored in addition to more common maximum likelihood techniques (Agresti 2010).

References

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Standard Operating Procedure (SOP) No. 9 - Power Analysis

Version 2.0 (September 2011)

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9.0 Power Analysis to Detect Trend

9.1 Methods

Monte Carlo simulation was used to estimate power to detect trend in occupancy (e.g., a significant year effect). The zero-inflated mixture model fits occupancy in terms of the logit, so we can detect significant linear trend effects in the logit, which correspond to non-linear changes in occupancy probability. As a result of the transformation from logit to probability, we simulated a non-linear decline in the probability of occupancy. We considered average annual declines of 2.5 and 5.0%, projected for 10 years.

To determine power, bootstrap data sets of occupancy covariates were generated from the pilot data. Occupancy and detection probabilities were generated from the bootstrapped covariate data using the optimal model, without the year effect. The joint probability of occupancy and detection was used in a Bernoulli random trial to generate a response variable for each observation in the bootstrapped data set. As years passed in the simulation, the probability of occupancy was reduced (and therefore the p in the Bernoulli trial) according to the specified annual decline (2.5% or 5.0%).

Two models were then fit to each bootstrapped data set, 1 without a year effect and 1 with a year effect. A one-sided likelihood ratio test was performed using the likelihood of each model. The power to detect a trend effect, for a given decline, was calculated as the proportion of bootstrap data sets that rejected the null hypothesis of no declining trend (year) effect. Power was calculated for the existing panel design with 22, 32, and 42 sites, sampled $k=2$ and $k=3$ times each season.

The initial power analysis was done with data from the 2006-2009 surveys done by NPS. The other 11 sites surveyed during those years (by Pepperdine and RCD, see SOP 1) were not included in this power analysis because they were not available or complete at the time of analysis. Therefore, the actual number of surveys that were used for this analysis was 22, and the potential number of surveys that will be done is 33. In addition, for this analysis, we assumed variability of sentinel and GRTS sites was similar, so we pooled data across panels for the power analysis. In future estimates of trend, the occupancy model will include a fixed panel effect (sentinel vs. GRTS) and a random effect for sites nested within panels. The estimate of random effect for sites nested within panels will be possible after 2 replicate samples of GRTS sites have been made (i.e., six years). A global test for trend effect will be conducted first. When

the global test is significant, park-wide inferences will be made by testing for trend effects within GRTS sites. Sentinel site inferences will be made by testing for trend effects within sentinel sites.

9.2 Results

Power to detect a 2.5% annual average decline ($\alpha = 0.10$) in occupancy over 10 years was 0.395 for HYCA, given a sample size of 22 sites sampled twice per year (Table 9.1, Figure 9.1). If sampled three times per year, power to detect a 2.5% annual decline increased above 0.50 only for 32 and 42 sites (Figure 9.1).

Table 9.1. Power estimates to detect 2.5% and 5.0% annual average declines ($\alpha=0.10$) in occupancy over 10 years for 22, 32, and 42 sites, with 2 and 3 sampling events per year.

Species Code	Annual Average Decline (%)	# Sites	# Sampling Events (<i>k</i>)	Power
HYCA	2.5	22	2	0.395
	2.5	22	3	0.432
	5.0	22	2	0.770
	5.0	22	3	0.880
	2.5	32	2	0.453
	2.5	32	3	0.635
	5.0	32	2	0.858
	5.0	32	3	0.959
	2.5	42	2	0.542
	2.5	42	3	0.637
	5.0	42	2	0.923
	5.0	42	3	0.973
TATO	2.5	22	2	0.510
	2.5	22	3	0.567
	5.0	22	2	0.898
	5.0	22	3	0.965
	2.5	32	2	0.597
	2.5	32	3	0.713
	5.0	32	2	0.963
	5.0	32	3	1.000
	2.5	42	2	0.693
	2.5	42	3	0.822
	5.0	42	2	0.992
	5.0	42	3	0.998

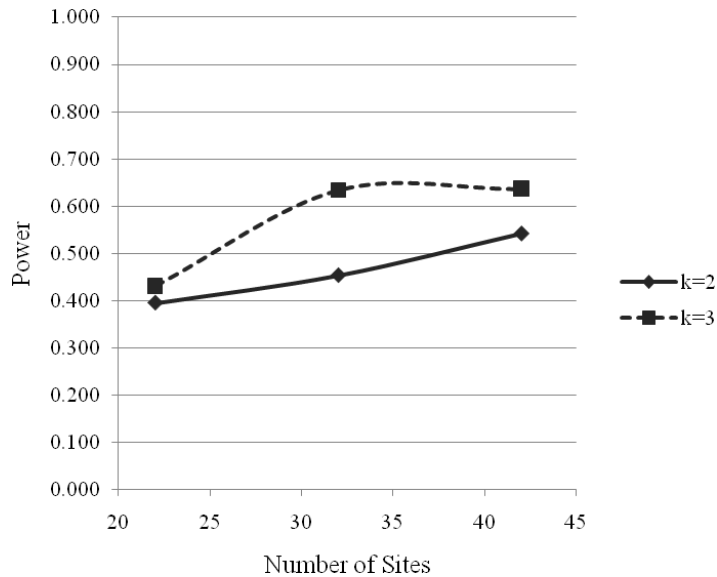


Figure 9.1. HYCA power curve estimates to detect significant ($\alpha=0.10$) annual occupancy decline of 2.5% for 22, 32, and 42 sites with 2 and 3 sampling events per year, for 10 years.

Power to detect a 5.0% annual average decline ($\alpha = 0.10$) over 10 years was greater than 0.75 for all sample size combinations (Figure 9.2).

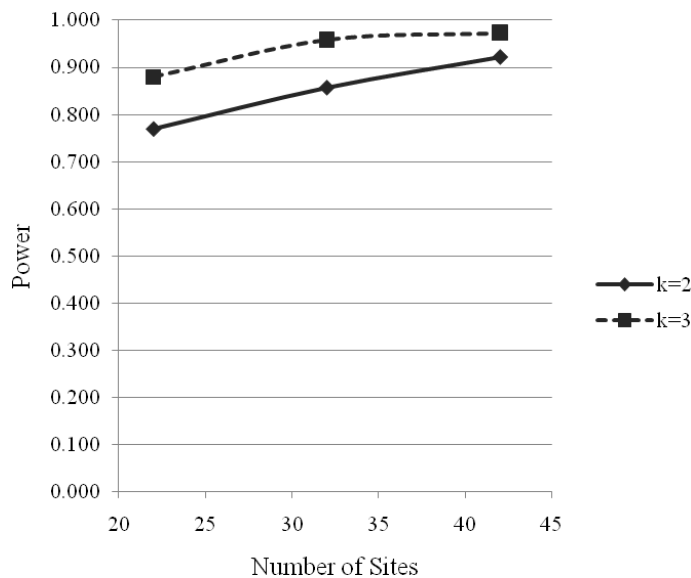


Figure 9.2. HYCA power curve estimates to detect significant ($\alpha=0.10$) annual occupancy decline of 5.0% for 22, 32, and 42 sites with 2 and 3 sampling events per year, for 10 years.

Power to detect a 2.5% annual average decline ($\alpha = 0.10$) in occupancy over 10 years was 0.510 for TATO, given a sample size of 22 sites sampled twice per year (Table 9.1, Figure 9.3). Equivalent increases in power would be realized if the number of sites sampled was 32, with

$k=2$, or if the number of sites sampled remained at 22 and they were sampled $k=3$ three times per year (Figure 9.3).

