Supplemental Material

Appendix S1. Details of Methods and Results

Regional Occurrence of Rana boylii

To assess the association between dams and the distribution of *R. boylii*, we mapped historic (pre-1975) sites compiled from museum records and assessed a set of variables representing aspects of dams such as size, proximity, and reservoir capacity. The major era of dam building preceded 1975 (Rosenberg et al. 2000). For California, we began with a previously compiled database of narrative descriptions (e.g. “3 miles upstream of Smith Road crossing of Jones Creek”) for 1049 unique *R. boylii* sites from museum collections and field notes sources (Jennings & Hayes 1994, Davidson et al. 2002). This database represented the potential set of historic sites. We randomly selected a subset of 10 sites from each county in which *R. boylii* occurred (all sites were selected in counties with less than 10) to arrive at a broad distribution of historic sites across California. We used 1:100,000-scale U.S. Geological Survey (USGS) digital topographic quadrangles and ArcView version 3.2 GIS software (Environmental Systems Research Institute [ESRI] 1999) to map each of the resulting 328 sites. For Oregon, we used 90 unique museum and other site records (Borisenko & Hayes 1999). We used an Albers map projection (datum NAD27) for site mapping as well as for data processing of dam-related variables (see below) to achieve the highest accuracy possible given the geographic scope of the data (ESRI 1992).

To determine current presence or absence for California historic sites, we reviewed field accounts (Jennings & Hayes 1994; Jennings 1996), queried species experts, and conducted field visits. Experts had information on occurrence at 53% of sites; field accounts (late 1980’s-early1990’s) and summer visits (2000-2002) were used for the remaining 47%. We also validated the resulting designation of current presence and absence by comparing a draft map with information from surveys conducted by United States Geologic Survey (USGS) personnel in the late 1990's (G. Fellers, pers. comm.). Our map was consistent with the general pattern of presence and absence observed in the USGS data. For Oregon, current presence or absence of frogs was determined by field surveys of all sites in 1997 and 1998 (Borisenko & Hayes 1999, Borisenko 2000). Field surveys were performed during summer months and presence was defined as the presence of any life stage. The combined California/Oregon data set included 418 sites with known presence or absence throughout the range of the species. However, because global amphibian declines are widely believed to have begun in the 1970s, we used only sites where presence was first determined prior to1975. We omitted sites for which the first visit was after 1975 (n = 24) from further analyses, resulting in a final sample size of 394 historical sites. For California, the resulting historic information ranged over the time period 1850-1975 with an average date of 1948. For Oregon, historic site dates ranged from 1911-1975 with an average of 1945. Thus, these historic and current presence/absence data cover an average time span of 54 yr for California, and 53 yr for Oregon.

We determined the presence, proximity, and size of dams within watersheds associated with each *R. boylii* historic site from existing spatial data sources. For California, we used a University of California Berkeley Digital Library Project (BDL 2000) database, based on a California Department of Water Resources document (CDWR 1993). This database included location and characteristics (height, reservoir area, etc.) of 1391 dams. We used the latitude/longitude values in the BDL dams database to create a GIS data layer. We verified the BDL data set by comparing it with a GIS data layer of dams from the Bureau of Reclamation (BOR). This data layer contained locations for 1379 dams but lacked details on characteristics of dams. Any BOR dams not found in the BDL data set (n = 19) were added to the BDL data set. This resulted in a total of 1410 dams for California. To delineate the specific watershed boundary upstream of each *R. boylii* site, we used a statewide DEM at 0.36 ha resolution (60 m cells) (U.S. Forest Service 2003). Because even small errors during mapping could result in some records being outside of stream courses, we relocated each point site for *R. boylii* to the lowest elevation point within 300 m. This approach helped to avoid delineating very small, hydrologically meaningless watersheds. After establishing a new site point on the basis of the previously mentioned DEM, we used ARC macro language scripts to delineate watersheds and identify all dams upstream of historic sites, then calculated the distance between each dam and the downstream frog site (C. Davidson, personal communication; ArcGIS 8.3 (ESRI 2002). We derived several variables on the basis of the characteristics of dams available in the BDL database. We categorized dams according to criteria of the International Commission on Large Dams (ICOLD 1997), with large dams defined as being higher than 15 m, higher than 10 m and with more than 500 m crest length, or more than 1 million m^3 storage capacity. Very large dams are higher than 30 m. We also developed two variables that represented the potential influence of dams at the watershed scale. One was simply a count of dams upstream of each *R. boylii* site and the second was a ratio of total reservoir area to watershed area. Importantly, none of these variables convey information on flow regimes resulting from different types of dam operation (e.g. water storage vs. hydroelectric). Such data are likely to be more ecologically relevant than the above metrics, but are rarely available and difficult to synthesize (Poff & Hart 2002). For Oregon, data were limited to dam presence or absence upstream of *R. boylii* sites (Borisenko & Hayes 1999, Borisenko 2000, *pers. comm.* with Borisenko & Hayes). Thus, the range-wide analysis in Oregon and California includes only one predictor variable, the presence of at least one dam in the watershed upstream of each site.

