Field validation of a landscape habitat model for the foothill yellow-legged frog (*Rana boylii*) in Oregon

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The foothill yellow-legged frog (*Rana boylii*) is a Sensitive species in Oregon for both the Oregon/Washington Bureau of Land Management and Region 6 of the US Forest Service (Interagency Special Status and Sensitive Species Program, (ISSSSP); information available at http://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-amphibians.shtml.

INTRODUCTION

The status of the foothill yellow-legged frog (*Rana boylii*) is of concern throughout its entire range in California and Oregon. In Oregon, only 43% of historic sites were observed with frogs during a survey in the late 1990s (Borisenko and Hayes 1999). The ISSSSP Conservation Assessment for this species (Olson and Davis 2007a) states an information need includes a better definition of habitat and habitat associations, and a habitat map for Oregon. A habitat model using landscape-scale attributes was developed in 2007 (Olson and Davis 2007a), and a habitat suitability map was created for Oregon.

In the summer of 2007, the habitat suitability map was used to focus field surveys for *R. boylii* in the northern portions (Figure 1) of its historical range in Oregon (Olson and Davis 2007b). The survey area contained eight historic *R. boylii* sites that were surveyed by Borisenko and Hayes in 1999, but with no detections. The objective of the 2007 federal survey effort was to advance our understanding of the northern distribution of the foothill yellow-legged frog on federal lands in Oregon, with a focus on the Coast Range, although portions of the western Cascades were also surveyed. A total of 41 reaches modeled as suitable or optimal habitat (HS≥40) and covering 35km of streams or rivers were surveyed. No *R. boylii* were found during this survey. Another survey effort conducted in 2006-2007 in the northern portions of the range (Rombough 2008) covered 966-km of stream habitat within the Santiam and Calapooia basins and found *R. boylii* at only one of eight historic locations and one previously unknown site at Wiley Creek, both within the Santiam basin. Both of these sites are modeled as suitable habitat in the map developed in 2007 (Olson and Davis 2007a). The cumulative evidence of these three survey efforts indicates that *R. boylii* has vanished from numerous historical locations and the species may become extirpated in northwestern Oregon in the near future.

In the summer of 2008, field surveys were conducted along modeled optimal, suitable, marginal and unsuitable habitats within the central portion of the range of the foothill yellow-legged frog in Oregon, with known *R. boylii* occurrence. The purpose of this survey was to; 1) field validate the habitat suitability map developed during the conservation assessment and 2) improve our understanding of species-habitat relationships that may be important and which may be affected by federal agency land management decisions.

METHODS

Since a primary aim of the 2008 survey was to field validate the habitat suitability map, we focused survey efforts within the core area of *R. boylii* occurrence in Oregon in order to provide a representative sample from a broad area of known species occupancy. This core area was delineated by a 95% kernel for recently compiled sites (presence data: 1990 to 2006). The process of delineating this core area is explained in Olson and Davis (2007a). Within this core area, our sampled landscape was framed by federal lands within eleven 5th-field watersheds (5th-level hydrologic unit code[1]). The survey area covered

[1] see http://water.usgs.gov/GIS/huc.html

about 451,000 hectares, with about half located in the western Cascade Range and the other half in the Coast Range (Figure 1).

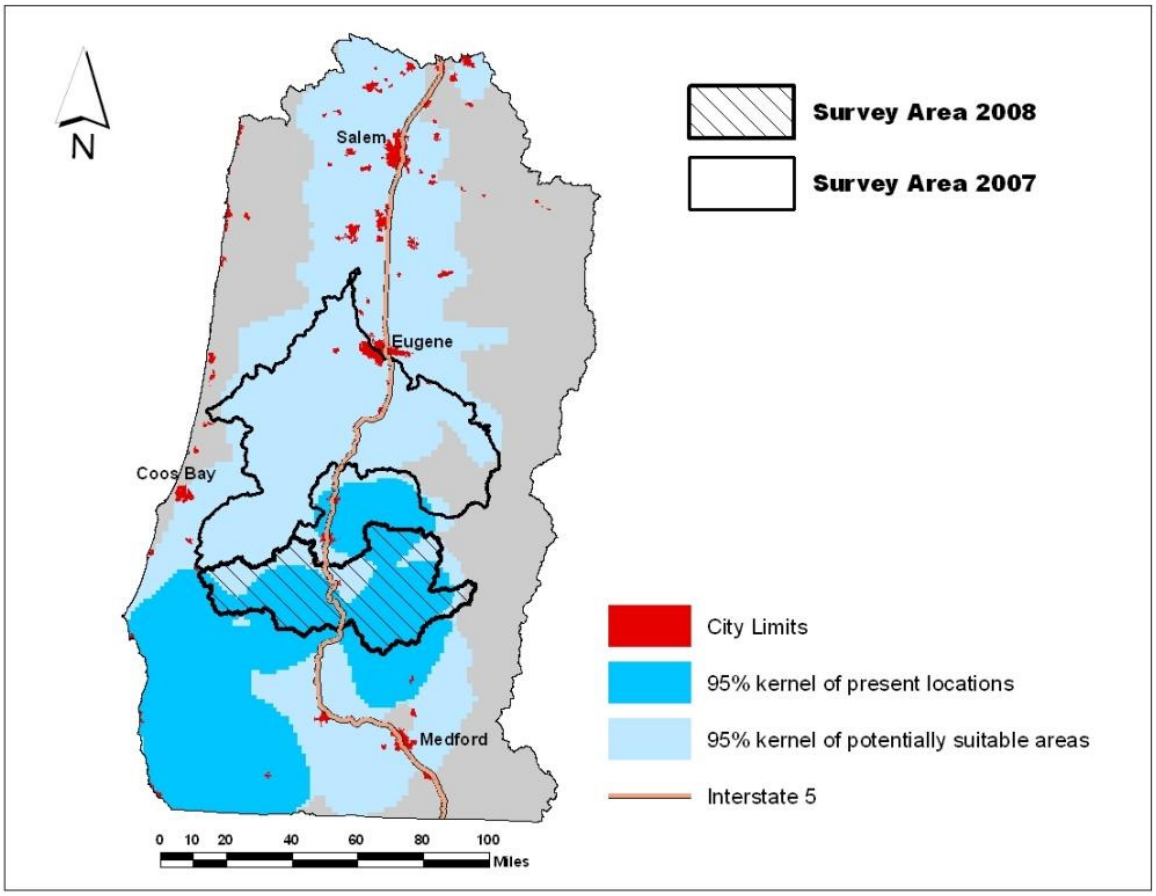

Figure 1. Survey area for *Rana boylii* surveys in 2008 (cross-hatched area) for validation of the habitat map (version 1.0). The survey area from 2007 to determine northern occurrence is shown for reference (Olson and Davis 2007b). The 95% kernels were determined during development of the R. boylii habitat model (http://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-amphibians.shtml).

