Jollyville Plateau Salamander Interim Report, 2010, for the Balcones Canyonland Preserve

Nathan F. Bendik
Environmental Scientist
Watershed Protection Department

Introduction

This document is a summary of the survey results conducted under the permits Bendik 2009 (direct counts and mark-recapture). We conducted salamander surveys on the following Balcones Canyonland Preserve (BCP) tracts: Hanks, Franklin, Lanier, and Stillhouse Hollow and Barrow Preserve tracts, jointly managed with Austin Parks and Recreation Department (Figure 1). Figures 1 and 2 provide a summary of all quarterly and annual monitoring results from 2008-2010, and places the recent 08-09 drought in the context of salamander counts. Table 1 contains a summary of the capture-mark-recapture (CMR) results from December 2009 through October 2010. For additional details about the project and including background and methods, please consult the original permit proposals, QAPPs and referenced reports therein.

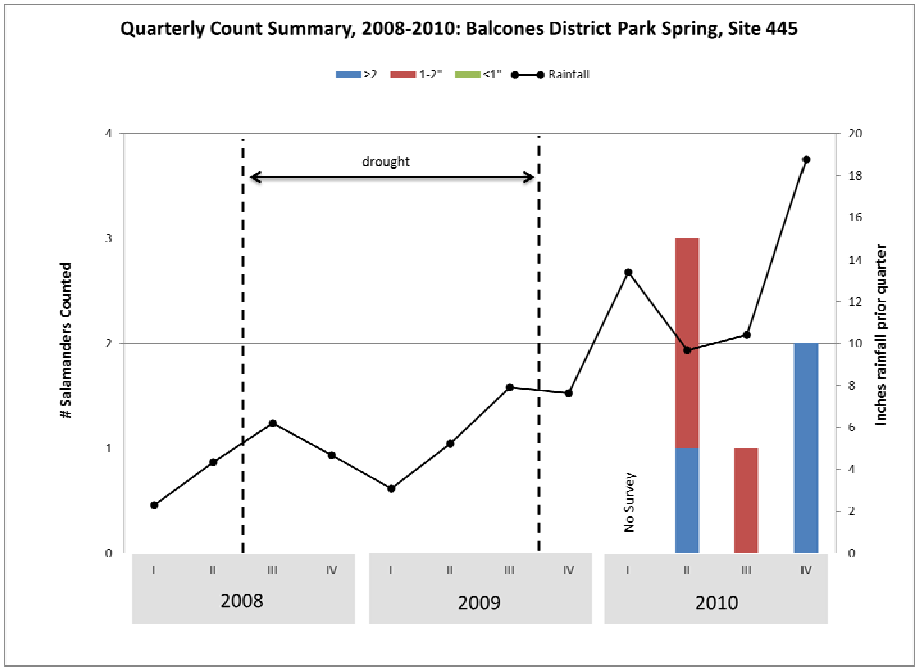
In this report, I focus on a comparison of drought and post-drought salamander counts. I also provide a summary of the model results of the CMR analysis and briefly discuss their significance.

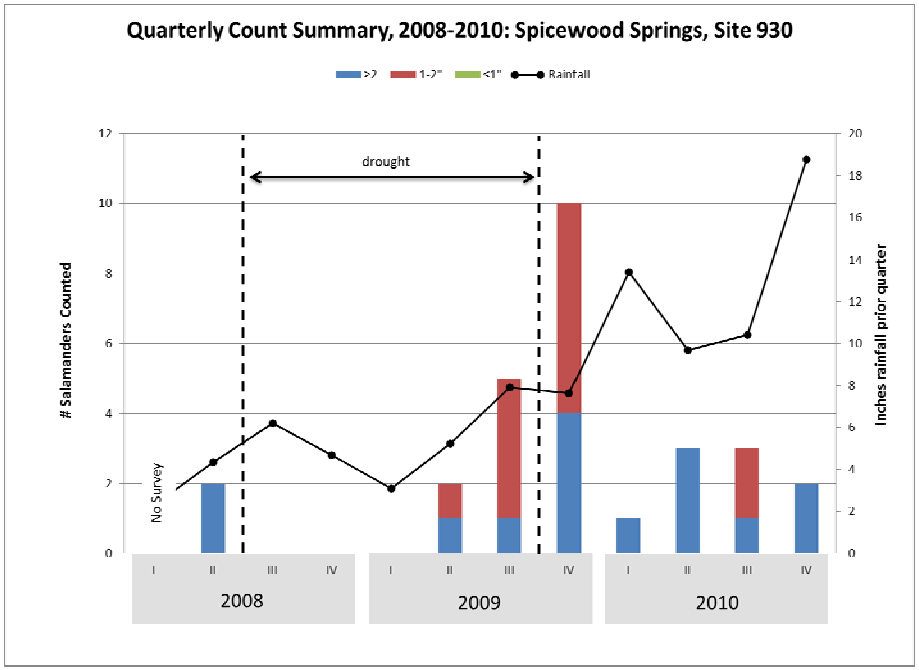
Table 1. Summary of capture-mark-recapture surveys conducted from December 2009 through October 2010.