Statistical tests included chi-square contingency analysis to assess presence of dams relative to *R. boylii* occurrence, two sample t-tests (unequal variances) comparing mean values of dam characteristics at present and absent sites, and Pearson product-moment correlations (*r*) between frog occurrence and dam factors. In order to identify ecological trends and reduce the likelihood of Type II errors given the variability that exists across the landscape in a species range-wide analysis such as this, we chose an alpha level of 0.10. Data on dams were also used in a broader analysis of multiple stressors of *R. boylii*; for details and results of that analysis, see Lind (2005). We used SAS/STAT software, Version 8 of the SAS System for Windows (SAS Institute 1999) for the range-wide analysis.

Northern California Abundance Assessment

To assess extant populations of *R. boylii* we compiled breeding census data collected by ourselves, academic researchers, utility companies, and government agencies. We culled information from the published literature, student theses and dissertations, unpublished reports from recent hydropower relicensing proceedings, and unpublished data shared by species experts throughout California. For ranid frogs that oviposit a discrete clump of eggs (clutch, hereafter) per year, clutch counts are commonly used as an index of population size (Crouch & Patton 2000; Loman & Andersson 2007; Petranka et al. 2007). Clutches of *R. boylii* are readily visible on rocks where they are attached, even after stranding and desiccation (Fig. S1.1). Clutch counts closely correspond to the number of adult females derived from mark-recapture estimates for *R. boylii* (Van Wagner 1996). Clutch data for 27 populations of *R. boylii* (Table S1.1) met our criteria which included multiple visits each breeding season by experienced and competent surveyors. Searches encompassed at least several riffle-pool sequences or entire reaches of river, defined by a dam upstream and a reservoir downstream, and were not isolated spot checks of breeding sites. Multiple visits ensure high detectability because any previously overlooked clutches are found upon return. For censuses we conducted ourselves, such instances of missed clutches were rare. For external data sets, we communicated directly with personnel involved in conducting the censuses to investigate if there were any detectability issues. Data were not included in our evaluation if survey methods were dissimilar, or if breeding was confirmed by presence of tadpoles but not quantifiable because clutches were not found. We calculated mean abundance over time for sites with multiple year data sets.

We compared the natural log of mean breeding density (clutches$\cdot$km^{-1}) of coastal and montane populations (geographic location) in regulated and unregulated rivers (hydrologic status) with a general linear model, and report the coefficients (effect sizes) and statistical significance of both main effects (geographic location, hydrologic status) and their interaction. The 27 data sets are not a random sample of extant populations as all data available that met our minimum criteria were used, and represent the diversity of stream and river types currently occupied by *R. boylii*.

Census Methods and Time Series Analysis of Clutch Density in Three Focal Watersheds