A stratified random sampling procedure was used to select 44 survey reaches on federal lands within the eleven 5th-field watersheds. A stratification of the Habitat Suitability (HS) map was needed to ensure that survey reaches covered the full spectrum of HS values, because the preponderance of lower HS values in the area produces a non-normal distribution and a purely random selection of survey reaches would have over-sampled unsuitable habitats and under-sampled suitable habitats. For each 5th-field, we randomly selected one survey reach from four classes of HS (unsuitable (0-14); marginal (15-39); suitable (40-74); and optimal (75-100)) using the following process in ArcGIS 9.2:

1. Mask out all non-federal lands.
2. Reclassify the HS map into categories defined above (see Figure 3 and also in Appendix A of the Conservation Assessment
3. Convert raster cells to points using "Raster to Point" tool.
4. For each 5th-field watershed, randomly select one point in each HS class using Hawth's Tools "Random Selection within Subsets" sampling tool.

5. Overlay the HS class grid and randomly selected points on a stream layer.
6. Per selected point (reach), confirm there are at least 5 contiguous pixels within the same HS class along the stream channel, otherwise throw out the point and resample for that HS class.
7. Per selected reach, confirm *R. boylii* presence is not already known, otherwise throw out the reach and resample for that HS class.
8. Once a reach is selected, delineate 500 meters of stream channel, taking into consideration field logistics, such as road crossings and access. For example, start a survey reach at an easily identifiable and locatable road crossing and delineate it upstream as it falls within the appropriate HS class.

Laminated field maps, field forms and GPS data were prepared and provided to the field crew, to ensure accurate location of the forty-four 500-m reaches selected.

Field Sampling Protocol

Surveys were conducted following procedures outlined in Appendix A, but are summarized here briefly. Visual encounter survey methods were used. Stream reaches were walked by a 2-person crew in an upstream fashion. Warm, sunny days were chosen for surveying to increase likelihood of finding *R. boylii*. Frogs were captured and/or photographed in situ to obtain photographic vouchers to ensure proper identification, and then released. Habitat parameters were recorded at the start and stop of each reach, and summarized for the entire reach. Where *R. boylii* were encountered, information on life stage and habitat conditions was also recorded and the site location was recorded using a GPS. Other species encountered were recorded, but without habitat measurements. Field equipment was swapped out or disinfected between survey reaches when survey reaches occurred in different watersheds, to avoid spread of potentially harmful pathogens.

Statistical Procedures

To test the validity of the HS map, a chi-square test was performed on the number of *R. boylii* detected in each of the four HS classes to determine if there were significant differences between the classes. This was followed by a Spearman rank (r) correlation to determine the relationship between the four habitat suitability classes and the abundance and frequency of *R. boylii* detections within each HS class. To determine the overall accuracy of the map for predicting *R. boylii* presence, a kappa (k) coefficient (Cohen 1960) was calculated for predicted and observed presence and absence for a two-class system, where absence was predicted in reaches with HS<40 and presence was predicted in reaches with HS≥40. Habitat relationships were examined using Student t-tests.

RESULTS

A total of 44 reaches covering about 25 km of stream were surveyed from 14 July through 10 September 2008. Survey reaches averaged between 551 - 589 m (95% confidence interval) based on start and stop GPS measurements. A total of 41 individual *R. boylii* were found in 8 of these reaches, consisting of 21 adults, 12 juveniles and 8

tadpoles. Five other frog species were also detected; including 24 red-legged frog (*Rana aurora*), 4 Pacific tree frog (*Pseudacris regilla*), 3 Cascades frog (*Rana cascadae*), 3 bullfrog (*Lithobates catesbeianus*) and 1 tailed frog (*Ascaphus truei*). Other amphibian species detected included *Dicamptodon tenebrosus*, *Taricha granulosa*, *Plethodon vehiculum* and *Plethodon dunni*. Reptiles observed included *Thamnophis* spp., *Elgaria* spp., and *Sceloporus occidentalis*.