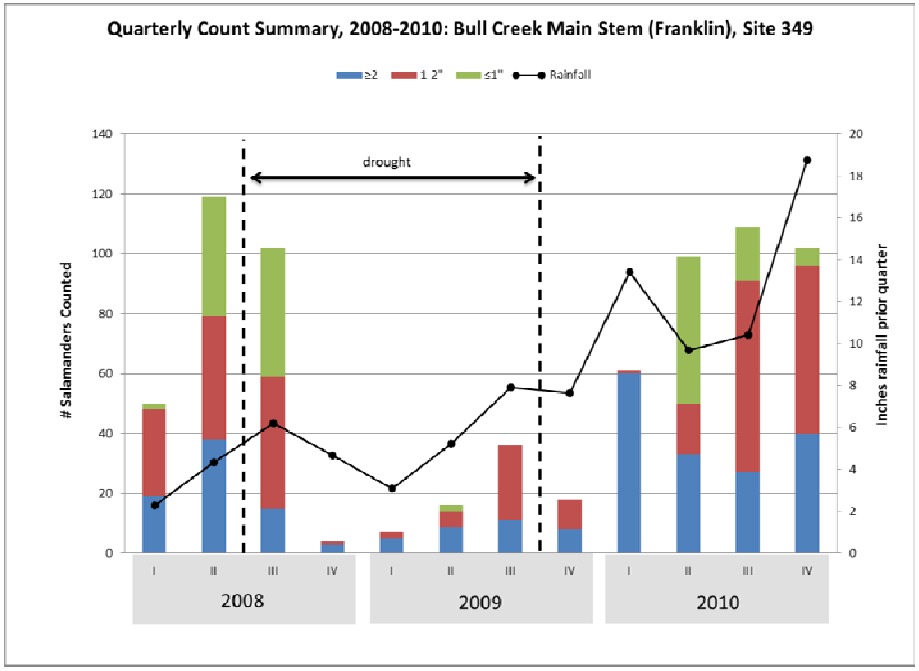
Site	Month	Total Count	Total Marked	Total Recaptured
Lanier Spring	December 2009	109	43	66
Wheless Spring	December 2009	238	105	133
Wheless Spring	March 2010	215	40	175
Lanier Spring	March 2010	169	46	123
Ribelin Spring	March 2010	176	89	87
Ribelin Spring	September 2010	43	18	25
Wheless Spring	October 2010	528	383	145
Lanier Spring	October 2010	144	82	62
	Totals	1622	806	816