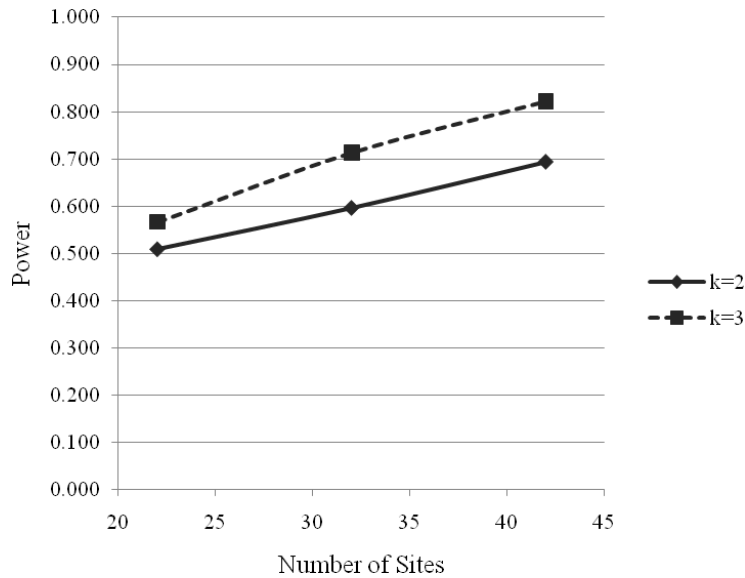


Figure 9.3. TATO power curve estimates to detect significant ($\alpha=0.10$) annual occupancy decline of 2.5% for 22, 32, and 42 sites with 2 and 3 sampling events per year, for 10 years.

Power to detect a 5.0% annual average decline ($\alpha = 0.10$) over 10 years was ≥ 0.90 for all sample size combinations (Figure 9.4).

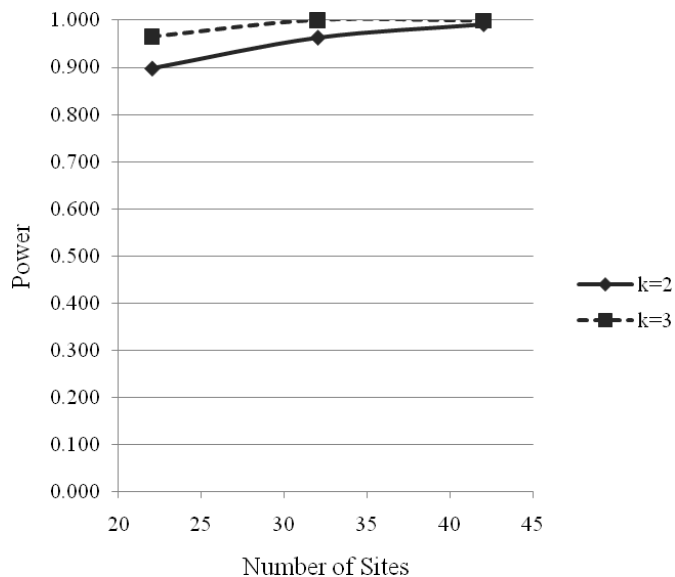


Figure 9.4. TATO power curve estimates to detect significant ($\alpha=0.10$) annual occupancy decline of 5.0% for 22, 32, and 42 sites with 2 and 3 sampling events per year, for 10 years.

9.3 Discussion

Because the number of sites per year surveyed by NPS and partners will be 34 according to the proposed protocol, we extrapolated the power for surveys done $N=32$ sites and $k=2$ surveys (highlighted in yellow, Table 9.1).

Power estimates will be most reliable when all covariates affecting detection and occupancy are present in the model, the covariates are linear in the logit, and stable estimates of model parameters can be made. In general, the power analysis indicates that, if resources allow an increase in sampling effort, increasing k will produce similar increases in power as increasing sites. Increasing k will allow for more precise estimates of detection; increasing the number of sites will allow for more accurate estimates of spatial variability. If both Type I and II errors are equally costly, $\alpha=0.10$, and resources are not available to increase sample size to achieve power of 0.90, α could be increased to equalize the Type I and II error risk. In the case of Type II errors being more costly than Type I errors, it may be reasonable to increase α beyond 0.10 so power exceeds $(1-\alpha)$. Although we estimated power for a declining population, these power estimates will also apply to an increasing population. That is, the power to detect a decline of 2.5% for a given sample size will be approximately equal to the power to detect an increase of 2.5%. Questions of this sort may be important to determine if a management activity is having the intended effect.

Standard Operating Procedure (SOP) No. 10 - Personnel Requirements and Training

Version 2.0 (September 2011)

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Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

10.0 Personnel Requirements and Training

10.1 Personnel Requirements

Roles and Responsibilities

- One full-time Monitoring Project Manager (Wildlife Biologist or Natural Resource Specialist 0486/0401- GS 11). Manager serves as project coordinator, and is responsible for coordination between cooperating agencies, maintenance and calibration of equipment, renewal and holding of all necessary permits, and data entry. The project manager is also responsible for data analysis, written annual reports, and periodic trend reports. In addition, manager hires and conducts initial and periodic training for wildlife interns and technicians (see SOP 10).
- One wildlife technician (0404 – GS 5/6/7). Technician assists the Monitoring Project Manager, and is responsible for amphibian counts and physical habitat data collection from April to July (4 months; full-time).
- Two wildlife interns. Interns are trained by and assist the Monitoring Project Manager and wildlife technician. Interns are responsible for assisting in amphibian counts and all other data collection. Note that interns are not paid by the I & M program but are internally funded by the park.

10.2 Personnel Training

Training procedures will be conducted at the beginning of each season's stream surveys (early April, or as soon as it is possible). Using field guides, websites, and discussions with experienced field personnel, new staff will be trained to locate and identify local amphibian species at adult and juvenile phases, as well as egg masses (see Appendix A). Background will be gained through a combination of field experience and training by senior personnel. In addition, all technicians and interns will read and review this protocol, and also will be shown and can choose to carry a copy of Appendix A. To ensure that data collection is consistent and accurate, the Monitoring Project Manager will accompany field crews on a regular basis.

Standard Operating Procedure (SOP) No. 11 - Safety

Version 2.0 (September 2011)

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11.0 Safety Precautions

11.1 Weather and Field Attire

In the Santa Monica Mountains National Recreation Area, summer conditions are often hot, (between 80-110°F) and winter conditions can be cold and muddy (between 4– 70°F). Clothing worn for field surveys should be appropriate for weather conditions, and comfortable to wear while traversing streams. In addition, it is important to bring an extra change of clothes, since field attire will get wet. Field personnel should also carry snack food and drinking water into the field.

11.2 Off-road driving safety

Winter and spring conditions are the wet season in the Santa Monica Mountains, and many roads are not suitable for driving in muddy conditions. Off-road (4x4) driving should only be done by experienced field staff familiar with the dirt roads and trails in the SMM. Less experienced drivers should be accompanied by experienced staff with at least a year's familiarity with off-road conditions. All personnel must read an educational document regarding driving rules, regulations, and driving conditions. The document will then be signed by all drivers and kept by Monitoring Project Manager in a file at headquarters.

11.3 Animal Handling

There is no immediate danger in handling the local amphibians; however, amphibians can carry salmonella and California newt skin contains a toxin that should not be ingested. Therefore, hands must be washed thoroughly prior to eating and drinking.

Equally important is the safety of the animals themselves. Diseases and fungus, such as chytrid fungus (*Batrachochytrium dendrobatidis*), can easily be spread from one site to the next. Consequently, it is important to ensure that all field equipment (including footwear) has been disinfected with mild bleach solution prior to use between stream sites.

11.4 Other Field Hazards

Rattlesnakes (*Crotalus viridis*) are present in many study areas and caution should be used when traveling through streams, walking along trails or climbing through vegetation. In the event of a rattlesnake bite seek immediate medical attention. Draw a line or circle around the bite wound and take note of the time at which the incident occurred. This information is important in determining the extent of the swelling and in prescribing how much anti-venin to use.