We took precautions to ensure that censuses were consistently thorough across years. Duration of the breeding period can vary among years and sites from a few weeks to a few months. At the beginning of each season our surveys began when male frogs were present and calling but no clutches had been laid. At the end of the season our surveys continued until no new clutches were observed. Thus, there is year-to-year and site-to-site variation in the number of search hours necessary to accomplish a complete census. Censuses began in March (Ohlone Reach of Alameda Ck) or April (Poe Reach north fork Feather and south fork Eel) when water temperatures exceeded 10°C. Once clutches were found on the Poe Reach, searches began on the Cresta Reach during the next survey round. Similarly, once clutches were found on the Ohlone Reach, Sunol Reach surveys began. Re-surveys commenced at 10-14 day intervals until no new clutches were found for two consecutive survey rounds on the Cresta Reach and one survey round on the Poe Reach, south fork Eel. Ohlone and Sunol Reaches of Alameda Ck. On the north fork Feather we used the protocol of Pacific Gas and Electric (2002) including a snorkeler with a wader. On the shallower south fork Eel and Alameda Ck, snorkeling was not needed. Observers used Plexiglas viewing trays and polarized sunglasses to enhance visibility. Pairs of observers moved from downstream to upstream to enhance viewing the lee sides of rocks, to feel under overhangs, and mark clutches with bamboo skewers placed in the riverbed or flagging tied around a rock. This prevented double counting and enabled us to follow clutch survival to hatching, and attribute losses to either stranding or scouring as flows fluctuated (Fig. S1.1). Background variation in survival for clutches reared *in situ* and protected from flow fluctuation is similar among the populations (Kupferberg et al. 2009). At the Feather River where breeding sites can be more than a kilometer apart, tallies of search time are limited to time spent at breeding sites with searches in between breeding sites to verify no oviposition between sites conducted independently. In the three watersheds, annual mean (SE) total person hours are: south fork Eel = 59.2 (3.9); north fork Feather Poe = 29.1 (2.2); north fork Feather Cresta = 29.8 (4.0); Alameda Ohlone = 31.7 (3.6); Alameda Sunol = 25.0 (2.9). The primary observers in each system remained the same across years.

Time series of the response variable, $\ln(0.01 + \text{clutches} \cdot \text{km}^{-1})$, were modeled with generalized least squares accounting for autocorrelation structure of 1-, 2-, and 3-yr lags and differences in variance by reach (Alameda Creek and North Fork Feather). Candidate models included all combinations of intercept, *Time* (and *Reach* for Alameda and North Fork Feather), and interactions (*Time* × *Reach*). We evaluated goodness of fit by maximum likelihood for all models (Table S1.2)

Fig. S1.1. Three year life cycle for female foothill yellow-legged frog (*Rana boylii*) with flood susceptible early life stages (eggs, embryos, and tadpoles) in dark gray box and mobile post-metamorphic stages in light box. Each pair of amplecting frogs oviposits a discrete clutch of eggs on a rock (upper left), and clutches can be stranded or scoured by flow fluctuation. A recently metamorphosed juvenile (lower right) shows a flourescent mark used in a recapture study.

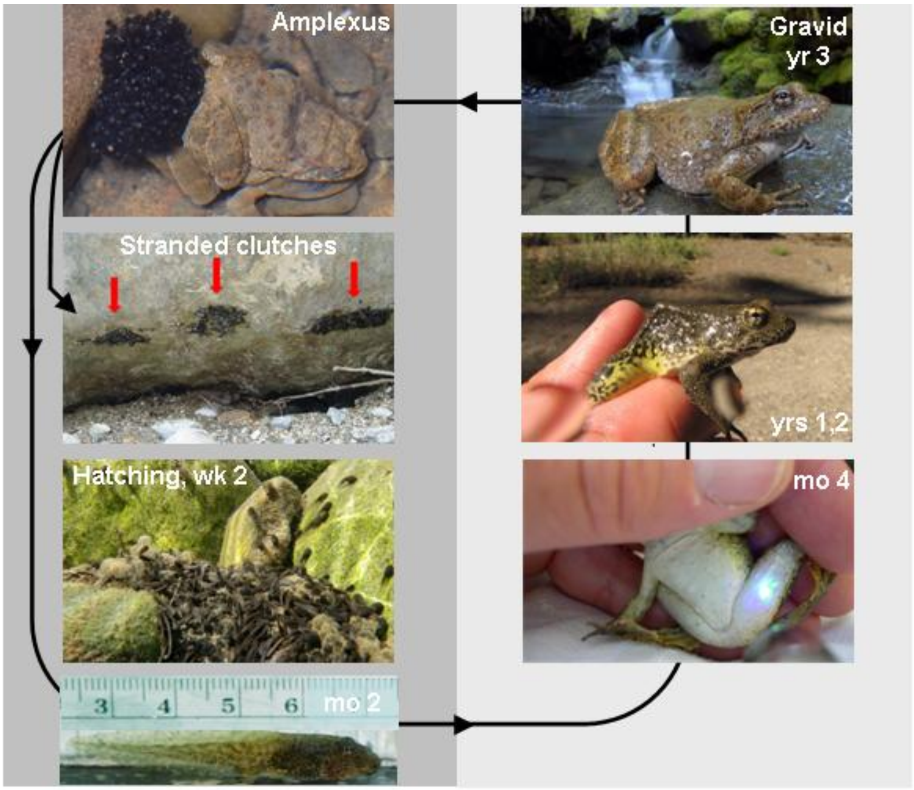

Table S1.1 Summary of clutch data from California populations of foothill yellow-legged frog (*Rana boylii*).