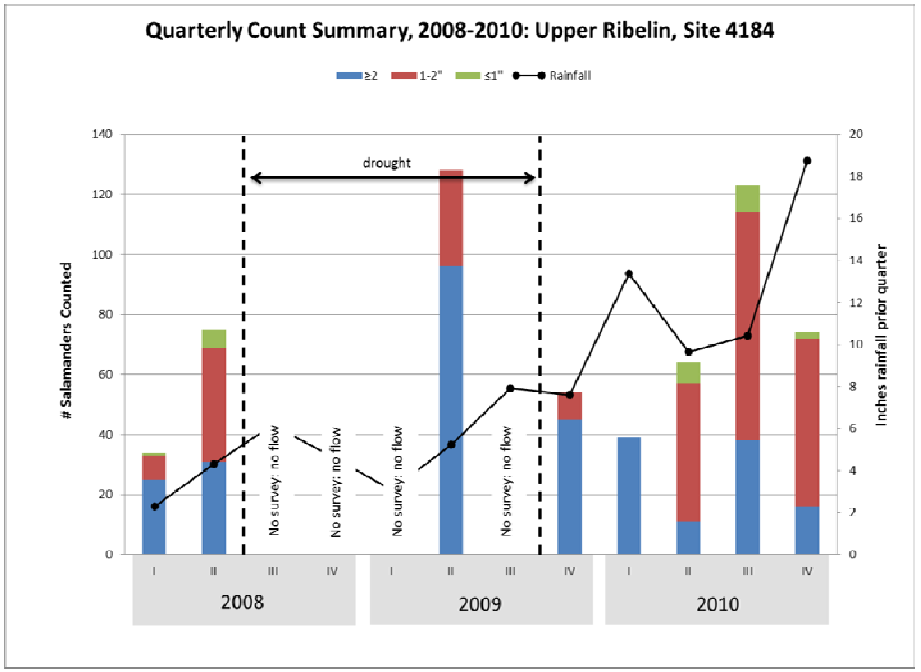
Figure 1: Quarterly Count Summary

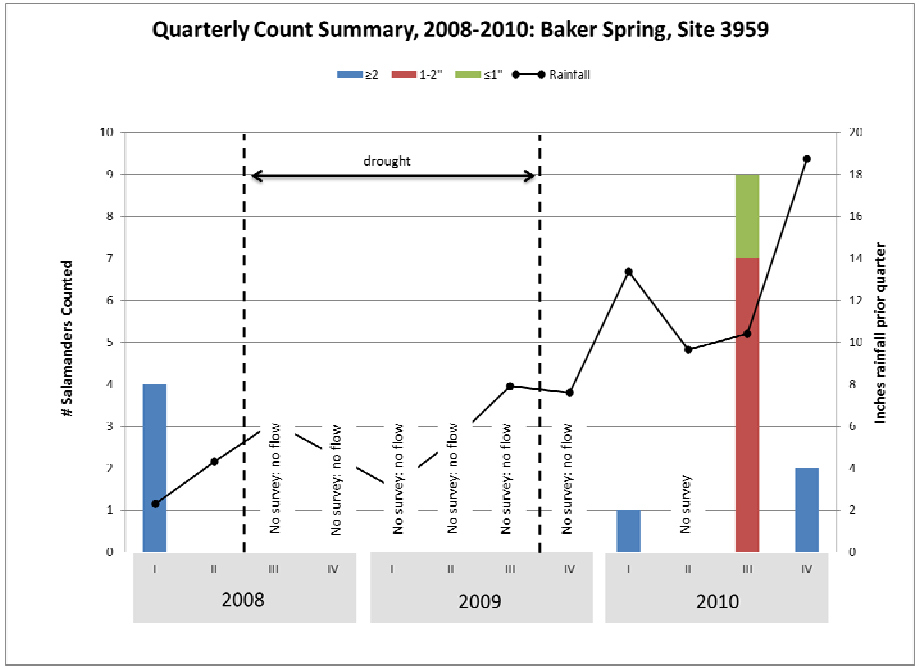
Below are the quarterly results of count surveys conducted at ten sites between 2008 and 2010. Total salamander counts are partitioned by size class: ≤1 inch, 1-2 inches, and ≥2 inches. Each graph has the same x-axis and secondary y-axis, but different primary y-axes (left side). Missing data are noted on each graph, and it is noted when surveys were skipped due to an absence of flowing water. Otherwise, blanks on the chart represent survey totals of zero salamanders. The drought of 2008-2009 is also indicated in each graph. The time period for the drought was based on discharge levels at Barton Springs (Barton Springs/Edwards Aquifer Conservation District). Rainfall is shown as lagging 3 months prior to the first day of each quarter (secondary y-axis). Each quarter is three months long, starting in January, for quarter I. Most surveys were conducted during the beginning of each quarter, so that consecutive surveys at the same site would more or less have the same time interval (3 months) between them.