Poison Oak (*Toxicodendron diversilobum*) is found in more mesic habitats of southern California. Before doing any fieldwork personnel are to become familiar with the dangers associated with exposure to this native plant. If exposure occurs wash thoroughly with soap and rinse with plenty of water upon returning from the field and then apply Tecnu® ointment (provided at headquarters). If a reaction occurs, seek medical attention.

11.5 Job Hazard Analysis

Job Step	Hazard	Safe Behavior/Procedure
1. Walking around carrying equipment.	1. Tripping hazards, injury from falling, sharp objects, slipping on rocky surfaces.	1. Pay careful attention to where stepping. Walk slowly. Secure all equipment so both hands are free.
2. Squatting, bending, and climbing on slippery surfaces.	2. Back strain, knee strain, fatigue, possible fall.	2. Stand upright and stretch occasionally. Secure yourself. Have someone spot you. Wear proper non-slip water shoes.
3. Walking or swimming through water.	3. Possible fall, hypothermia, drowning.	3. Pay careful attention to where stepping, work slowly, pay attention to submerged logs or vegetation, get warm by exiting stream if shivering.
4. Entering low-light areas.	4. Eyes are not adjusted to changing light conditions. Tripping hazards or other injuries.	4. Stop moving when entering an area with different light conditions. Allow eyes to adjust. Use a flashlight when needed.
5. Walking through scattered and dense vegetation.	5. Potential for scrapes and cuts on exposed arms and legs from branches.	5. Stay on defined trails as much as possible. Wear appropriate clothing such as pants and a long-sleeved shirt. Proceed with caution through the shrubs and bushes.
6. Being in sun for hours.	6. Sun burn, dehydration, fatigue-induced inattention.	6. Wear sunscreen, sunglasses, and broad-brimmed hat. Bring water and snacks with you. Take breaks when needed.
7. Coming in contact with venomous reptiles and invertebrates.	7. Fatigue, illness, stinging sensation, paralysis.	7. Use caution when traversing stream. Make noise and walk heavily over exposed vegetation and on stream banks. Do not place hands, feet, or body in places you cannot visibly check first. Report any sightings to survey partner.
8. Coming in contact with poison oak.	8. Itchy rash, potentially strong allergic reaction	8. Identify poison oak in the study area. Avoid touching leaves, stems, and roots. Wear long sleeves and long pants. If touched, treat with Tecnu and shower at headquarters. Seek medical attention for serious allergic reaction.
9. Ingesting California newt toxic skin secretions.	9. Severe stomach pain, numbness, paralysis.	9. Wash hands thoroughly after handling newts.

Standard Operating Procedure (SOP) No. 12 - Driving Directions to Stream Survey Sites

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12.0 Driving Directions to Stream Survey Sites

Listed below are the directions for the stream sites monitored by NPS staff. The start point for all driving directions is the Santa Monica Mountains National Recreation Area headquarters at 401 West Hillcrest Blvd., Thousand Oaks, California.

12.1 Sentinel Sites

1. Big Sycamore Canyon (S_BIGSYC)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles.
- Turn LEFT onto LYNN RD. Drive 4.6 miles
- Turn LEFT onto SOUTH REINO RD. Drive 0.1 miles
- Turn RIGHT onto WEST POTRERO RD. Drive 0.4 miles
- Turn LEFT onto RANCHO SIERRA VISTA RD. Drive 0.4 miles to the Big Sycamore Canyon Trail head at Rancho Sierra Vista. Note: Entry to the trailhead with a vehicle requires a BC-1 key at the gate in front of the Satwiwa Culture Center.
- Drive 1.1 miles to the trailhead for the Upper Sycamore Canyon Trail and park vehicle.
- Hike approximately 0.5 miles along the Upper Sycamore Canyon Trail to the survey start point, where the water from the creek crosses the trail.

2. Carlisle Canyon (S_CARLISLE)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 2.1 miles
- Take the CA-23 S / WESTLAKE BLVD exit. Turn RIGHT onto CA-23 S / S WESTLAKE BLVD. Drive 2.7 miles.
- Turn RIGHT onto CARLISLE RD. Drive to end of public road and park vehicle. The survey start point is approximately 700 m up the private road, near a house on the creek (where a footbridge from the house crosses the stream).

3. Erbes (Lower) (S_LANRNCHS)

- Start out going EAST on HILLCREST DR. Drive 1.2 miles.

- Turn LEFT onto ERBES RD. Drive 1.4 miles.
- Turn LEFT onto MARVIEW DR. Drive 0.3 miles.
- Park vehicle in parking lot for Old Meadows Park. Walk across soccer field, survey start point is the culvert located at the downstream end of Old Meadows Park. You must hop the fence to enter the culvert.

4. Lang Ranch (North) (S_LANRNCHN)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles.
- MERGE onto US-101 S toward LOS ANGELES. Drive 1.5 miles.
- Merge onto CA-23 N toward FILLMORE. Drive 2.8 miles.
- Take the AVENIDA DE LOS ARBOLES exit. Turn RIGHT onto E AVENIDA DE LOS ARBOLES. Drive 1.4 miles.
- Turn RIGHT onto N WESTLAKE BLVD. Drive 0.2 miles.
- Turn LEFT onto LANG RANCH PKWY. Drive 0.4 miles.
- Park vehicle on LANG RANCH Road, in front of the entry to the Chumash Interpretive Center, 3290 Lang Ranch Pkwy, Thousand Oaks. The survey start point is above the Chumash Center at the large ten-foot boulder just before the waterfall off Westlake Boulevard.

5. Las Virgenes (North) (S_ULASVIR)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.9 miles
- Take the LAS VIRGENES RD exit toward MALIBU CANYON. Turn LEFT onto LAS VIRGENES RD.
- Drive to the end of LAS VIRGENES ROAD, stopping at the entrance gate for the Las Virgenes Canyon trailhead. Note: Entry to the trailhead with a vehicle requires a BC1 key. Drive across the stream and take the left fork on the road. Survey start point is the next stream crossing after the fork in the road.

6. Las Virgenes (South) (S_LLASVIR)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 1.1 mile.
- Turn RIGHT into White Oak Farm, just prior to the large Santa Monica National Recreation Area sign and turnout near Mulholland..
- The survey start point is the first bridge on the White Oak Farm road.

7. Medea Creek (North) (S_UMEDCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.1 miles.
- Take the KANAN RD exit. Turn RIGHT onto KANAN RD/ CR-N9 S. Turn SHARP LEFT onto KANAN RD / CR-N9 N. Continue to follow KANAN RD. Drive 1.9 miles
- Turn LEFT onto FOUNTAINWOOD ST. The survey start point is at the culvert on Conifer St.

8. Medea Creek (South) (S_LMEDCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.1 miles.
- Take the KANAN RD exit. Turn RIGHT onto KANAN RD/ CR-N9 S. Drive 0.3 miles.
- Turn LEFT onto CORNELL WAY. CORNELL WAY becomes CORNELL RD. Drive 2.1 miles.
- Turn RIGHT at gate before Paramount Ranch (near Pitfall Array 52). Gate requires a BC-1 key. The survey start point is near the large stream crossing into Paramount Ranch on the Bwana trail, there are planks of wood across the crossing.

9. Solstice Canyon (S_SOLSCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn RIGHT onto PACIFIC COAST HWY / CA-1 N. Drive 2.2 miles.
- Turn RIGHT onto CORRAL CANYON RD. Drive 0.2 miles
- Turn LEFT into the entrance for Solstice Canyon. The survey start point is at entry gate above the parking lot, near the education pavilion. Note: entry through gates requires a BC-1 key.