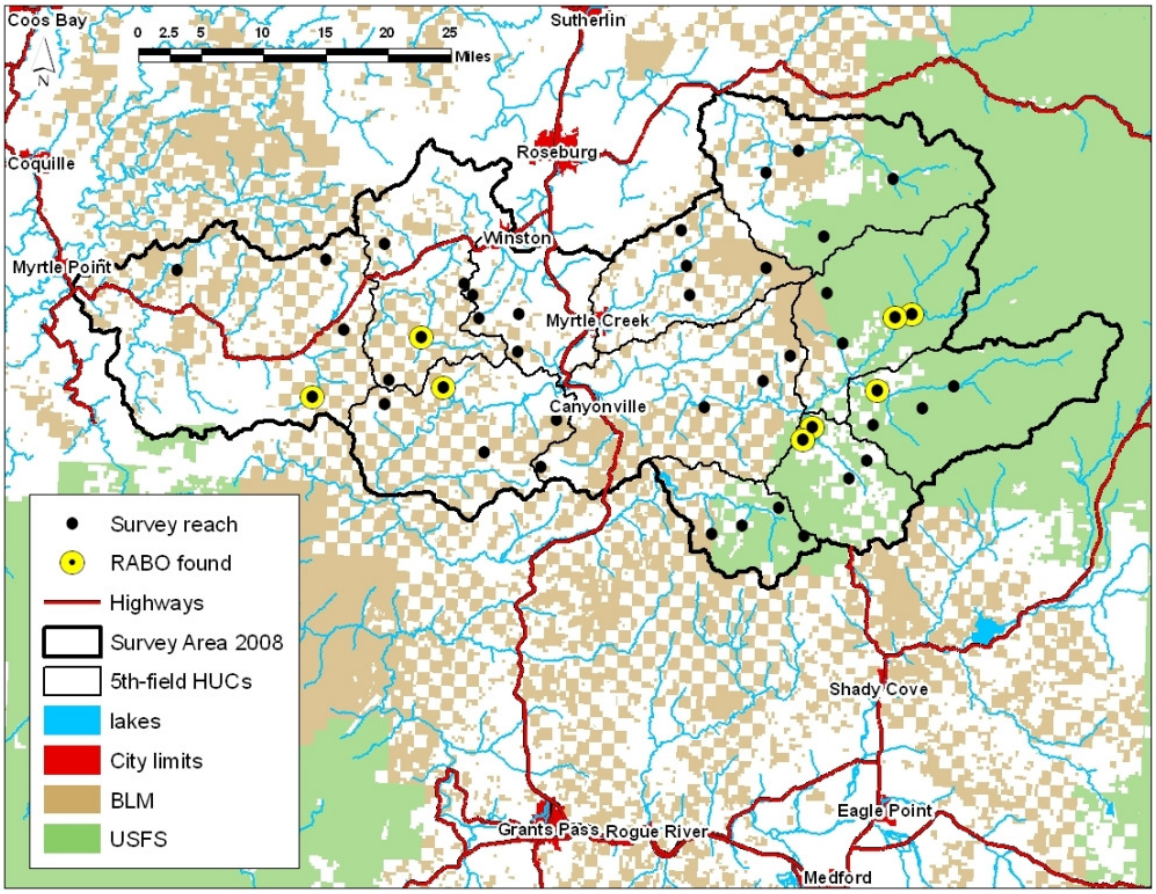

Figure 2. The survey area, survey reaches, and locations of *R. boylii* found in the summer of 2008.

Habitat Suitability

Based on the chi-square test (chi-square = 20.366 with 3 degrees of freedom), there was a significant difference (P = 0.0001) between the number of *R. boylii* detections in each HS class. The relationship between habitat suitability to both *R. boylii* abundance and frequency of detection was positive, with $r = 1.0$ (P = 0.10), similar to that shown in the *k*-fold cross-validation conducted during initial habitat modeling (Oslon and Davis 2007). Total abundance and frequency of detection (defined as the percentage of reaches with detections) increased with increasing habitat suitability classification (Figure 4). *Rana boylii* were mostly found in suitable and optimal reaches, and in only one marginal reach. No *R. boylii* were found in reaches classified as unsuitable by the habitat map. Overall map accuracy was fair with $k = 0.27$ ($\alpha = 0.05$) with a classification accuracy of 64% when HS classes were combined into two classes representing predicted presence (HS≥40) and absence (HS<40).

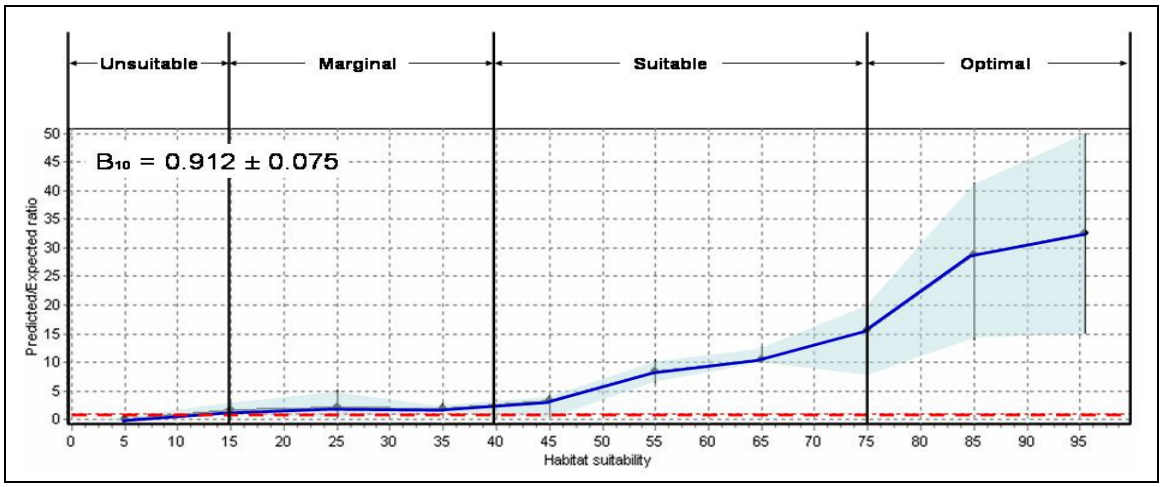

Figure 3. Cross-validation curve used to classify habitat suitability classes in Olson and Davis (2007a). Blue line = median, blue-shaded area = 90%-confidence interval.

HS RANGE	CLASSIFICATION	ABUNDANCE	FREQUENCY
0-14	unsuitable	0	0
15-39	marginal	7	9
40-74	suitable	16	27
75-100	optimal	18	36