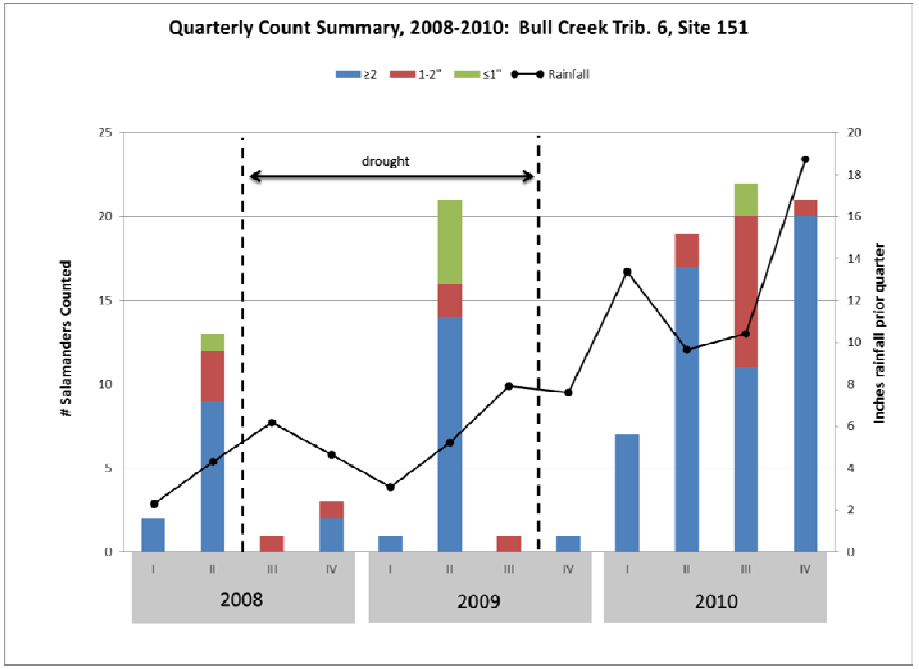


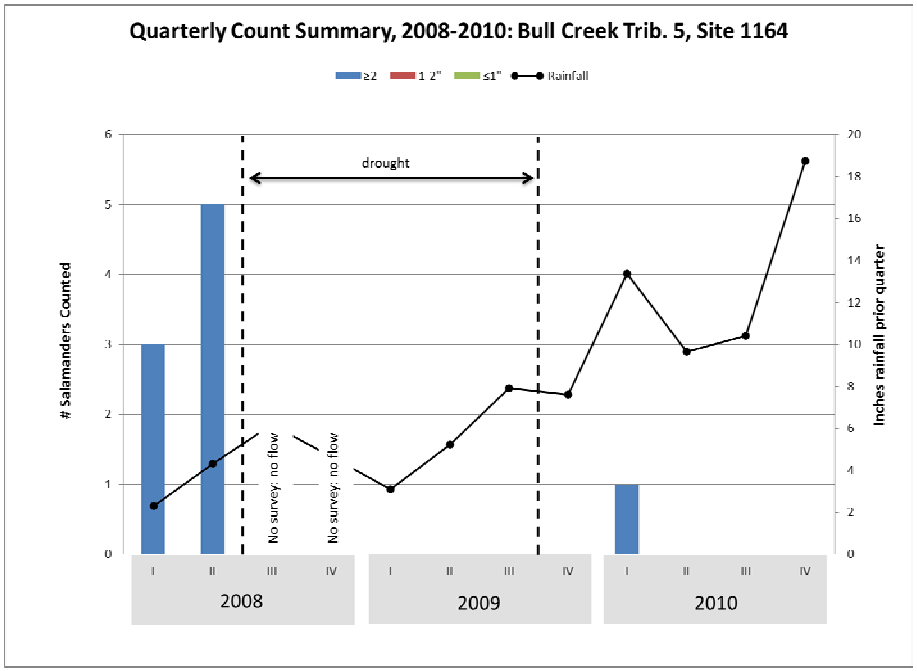


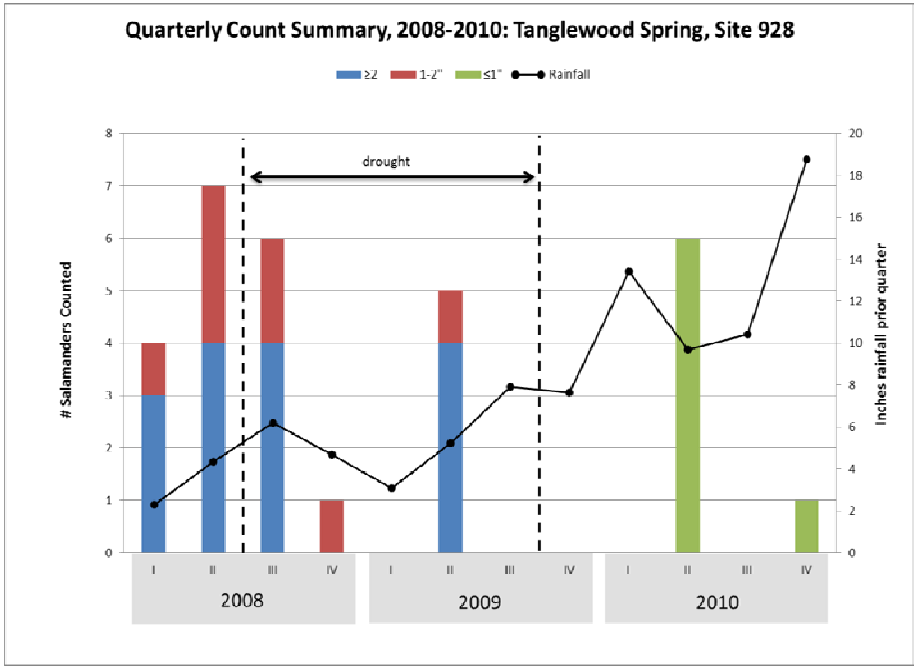

Quarterly Count Summary, 2008-2010: Bull Creek Main Stem (Franklin), Site 349
≥2
1-2"
≤1"
Rainfall
drought
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010