10. Temescal Canyon (S_TEMECYN)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.

- Turn LEFT onto PACIFIC COAST HWY / CA-1 S. Continue to follow CA-1 S. Drive 10 miles.
- Turn LEFT onto TEMESCAL CANYON RD. Drive 1.0 miles.
- Turn RIGHT onto W SUNSET BLVD. Drive 0.1 miles
- End at Temescal Gateway Park, 15601 W Sunset Blvd, Pacific Palisades.
- Park vehicle in the MRCA parking lot. Walk approximately 0.5 miles up the Topanga Canyon Trail into Topanga State Park. The survey start point is under the first footbridge along the trail that crosses the creek.

12.2 RANDOM 1 (R1) Stream survey sites

Listed below are directions for the 12 1st Year GRTS stream sites monitored by the NPS. The start point for all driving directions is the Santa Monica Mountains National Recreation Area headquarters at 401 West Hillcrest Blvd., Thousand Oaks, California.

1. Sullivan Canyon (R1_SULLCYN)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn LEFT onto PACIFIC COAST HWY / CA-1 S. Continue to follow CA-1 S. Drive 10 miles.
- Turn LEFT onto TEMESCAL CANYON RD. Drive 1.0 miles.
- Turn RIGHT onto W SUNSET BLVD. Drive 3.6 miles
- Turn LEFT onto Mandeville CANYON RD. Drive 0.2 miles
- Turn LEFT onto WESTRIDGE RD. Drive 1.1 miles
- Turn LEFT onto W. BAYLISS RD. Drive 0.2 miles
- Turn LEFT onto QUEENSFERRY RD. Drive <0.1 mile
- PARK at end of street and walk down into SULLIVAN CANYON
- Walk approximately 1 mile upstream to where the trail begins to make an ascent away from the creek. Look for a large bedrock outcrop in the stream near two mature oak trees. This is the starting point.

2. Las Flores Canyon (R1_LASFLORES)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.

- Turn LEFT onto PACIFIC COAST HWY / CA-1 S. Continue to follow CA-1 S. Drive 4 miles.
- Turn LEFT onto LAS FLORES CANYON RD. Drive 1.5 miles.
- Turn RIGHT onto GORGE RD. Drive approximately 1 mile to a black gate. Stream survey begins below gate. The gate and land behind is private property, do not park in front of it. There are ruins of a house, and an RV parked there.

3. Solstice Canyon (upper) (R1_SOLSCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn RIGHT onto PACIFIC COAST HWY / CA-1 N. Drive 2.2 miles.
- Turn RIGHT onto CORRAL CANYON RD. Drive 0.2 miles
- Turn LEFT into the entrance for Solstice Canyon. Drive up the canyon and make a right after the bridge. At the next bridge (the Keller Bridge) park car in the parking area on the other side. Survey begins below the Keller bridge. Note: entry through gates requires a BC-1 key.

4. Ramirez Canyon (R1_RAMICYN)

Streisand Center—Headquarters of the Santa Monica Mountains Conservancy

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn RIGHT onto KANAN RD. Drive 12 miles.
- Turn LEFT onto PACIFIC COAST HWY. Drive 1.2 miles
- Turn LEFT onto WINDING WAY RD. Drive to next intersection.
- Turn LEFT onto DELAPLANE. Drive to the next intersection which is RAMIREZ CANYON RD.
- Turn RIGHT onto RAMIREZ CANYON RD. Drive to end of road and a gate. Push the button on the gate console and explain your purpose and they should let you in.
- Walk up the canyon passed the compound. Upstream of the compound there is a small trail. Take the trail about 500 meters to the end. The stream survey begins at the end of the trail.

5. Little Sycamore Creek (R1_LITTLESYC)

NOTE: We have permission to enter the camp to conduct stream surveys, however we need to call ahead the day you survey. The contact person is: JOHN J. BARD Executive Chef/Guest Services 310-457-7861.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn RIGHT onto KANAN RD. Drive 12 miles.
- Turn RIGHT onto PACIFIC COAST HWY. Drive 10 miles
- Turn RIGHT onto YERBA BUENA
- Turn LEFT into CAMP HESS KRAMER
- Drive down into the camp and take the road that follows the creek (it crosses the creek several times). Follow road passed the campground and cabins (approximately 1.5 miles). Take the road across a deep culvert and park on the other side, near the bridge. Follow the creek up to another bridge (with yellow railings). The stream survey point begins immediately after the bridge.

6. West Fork Trancas (R1_WFTRANCAS)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn RIGHT onto KANAN RD. Drive 12 miles.
- Turn RIGHT onto PACIFIC COAST HWY. Drive 5.5 miles
- Turn RIGHT onto ENCINAL RD. Drive up the canyon to LA. COUNTY FIRE DEPARTMENT AND CAMP 13. Across Encinal Road north of the camp there is a dirt road and a boneyard. Look for a wooden cabin in the bone yard and this is where to begin surveying the stream.

7. Malibu Creek (R1_MALICRK)

In Malibu Creek State Park.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 1.5 miles.
- Turn RIGHT into Malibu Creek State Park. At the fee booth tell them you're with the National Park Service conducting water quality or amphibian surveys and they should let you in free of charge.

- Turn RIGHT at first gated dirt road along parking area. This is the trail to the Visitor Center/Century Lake. Drive 0.8 miles. **Note you will need a State Park Key or LA. County Fire Key to open the gate.**
- Turn LEFT at second fork (do not cross at wet crossing) and cross the bridge, veer left. Drive 0.3 miles.
- Turn Right at second fork to MOTT RD. Drive 0.5 miles.
- Park vehicle at picnic area just before the gates to Salvation Army Camp.
- Survey starts in big pool with large boulders, down from parking area.

8. Liberty Canyon (R1_LIBCYN)

Confluence of Liberty and Las Virgenes Creeks near Pitfall Array 56

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 1.0 mile.
- Turn RIGHT on White Oak Farms (before Mulholland Rd.)
- Follow dirt road over bridge. Then follow driveway of house on left. Park car on west end of the house and follow path to pitfall array 56. Survey point begins at confluence of both creeks, but survey will follow Liberty Creek.

9. North Medea Creek (R1_MEDCRK)

North of Kanan Road in Oak Canyon Community Park.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn LEFT onto KANAN RD. Drive 3.0 miles
- Turn RIGHT onto Hollytree Drive and turn into Oak Canyon Community Park.
- Survey point begins above duck pond.

10. Eleanor (R1_ELEANOR)

Carlisle Creek at Westlake Blvd. and Carlisle Canyon Rd. intersection.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 2.1 miles
- Take the CA-23 S / WESTLAKE BLVD exit. Turn RIGHT onto CA-23 S / S WESTLAKE BLVD. Drive 2.7 miles.
- Park at pullout marked by a sign that says “NO DUMPING”, right before CARLISLE RD. Begin survey by this sign. Upstream you will go under the road.

11. Arroyo Conejo (R1_ARRCONEJO)

Arroyo Conejo Tributary south of Potrero Road near Rancho Sierra Vista at the Wendy Trail Head.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 4.7 miles
- Turn LEFT onto REINO RD.
- Turn LEFT onto POTRERO RD.
- Drive to intersection of POTRERO RD. and WENDY DR. Park on Wendy Trail Head
Take trail to where it crosses creek and begin survey.

12. Conejo Creek (R1_CONCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn RIGHT onto LYNN RD. Drive 2.4 miles.
- Turn LEFT onto W. AVENIDA DE LOS ARBOLES. Drive 1.0 miles.
- Turn LEFT into the Wildwood Neighborhood Park/Fort Wildwood Park near the school parking lot.
- Take sidewalk past bathrooms and walk toward the wooden fort.
- Before the fort take sidewalk on the left and follow it downhill to the creek.
- Survey starts above Shenandoah Bridge.