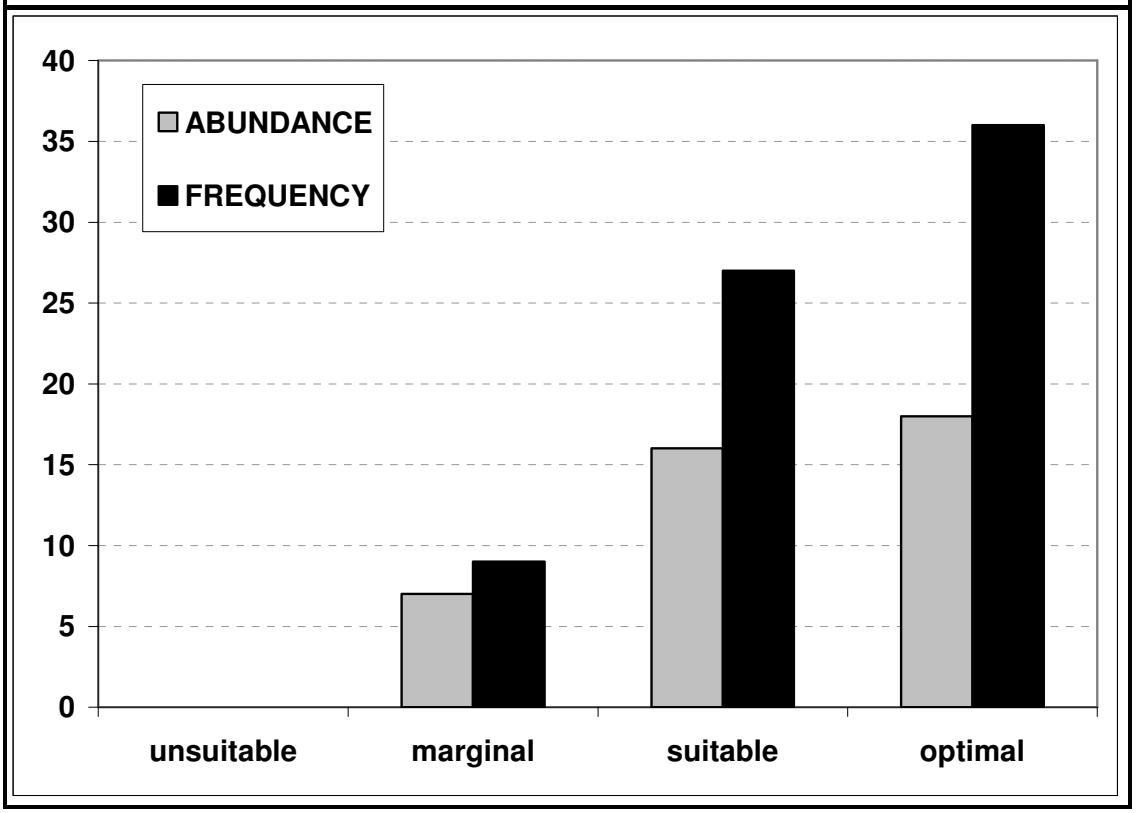

Figure 4. The 2008 survey results show increasing abundance (total *R. boylii*) and detection frequency (percent of reaches with *R. boylii*) with increasing habitat suitability (r = 1.0, P = 0.10).

Habitat Relationships

Habitat data from *R. boylii* sites and reaches with *R. boylii* were analyzed for differences between them and suitable and optimal (HS≥40) reaches where *R. boylii* were not detected, to try to determine site-specific factors that might explain absence of *R. boylii*. The results of a Student's t-test showed significant ($p<0.01$ and $p<0.05$, respectively) differences between water temperature and stream vegetation cover. Suitable/optimal reaches that lacked *R. boylii* were cooler and had 2 to 3 times as much vegetation (e.g., trees, shrubs, etc.) covering the stream than sites or reaches with *R. boylii* (Figure 5).

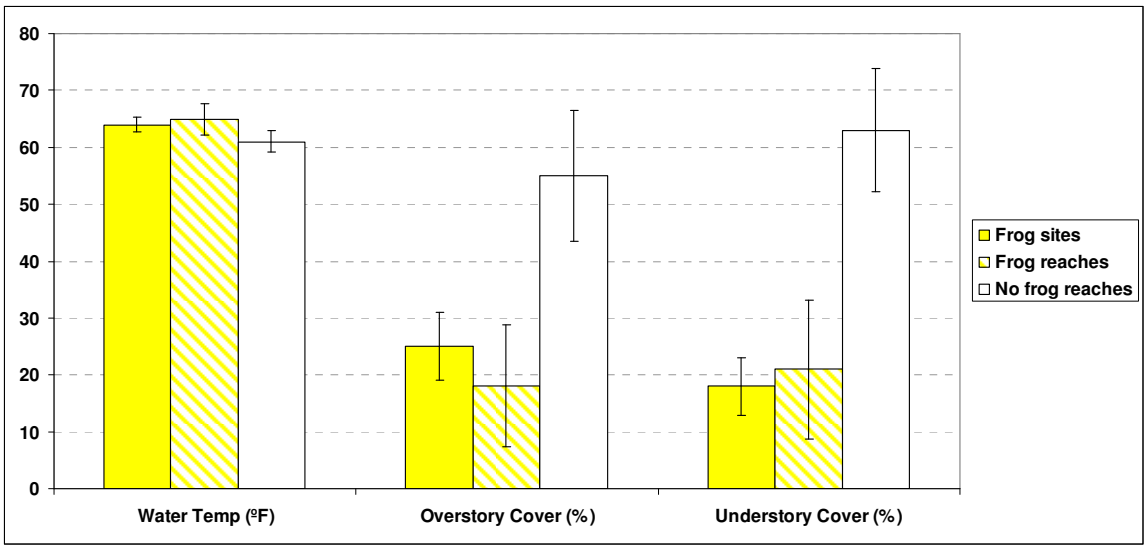

Figure 5. Comparison of water temperatures and canopy cover between actual *R. boylii* sites, reaches containing *R. boylii* and reaches that were modeled as suitable or optimal, but where *R. boylii* were not detected.

Reaches with *R. boylii* detections had a larger portion of slow-moving water habitat than suitable/optimal reaches without *R. boylii*, with significant differences in frequency of glides (P = 0.037) and riffles (P = 0.038), but no significant difference in pool habitats. The stream substrates of sites and reaches with *R. boylii* detections were dominated mostly with coarser, rocky substrates (e.g., cobble, boulders and bedrock) overlaid on gravels and sands (Figure 7). Reaches without *R. boylii* detections had significantly more amounts of fines like sand and mud (P<0.001) as the dominant substrate, which tend to fill in interstitial spaces and embed the coarser substrates. The biggest difference is subdominant stream substrate was in the amount of coarse sand at sites and in reaches with *R. boylii*. The frog's skin coloration, and especially texture, blends in well with the stream's coarser sandy substrate (Figure 6).

Figure 6. Cryptic coloration and texture of *R. boylii* in coarse sand substrates.