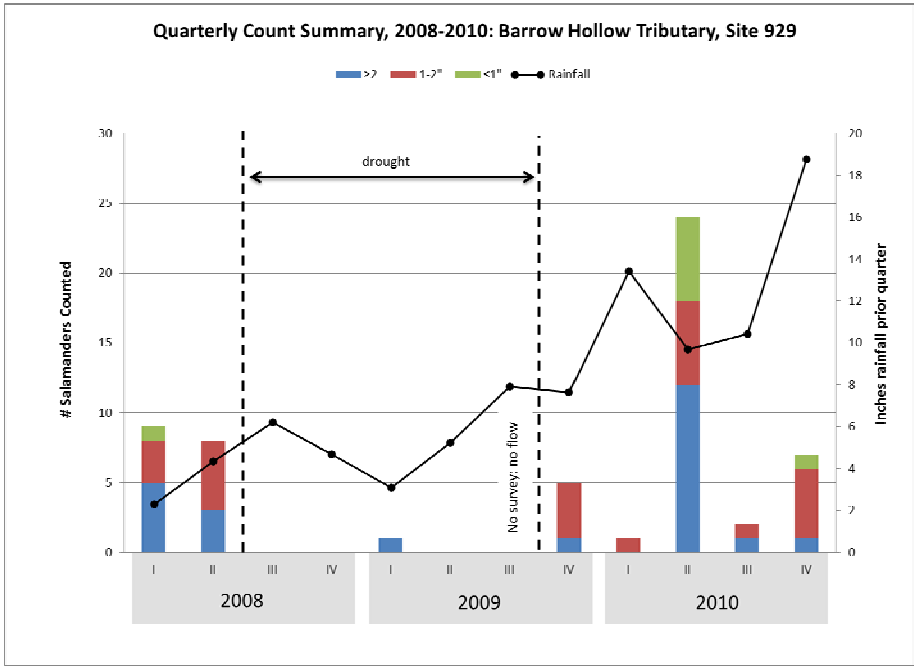

Quarterly Count Summary, 2008-2010: Upper Ribelin, Site 4184
≥2
1-2"
≤1"
Rainfall
drought
No survey: no flow
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010


Quarterly Count Summary, 2008-2010: Baker Spring, Site 3959
≥2
1-2"
≤1"
Rainfall
drought
No survey: no flow
No survey
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010


Quarterly Count Summary, 2008-2010: Bull Creek Trib. 6, Site 151
≥2
1-2"
≤1"
Rainfall
drought
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010


Quarterly Count Summary, 2008-2010: Bull Creek Trib. 5, Site 1164
≥2
1-2"
≤1"
Rainfall
drought
No survey: no flow
No survey: no flow
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010


Quarterly Count Summary, 2008-2010: Tanglewood Spring, Site 928
≥2
1-2"
≤1"
Rainfall
drought
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010


Quarterly Count Summary, 2008-2010: Barrow Hollow Tributary, Site 929
>2
1-2"
<1"
Rainfall
drought
No survey: no flow
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010

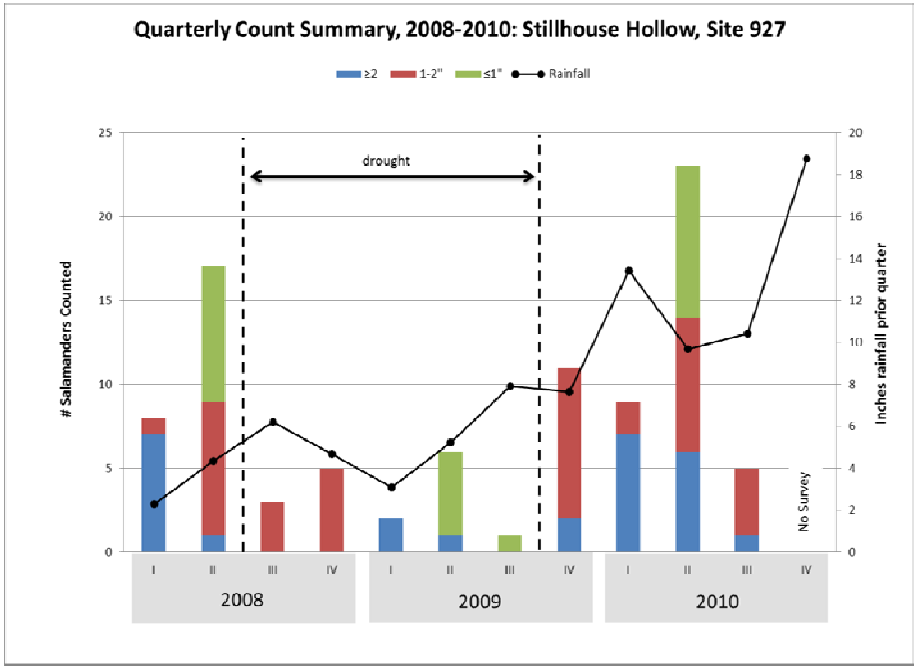
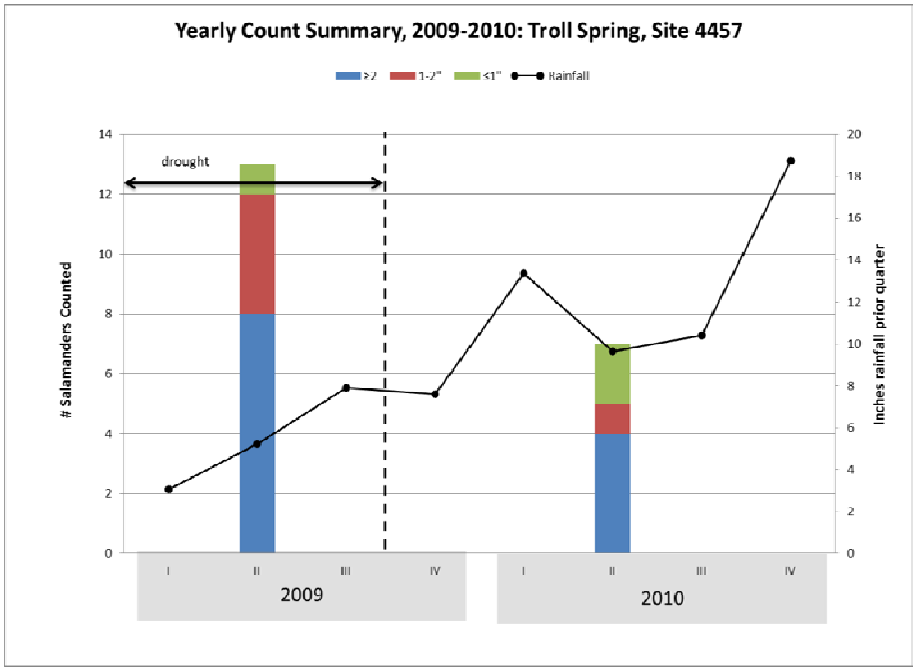
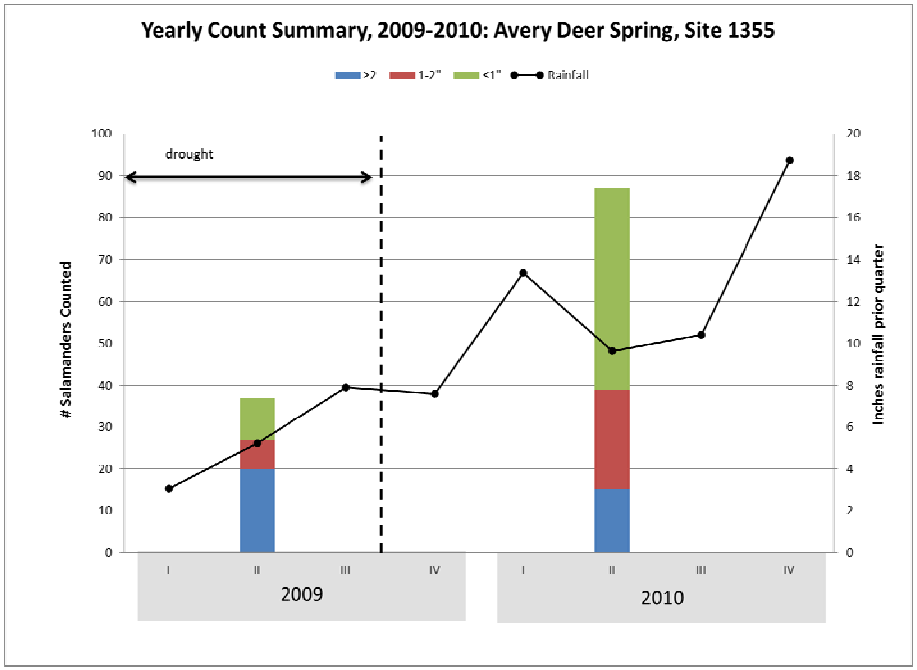
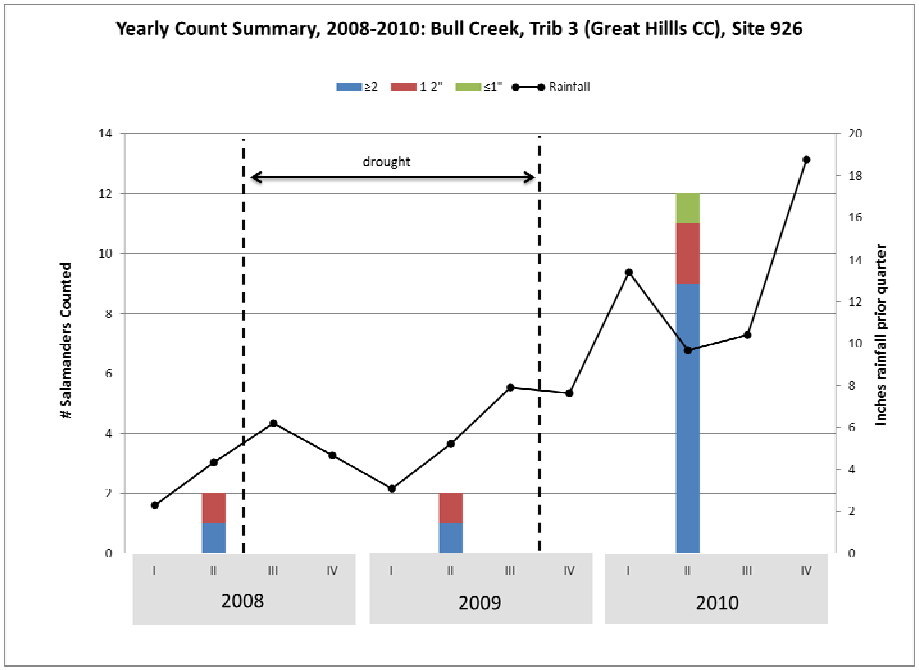

Quarterly Count Summary, 2008-2010: Stillhouse Hollow, Site 927
≥2
1-2"
≤1"
Rainfall
drought
No Survey
Salamanders Counted
Inches rainfall prior quarter
2008
2009
2010

Figure 2: Yearly Count Summary

Below are the yearly results of count surveys conducted at three sites between 2008 and 2010. These sites are surveyed only once per year, during quarter II. Surveys were initiated for sites 4457 and 1355 in 2009. Graph notation is the same as above.







Methods

To compare recruitment rate and total salamander count during and post-drought, I summed results from quarterly monitoring sites 151, 349, 445, 926, 927, 928, 929, 930, 1164, 4184, and yearly monitoring sites 1355 and 4457 across 5 survey-quarters each of drought (QIII 2008- QIII 2009) and post-drought (QIV 2009- QIV 2010) conditions. Drought and post-drought counts were tested for a significant difference using a non-parametric Wilcoxon signed rank test (SAS `proc univariate` on group differences), because differences were not normally distributed (Shapiro-Wilk, $P<0.001$ for both total count and juvenile comparisons).

CMR data were analyzed with the program MARK version 6.0 (White & Burnham 1999) for all available data through 2009. Although estimates of detection probability can be obtained with closed population models, it is confounded by temporary emigration and can bias estimates of population size (Kendall et al. 1997). I therefore used the robust design, which allows for accounting of temporary emigration parameters (γ" and γ'), to examine a suite of models in order to test hypotheses about variation in detection probability and the movement of salamanders in and out of the study area. Sixty possible models tested for each dataset.

Results and Discussion

The 2008-2010 data set also show pronounced effects of the 2008-2009 drought on salamander counts. Total counts by site for the 5 months during the drought were significantly lower than the following 5 month period (signed rank S=33.5, P=0.005). Recruitment was also significantly greater during post-drought conditions (signed rank S=31.5, P=0.003). Although counts were higher on average for 2010 (post-drought), zero salamanders were observed on at least one occasion at two sites (Trib. 5 and Tanglewood). These results are consistent with a pattern of very low salamander density at these sites (Figure 1). In contrast, salamanders were observed at Balcones District Park Spring (BDPS) for the first time since 2005 (Figure 1). Although there was only a total of 6 salamanders observed from 3 surveys conducted in 2010, BDPS has a very small amount of surface habitat (<9 sq. m). Counts continue to be high at Franklin and Upper Ribelin (Figure 1).

The effect of the recent drought on JPS population dynamics sheds some light on the interaction with and importance of groundwater refugia. Overall population response following the drought was positive, indicated by significantly higher total salamander counts and juvenile recruitment post-drought. Reproduction can occur relatively rapidly following the resumption of spring flow. In one case, over 20 juveniles (0.5-1 inch) were observed only a few months following completely dry surface conditions (Lanier Spring, December 2009). Estimates of incubation period for the Barton Springs Salamander, a closely related species, is 3-4 weeks (captive breeding report), indicating that these eggs could have been laid just after or even before spring flow resumed at Lanier Spring. These results and field observations suggest a resiliency of JPS to natural drought conditions, and at least in some cases, that they are able to allocate energy towards reproduction (e.g. egg development) before surface flow resumes.

The best CMR models for each site (Table 2) included full time-varying detection probability, $p(t,t)$, constant survival (due to convergence issues with time-varying survival models) and either Markovian movement (for Lanier and Wheless) or no movement (Ribelin). Mean estimates of detection probability were relatively close in range (Table 3), although their individual estimates varied greatly between sites and within primary periods. This suggests that detection probability is quite variable and should probably not be derived at one site to be used in another, such as in a double-sampling design (Pollock et al. 2002). At Lanier and Wheless, temporary emigration was quite high (Table 4), indicating that a large proportion of the population is typically unavailable for capture at the surface. Monthly survival estimates at both sites between the longest dry periods were surprisingly high (~10 months at Lanier, 0.97±0.01; ~18 months at Wheless, φ=0.92±0.01), perhaps representing a resiliency of JPS to dry surface conditions. Survival between shorter "dry" intervals at Lanier indicated a declining trend (Figure 3).

Table 2. The best models chosen for each dataset and their corresponding QAICc values and weights, excluding models with partial convergence failures. Lanier and Wheless both had a single highly supported model, while Ribelin had many competing models. The top three models are listed for Ribelin, all others had a corresponding QAICc weight of 0.03 or less.

Dataset	Model	QAICc	QAICc Weight
Lanier	φ (*flow*) $p(t,t) = c(t,t)$ Markov(.)	-2893	1.00
Wheless	$\varphi(.)$ $p(t,t) = c(t,t)$ Markov(.)	-3684	1.00
Ribelin	$\varphi(.)$ $p(t,t) = c(t,t)$ no mov	-880	0.51
Ribelin	$\varphi(.)$ $p(t,t) = c(t,t)$ random(.)	-879	0.23
Ribelin	$\varphi(t)$ $p(t,t) = c(t,t)$ no mov	-877	0.10

Table 3. Summary of conditional capture probabilities, $\hat{p}(t,t)$, from best models at each site. Mean and standard error (SE) were calculated using the variance components method in mark (White et al. 2001).

Site	n	Range	Mean	SE
Lanier	36	0.096-0.431	0.240	0.082
Wheless	27	0.081-0.289	0.174	0.058
Ribelin	18	0.030-0.420	0.204	0.069

Table 4. Estimates of temporary emigration for each site. *the no mov model was the best model.

Site	$\hat{\gamma}'$	$\hat{\gamma}''$
Lanier	0.94	0.42
Wheless	0.97	0.43
Ribelin*	0.00	0.00

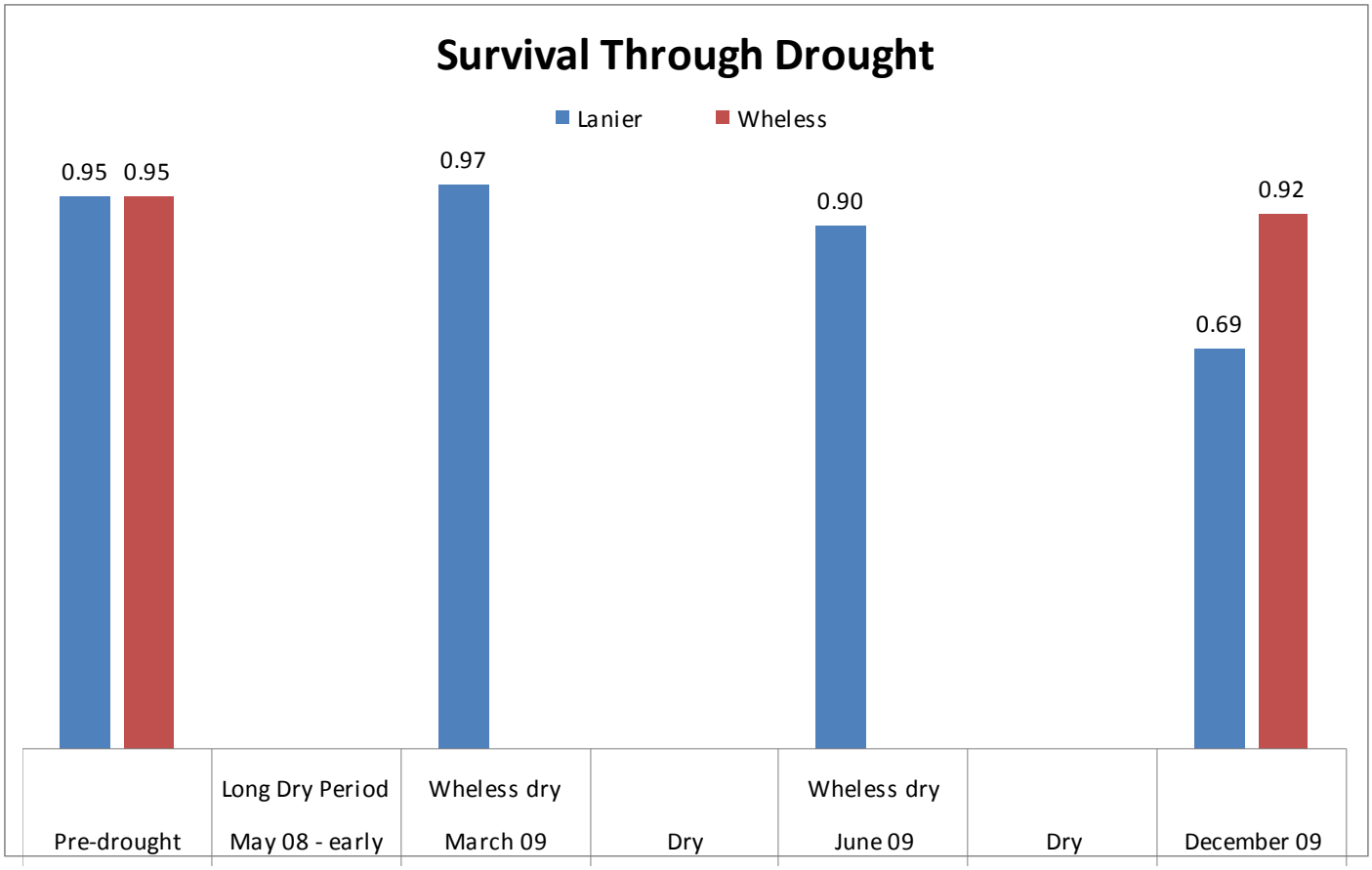


Figure 3. Estimates of survival at Lanier and Wheless between periods where spring flow had ceased during the drought. The best models of Lanier and Wheless (both constant survival, $\varphi(.)$) were modified to allow survival to vary between periods where surface flow had cased at the springs ($\varphi(flow)$). This resulted in two survival estimates for Wheless because there was only one dry period (~18 months), and four survival estimates for Lanier, which had one long dry period between 2008 and 2009, and two shorter dry periods during 2009.

Literature Cited

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