12.3 RANDOM 2 (R2) Stream survey sites

Listed below are directions for the 12th Year GRTS stream sites monitored by the NPS. The start point for all driving directions is the Santa Monica Mountains National Recreation Area headquarters at 401 West Hillcrest Blvd., Thousand Oaks, California.

1. Chesebro Canyon (R2_CHEESEBORO)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 9.4 miles
- Take the CHESEBRO RD exit. Turn SLIGHT RIGHT onto CHESEBRO RD. Drive 0.1 mile.
- Turn RIGHT onto CHESEBRO CANYON RD. Drive approximately 0.5 miles.
- Turn RIGHT onto CHESEBRO CANYON PARKING LOT.
- Drive through gate and travel up canyon approximately 1.25 miles to intersection of CHESEBRO CANYON TRAIL and CHESEBRO RIDGE TRAIL
- Stream survey begins near wet crossing (look for picnic tables as a marker).

2. Las Virgenes Creek (R2_LASVIRGENES)

Near City Hall near 101 freeway

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.9 miles
- Take the LAS VIRGENES RD exit. Drive 0.2 miles
- Turn LEFT onto LAS VIRGENES RD. Drive 0.4 miles.
- Turn RIGHT into the first driveway (parking lot) and drive toward the 101 freeway and park vehicle.
- On the southeast side of the lot there is a gate to the creek. Begin the survey where this little access road drops into the creek.

3. Triunfo Creek (R2_TRIUNFO)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.1 miles
- Take the KANAN RD exit- EXIT 36. Drive 0.2 miles
- Turn RIGHT onto KANAN RD / CR-N9 S. Drive 3.2 miles
- Turn RIGHT onto TRIUNFO CANYON ROAD and drive to end of road. There is a trailhead for the Santa Monica Mountains Conservancy, from the trailhead you can hike down into the creek to start the survey.

4. Olsen Road (R2_OLSEN)

In Conejo Creek off of Olsen Rd., across from CLU University.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn RIGHT onto LYNN RD. Drive 3.1 miles *note: Lynn Road transitions into Olsen Road.*
- Turn Left onto Campus Drive. Survey start point is at the creek and Campus Dr. Find a route into the creek at Campus Drive.

5. Circle X (Grotto Trail) (R2_CIRCLEX)

West Fork of Arroyo Sequit in the Grotto of Circle X Ranch.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 4.1 miles.
- Take the WESTLAKE BLVD / CA-23 S exit.
- Turn RIGHT onto S WESTLAKE BLVD / CA-23 S. Continue to follow CA-23 S. Drive 7.0 miles.
- Turn SLIGHT RIGHT onto MULHOLLAND HWY. Drive 0.4 miles.
- Turn RIGHT onto LITTLE SYCAMORE CANYON RD. Drive 4.4 miles. *Note: LITTLE SYCAMORE CANYON RD becomes YERBA BUENA RD. Circle X Ranch will be on your left park near the group parking lot.*

- Hike 1.75 miles down Grotto Canyon Trail. Once in the creek hike approximate 0.5 miles downstream.

6. Rustic Creek (R2_RUSTIC)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 26.0 miles.
- Merge onto I-405 S toward SANTA MONICA. Drive 6.5 miles.
- Take the exit toward SUNSET BLVD.
- Turn LEFT onto N CHURCH LN. Drive <0.1 miles
- Turn RIGHT onto SUNSET BLVD. Drive 4.5 miles
- Turn RIGHT onto WILL ROGERS STATE PARK RD. Follow the road past the polo field. Park the vehicle on the far northwestern side of the polo field.
- Walk 0.5 miles down into Rustic Creek on RUSTIC CANYON TRAIL. Survey starts where the creek and trail meet.

7. Bulldog Motorway (off Malibou Lake) (R2_BULLDOG)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 8.1 miles.
- Take the KANAN RD exit- EXIT 36.
- Turn RIGHT onto KANAN RD / CR-N9 S. Drive 0.3 miles.
- Turn LEFT onto CORNELL WAY/CORNELL RD. Drive 2.3 miles.
- CORNELL RD becomes LAKE VISTA DR. Drive 1.0 miles
- Turn LEFT on CRAGS RD. Drive 0.4 miles.
- Turn RIGHT to stay on CRAGS DR. Drive another 0.3 miles.
- Drive to end of road, for gate access use Los Angeles County Fire Key or park and walk 0.3 miles.
- When you reach a fork in the road, veer RIGHT onto BULLDOG MOTORWAY.
- Walk or drive up the road 0.4 miles to a water tank. Stream survey begins at culvert before the water tank.

8. Sutthpur Creek (Santa Maria Rd.) (R2_SUTTPHUR)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 15.8 miles.
- Take EXIT 29 toward MULHOLLAND DR / VALLEY CIRCLE BLVD.
- Turn LEFT onto CALABASAS RD. Drive <0.1 miles.
- Turn RIGHT onto MULHOLLAND DR. Drive 2.1 miles.
- Turn RIGHT onto TOPANGA CANYON BLVD / CA-27. Drive 3.7 miles.
- Look for a pullout with a chain link fence around it. Walk around the fence, entrance is behind pepper tree. Creek survey begins by an old concrete shed.

9. Santa Ynez Canyon Trail (Pacific Palisades Dr.) (R2_SANTAYNEZ)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 11.2 miles.
- Take the LOST HILLS RD exit- EXIT 33.
- Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1.0 mile
- Turn RIGHT onto LAS VIRGENES RD. Drive 7.8 miles
- Turn LEFT onto PCH. Drive 8.7 miles.
- Turn LEFT onto SUNSET BLVD.
- Turn LEFT onto PALISADES DR. Drive 2.4 miles up.
- Turn LEFT onto VERDE DE LA MONTURA. The road ends by two gated communities, and there is a trail access on the left. Hike the trail to the first stream crossing after the unusual cement culvert.

10. Sostomo Trail (above Tropical Terrace) (R2_SOSTOMA)

Solstice Creek near Sostomo Trail above Tropical Terrace.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn RIGHT onto PACIFIC COAST HWY / CA-1 N. Drive 2.2 miles.
- Turn RIGHT onto CORRAL CANYON RD. Drive 0.2 miles. Turn LEFT into the entrance for Solstice Canyon. Go through gate (**need a BC-1 key**) in the parking lot near the Education Pavilion.
- Drive up the canyon and make a right after the first bridge. Drive all the way up to the end of the road and park at the burned out house pad called Tropical Terrace. Take the Sostomo Trail to Deer Valley Loop which is just to the left of the entrance to the Tropical Terrace. The creek survey begins at the first creek crossing on Sostomo Trail.

11. Las Flores Creek, year 2 (R2_LASFLORES)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn LEFT onto PACIFIC COAST HWY / CA-1 N. Drive 3.9 miles.

- Turn LEFT onto LAS FLORES CANYON ROAD
- On the left is a small city park with picnic tables. Survey begins here.

12. Escondido Creek (R2_ESCONDIDO)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn RIGHT onto KANAN RD. Drive 12 miles.
- Turn LEFT onto PACIFIC COAST HWY. Drive 1.2 miles
- Turn LEFT onto WINDING WAY. Veer RIGHT to stay on WINDING WAY
- Turn RIGHT onto WINDING WAY EAST take the road till it dead-ends at Escondido Canyon. Stream survey begins at the second creek crossing.

12.4 RANDOM 3 (R3) Stream survey sites

Listed are directions for the 12 3rd Year GRTS stream sites monitored by the NPS. The start point for all driving directions is the Santa Monica Mountains National Recreation Area headquarters at 401 West Hillcrest Blvd., Thousand Oaks, California.