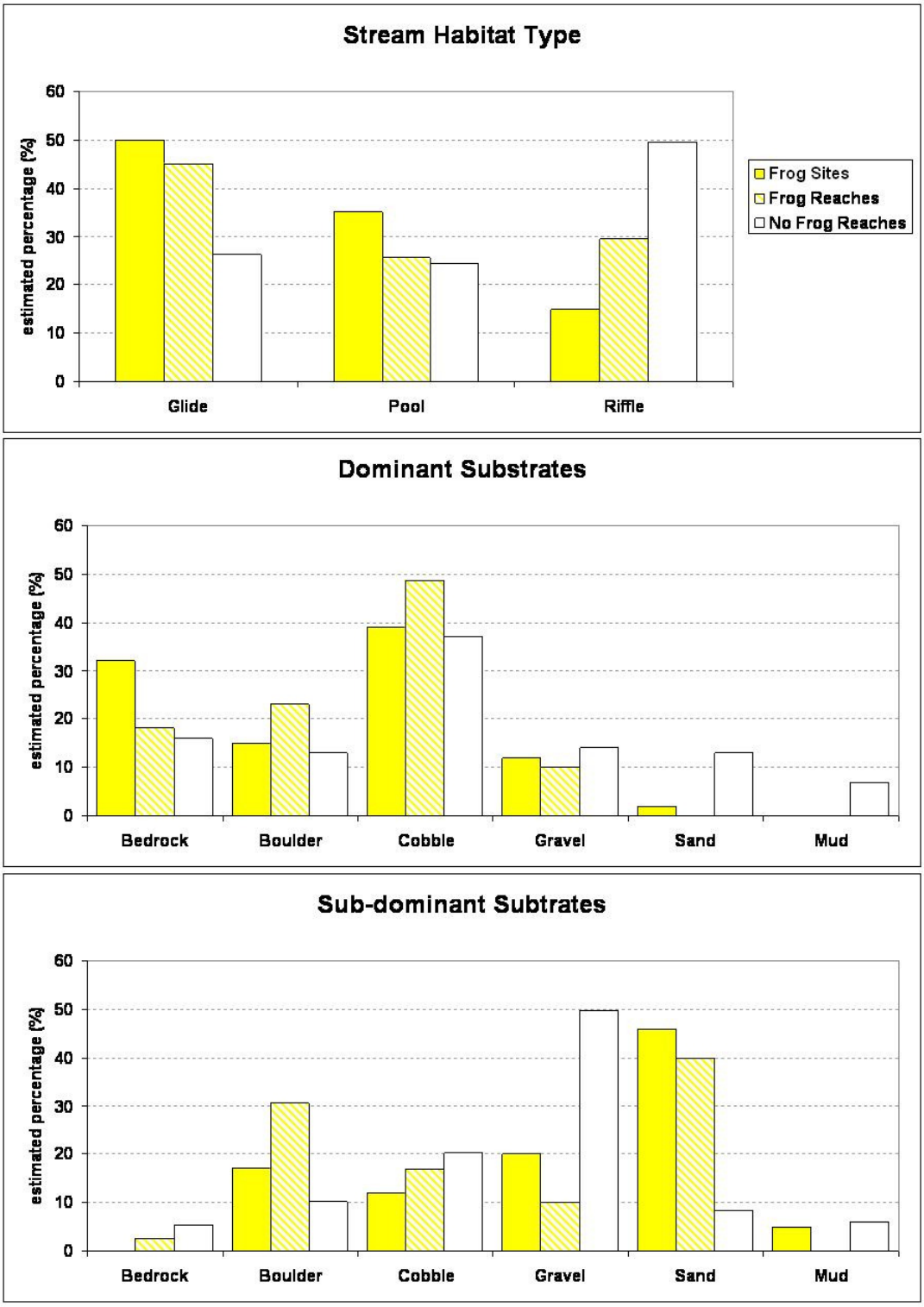

Figure 7. Comparison of stream habitat types and substrates between actual *R. boylii* sites, reaches containing *R. boylii* and reaches that were modeled as suitable or optimal, but where *R. boylii* were not detected.

The frog's coloration (especially in the older tadpole stages) blends in well with the stream's algae-covered rocky substrates such as cobbles and bedrock (Figure 8).

Figure 8. Tadpole *R. boylii* blending into the stream substrate in the South Umpqua River.

The presence of larger substrates such as boulders and cobble were observed to provide cover both in (Figure 9) and outside of the water. Boulders with interstitial spaces underneath them along stream banks may also provide thermal cover.

Figure 9. Adult *R. boylii* using submerged boulder and cobble substrate to hide underwater.

Landscape Relationships

Landscape data were analyzed for differences between suitable and optimal (HS≥40) reaches where *R. boylii* were detected to those surveyed reaches (HS≥40) where they were not detected, to try to determine if landscape-scale factors might offer some explanation for the absence of *R. boylii* in otherwise suitable habitat. To focus our analysis, we used the threat assessment done in the Conservation Assessment (Oslon and Davis 2007a) and tested potential threats that occurred in the survey area. The results of this analysis are shown in Table 1.

Table 1. Results of the Mann-Whitney test are shown below.

Potential Threat - Landscape Variable	Presence (n = 8)	Absence (n = 15)	U	p-value
Distance from agriculture (km)	8	1	98.5	0.011
Distance from cities (km)	26.5	13	98	0.013
Agriculture within a 5-km radius (%)	0	2	93.5	0.028
Distance from streamnet dams (km)	17.5	10	81.5	0.169
Road Density (mi/mi^2)	3	5	77	0.294
Clearcuts within a 5-km radius (%)	12.5	11	76	0.325
Stand-replacing wildfire within 5-km radius (%)	1	2	67.5	0.636

Based on the results of the Mann-Whitney test of the 2008 survey data, we found similar patterns of sites without frog detections occurring in areas near cities and agricultural areas (Figures 11 and 12) as described in the Conservation Assessment. The most significant differences in landscape-scale threat variables were associated with agriculture and urbanization. Reaches with *R. boylii* had no agriculture within a 5-km radius and the median distance from agriculture was 8-km. Sites without R. boylii had a median distance of 1-km from agriculture.

We did not test for distance to hydropower, because none of the survey reaches were in areas that would be affected by hydropower effects (e.g., ramping). There was no significant difference in distance to small dams, but there were very few small dams in the survey area, and none of the survey reaches were in stream or river segments that had dams. Reaches that had *R. boylii* had lower road densities, but the difference was not significant. There were no significant indications that stand-replacement disturbances such as clearcutting or fire might have an effect on frog occurrence or absence.