Watershed (Upstream Dam or Reach Name*)	#/km	SE	Length (km)	Years Sampled	Data Source
Regulated Coastal					
Trinity (Lewiston Dam)	0.45	0.17	22.5, 33.3	1991-1994, 2004-2006	Lind 2005; Ashton, Bettaso, and Welsh unpublished data
Eel (Scott Dam)	2.9	--	12.8	2010	Catenazzi, unpublished data
Alameda (Calaveras Dam)	3.7	1.6	1.9	2003-2010	Bobzein and DiDonato 2007
Regulated Sierran					
NF of NF American (Lake Valley Canal Diversion Dam)	0.5	--	4	2008	Nevada Irrigation District and PG&E, 2010
MF American (French Meadows Dam)	0.65	--	3.1	2007	Placer County Water Agency 2008
McCloud (McCloud Dam)	1.23	--	9.73	2008	PG&E 2009
SF Yuba (Spaulding Dam)	1.9	--	10	2008	Nevada Irrigation District and PG&E, 2010
NF Feather (Cresta Dam)	2.1	0.4	7.6	2002-2010	PG&E 2010
Butte Creek (Forks of Butte Diversion)	4.1	--	1.9	2006	PG&E 2007
MF Stanislaus (Sand Bar Dam)	6.2	3.6	1.0	2001-2003	PG&E 2004a
Pit (Pit 4 Dam)	8	2.7	7	2002-2005	PG&E 2004b, Ellis *pers. comm*
Butte Creek (Centerville Dam)	9.1	--	5.9	2006	PG&E 2007
Rubicon (Hell Hole Dam)	9.2	--	7.9	2007	Placer County Water Agency 2008
NF Feather (Poe Dam)	10.5	1.7	8.3	2001-2010	PG&E 2010
MF Yuba (Milton Diversion Dam)	13	--	4	2008	Nevada Irrigation District and PG&E, 2010
W Br. Feather (Hendricks Head Dam)	15.1	--	3.4	2006	PG&E 2007
Unregulated Coastal					
Coyote (US Coyote Lake)	11.2	--	7.8	2004-2005	Gonsolin 2010
Eel (Ten Mile Ck)	12.3	2. 6	4	1993-2003, 2008-2010	Kupferberg 1996, and unpub. data
Alameda (Camp Ohlone)	21.9	4.3	1.6	1997-2010	Bobzein and DiDonato 2007
Smith (Hurdygurdy Ck)	34.6	4.5	4.8, 1.7	1991-1992, 1998-2000 2002-2007	Lind 2005 Wheeler and Welsh 2008
Trinity (SF Trinity)	69.9	22.5	15.6, 5.9	1992-1994, 2004-2006	Lind 2005; Ashton, Bettaso, Welsh unpub. data
Eel (SF Eel)	105.7	6.5	5.2	1992-2010	Kupferberg 1996
Unregulated Sierran					
San Joaquin (Jose Ck)	4.6	--	1.2	1995, 2002	Lind et al. 2003
Tuolumne (NF Tuolumne)	9	--	0.3	2001	Lind et al. 2003
Yuba (Shady Ck.)	14.4	--	3.2	2003	Yarnell 2005
Stanislaus (Rose Ck.)	29	--	0.65	2001	Lind et al. 2003
Yuba (Clear Ck.)	29	9.5	0.82	1992-1994	Van Wagner 1996

* BR, branch; MF, middle fork; NF, north fork; SF, south fork. Populations are sorted from lowest to highest density within region and flow type.

Table S1.2. Best supported (ΔAICc <1, bold) and all models used in generalized least squares analyses of frog density (ln[0.01 + clutches/km]) in 3 California watersheds accounting for autocorrelation structure of 1-, 2-, and 3-yr lags (AR1, AR2, AR3) and differences in variance among reaches.