1. Arroyo Sequit (year 3) (R3_ARRSEQ)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 4.1 miles.
- Take the WESTLAKE BLVD / CA-23 S exit.
- Turn RIGHT onto S WESTLAKE BLVD / CA-23 S. Continue to follow CA-23 S. Drive 7.0 miles.
- Turn SLIGHT RIGHT onto MULHOLLAND HWY. Drive about 5.0 miles.
- Park at the pullout off Mulholland near Malibu Springs North Trail (Oak Alley, cross closed foot bridge). Walk 0.3 miles up trail that parallels stream. Begin stream survey near a steep dirt hill.

2. Cold Creek (off Stunt Rd.) (R3_COLDCKRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD, which turns into MALIBU CANYON RD. Drive 3.2 miles.
- Turn LEFT on MULHOLLAND RD. Drive 4.0 miles.

- Turn RIGHT on STUNT RD. Drive 0.8 miles up STUNT RD.
- Pull out from STUNT RD along hairpin turn just before CALABASAS PEAK MOTORWAY.
- Take trail 1/4 – 1/2 mile, passing a few runoff crosses along trail. Cut into stream at runoff crossing that is close to GPS coordinate 10-20 meters. Start where you connect with main creek, fallen sycamore tree.

3. Conejo Creek (R3_CONCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn RIGHT onto LYNN RD. Drive 0.5 miles
- Turn LEFT on DOS RIOS. Drive 0.4 miles.
- Turn RIGHT on CALLE TRANCAS. Drive 0.3 miles.
- Enter the gated fire road off of CALLE TRANCAS.
- Survey start point is at the bottom of the fire road where it crosses the creek.

4. Malibu Creek (Craggs Rd.) (R3_CRAGSRD)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 1.5 miles.
- Turn RIGHT into Malibu Creek State Park. At the fee booth tell them you're with the National Park Service conducting water quality or amphibian surveys and they should let you in free of charge.
- Turn RIGHT at first gated dirt road along parking area. This is the trail to the Visitor Center/Century Lake. Drive 0.8 miles. **Note you will need a State Park Key or LA. County Fire Key to open the gate.**
- Drive down CRAGS RD. (fire road) towards the M*A*S*H site, park near Century Lake.
- Walk down CRAGS RD. (fire road) towards the M*A*S*H site. Survey starts at the bridge that crosses the creek, approximately 0.2 miles from the end of Century Lake.

5. Malibu Creek (at Cross Creek) (R3_CROSSCRK)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.

- Turn RIGHT onto LAS VIRGENES RD, which turns into MALIBU CANYON RD. Drive approximately 9.5 miles.
- Park in very large dirt pullout on the west side of the road.
- Cross Malibu Canyon Rd. and walk north east down the COASTAL SLOPE TRAIL fire road. About 10m down (343783 / 3768823) take trail to left. Follow trail to bottom, but do not cross ditch at bottom, follow new trail to left. Watch for short trail down an embankment on the right. This will meet up with a strong trail, head north to starting point. Start in large pool with tall sycamore trees, and a large rusty pipe. Start above pipe.

6. Liberty canyon (R3_LIBCYN

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive approximately 10.5 miles
- Take the LIBERTY CANYON RD exit, head SOUTH on LIBERTY CANYON RD for 0.9 miles until you come to a black gate.
- Park car and walk from here. Take trail to the right toward PHANTOM TRAIL, when you get to the creek culvert. Follow this right trail until you get across from the GPS coordinates for the stream then walk through grass to the stream.

7. Malibu creek (rock pool) (R3_MALICRKSP)

In Malibu Creek State Park.

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 1.5 miles.
- Turn RIGHT into Malibu Creek State Park. At the fee booth tell them you're with the National Park Service conducting water quality or amphibian surveys and they should let you in free of charge.
- Turn RIGHT at first gated dirt road along parking area. This is the trail to the Visitor Center/Century Lake. Drive 0.8 miles. **Note you will need a State Park Key or LA. County Fire Key to open the gate.**
- Turn LEFT at second fork (do not cross at wet crossing) and cross the bridge, veer left. Drive 0.3 miles.
- Turn Right at second fork to MOTT RD towards Salvation Army Gate. Drive 0.35 miles.
- Pass high pipe/bridge over the creek, continue on MOTT RD until you are even with the starting GPS coordinates. Take small deer trail down to sandy beach.

8. Topanga Creek

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 15.8 miles.
- Take EXIT 29 toward MULHOLLAND DR / VALLEY CIRCLE BLVD.
- Turn LEFT onto CALABASAS RD. Drive <0.1 miles.
- Turn RIGHT onto MULHOLLAND DR. Drive 2.1 miles.
- Turn RIGHT onto TOPANGA CANYON BLVD / CA-27. Drive 6.5 miles.
- Turn RIGHT on SUMMIT RD/STONEWALL TRAIL/HILLSIDE DR.
- Survey starts at the bridge that crosses the stream when when you have turned off TOPANGA CANYON BLVD.

9. Topanga Creek (off Topanga Canyon Blvd.) (R3_TOPANGA)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 15.8 miles.
- Take EXIT 29 toward MULHOLLAND DR / VALLEY CIRCLE BLVD.
- Turn LEFT onto CALABASAS RD. Drive <0.1 miles.
- Turn RIGHT onto MULHOLLAND DR. Drive 2.1 miles.
- Turn RIGHT onto TOPANGA CANYON BLVD / CA-27. Drive 8.5 miles.
- Access from Topanga Canyon at 352367 / 3772883. Park on Topanga Canyon Blvd. and
- Drop into stream (on East side of Topanga Canyon Blvd., between houses (very steep). Start in pool below first overhanging house with red posts.

10. Malibu Nature Preserve

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- Merge onto US-101 S toward LOS ANGELES. Drive 4.1 miles.
- Take the WESTLAKE BLVD / CA-23 S exit.
- Turn RIGHT onto S WESTLAKE BLVD / CA-23 S. Continue to follow CA-23 S. Drive 5.4 miles.
- Turn SLIGHT LEFT onto MULHOLLAND HWY. Drive 1.1 miles.
- Turn LEFT onto CLARK RANCH RD. Drive 0.7 miles.
- Turn RIGHT onto ENCINAL CANYON RD. Drive 1.0 mile.
- Turn RIGHT onto PCH-Hwy 1. Drive 1.5 miles.
- Turn RIGHT into the Malibu Nature Preserve/Malibu Riding & Tennis Club.

11. Tuna Canyon (R3_TUNACYN)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 11.2 miles
- Take the LOST HILLS RD exit. Turn SLIGHT RIGHT onto LOST HILLS RD. Drive 1 mile.
- Turn RIGHT onto LAS VIRGENES RD. Drive 3.2 miles.
- LAS VIRGENES RD becomes MALIBU CANYON RD. Drive 4.6 miles.
- Turn LEFT onto PACIFIC COAST HWY / CA-1 N. Drive approximately 7 miles.
- Turn LEFT onto TUNA CANYON RD. Park near the intersection of TUNA CANYON RD and PCH.
- Stream is on the west side of TUNA CANYON RD, survey starts right above PCH.

12. Lady Face (R3_LADYFACE)

- Start out going WEST on W HILLCREST DR. Drive 0.5 miles
- Turn LEFT onto LYNN RD. Drive 0.1 miles
- MERGE onto US-101 S toward LOS ANGELES. Drive 8.5 miles
- Take the KANAN RD exit
- Turn RIGHT onto KANAN RD. Drive 0.1 miles.
- Turn RIGHT onto AGOURA RD. Drive 0.1 miles.
- Turn LEFT into a large pullout on AGOURA RD. There is a trail and a fire road that parallels the stream, begin survey at GPS coordinates approximately 50 meters from pullout.