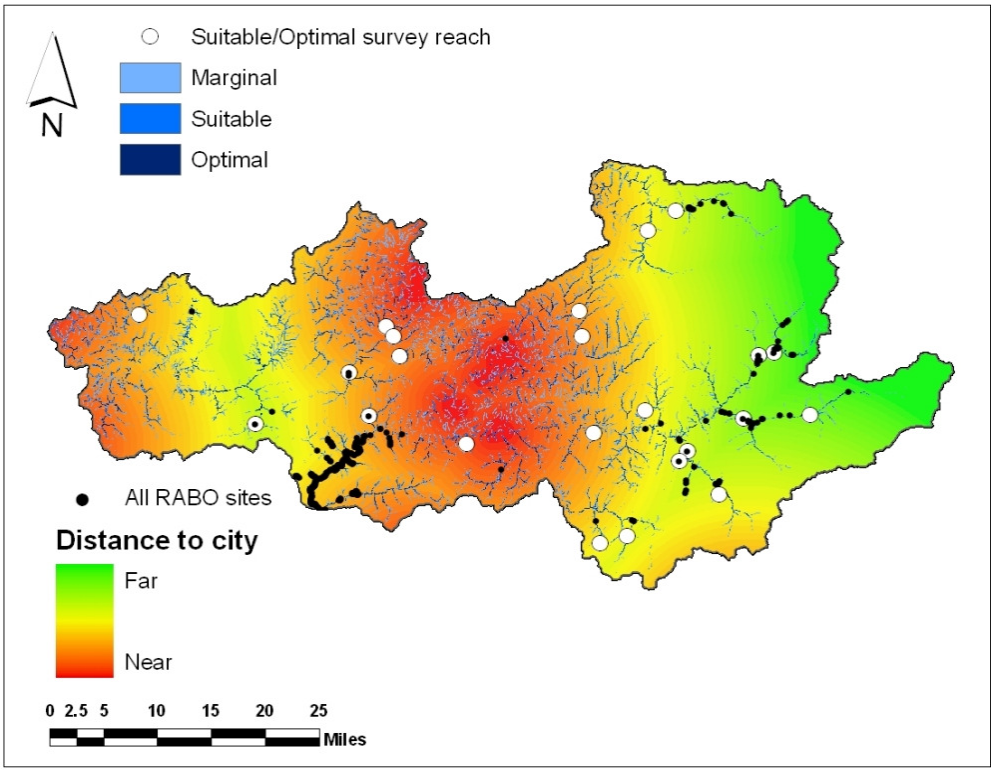

Figure 10. White circles represent locations of survey reaches that were modeled as suitable or optimal. Black dots represent *R. boylii* locations found during this survey and other detections.

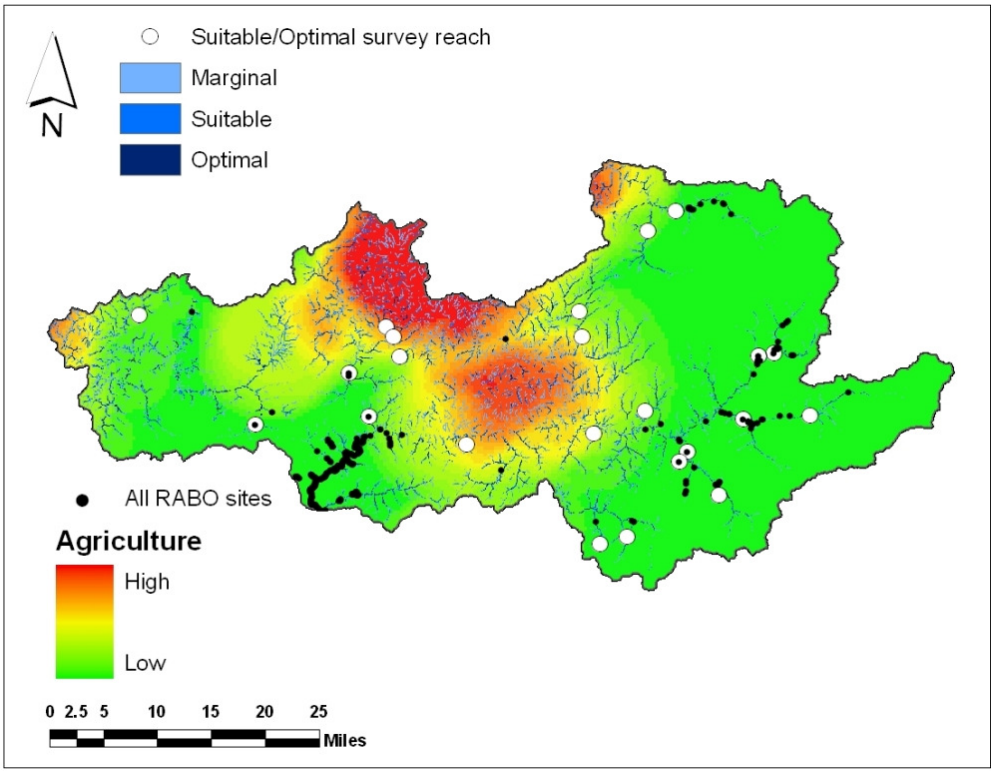

Figure 11. White circles represent locations of survey reaches that were modeled as suitable or optimal. Black dots represent *R. boylii* locations found during this survey and other detections.

DISCUSSION

The main intent of this survey was to validate the habitat suitability map created in 2007. Results from this survey showed that the classification based on HS values as defined by the cross-validation curve was directly correlated to the total abundance and frequency of *R. boylii* detections. However, the HS map was not completely accurate in predicting *R. boylii* occurrence. To provide some insight into map inaccuracies, we focused on the suitable and optimal habitat (HS≥40) reaches with and without *R. boylii* detections to determine potential differences at the landscape, reach and site-specific scales. We found some significant differences at all spatial scales. In summary, at the reach and site-specific scales, suitable/optimal reaches that lacked *R. boylii* detections were cooler had more vegetation cover (less sun exposure) and more sand and mud substrates. At the landscape scale, suitable/optimal reaches nearer urbanized or agriculturally developed areas lacked in *R. boylii* detections.