Location, species, time, model	**K**[*]	**AIC_c**	**$\Delta\mathrm{AIC}_c$**	**w**	**L**	**Model**	**K**	**AICc**	**ΔAICc**	**w**	**L**
Alameda Creek, *R. boylii* (Sunol, Ohlone reaches 2003-2010)						**Alameda Creek, *R. draytonii* (Sunol, Ohlone 2003-2010)**					
int + AR1	**4**	**62.24**	**0**	**0.36**	**-25.30**	**reach × yr + AR1**	**7**	**58.60**	**0**	**0.51**	**-15.3**
reach + AR1	**5**	**62.44**	**0.2**	**0.33**	**-23.22**	reach + AR1	5	60.66	2.07	0.18	-22.33
reach + AR2	6	63.84	1.6	0.16	-21.25	reach × yr + AR2	8	60.69	2.09	0.18	-12.06
yr + AR1	5	66.28	4.04	0.05	-25.14	int + AR1	4	62.62	4.02	0.07	-25.49
int + AR2	5	66.43	4.18	0.04	-25.21	int + AR2	5	65.22	6.62	0.02	-24.61
reach + yr + AR1	6	67.50	5.25	0.03	-23.08	reach + yr + AR1	6	65.99	7.4	0.01	-22.33
reach + AR3	7	69.88	7.64	0.01	-20.94	reach + AR2	6	66.00	7.4	0.01	-22.33
reach + yr + AR2	7	70.43	8.19	0.01	-21.21	yr + AR1	5	66.92	8.32	0.01	-25.46
int + AR3	6	71.10	9.21	0	-24.88	reach × yr + AR3	9	67.17	8.58	0.01	-9.59
yr + AR2	6	71.45	11.81	0	-25.06	int + AR3	6	70.04	11.4	0	-24.36
reach × yr + AR1	7	74.05	14.74	0	-23.03	yr + AR2	6	70.54	11.9	0	-24.61
reach × yr + AR2	8	76.98	15.41	0	-20.20	reach + AR3	7	72.65	14.0	0	-22.33
yr + AR3	7	77.54	15.30	0	-24.77	reach + yr + AR2	7	72.66	14.0	0	-22.33
reach + yr + AR3	8	78.43	16.19	0	-20.93	yr + AR3	7	76.69	18.1	0	-24.35
reach × yr + AR3	9	87.68	25.44	0	-19.84	reach + yr + AR3	8	81.22	22.6	0	-22.33
north fork Feather, *R. boylii* (Cresta, Poe reaches 2002-2010)						**south fork Eel River, *R. boylii* (1992-2010)**					
reach × yr + AR1	**7**	**27.36**	**0**	**0.34**	**-1.08**	**int + AR1**	**3**	**6.81**	**0**	**0.66**	**0.39**
reach + yr + AR1	**6**	**27.38**	**0.02**	**0.33**	**-3.87**	int + AR2	4	9.71	2.9	0.16	0.57
yr + AR1	5	28.52	1.16	0.19	-6.76	yr + AR1	4	10.05	3.23	0.13	0.41
reach × yr + AR2	8	30.6	3.23	0.07	0.7	year + AR2	5	13.45	6.64	0.02	0.58
reach + yr + AR2	7	32.47	5.1	0.03	-3.63	int + AR3	5	13.46	6.65	0.02	0.58
yr + AR2	6	33.09	5.73	0.02	-6.73	yr + AR3	6	17.83	11.0	0	0.58
reach × yr + AR3	9	33.52	6.16	0.02	3.49						
int + AR1	4	35.27	7.9	0.01	-12.09						
reach + AR1	5	37.33	9.97	0	-11.17						
int + AR2	5	38.26	10.9	0	-11.63						
yr + AR3	7	38.53	11.17	0	-6.67						
reach + yr + AR3	8	38.62	11.25	0	-3.31						
reach + AR2	6	40.71	13.34	0	-10.54						
int + AR3	6	42.78	15.42	0	-11.57						
reach + AR3	7	46.15	18.78	0	-10.47						

[*] K, number of fixed parameters: AIC_c, raw score of Akaike's Information Criteria for small sample sizes; $\Delta\ \mathrm{AIC}_c$, ratio of AIC_c relative to smallest AIC_c; w, weight of support for that model; L, negative log likelihood.

Table S1.3. Analysis of variance of foothill yellow-legged frog (*Rana boylii*) density, ln(clutches/km) within the Poe (control) and Cresta (effect) reaches of the north fork Feather River before and after (with a 3-year lag[a] after institution of white-water boating flows during the summer; multiple $r^2 = 0.36$).

Factor	**Mean Square**	**df**	***F* ratio denominator**[b]	***F***	***p***
Before vs. after white-water boating, B	0.47	1	T(B)	1.6	0.26
Control vs. impact, C	6.84	1	T(B)	32.5	0.005
B × C	2.38	1	T(B) × C	15.4	0.03
Time nested within B , T(B)	0.29	5	residual	0.01	1.0
T(B) × C	0.26	5	residual	0.01	1.0
Residual	24.2	1			

[a] The lag represents the time between flows that would affect tadpoles and the time when those cohorts would reach sexual maturity, lay clutches of eggs, and thus be counted in breeding censuses.

[b] Calculated from expected values of mean squares as in Underwood (1994, Table 1). B, before vs. after white-water boating; C, control vs. impact; T(B), time as a nested factor with the before or after periods.

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Appendix S2. We compiled discharge data from five USGS gaging stations (United States Geological Survey 2007) and a sensor established by M. E. Power and W. E. Dietrich at a decommissioned station at the South Fork Eel River.

Table S2.1 Characteristics of the focal rivers' hydrology, morphology, and vegetation.

Location	USGS gage	Dam	Area[a] (km^2) Elevation (m)	Mean (SD) Annual Discharge[b] ($m^3 sec^{-1}$)	Channel Morphology	Upland Vegetation	Riparian Vegetation	Latitude Longitude
North Fork Feather River	11404330	Cresta	4976 488-424	22.5 (25.6)	Riffle-pool	Mixed Conifers, Chaparral	Willow, Alder, sedge	39.801756° N, 121.446544°W
	11404500	Poe	5078 424-287	25.9 (27.4)	Riffle-pool			
South Fork Eel River	11475500[c]	none	114 427-365	4.88 (1.7)	Riffle-pool	Douglas Fir	Alder, sedge	39.733000°N 123.646512°W
Alameda Creek	11172945	none	88 380-365	0.77 (0.42)	Riffle-run	Oak, Grassland	Sycamore, Mulefat, Alder, sedge	37.488322°N121.744703°W
	11173510[d] 11173575	Calaveras	273 134-122	1.17 (1.07)	Riffle-run			

[a] Area upstream of the gaging station (USGS 2007). United States Geological Survey. 2007. Water Resources of California. Available from http://ca.water.usgs.gov/archive/waterdata (Accessed April 2011).

[b] Calculated from the following years of record: north fork Feather Poe, 1980–2006, Cresta, 1986-2006; south fork Eel, 1946-1970 and 1991–2006, synthetic record derived from Leggett data; Alameda, above diversion 1995–2006, below confluence with Calaveras 1999-2006.

[c] Branscomb gage USGS 1946-1970, re-established by W. Dietrich and M. E. Power 4/1990. Available from http://angelo.berkeley.edu/sensors/met/index.php (Accessed April 2011).

[d] Alameda Ck, high flow discharges from gage near Welch Ck., approximately 5 km downstream of survey reach, gage below Calaveras confluence is a low-flow gaging station.

Appendix S3. Early life stage survival and lag to population response.

At the unregulated south fork Eel River, we examined lags between hydrologic impacts to early life stage cohorts and response in inferred breeding female abundance (clutches·km^{-1}). We categorized years as ‘no pulse’ when flow slowly declined creating benign conditions for embryos and tadpoles, and ‘pulse’ when maximum flow occurred post-breeding, creating scour conditions (Table S3.1). We used one-tailed *t*-tests to compare annual change in clutch counts ($\lambda = N_{t+1}/N_t$) after ‘pulse’ and ‘no-pulse’ springs at lags of one, two, and three years. We found support for a three year lag between scouring conditions and decreases in clutch counts (Fig. S3.1). The correlation between total post-spawning rainfall and λ three years later was similarly significant ($r = -0.52$, $n = 16$, $p < 0.05$).