Table 12.1. Survey site names, codes, and GPS coordinates.

Survey Site	Site Name	Site Code	X Coord	Y Coord	Datum
SENTINEL	Big Sycamore Canyon	S_BIGSYC	319118	3779571	Nad27
SENTINEL	Carlisle Canyon	S_CARLISLE	326005	3776606	Nad27
SENTINEL	Erbes (Lower)	S_LANRNCHS	329684	3785897	Nad27
SENTINEL	Lang Ranch (N)	S_LANRNCHN	334010	3786741	Nad27
SENTINEL	Las Virgenes (N)	S_ULASVIR	342811	3782854	Nad27
SENTINEL	Las Virgenes (S)	S_LLASVIR	342125	3775434	Nad27
SENTINEL	Medea Creek (N)	S_UMEDCRK	337686	3781820	Nad27
SENTINEL	Medea Creek (S)	S_LMEDCRK	338558	3777073	Nad27
SENTINEL	Solstice Canyon	S_SOLSCRK	338744	3767519	Nad27
SENTINEL	Temescal Canyon	S_TEMECYN	358333	3770551	Nad27
RANDOM1	Arroyo Conejo	R1_ARRCONEJO	320243	3780686	Nad27
RANDOM1	Conejo Creek	R1_CONCRK	325853	3787363	Nad27
RANDOM1	Eleanor	R1_ELEANOR	328872	3777596	Nad27
RANDOM1	Las Flores	R1_LASFLORES	348997	3769453	Nad27
RANDOM1	Liberty	R1_LIBCYN	342106	3774948	Nad27
RANDOM1	Little Sycamore	R1_LITTLESYC	318892	3770914	Nad27
RANDOM1	Malibu Creek	R1_MALICRK	341388	3773312	Nad27
RANDOM1	Medea Creek	R1_MEDCRK	336947	3783656	Nad27
RANDOM1	Ramirez	R1_RAMICYN	334458	3767917	Nad27
RANDOM1	Solstice Canyon (upper)	R1_SOLSCRK	338247	3768156	Nad27
RANDOM1	Sullivan	R1_SULLCYN	359927	3772994	Nad27
RANDOM1	West Fork Trancas	R1_WFTRANCAS	327854	3772856	Nad27
RANDOM2	Bulldog Motorway (off Malibou	R2_BULLDOG	338183	3773945	Nad27
RANDOM2	Cheeseboro Creek (above	R2_CHEESEBORO	341204	3782573	Nad27
RANDOM2	Circle X (Grotto Trail)	R2_CIRCLEX	322423	3774459	Nad27
RANDOM2	Escondido Creek	R2_ESCONDIDO	336645	3767184	Nad27
RANDOM2	Las Flores (year 2)	R2_LASFLORES	348928	3767371	Nad27
RANDOM2	Las Virgenes Creek (near City	R2_LASVIRGENES	343597	3779915	Nad27
RANDOM2	Olsen Road (CLU)	R2_OLSEN	326791	3788580	Nad27
RANDOM2	Rustic Creek (Will Rogers SHP)	R2_RUSTIC	361042	3769456	Nad27
RANDOM2	Santa Ynez Canyon Trail	R2_SANTAYNEZ	355597	3772207	Nad27
RANDOM2	Sostoma Trail (above Tropical	R2_SOSTOMA	338105	3768949	Nad27
RANDOM2	Suttphur Creek (Santa Maria	R2_SUTTPHUR	353353	3776838	Nad27
RANDOM2	Triunfo Creek	R2_TRIUNFO	333491	3778100	Nad27
RANDOM3	Arroyo Sequit (year 3)	R3_ARRSEQ	323756	3773670	Nad27
RANDOM3	Cold Creek (off Stunt Road)	R3_COLDCRK	347583	3773730	Nad27
RANDOM3	Conejo Creek (year 3)	R3_CONCRK	324278	3785975	Nad27
RANDOM3	Ladyface	R3_LADYFACE	337443	3779202	Nad27
RANDOM3	Liberty Canyon (above pitfalls)	R3_LIBCYN	341143	3777077	Nad27
RANDOM3	Malibu Creek (at Cross Creek)	R3_CROSSCRK	343917	3768988	Nad27
RANDOM3	Malibu Creek (Craggs Road)	R3_CRAGSRD	339724	3774729	Nad27
RANDOM3	Malibu Creek SP (rock pool)	R3_MALICRKSP	341176	3773571	Nad27
RANDOM3	Malibu Nature Preserve	R3_MALINP	323986	3768043	Nad27
RANDOM3	Topanga Creek (at Summit Road)	R3_TOPACRK	353198	3774779	Nad27
RANDOM3	Topanga Creek (off Topanga Blvd)	R3_TOPANGA	352365	3772720	Nad27
RANDOM3	Tuna Canyon (from PCH)	R3_TUNACYN	353354	3767502	Nad27

Standard Operating Procedure (SOP) No. 13 - Revising Standard Operating Procedures

Version 2.0 (September 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

13.0 Revising Procedures

Periodically it is important to make changes or edits to existing protocols. Any revisions that are made should first be brought up with the network Program Manager and changes coordinated between the parks and partnering agencies. In addition, changes to methods or sampling design may be subject to additional peer review. In this way, all data is consistent and useable to assess ecological or population changes between parks and partnering agencies.

At the top of each SOP there is a revision history log. It is important to fill out the history log for each SOP to document changes made to the protocols. Older versions of the SOP's should be archived or kept as an appendix to this document.

13.1 Naming Convention

Each change of the SOP requires a new version number. Minor changes are recorded as decimal numbers (*e.g.*, 1.0, 1.1, 1.2, *etc.*). A large modification of the protocols such as changes from a trapping methodology to a visual transect survey would be a change in the first number (*e.g.*, 1.0, 2.0, 3.0).

Standard Operating Procedure (SOP) No. 14 - Contact Information

Version 2.0 (September 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #

14.0 Contact Information

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Appendix A

Training document – Amphibian identification

NOTE: All photos (unless otherwise indicated) are found on www.californiaherps.com

A.1 Pacific tree frog

HYRE: *Pseudacris regilla* - Pacific Treefrog (Currently *Pseudacris hypochondriaca* *hypochondriaca* - Baja California Chorus Frog, Formerly *Hyla regilla*).

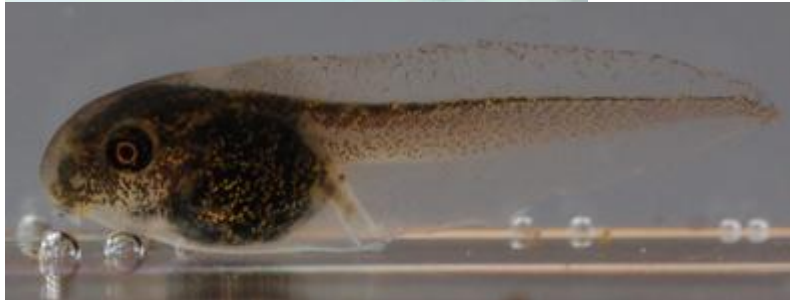
Tadpoles are up to 1 7/8 inches long (4.7 cm) blackish to dark brown and light below with a bronze sheen. The intestines are not visible. Viewed from above, the eyes extend to the outline of the head. Copper on ventral flanks, belly off-white. Head shape more oblong and rounded than *H. cadaverina*.

Most common tadpole in the Santa Monica Mountains and Simi Hills.

Breeding and egg-laying occurs between November until July, depending on the location. Tadpoles metamorphose in about 2 to 2.5 months, generally from June to late August. In summer, there are often large congregations of new metamorphs along the banks of breeding pools. Metamorphosed juveniles leave their birth pond soon after transformation, dispersing into adult habitats.

Diagnostic features

1. Eyes on side of head
2. Head shape rounded and elongated
3. Off-white belly



Adults and juveniles can be green, tan, brown, or mottled, but can be identified by the prominent dark brown or black eye stripe. *H. cadaverina* adults and juveniles do not have the eye stripe.



Egg masses are loose clusters of eggs, usually found in calm water attached to submerged vegetation or sticks.



A.2 California tree frog

HYCA: Currently *Pseudacris cadaverina* - California Treefrog (Formerly *Hyla cadaverina*)

Mating and egg-laying occurs from early February to early October after the high-flow from seasonal storms starts to decrease. Tadpoles metamorphose 40 - 75 days after hatching.

Less common in our streams, but co-occurs with *P. regilla*. Breeds later than *P. regilla*. Found in streams with boulders where adults are easily camouflaged.

Diagnostic features

1. Eyes on top of head, can see some cheek when looking down on tadpole.
2. Head shape, cheeks protruding more than *P. regilla* giving head non-round shape.
3. Bright white belly.



Adults are usually gray and are very cryptic against granite boulders. Shown here is a picture of an adult *H. regilla* above and and adult *H. cadaverina* below.



HYCA lays single eggs that are extremely hard to find.

A.3 Western toad

BUFO: *Bufo boreas halophilus* - California Toad/Western Toad (also *Anaxyrus boreas halophilus* - Southern California Toad).

Large schools of tadpoles often feed in shallow water. Tadpoles are dark brown or black, and grow to about 1 inch in length before metamorphosis. Tadpole development also depends on water temperature; tadpoles enter metamorphosis in 30 - 45 days, usually in late summer or early fall.

Un-common in our stream surveys, as they are mostly pond breeding. Found in streams with shallow calm pools that are pond-like.



Adults have a prominent stripe down the back.



Eggs are laid in a string and can be hard to find.

A.4 California newt

TATO: *Taricha torosa torosa* - Coast Range Newt (also *Taricha torosa* - California Newt)

Larvae are transparent and very small. External gills can be seen only underwater.



Adults are reddish dorsally, and yellowish ventrally. Easily seen in pools, and sometimes on stream banks.



Egg masses are hard gel balls attached to the underside of submerged rocks or logs. These can be easily felt and distinguished from HYRE egg masses. Care should be taken not to disturb or dislodge egg masses. Many or only one can be found. Shown in the picture is a cluster of many egg masses.



A.5 California red-legged frog

RAAU: *Rana draytonii* - California Red-legged Frog (Formerly *Rana aurora draytonii* - California Red-legged Frog)



Tadpoles are brown marked with small dark spots with eyes set in from the margin of the head. Creamy white coloring flecked with small spots covers the lower body. Eyes are set in from the margin of the head. Much larger than HYCA or HYRE.





Breeding occurs from late November to April, depending on the location, and lasts for only a week or two. Eggs hatch after about four weeks. Tadpoles metamorphose in four to seven months, but at some sites they overwinter and metamorphose the following summer. Currently found in one stream in SMMNRA, and we do not survey that stream. Found 1 adult in 2009, and 2010 in N. Las Virgenes sentinel site.

Adult is a large true frog with prominent dorso-lateral ridges, the underside of legs are red.
A PERMIT IS REQUIRED TO HANDLE RED-LEGGED FROGS – DO NOT CAPTURE OR DISTURB.

A.6 American bullfrog

RACA: *Rana catesbeiana* - American Bullfrog (also *Lithobates catesbeianus*)

Tadpoles are greenish yellow with small spots, growing up to 6 in. (15.3 cm). Much larger than native tadpoles. These invasive species are found in some of our streams.



Adult bullfrog in Zuma Canyon (left), and a picture from

http://soundwaves.usgs.gov/2006/01/Bullfrog1CBrown_altLG.jpg (right)



A.7 Red swamp crayfish

CRAY: *Procambarus clarkia* - Red swamp crayfish

Small fresh water crustacean. Looks like a small lobster.



Photo by Gary Busteed

A.8 New Zealand mud snail

NZMS - *Potamopyrgus antipodarum* - New Zealand mud snail

Very small, clonal, extremely invasive (<http://rivrlab.msi.ucsb.edu/NZMS/ident.php>)

Color: Shell-dark to very dark brownish, the head, foot, and mantle are colored dark with melanin pigments.

Size: 5-12 mm. The snail is usually 4–6 mm in length in USA populations, but grows to 12 mm in its native range. The periostracum (outer layer of the shell) is usually thin, and is often colored.

Shell: dextral (if held tip down and opening toward you, the opening is on the right), the shell has about 5.5 strongly convex whorls (the North American strain lacks a ridge or processes on the whorls). The shell opening is roundish to somewhat ovate as opposed to strongly ovate or lunate. There is an attached operculum which can close off the opening. The operculum is a kind of shell door that the snail can close to seal its shell shut when it feels threatened.



NZMS photo

Appendix B

Instructions for filling out Stream Survey Field Form

Fill in all blanks for each 250-meter stream reach. Stream coordinates and field crew information are recorded in the first section of the form. Each stop is identified as run, riffle or pool habitat. At each stop, habitat length and depth are measured for the habitat segment. Amphibians and non-native species are identified. Numbers for each species and age-classes are recorded for each habitat segment. Major changes in vegetation types or presence of boulders are recorded.

Stream Name – name of site being surveyed. Indicated whether it is a sentinel or rotating site.

Date – Date of survey.

Start time – Start time of survey.

Field crew – First initial or full name and full last name of all field personnel present for the survey.

Coordinates – Coordinates of the start site, the datum used, elevation, and GPS accuracy should be noted here.

Flow – Calculate after the survey is completed.

Occupancy Sampling – Note the presence of species encountered during the 250 meter survey.

Intensive Sampling – Stop #1 begins at the starting point. Habitat type (run, riffle, pool, dry) should be noted and the length and depth of each stop measured and recorded. At each stop, the population class (or abundance category) and life stage (age) of each species (according to the table present on the data sheet) should be counted. Overhead vegetation and the presence of boulders are also noted at each stop.

If side pools, runs, or riffles run parallel to the main stream, all of the same data is collected. These are considered secondary habitat stops and are noted as such in the box called “habitat” by indicating if the stop is a side pool, a side run, or a side riffle.

Stream Survey Field Form

STREAM NAME _____ **DATE** ____/____/____ **Start Time** ____:____
Field Crew _____
Coordinates: X _____ Y _____ Datum _____ Accuracy _____ m Elevation _____ m
Flow _____ m³/s = W _____ m x Avg D _____ m x Flow _____ m/s
Notes / Comments _____

Occupancy Sampling

☐ BUFO (poisonous toad)	☐ CRAY (crayfish)	Notes / Comments _____ _____ _____ _____
☐ HYRE (pacific tree frog)	☐ FISH _____ species	
☐ HYCA (california tree frog)	☐ OTHER _____ species	
☐ TATO (california newt)		

Intensive Sampling: Habitat and Species Observations

HABITAT: Pool, Riffle, Run, Dry		L = length (m), D = depth (m)		POPULATION CLASS: <5, 5-20, 21-100, 101-500, >500	
BOULDERS: Yes / No		VEGETATION: oak (o), willow (w), mullet (mf), chaparral (ch), coastal sage (cs)			
SPECIES:	Adult (A)	Juvenile (J)	Larvae (L)	Egg (E)	
All Frogs and Toads (BUBO, HYCA, HYRE, RAAU, RACA*)	Exact	Popn Class	Popn Class	NA	
TATO	Exact	Exact	Exact	Exact	
CRA* and FISH (native and nonnative)	Popn Class	Popn Class	NA	NA	

[illegible]

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
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