Given the lack of data, we did not analyze for other localized threats, such as those from invasive species such as smallmouth bass and bullfrogs, or human-caused impacts (e.g., recreation, oil spills, etc.). We do note anecdotally, that one third of all otherwise suitable/optimal habitats that lacked *R. boylii* were in areas with obvious signs of recreation, and one site had a large piece of machinery abandoned in it, that was leaking oil into the stream.

Other noteworthy observations include that even though red-legged frogs and yellow-legged frogs were sometimes found in the same survey reach, they were seldom found at the same site together, and sometimes occurred in a "leap-frog" fashion. One otherwise suitable creek (Brownie Creek) had nothing but red-legged frogs, although nearby streams had yellow-legged frogs. Perhaps this may be due to interspecific competition or perhaps each frog is taking advantage of site-specific habitat conditions, whereas, red-legged frogs seemed to prefer areas with more vegetative cover.

We also documented the presence of *Thamnophis* spp. in 75% of reaches that had *R. boylii*, as opposed to only 20% of otherwise suitable/optimal reaches where *R. boylii* were not detected. Garter snakes are one of the primary predators of yellow-legged frogs (Lind and Welsh 1994) and their presence or absence may relate to presence or absence of their prey.

In spite of the less-than-perfect predictive capability of the habitat model, the current version of the habitat map appears to be a useful tool for biological evaluations and other conservation efforts. Use of this map as the first step to screen projects during land management planning is reasonable. This map can be used to determine likelihood of frog presence. Projects within unsuitable habitat classes may be cleared during the pre-field biological evaluation process, unless site-specific information indicates otherwise. Projects in marginal habitat have a low likelihood of frog occurrence. Frog presence is more likely in suitable and optimal habitat classes. In addition, this species of frog may have a normally patchy distribution in Oregon.

RECOMMENDATIONS

We recommend revising the current version of the habitat map, using a larger set of *R. boylii* presence data provided by this and other surveys, including other recent incidental observations. We also recommend including additional mappable variables that relate to distance to city and agricultural use to provide supplementary maps that might provide a more realistic "picture" of frog occurrence.

ACKNOWLEDGMENTS

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APPENDIX A

RABO SURVEYS 2008
Field Survey Instructions

TIMING OF SURVEYS

Survey should only occur during days with low wind, sunny skies and maximum air temperatures >70ºF. These conditions result in greater likelihood of frog detection. Surveys should begin in June and end in September. Conduct surveys in lower elevation reaches prior to higher elevation reaches.

GENERAL APPROACH

Surveys will be conducted in either an upstream or downstream direction by a 2-person field crew. Upstream is the preferred direction, to prevent turbidity from hindering frog observations. Both surveyors will be located on one stream bank, and will visually search for frogs while walking. Visually search the reach ahead of you with binoculars prior to conducting the walking search. Focus on streambank margins, gravel bars and tops of rocks above, but within, the stream.

In small streams, one person will walk ahead of the other and visually scan upstream for frogs, particularly those moving at the stream-bank interface. The 2nd person will follow, looking in the more immediate area and will look for eggs, larvae, and metamorphosed froglets. When searching for larvae, their feces on the stream bottom may be an important indicator of presence, which may then be detected by flipping rocks; most frogs may be expected to be seen within 1-meter of water. Surveyors should take caution to avoid stepping on eggs, tadpoles, or juveniles that may be underneath substrate or along the river or creek margin.

The start point of each survey will be marked by flagging tape, and recording using a Global Positioning System (GPS). The ending point will be similarly flagged. A minimum stream distance of 0.5 km will be surveyed per reach.

FROG OBSERVATIONS

When larvae, froglets or adult frogs are observed, they will be captured for species identification and collection of photographic vouchers. If the field crew is confident that subsequent observations from initial captures are the same species, they do not need to capture all animals seen. Occasional captures to confirm species identification will be conducted though. The number of *Rana boylii* of each life history stage (egg, larva, froglet [< ~18-35 mm], frog) observed in/along the stream reach will be recorded in field forms and a GPS location will be taken. Frogs will not be measured or marked as part of this inventory, and will be released at the capture location. Frogs that cannot be captured will be noted. Other species of amphibian, reptile or fish detected during the survey will be recorded. GPS coordinates of introduced species (smallmouth bass or bullfrog)

or rare species (e.g., king snakes, harlequin ducks, etc.) locations will be collected, as possible. The following is from Seltenrich and Pool (2002).

Egg masses - Typically attached to rocky substrate in calm or slow-flowing, shallow (usu. < 500cm) water near the shore with stream velocities <20 cm/sec. Egg masses are usually laid in open areas along the stream where very little shading occurs. Egg masses are sometimes attached to underwater woody debris. Egg masses are typically round and gelatinous, and are about the size of a fist (3-4 inches in diameter), but can be smaller. For several days following oviposition, egg masses often appear bluish in color. As the egg mass matures, the blue color fades and becomes relatively clear. In areas with little or no flow, egg masses typically become partially or completely covered in detritus, silt, or other fine sediments, making detection more difficult. Throughout the entire developmental process, the ova remain distinctly black.

Tadpoles - When tadpoles first emerge they are about 7-8 mm in length and are entirely black. They remain close to the egg mass (which serves as food for the tiny tadpoles) and begin to disperse as the gelatinous mass decomposes. When they initially begin to disperse, the small black tadpoles are usually easy to observe feeding on diatoms and other algae on the surface of the substrate. However, as they grow, tadpoles lose the black coloration and become a more camouflaged coloration that blends with the background substrate. Tadpoles generally hide between cobble and boulders, often well hidden under a layer of detritus. To locate tadpoles, surveyors should first walk slowly along the shoreline looking for quick darting movements. If nothing is readily observed, surveyors should prod crevices and detritus slowly with net handle or fingers.

Juvenile/Subadult and Adult Frogs - Can be observed along stream margins on sunny days. However, areas with a canopy and partial sun and shade are also used. In general, adult frogs are not usually found in sections of creek that have moderate to high amounts of overhanging cover (shade). Following metamorphosis, juvenile frogs may congregate and are usually conspicuous along stream margins. Juveniles will typically remain in the vicinity of breeding locations for the remainder of the summer and fall. When associated with river cobble bars, some juveniles may disperse to nearby isolated pools or side channels.