The hydrograph and clutch scouring history from one particular year, 2005, (Fig. S3.2) illustrates the utility of the simplifying metric we used to relate hydrologic variability to survival across the five different study populations of *R. boylii*. Four storms occurred in 2005 at the south fork Eel River. The second pulse had the largest magnitude and scoured the largest total number of clutches. All clutches that survived the first pulse, and a portion of the cohort laid between the two storms, were scoured. We did not find embryos and tadpoles along the margins of the channel during subsequent surveys. When comparing the effects of the pulses, we observed that a smaller magnitude pulse can cause similar loss if it comes late in the breeding season. Of the clutches deposited prior to the first flow pulse (an increase from 2 to 18 m^3/sec), 59% survived intact. For the 119 clutches exposed to the third pulse, the magnitude was less than half (from 2.5 to 8.7 m^3/sec), yet survival was only slightly higher, 65%. This is likely due to the pattern that as clutches age, the clutches lose cohesion and adhesion to the rocks. Although the metric we developed (maximum: minimum daily discharge post-spawning) did not fully capture such complexities, it was effective for simplifying the overall association between extreme flow fluctuation and poor clutch survival.

Table S3.1. Hydrologic events relevant to foothill yellow-legged frog (*Rana boylii*) breeding at the South Fork Eel River.

Year	λ	Spawning		Post-spawn pulse date	Post-spawn peak discharge (m^3/sec)	Post-spawn rainfall (cm)
		date of first clutch	daily discharge (m^3/sec)			
1990		Apr 24*	6.7	May 27	82.0	37.0
1991		Apr 24*	7.78	--	--	5.8
1992		Apr 25	9.66	--	--	9.2
1993	0.63	Apr 30	4.33	June 1	67.0	28.0
1994	1.38	Apr 11	2.25	Apr 26	8.77	14.3
1995	0.87	May 3	13.02	--	--	8.8
1996	0.85	Apr 28	11.22	May 22	24.3	17.4
1997	0.83	Apr 24	5.38	--	--	8.5
1998	1.41	Apr 27	5.22	May 29	10.8	11.7
1999	0.64	Apr 22	3.48	--	--	3.1
2000	1.12	May 8	2.71	--	--	4.9
2001	1.18	Apr 19	0.66	Apr 21	.96	1.5
2002	0.84	Apr 17	1.21	--	--	7.7
2003	0.97	May 13	2.27	--	--	0.0
2004	0.93	Apr 15	2.41	Apr 21	15.2	8.4
2005	1.13	Apr 28	2.50	May 18	77.8	39.0
2006	2.11	Apr 29	4.62	--	--	4.1
2007	0.78	Apr 4	1.63	Apr 22	4.22	14.1
2008	0.97	Apr 13	1.27	Apr 22	3.36	5.5
2009	0.88	Apr 12	2.2	May 5	100	*no data*
2010	1.04	May 4	7.4	June 5	12.8	*no data*
Mean(SE)	1.04(0.01)	Apr24(0.3d)	4.6 (0.1)	19.1 (0.6)	29.4 (1.6)	12.0 (0.3)

*Spawning initiation date estimated as mean of other years.

Figure S3.1. Annual change in clutch counts of foothill yellow-legged frog (*R. boylii*) in the south fork Eel river following years with or without post-breeding flow pulses. The difference was significant with a three year lag (t = 2.58, df = 15, *p* = 0.018, Bonferroni corrected *p* = 0.054), but not after one or two years.

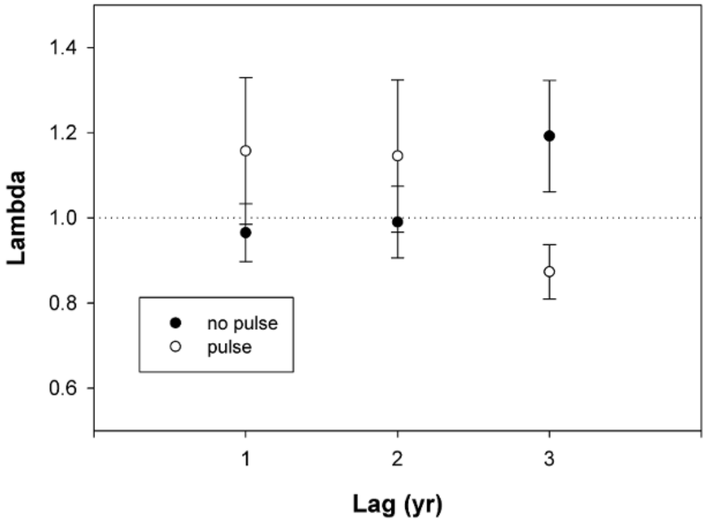

Fig. S3.2. Census timing in relation to discharge events (top) during spring 2005 at the South Fork Eel River.