HABITAT INFORMATION

General habitat information will be recorded for each reach, including a visual estimate of average wetted width of stream channel, stream depth, dominant and subdominant substrates, and bank characteristics (substrate, vegetation). At foothill yellow-legged frog locations, these attributes will be recorded in more detail. No site specific information is required for other species for this survey.

Stream Habitat Types

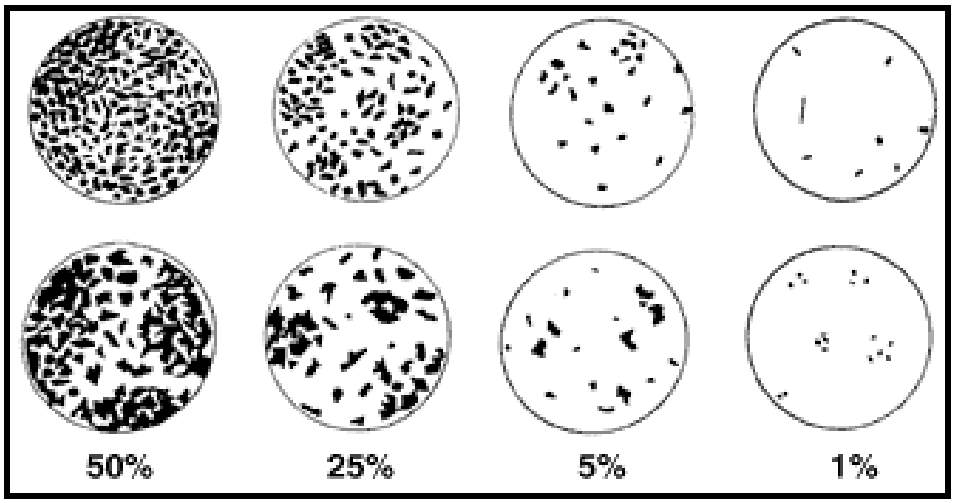
Riffle – sections of stream with fast current and shallow depth; the water surface is visibly broken and turbulent.
Glide – sections of stream with moderately fast flowing water with no surface turbulence and moderate depths.
Pool – sections of stream where the water is impounded to form deeper than average, slow-moving water areas.

Substrates

Bedrock = consolidated rock
Boulder = >256 mm
Cobble = 64 to 256 mm
Gravel = 2 to 64 mm
Sand = 0.625 to 2 mm
Mud = consolidated silt, clay and organic material <0.625 mm

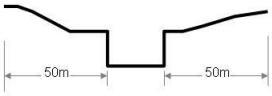
Streambank Habitat

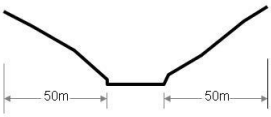
Overstory – If multiple layers occur over the stream, then this is the upper story. Record as "trees" or "shrubs".
Understory – If multiple layers occur over the stream, then this is the dominant lower story. Record as "shrubs" or "grass/forbs". If only on story exists… then record as none (this should be rare).
Percent Cover – record the approximate percentage of stream channel covered by the cover type.



Sketch a cross-section of the average shape of the reach's channel morphology going out from each bank by 50-meters. For example, the sketch on the left shows a deeply incised stream channel, and the sketch

on the right shows a well-defined, but not incised channel. You can include another line over the cross section to represent canopy cover.





DISINFECTION PROCEDURES

Always start field work with sterilized equipment. Between sampling of different reaches, field gear including boots and nets will be disinfected with a 5% bleach solution. Mix bleach solution in a five gallon bucket ***located well away from streams and other aquatic habitat***. Mix just enough solution to adequately disinfect your equipment. Soak for about 2-minutes. Scrub if necessary. Use of sprayers can be used, but ensure adequate application (enough to saturate the equipment). Allow equipment to drip dry between reaches. Avoid taking wet equipment saturated with disinfectant into aquatic habitats.

Take adequate safety precautions (follow label instructions) when mixing or handling the disinfecting chemicals. Dispose of the contents of the bucket in an appropriate manner. Do not dump contents directly into stream and aquatic systems, nor locations where overland flow into these systems might occur. If small snails are found on equipment during this procedure, then collect specimens for later identification.

GENERAL SAFETY

Prior to each survey day, a tail-gate session will be held, to review safety procedures. Safety hazards include swift flowing water, deep pools, rugged terrain with sometimes dense brush, slippery footing, hornets and wasps, poison oak and mixing of chlorine disinfectant. Proper safety gear should be used, such as felt bottom or corked shoes, hard hats, safety goggles. If allergic to bee stings, then inform your co-worker and carry an epinephrine sting kit. Also carry a hand-held radio. Ensure your supervisor knows where you will be working, and use a check-out/check-in system. Develop a list of phone numbers to call in case of emergencies. Wash hands after handling herps before eating. Always be aware of your surroundings and do not take chances. If a reach appears to be too dangerous to survey, it can be substituted with another reach or dropped.

Citations

Seltenrich, C. P. and A. C. Pool. 2002. A standardized approach for habitat assessments and visual encounter surveys for the foothill yellow-legged frog (*Rana boylii*). Pacific Gas and Electric Company.

RABO Surveys

Watershed: _____ **Reach:** _____ **Date:** _____

Weather: _____ **Surveyors:** _____

Start Time: _____ **Stop Time:** _____ **Start/Stop Air Temp:** _____/_____ **Start/Stop Water Temp:** _____/_____

General Stream Reach Characteristics (estimate after it has been walked)

habitat type	% reach	avg. width (m)	avg. depth (cm)	dominant substrate	subdom substrate
riffle					
glide					
pool					

General Streambank Characteristics

habitat type	cover type	% cover	sketch avg shape of channel morphology
overstory			
understory			
banks			

RABO Location Information (GPS each location)

meters from start	# ind	life stage	water temp	habitat type	width (m)	depth (cm)	dom substrate	subdom substrate	o/s cc (%)	u/s cc (%)	comments

Other species observed:

General comments: