2010 Monitoring Report

Columbia Spotted Frog

Dry Creek, Oregon

by

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2010 SURVEYORS

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PREFACE

This study was initiated in 2001 by the Vale District Bureau of Land Management and the U.S. Fish and Wildlife Service's Idaho Fish and Wildlife Office in Boise, Idaho in order to monitor long-term population trends, demographics and movement patterns for Columbia spotted frogs in Dry Creek. The Idaho Fish and Wildlife Office was responsible for the monitoring along Dry Creek until Janice Engle's departure to Sacramento, California in 2006. In 2007, the U.S. Fish and Wildlife Service's La Grande Field Office took over responsibility for the monitoring and reporting of the Dry Creek Columbia spotted frog monitoring study. This report constitutes the 2010 annual report for the long-term population monitoring study along Dry Creek and fulfills the annual reporting requirement under Intra-Governmental Order #L09PG00147.

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1. Introduction

1.1 Columbia Spotted Frogs

Spotted frogs are currently classified as two separate species, the Oregon spotted frog (*Rana pretiosa*) and the Columbia spotted frog (*Rana luteiventris*). Researchers found that while the two species are nearly identical morphologically, they differ genetically and occupy different ranges (Green *et al.* 1997). Green *et al.* 1997, indicates there is genetic evidence *R. luteiventris* may be one species with three subspecies or several weakly-differentiated species (Green *et al.* 1997). Additionally, Funk *et al*. 2008, found three highly divergent *R. luteiventris* clades, or groups consisting of a single common ancestor, that may actually represent different species.

Currently, there are four recognized populations of Columbia spotted frogs: Northern, Great Basin, Wasatch, and West Desert. Columbia spotted frogs occur from Alaska and most of British Columbia to Washington and Oregon east of the Cascade Mountains, Idaho, Montana, the Bighorn Mountains in Wyoming, the Mary's, Reese, and Owyhee River systems in Nevada, the Wasatch Mountains, and the western desert of Utah (Green *et al.* 1997, Funk *et al.* 2008). The Great Basin, Wasatch, and West Desert populations are experiencing declines, although the causes of decline are not fully understood. However, like most amphibians a major threat is believed to be the destruction, fragmentation and degradation of wetlands. The introduction of non-native predators such as bullfrogs, bass and predatory freshwater fish species are also believed to contribute to their decline.

Due to the population's current status, the Great Basin Columbia spotted frog is designated as a Federal candidate species for listing as endangered or threatened under the Endangered Species Act. The U.S. Fish and Wildlife Service (Service) has sufficient information on the biological status and threats for the Great Basin Columbia spotted frog to propose them for protection under the Endangered Species Act; however, development of a listing regulation is precluded by other higher priority listing activities (USDI 1993, USDI 2010).

Great Basin Columbia spotted frogs (spotted frogs) are highly aquatic and live in or near permanent bodies of water, including lakes, ponds, slow streams and marshes; movements of spotted frogs are generally limited to wet riparian corridors. Spotted frogs occur in riparian areas, where emergent vegetation and standing water are present, within the sage-juniper shrublands (Engle 2001). Standing water, flooded meadows, and willows provide breeding, foraging, and overwintering habitat. Most spotted frogs hibernate and aestivate; hibernation occurs in spring-fed ponds with willows (Engle 2001). Spotted frogs hibernate under water or in burrows and holes in the streambanks where the water does not freeze and there is adequate oxygen levels (Bull and Hayes 2002).

Spotted frog adults are light to dark brown, gray, or olive green with dark spots on the back, sides and legs. The number of spots and spotting pattern varies. The undersides of the legs are orange or yellow; this color may extend up to the chin or be replaced by a light, mottled gray on the chin, chest, and/or belly. Adult body length is 46 to 90 mm (Engle 2001). Spotted frogs breed during a short, two-week breeding window anywhere from early April to early June. Eggs are laid at the water surface in large, globular masses of 200 to 500 eggs (Engle 2001). Tadpoles are black after hatching and their eyes are located on the top of the head. Tadpoles are approximately 8 to 10 mm in length at hatching and commonly metemorphose at 23 to 33 mm (Engle 2001). Metamorphosis usually occurs from late July until freezing weather. The lifespan of spotted frogs can be seven to nine years (Engle 2001). Spotted frog diets can vary widely. Adults eat insects, mollusks, crustaceans, and arachnids; larvae eat algae and organic debris. Predators of spotted frog adults include herons and garter snakes, and the recently introduced bullfrogs. In addition, larvae may be consumed by the larvae of dragon flies, predacious diving beetles, fish and garter snakes.

1.2 Dry Creek

Dry Creek is a tributary to the Owyhee River and located in Malheur County in southeast Oregon. Dry Creek is characterized by steep canyons, scour pools, and meandering stream reaches with boulders, cobbles, and sandy substrate. The section of Dry Creek included in this study is an interrupted, perennial stream with a relatively wide open valley bottom and occasional narrow canyon pinches. Historically, the channel down cut several feet. The current stream channel is recovering and creating a new floodplain (Rockefeller pers. comm. 2011). Vegetation along Dry Creek consists of sedges, rushes, forbs and occasional willows and cattails. Oxbows and side pools along Dry Creek provide slack water and good habitat for breeding spotted frogs and developing tadpoles. However, periodic deep pools in Dry Creek contain large trout and may negatively affect and/or limit movement of frogs along the creek between breeding, foraging, and hibernation sites due to predation by these large fish.

Dry Creek has the largest known spotted frog population on the Vale Bureau of Land Management (BLM) District, excluding the Baker Resource Area. The spotted frog population along Dry Creek is part of the Great Basin population, while the Baker Resource Area populations are comprised of the Northern population of Columbia spotted frogs (Funk *et al.* 2008). Dry Creek was chosen for long-term population monitoring not only for its large population of Great Basin Columbia spotted frogs, but also because the population is relatively isolated with no connectivity to other watersheds (Tait pers. comm. 2007). These conditions create a unique opportunity to monitor population trend and age class survival within a population. In addition, much of the land along Dry Creek is in public ownership; therefore, there is an ability to monitor effects from management practices, and modify management if needed.

Spotted frogs in Dry Creek have been surveyed at least three times each year since 2001 (via mark-recapture surveys in June and recruitment surveys in August of each year). In 2010, the survey transect was visited a total of four times. On April 15, 2010, a spotted frog egg mass survey was conducted. Dry Creek was also visited from June 4 through June 9, 2010, to conduct the mark-recapture survey and record habitat parameters (each survey transect was visited twice) and on August 11, 2010, Dry Creek was visited to determine annual recruitment. Figure 1 shows the annual survey transect, photo point locations and water quality testing locations. Protocols followed for the 2010 surveys are described in the Methods section of this report and in Appendix I.

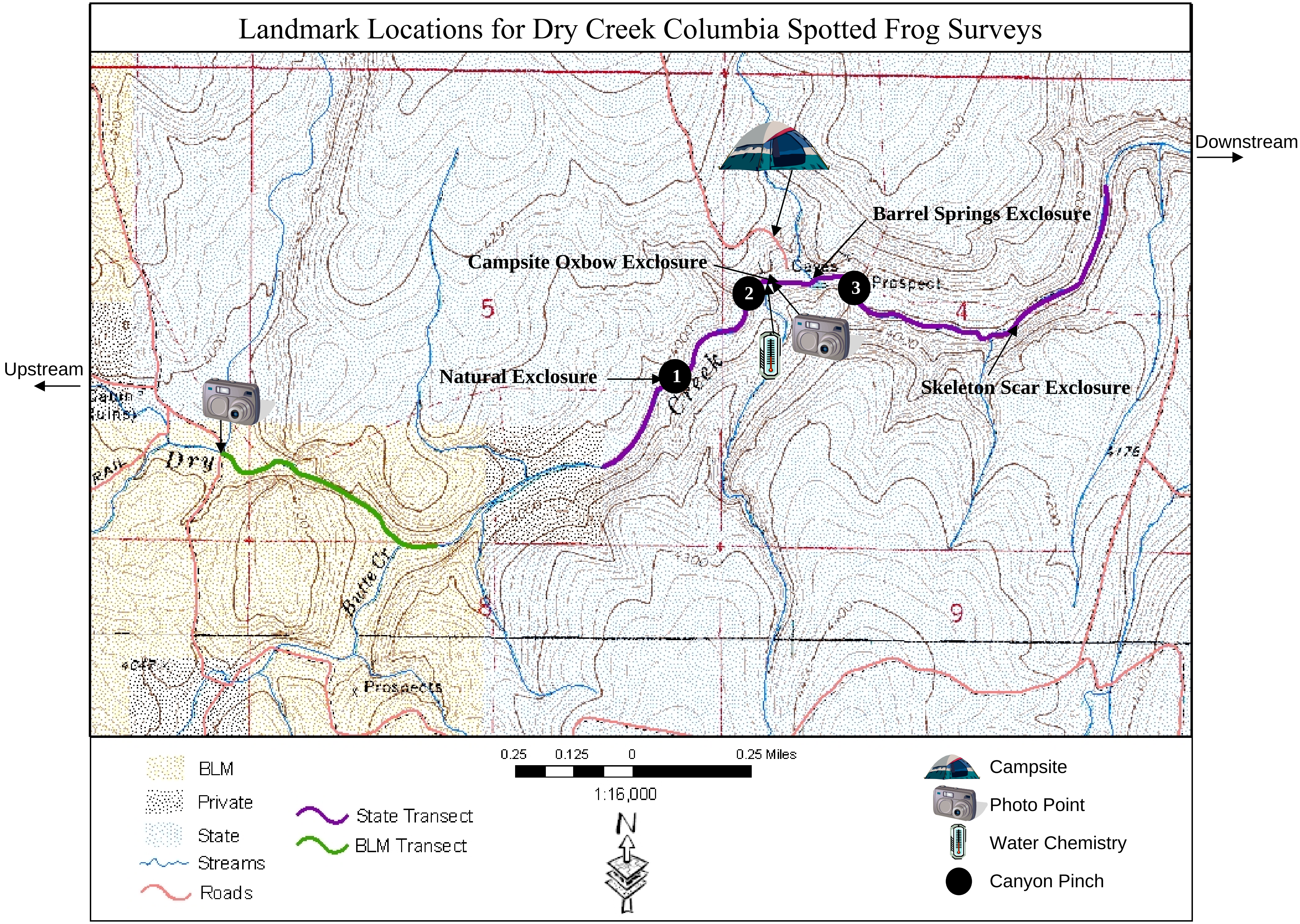

Figure 1. Landmark locations for the Columbia spotted frog survey transect along Dry Creek, Malheur County, Oregon.

2. Methods

Two population estimate methods are used in this monitoring strategy: 1) mark-recapture, and 2) visual encounter surveys. Mark-recapture methods provide accurate estimates of population size within the constraints of the following assumptions (Fellers 1997, Hayne 1949):

1. Immigration and emigration must not exist;
2. Recruitment must not occur; and
3. Each individual has the equal probability of being caught.

Visual encounter surveys provide an estimate of relative abundance as long as every individual is equally likely to be observed (regardless of weather, season, or other variables) and each frog is recorded only once so there are no observer-related effects (Fellers 1997).

These two methods are used to provide comparative numbers across years for the Dry Creek monitoring site. The goal is to accurately detect trends in numbers at the site over the long-term. Mark-recapture numbers are used to calculate the Lincoln-Peterson population estimate to estimate *occurrence size* in the spring and visual encounter numbers to assess *breeding success* in the late summer.

Surveyors visit the site three times each year: twice in the spring (early June) for a mark-recapture population estimate and habitat analysis and once in the late summer (August) for an assessment of breeding success and habitat analysis. Attempts are made to capture every frog, using dip nets, within the delineated area and within a specific time frame. Captured frogs are measured for snout-vent length (SVL), weighed, aged, and sexed. All frogs larger than 40 mm are tagged with Passive Integrated Transponder (PIT) tags. GPS locations are recorded for each frog captured along the transect route (using NAD27 datum). GPS locations are also recorded for beginning and ending points of the surveys (determined by ownership, accessibility, and occurrence boundaries from previous surveys).

Parameters measured during each survey, once in the spring and once in the late summer, include:

- Water chemistry: dissolved oxygen, temperature, pH, and conductivity; and
- Habitat/land use: streambank soil alteration rating (SSAR) and vegetation use by animals (VUBA) (Platts 1987). These ratings are further described in Appendix 1.

Data are recorded in a log book and the site is photographed from a standard point in the spring and late summer. A report is compiled annually and submitted to the BLM. The report consists of tables summarizing population numbers and maps of the area surveyed. Water chemistry and habitat/land use measures are discussed along with their relevance to population trends; raw data and field notes are included as appendices.

Additionally, egg mass surveys were conducted in April 2004, 2008 and 2010. Spotted frog egg masses are easily detected in the spring (Nussbaum *et al*. 1983, McAllister and Leonard 1997) via visual encounter surveys and have been conducted across much of Oregon and Washington to detect spotted frog egg masses with reasonable success (McAllister and Leonard 1997, Watson *et al*. 2000, McAllister and White 2001). The egg mass surveys were timed so they would be conducted during the peak egg laying period for spotted frogs along Dry Creek. Timing of the egg mass surveys were determined by tracking relative water temperatures and weather conditions in areas near Dry Creek. During the egg mass surveys, surveyors documented egg mass locations and any observations of spotted frogs. GPS locations were taken for each egg mass and/or frog observed.

3. 2010 Results

3.1 Egg Mass Survey

The 2010 egg mass survey along Dry Creek was conducted on April 15, 2010. During the 2010 survey, a total of 70 egg masses were recorded in 26 separate locations along the transect. From the condition of most of the egg masses observed, the survey was conducted within a few days of when the masses were deposited; however, a few pairs of frogs were still actively laying eggs during the survey. During this survey, a total of 215 frogs were observed (12 females, 6 males, 168 subadults, and 29 uncaptured frogs) along the transect. Figure 2 shows typical egg masses observed in April 2010. Egg masses were found along the entire transect; however, the number of egg masses were concentrated between the second pinch and the east end of the State transect. Figure 3 shows the locations of the frogs and egg masses observed in April 2010.

Figure 2. **Columbia spotted frog egg masses found in April 2010 along Dry Creek, Malheur County, Oregon.**

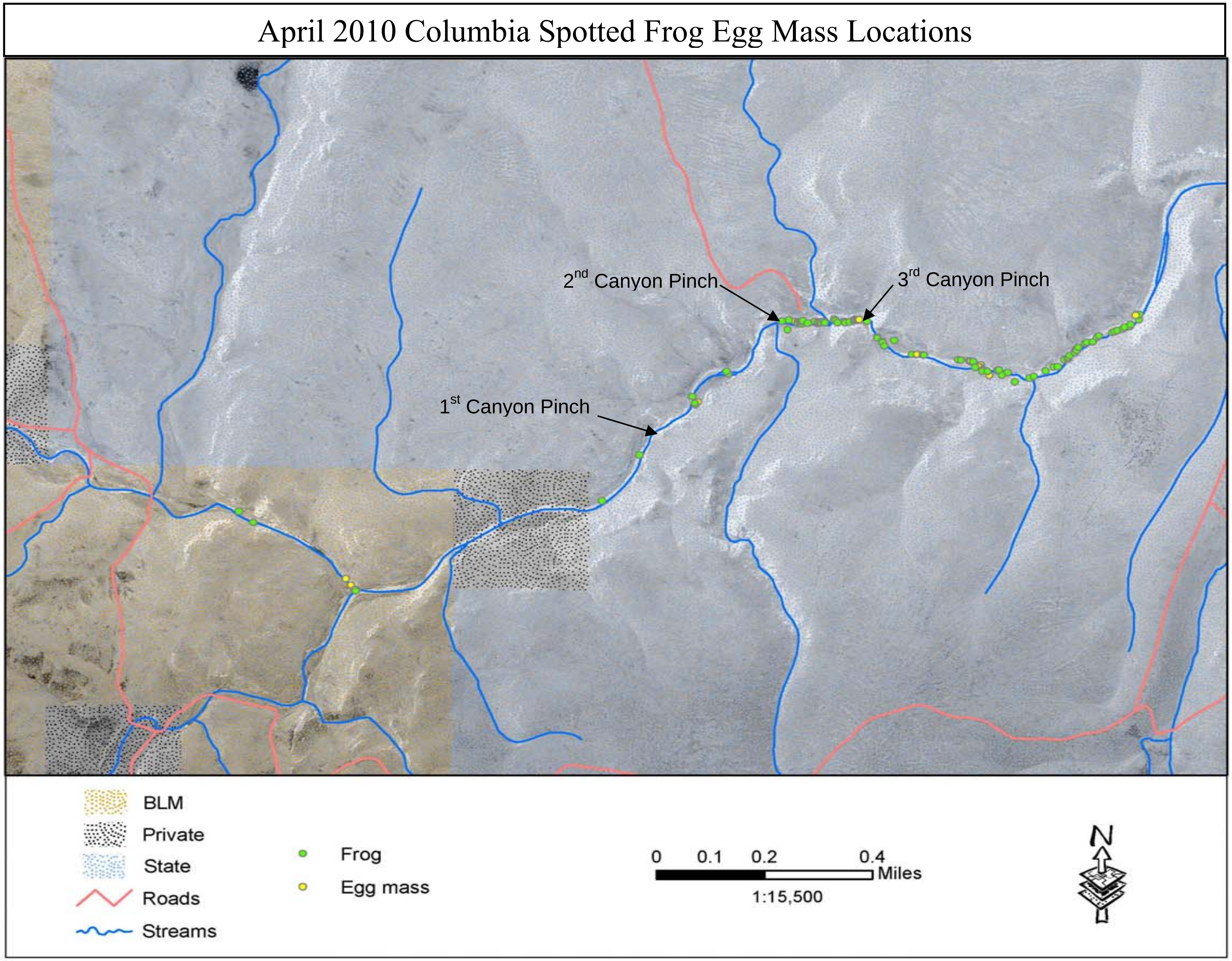

Figure 3. **Egg mass locations along the survey transect in April 2010 along Dry Creek, Malheur County, Oregon.**

3.2 Mark-recapture Survey

The spring of 2010 was a cool, wet spring with a considerable amount of rain in May and June. Additionally, the snow melt appeared to be another slow melt as there was no scouring of the streambanks evident in June. Aquatic habitat was uniform and well-connected in June. The water level and habitat present in 2010 was very similar to the habitat type and quantity present in June 2007 and June 2009. In addition, there was little livestock use evident along the transect.

The mark-recapture survey was broken into several sections in 2010, due to weather conditions and the number of anticipated frogs, in order to complete two passes of the entire transect. All passes were conducted between June 4 and June 9, 2010 and between 0900 and 1800 hours. Along the entire transect, a total of 1,428 individual frogs were recorded (111 males, 118 females, 1,187 subadults, and 12 uncaptured frogs) in June 2010. Frogs were found along the main channel and in available side pools and oxbows. Most frogs were caught after the second pinch down to the east end of the State land transect. Relatively, few frogs were recorded on BLM land (138 total frogs) and on State land down to the second pinch; however, more were observed in 2010 than in past years. Additionally, two deformities were noted in frogs during the June surveys (i.e., swollen tongue and missing toes). Figures 4, 5 and 6 show the capture locations of all frogs recorded along the mark-recapture survey route for June 2010.

3.2.1 Lincoln-Peterson Population Estimate

Population estimates are calculated for the State transect using the Lincoln-Peterson population estimate technique. This population estimate has been the most widely-used mark-recapture method for estimating population size (Nichols *et al.* 1981). The technique involves collecting a sample from the population, marking this sample, and then releasing the sample back into the population (Fellers 1997, Hayne 1949). This creates a ratio of marked to unmarked individuals in the population. After a period of time, a second collection is made and the ratio of marked to unmarked individuals is calculated. This ratio is then used to estimate the total population size (Fellers 1997, Hayne 1949). The Lincoln-Peterson technique uses the following assumptions:

- no immigration or emigration between the time of marking and the time of recapture;
- no recruitment (reproduction) between the time of marking and the time of recapture; and
- each individual has the equal probability of being caught.

Lincoln-Peterson population estimates are not calculated for the BLM transect because not enough frogs are captured on that transect to calculate a statistically valid population estimate. Additionally, frogs captured on the BLM transect cannot be combined with frogs captured on the State transect because of the intervening private land and the confluence of Butte Creek with Dry Creek. These existing conditions make it is impossible to ensure no individuals enter or leave the BLM transect during the survey period; therefore, it is impossible to ensure all assumptions of the Lincoln-Peterson method are accurate and true.

The Lincoln-Peterson population estimate is calculated as follows:

$$N = (m)(n)/r$$

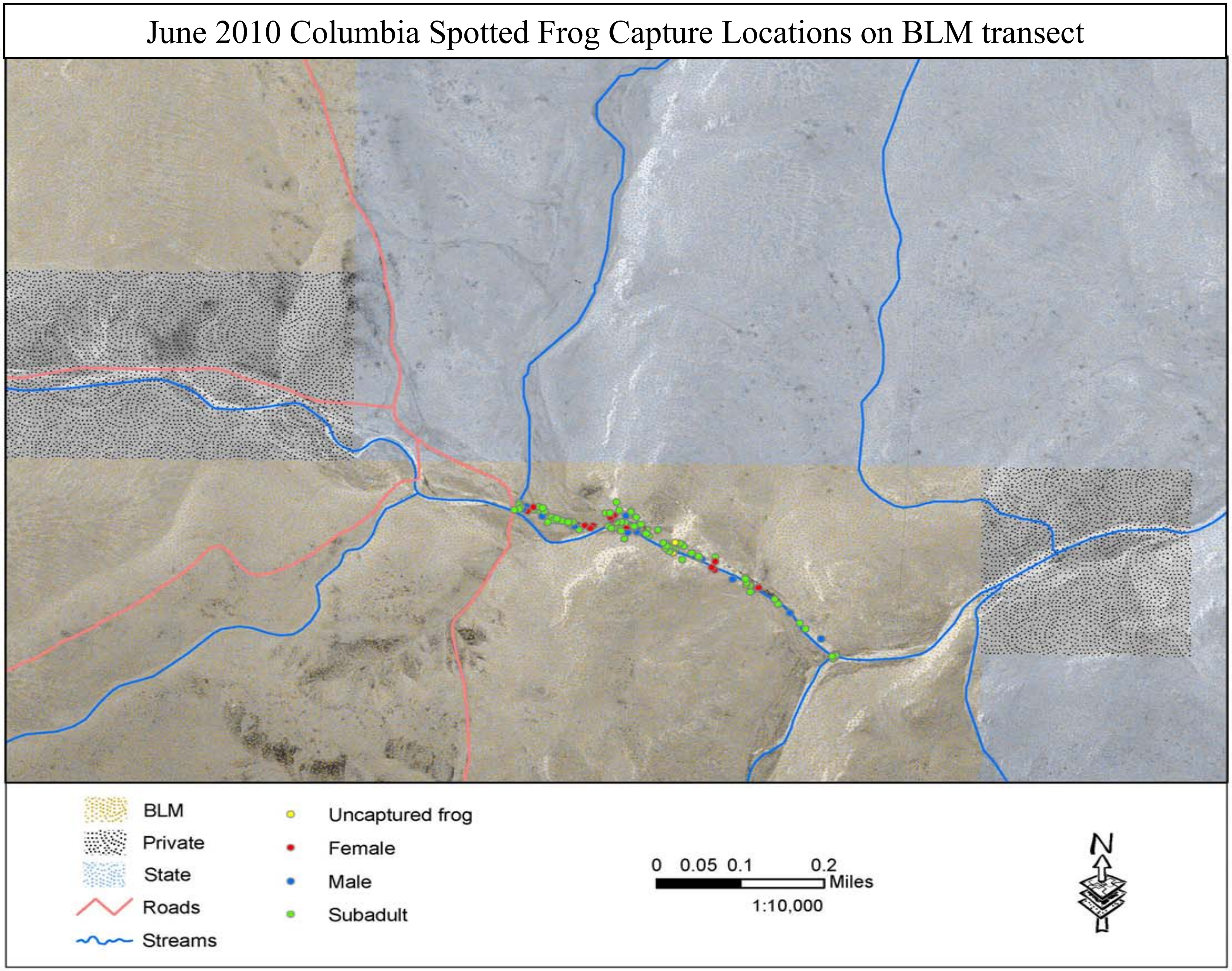

Figure 4. Columbia spotted frog capture locations for the June 2010 mark-recapture survey on the BLM transect along Dry Creek, Malheur County, Oregon.

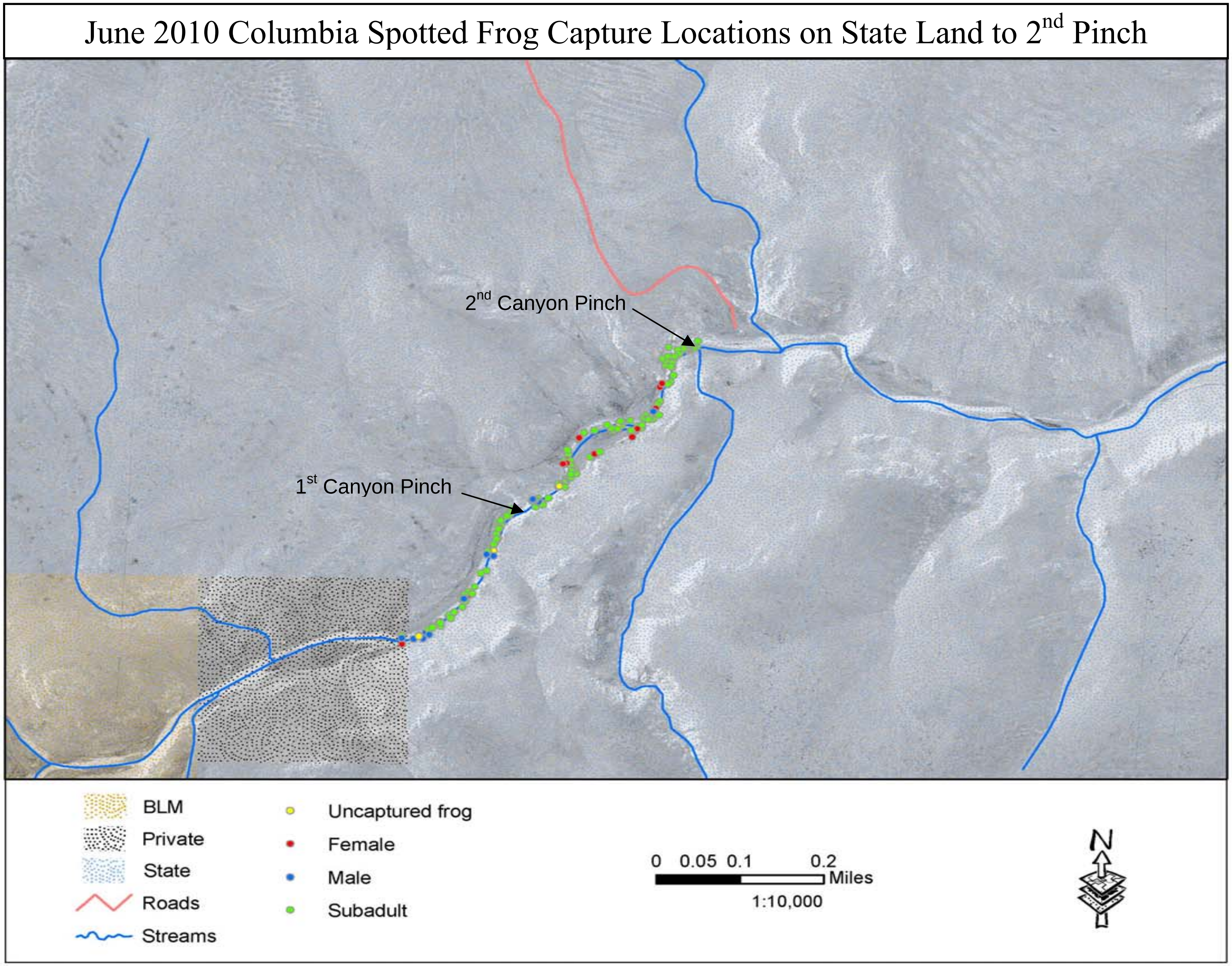

Figure 5. Columbia spotted frog capture locations for the June 2010 mark-recapture survey on State land to 2nd pinch along Dry Creek, Malheur County, Oregon.

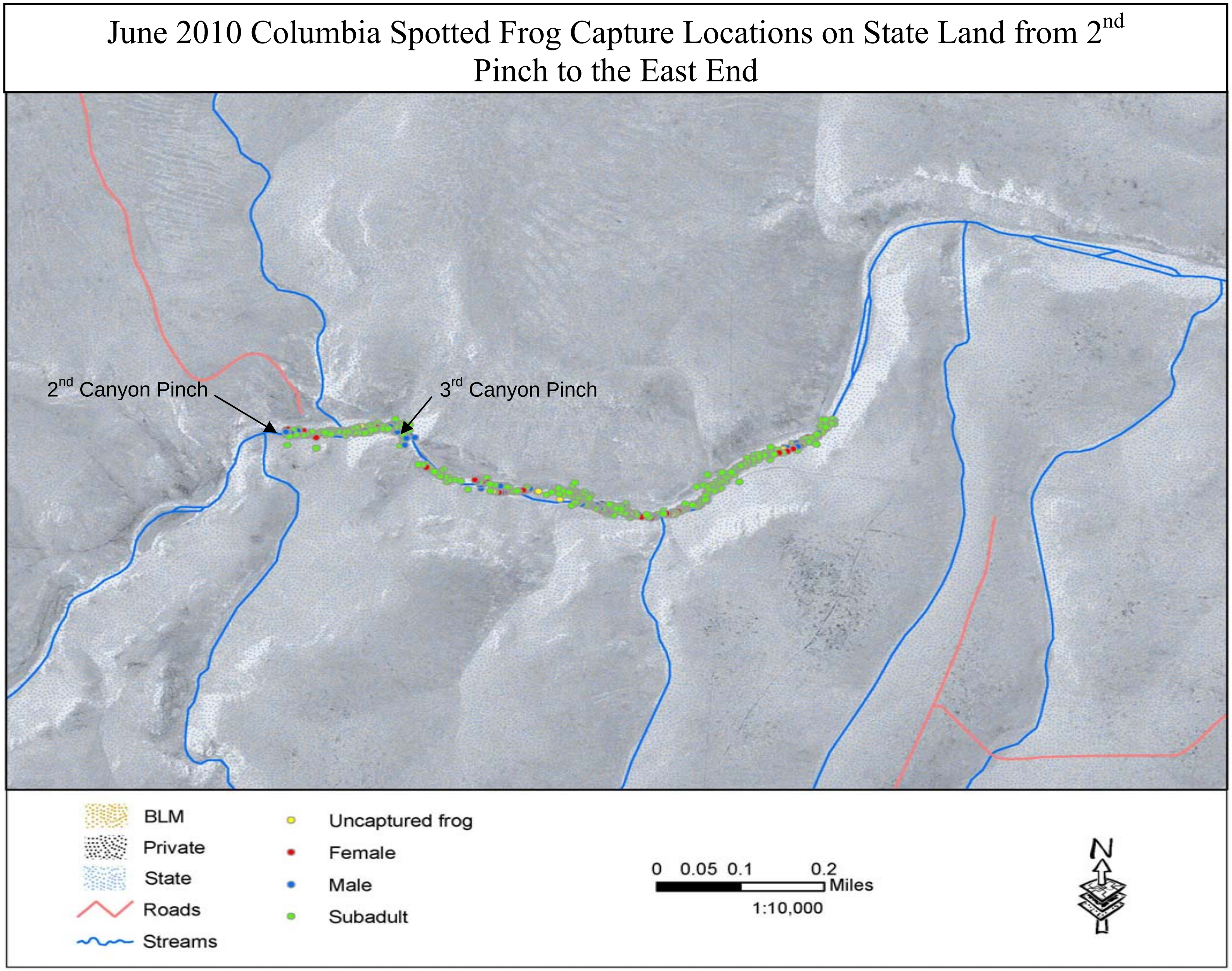

Figure 6. Columbia spotted frog capture locations for the June 2010 mark-recapture survey on State land from the 2nd Pinch to the east end along Dry Creek, Malheur County, Oregon.

Where:

N = population estimate
m = number of frogs caught, marked, and released on day #1
n = number of frogs caught on day #2
r = total number of recaptured frogs caught on day #2

Using the mark-recapture data, the 2010 Lincoln-Peterson population estimate for the State transect is calculated as follows:

N = (957) (1,015) / 595
N = 1,632 frogs

The accuracy of this estimate can be measured by calculating the standard deviation (S) as follows:

$$S = \sqrt{\frac{(m+1)(n+1)(m-r)(n-r)}{(r+1)^2\,(r+2)}}$$

$$S = \sqrt{\frac{(958)(1,016)(362)(420)}{(596)^2\,(597)}}$$

S = 26.41649

The 95% confidence interval (CI) of the estimate is calculated using the following equations:

$CI_l = N - 1.96S$
$CI_l = 1632 - (1.96)(26.41649)$
CI_l = 1,580 frogs

$CI_h = N + 1.96S$
$CI_h = 1632 + (1.96)(26.41649)$
CI_h = 1,683 frogs

Therefore, the 95% confidence interval range for the 2010 estimate is between 1,580 and 1,683 frogs.

Figure 7 shows the Lincoln-Peterson population estimates and CIs for the State transect from 2001 to 2010. A population estimate was not calculated for 2002 due to the PIT-tag reader failure during the mark-recapture survey. The population estimate has fluctuated throughout the years; however, there has been a steady increase in the population since 2006. The population estimate reached 493 ± 21.43 frogs (417 to 514 frogs) in 2008, almost doubled to a total of 890 ± 21.35 frogs (868 to 911 frogs) in 2009, and then doubled again to 1,632 ± 26.42 frogs (1,580 to 1,683 frogs) in 2010.

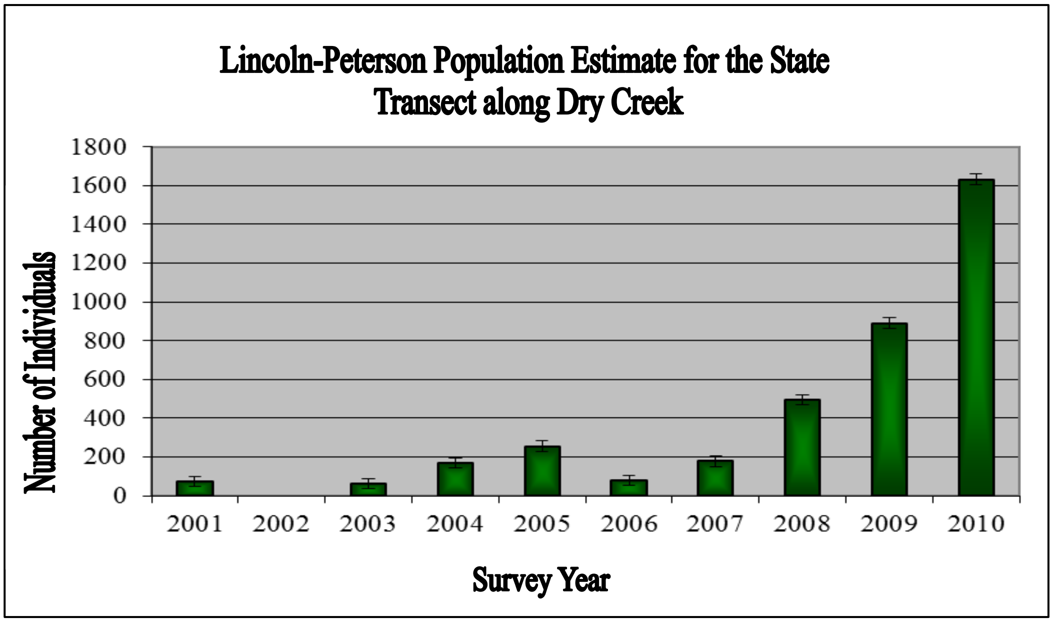

Figure 7. Lincoln-Peterson population estimates for Columbia spotted frogs on the State transect along Dry Creek from 2001 to 2010, Malheur County, Oregon. Note: Estimate for 2002 was not calculated.

A total of 1,294 individual frogs were recorded (i.e., 100 females, 97 males, 1,086 subadults, and 11 uncaptured frogs) along the State transect in June 2010. Table 1 shows the age and gender distribution of the frogs caught on the State transect in comparison to the Lincoln-Peterson population estimate from 2001 to 2010.

Table 1. Gender and age distribution for the June Columbia spotted frog mark-recapture surveys on the State transect along Dry Creek from 2001 to 2010, Malheur County, Oregon.

	Year									
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Females	9	9	9	26	18	22	7	42	95	100
Males	2	2	2	10	8	10	11	21	69	97
Subadults	39	20	41	61	119	25	108	317	628	1,086
Uncaptured	5	8	9	14	18	1	9	47	20	11
TOTAL	55	39	61	111	163	58	135	427	812	1,294
L-P Estimate	74	*	62	168	255	80	178	493	890	1,632

*** estimate could not be calculated**

3.2.2 Other Wildlife Observations

Snake numbers have been documented during the mark-recapture surveys each year since 2001 in an attempt to determine if predation is an important factor in spotted frog survival along Dry Creek. Table 2 shows how the number of snakes observed from 2001 to 2010. In June 2010, a total of 45 snakes were observed along the transect (44 western terrestrial garter snakes, one common garter snake).

Table 2. Snake observations from the June Columbia spotted frog mark-recapture surveys along Dry Creek from 2001 to 2010, Malheur County, Oregon.

	Survey Year									
Species	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Western terrestrial garter snake	-	14	40	14	15	58	30	21	37	44
Common garter snake	-	1	2	-	-	-	-	1	-	1
Gopher snake	2	1	4	-	-	5	2	-	1	-
Racer	2	1	2	1	1	1	2	-	-	-
Western rattlesnake	2	-	1	-	1	-	1	-	1	-
TOTAL	**6**	**17**	**49**	**15**	**17**	**64**	**35**	**22**	**39**	**45**

In addition to recording snake observations, other wildlife observations are noted along the survey route. In 2010, western meadowlarks, chukar, flicker, pigeons, prairie falcon, great-horned owls, killdeer, California quail, horned larks, common nighthawks, red-winged blackbirds, fence lizards, brown-headed cowbirds, bank swallows, mallards, and green-winged teal were observed along the transect.

3.3 Recruitment Survey

Aquatic habitat was fairly connected in August; however, portions of the BLM transect were again dry. Heavy livestock use was evident along the portion of the transect from the east end of the State-owned land to the third pinch and moderate to heavy livestock use from the west end of the State-owned land to the first pinch. The portion of the transect between the second and third pinches and the BLM portion of the transect showed very little signs of livestock use.

The recruitment survey was broken into three sections in 2010 due to the anticipated high numbers of frogs and metamorphs. All sections were surveyed between August 10 and August 12. Along the entire transect, 3,294 individual frogs were recorded (37 males, 28 females, 254 subadults, 2,941 metamorphs, and 34 uncaptured frogs). Frogs were recorded along the main channel and in available side pools, oxbows and exclosures. Again, fewer frogs were caught on BLM land and on State land down to the second pinch; most frogs were observed between the second and third pinches. Figure 8 shows the capture locations of all frogs recorded along the recruitment survey route for August 2010.

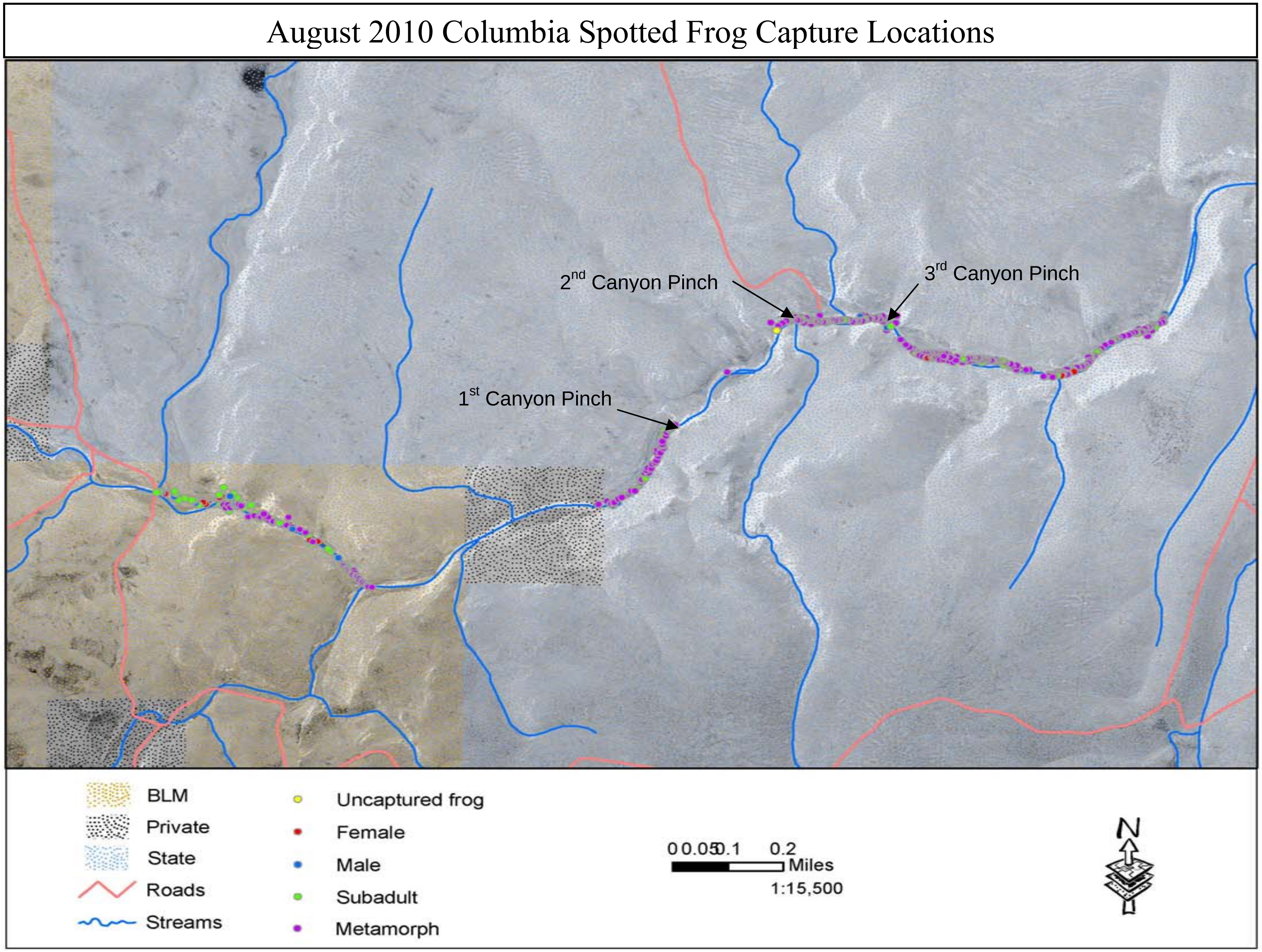

Figure 8. Columbia spotted frog capture locations for the August 2010 annual recruitment survey along Dry Creek, Malheur County, Oregon.

3.4 Habitat Conditions

In 2010, water quality variables (pH, conductivity, dissolved oxygen, and temperature) were sampled at the standard water chemistry point located on Dry Creek near the Campsite Oxbow Exclosure. Table 3 shows the results of the water quality tests conducted from 2001 to 2010. The results from the 2010 surveys are similar to other years.

Table 3. Habitat ratings and water quality monitoring results for the Dry Creek Columbia spotted frog surveys from 2001 to 2010, Malheur County, Oregon.

Date	Time	Water Temp (°C)	DO	Conductivity (ppm)	pH	SSAR (percent streambank soil alteration rating)	VUBA (percent vegetation use by animals)
June 6, 2001	1310	17.3	14.7	192	9.2	0-25	0-25
August 4, 2001	1335	22.3	16.5	246	9.3	26-50	76-100
June 6, 2002	1315	22.5	-- [1]	-- [1]	-- [1]	26-50	51-75
August 11, 2002	1300	21.8	-- [2]	340	8.9	51-75	76-100
June 6, 2003	1200	20.9	12.6	270	9.1	51-75	0-25
August 9, 2003	1355	24.9	16.3	310	8.9	51-75	26-50
June 6, 2004	1515	22.2	13.8	250	8.9	51-75	51-75
August 20, 2004	1440	26.0	14.8	280	9.0	26-50	26-50
June 6, 2005	1730	17.0	14.4	230	8.9	0-25	0-25
August 11, 2005	1249	21.0	15.4	260	9.1	51-75	76-100
June 3, 2006	1330	17.0	10.0	250	10.4	76-100	0-25
August 10, 2006	1302	22.0	7.5	280	8.4	76-100	76-100
June 6, 2007	1700	16.0	12.3	200	9.1	51-75	0-25
August 8, 2007	1210	19.0	9.0	190	8.1	51-75	76-100
June 3, 2008	1120	15.0	8.9	170	6.3[3]	0-25	26-50
August 6, 2008	1147	22.0	9.8	160	-- [1]	26-50	76-100
June 3, 2009	0840	19.0	7.6	160	8.5	26-50	0-25
August 5, 2009	1518	25.0	9.9	180	8.4	26-50	76-100
June 7, 2010	1140	18.0	9.6	150	10.8	26-50	0-25
August 12, 2010	1735	-- [2]	9.0	-- [1]	9.7	26-50	76-100

[1] **equipment failure**
[2] **not recorded**
[3] **possible equipment failure**

Additionally, streambank soil alteration rating (SSAR) and a vegetation use by animals (VUBA) rating using Platts (1987) have been documented during both the mark-recapture and recruitment surveys each year since 2001. Table 3 shows the percent streambank soil alteration rating

SSAR) and the percent vegetation use by animals (VUBA) results of the habitat ratings from 2001 to 2010.

Vegetation use along Dry Creek in June 2010 was light and did not vary much along the transect. There was also evidence the stream banks were continuing to stabilize and revegetate from the high winter 2005-2006 flows.

Vegetation use along Dry Creek varied in August 2010, making it more difficult to determine habitat ratings. Vegetation use along the portion of the transect from the east end of the State land to the third pinch showed signs of heavy grazing. Vegetation use between the third and first pinch was light to moderate. The portion of the transect from the first pinch to the west end of the of the State showed signs of moderate livestock use. The BLM portion of the survey showed signs of light livestock use.

Figure 9 shows the habitat ratings in combination with the Lincoln-Peterson population estimates from 2001 to 2010. Lincoln-Peterson population estimates are plotted on the same graph as the habitat measures to help determine if a relationship between frog numbers and habitat conditions exists. Population estimates first reached record documented numbers in 2005 at the same time when habitat ratings in June were at their best ratings. The 2008 through 2010 high population estimates also occurred while the habitat ratings in June were relatively good. Conversely, the low 2003 and 2006 population estimates were documented at a time when the June habitat ratings documented poor habitat conditions.

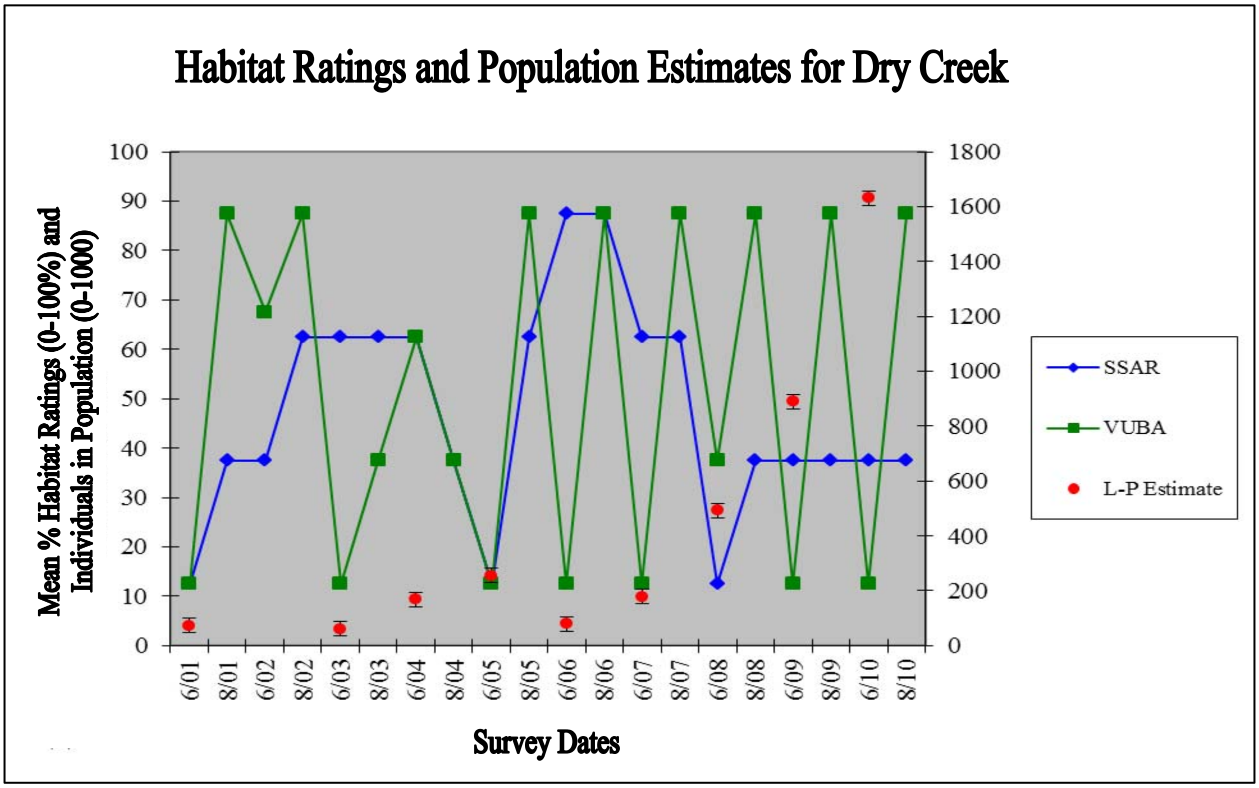

Figure 9. Habitat measures and Columbia spotted frog population estimates observed along Dry Creek from 2001 to 2010, Malheur County, Oregon. For both habitat ratings depicted here, higher percentages represent poorer habitat conditions. (See Appendix II for rating criteria.)

3.5 Exclosures

In June 2006, three small exclosures were built around areas believed to be important to the spotted frog population within the survey route. Since their construction, minimal maintenance has been completed on the exclosures and they are currently in need of repair (i.e., sagging wires, corner posts pushed up, etc.).

3.5.1 Campsite Oxbow Exclosure

The Campsite Oxbow Exclosure is located just south of the campsite. Due to its close proximity to a livestock trail, the area received a high amount of disturbance from trampling and vegetation loss prior to construction of the exclosure. This exclosure provides aquatic habitat for foraging and overwintering frogs. As of 2010, spotted frog breeding has not been documented at this site. This oxbow pool has had consistent capture success over the past nine years and contains perennial water. Figure 10 shows the Campsite Oxbow Exclosure in June 2010 with willows and cattails (middle of photo).

Figure 10. Campsite Oxbow Exclosure in June 2010 along Dry Creek, Malheur County, Oregon.

3.5.2 Barrel Spring Exclosure

The Barrel Spring Exclosure is located between the second and third pinches. This pool is a recharge area where water percolates back up to the surface in a cool, clear pool. This area reliably provides wet habitat connectivity when water is limited in late summer and it is thought to be an overwintering site for spotted frogs. Additionally, metamorph captures have been high in August of most years. As of 2010, spotted frog breeding has not been documented in this pool. Figure 11 shows the Barrel Spring Exclosure in June 2010 with willows (top right of photo).

Figure 11. Barrel Spring Exclosure in June 2010 along Dry Creek, Malheur County, Oregon.

3.5.3 Skeleton Scar Exclosure

The Skeleton Scar Exclosure is located downstream of the third pinch and is a documented breeding site. The Skeleton Scar Exclosure is a small, incised side channel that is usually isolated from the main channel. It usually remains approximately 18 inches deep throughout the year. Because of its rare connectivity to the main channel, any tadpoles that develop there are usually isolated until they metamorphose; therefore, predation by snakes can be extremely high in this concentrated pool.

The Skeleton Scar Exclosure was almost completely over-grown with sedges and rushes in June 2010. Livestock had gotten into the exclosure sometime before August and the vegetation was grazed short; however, water in the exclosure remained plentiful. As the vegetation continues to become more established and expand in the exclosure, the vegetation will need to be monitored to ensure it is providing the frogs with quality habitat and not filling in the channel. Figure 12 shows the Skeleton Scar exclosure in June 2010 with abundant sedges and rushes.

Figure 12. Skeleton Scar Exclosure in June 2010 along Dry Creek, Malheur County, Oregon.

4. Discussion

Mark-recapture and recruitment surveys have been conducted each year along a designated survey route from 2001 to 2010 in order to monitor long-term population trends, demographics and movement patterns for spotted frogs in Dry Creek (USDI 2007). Egg mass surveys have only been conducted in 2004, 2008 and 2010 due to the lack of access into the survey transect in early spring most years.

In addition, expanded surveys were completed in 2006 (immediately upstream and downstream of the annual survey transect) and in 2008 (three separate locations downstream of annual survey transect) to document presence and movements of marked frogs upstream and/or downstream of the annual survey route.

The results of this study show a dramatic increase in the Dry Creek spotted frog population over the life of the study (from a population estimate of 74 frogs in 2001 to 1,632 frogs in 2010). Additionally, the population appears to be cyclic, with very low population estimates in some years (2001, 2003 and 2006) and very high estimates in others (2009 and 2010). Several factors are known to affect spotted frog populations including habitat loss and alteration, precipitation and weather, livestock grazing, and disease. The following is a summary of the weather, habitat conditions, and population demographics observed during this study.

4.1 Weather Conditions

Habitat connectivity in Dry Creek varies from year to year and is most likely heavily dependent upon winter and spring precipitation. In addition, amphibians have been found to be sensitive to changes in precipitation and temperature (Corn 2003). Climate and weather conditions may affect amphibians in several ways, including changes in timing of breeding, survival of adult and juvenile frogs, and egg production (Bull and Shepherd 2008, Corn 2003). Bull and Shepherd (2008) found that weather conditions influence the survival of spotted frogs, as well as reproduction the following year. Monitoring effects of weather on the Dry Creek spotted frog population was not included as part of this study design. However, weather conditions and fluctuations most likely played a role in the results of this study; therefore, weather conditions are briefly discussed below.

The following is a summary of data from the Red Butte, Oregon remote automated weather station (RAWS). The Red Butte RAWS is the closest RAWS station to the study site (approximately six miles) and provides temperature and precipitation data reflective of the Dry Creek area. Throughout the life of the study, the amount of precipitation, timing of that precipitation and air temperatures have varied from one year to the next. The wettest years during the study were 2005 and 2010, with 10.49 inches and 9.22 inches of total precipitation, respectively (WRRC 2010). The driest years during the study were 2002 and 2003, with 4.25 inches and 4.97 inches of total precipitation, respectively (WRRC 2010). Figure 13 shows the yearly precipitation total from 2001 to 2010 and Figure 14 shows the amount and timing of precipitation as it compares to other years from 2001 to 2010. Although 2005 was the wettest year during the life of the study, a substantial amount of the precipitation came in December 2005, causing a high-flow event to move through the survey transect. The effects of this event were evident during the June 2006 survey when it was documented that the stream had been scoured out and the streambanks were folded back on themselves.

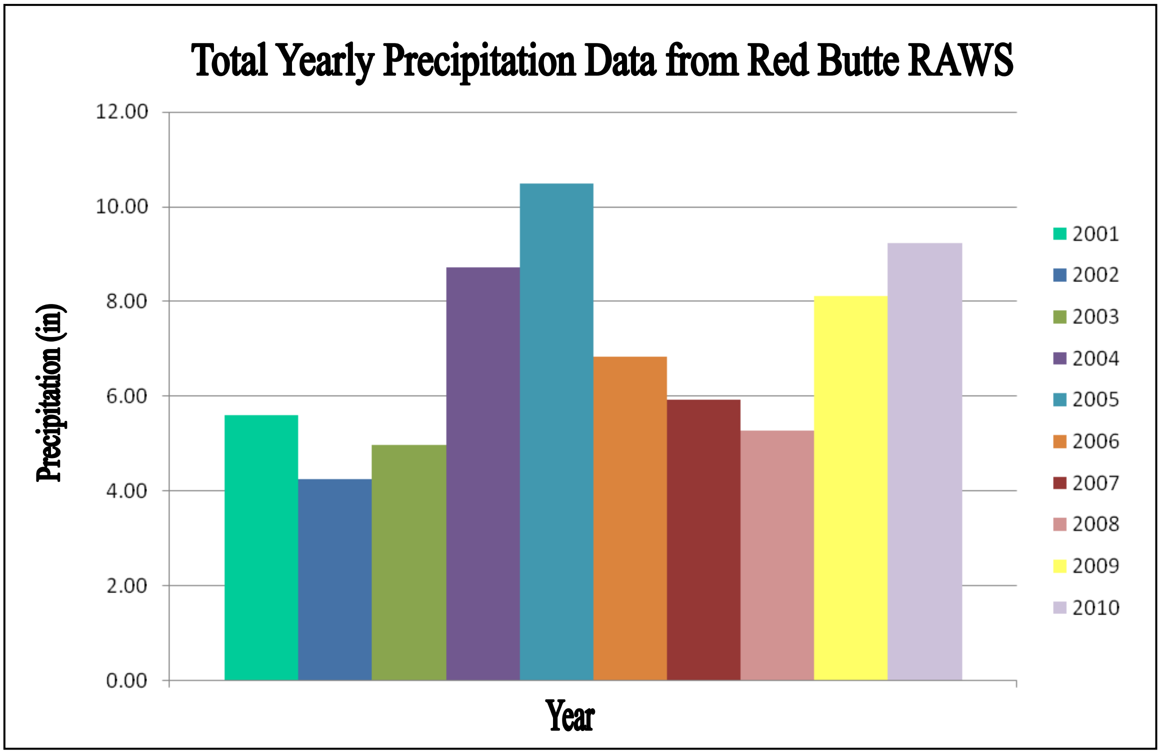

Figure 13. Yearly precipitation data for 2001-2010 from Red Butte RAWS station, Malheur County, Oregon.

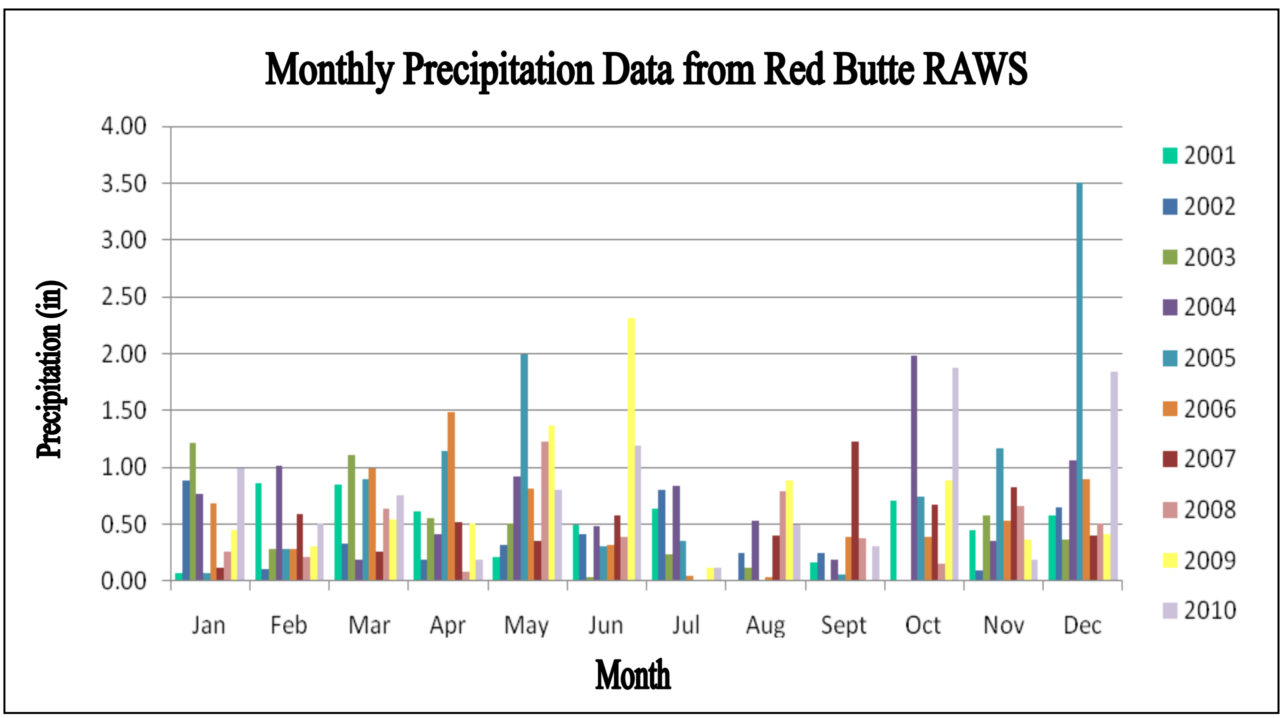

Figure 14. Monthly precipitation data for 2001-2010 from Red Butte RAWS station, Malheur County, Oregon.

In addition, the warmest year during the life of the study was 2003 with an average mean temperature of 49.3 º F, while the coolest year was 2008 with an average mean temperature of 45.4 º F (WRRC 2010). Figure 15 shows the average mean temperature by year from 2001 to 2010 and Figure 16 shows the average mean temperature broken down by month as it compares to other years from 2001 to 2010.

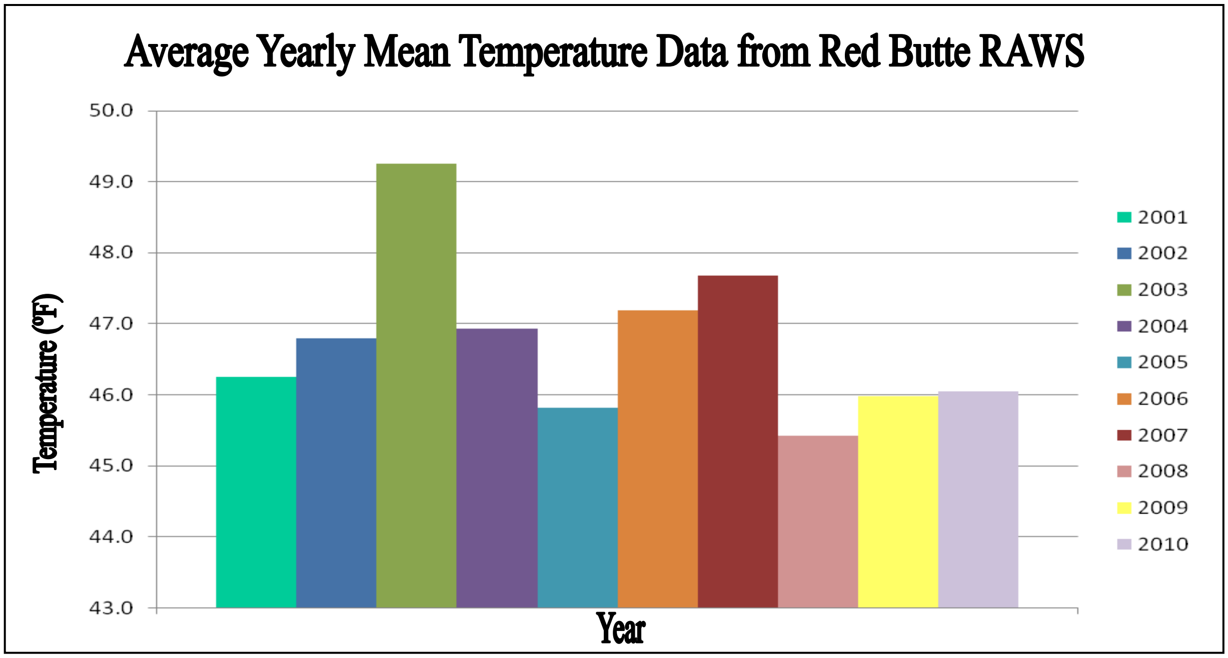

Figure 15. Average yearly mean temperature data for 2001-2010 from Red Butte RAWS station, Malheur County, Oregon.

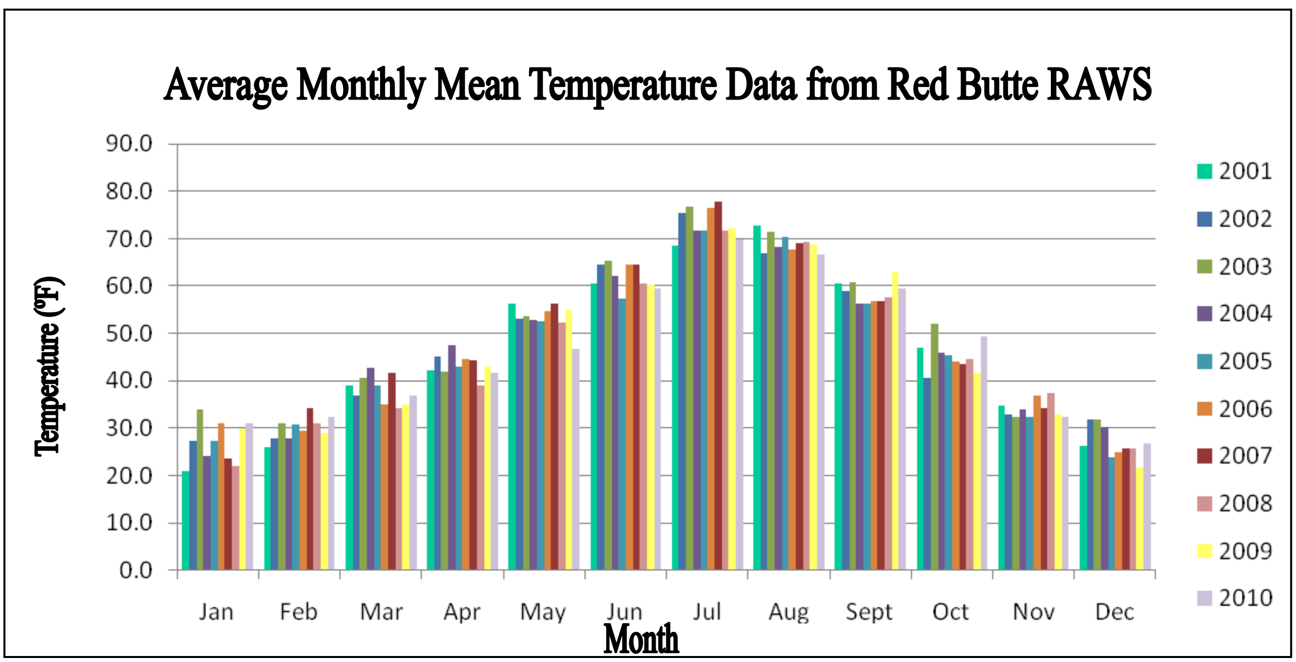

Figure 16. Average monthly mean temperature data for 2001-2010 from Red Butte RAWS station, Malheur County, Oregon.

Bull and Shepherd (2008) found that summer weather conditions (i.e., temperature and precipitation) may influence the reproduction of spotted frogs in the following year. . Hot, dry summers may reduce survival of adults and juveniles during the summer because of a loss of riparian habitat. Low water levels during the winter cause decreased levels of dissolved oxygen and may cause mortality under the surface of the ice where the frogs are overwintering (Bull and Shepherd 2008). Cooler, wetter summers could increase survival of both adult and juvenile frogs. Given that, it is interesting to note the 2004 and 2008 egg mass surveys were preceded by the two hottest summer periods (July-August) in 2003 and 2008, respectively. In addition, 2003 and 2008 were among the driest July-August periods throughout the life of the study. During both the 2004 and 2008 egg mass surveys, only a total of 13 egg masses were documented.

Conversely, the 2010 egg mass survey was preceded by the 2009 July-August period which was among one of the coolest and wettest July-August periods observed through the life of the study. During the 2010 egg mass survey, a total of 70 egg masses were documented. Figure 17 shows the combined average mean temperature for July and August by year from 2001 to 2010.

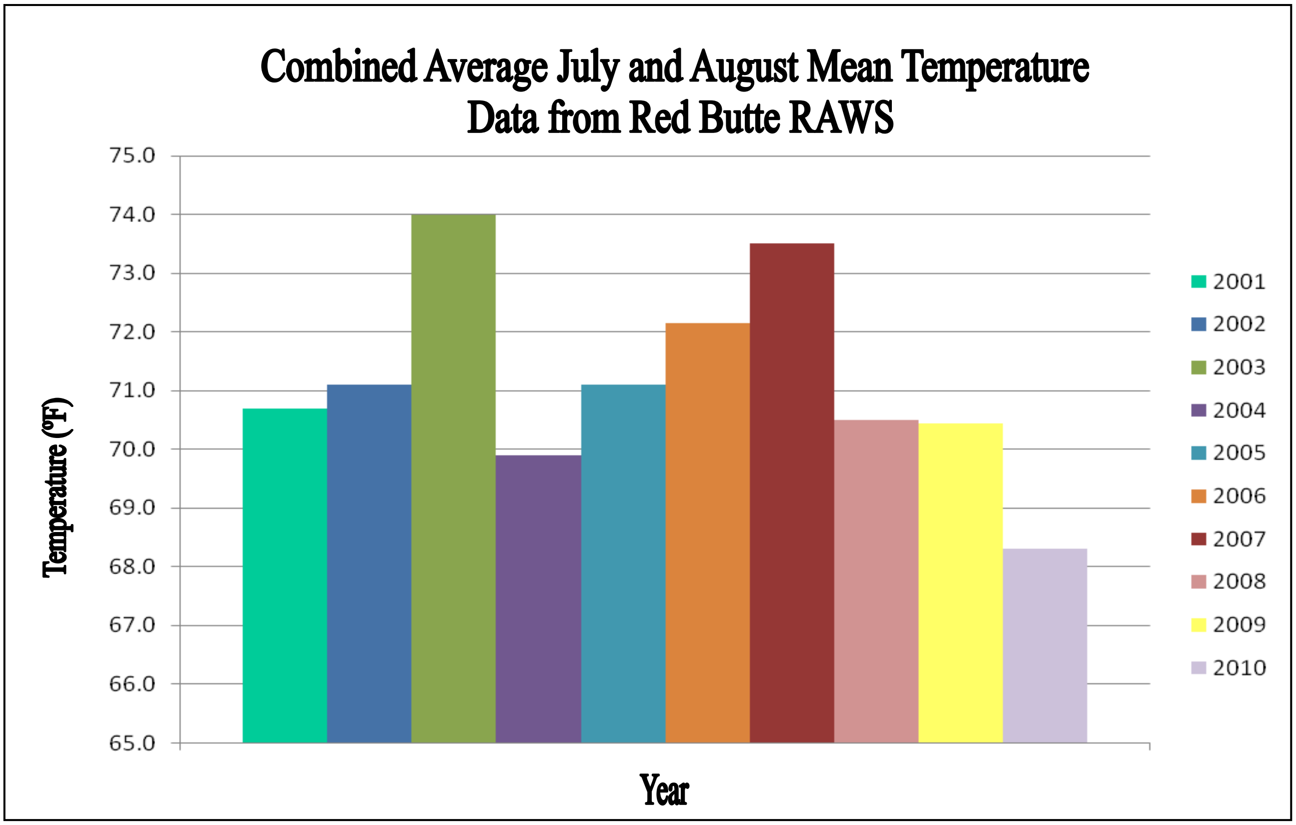

Figure 17. July-August average mean temperature data for 2001-2010 from Red Butte RAWS station, Malheur County, Oregon.

Summer temperatures and precipitation levels may help explain the cyclic nature of the Dry Creek spotted frog population; however, there may be other relationships that also affecting the population. Further analysis of the data collected during this study should be conducted to determine the effect of weather conditions on the spotted frog population in Dry Creek.

4.2 Habitat Conditions

Dry Creek has been degraded from several past management actions. The section of Dry Creek included in this study historically down-cut several feet and there is currently an active headcut upstream of the annual transect route near where the Crowley Road crosses Dry Creek (Rockefeller pers. comm. 2011). The historic down-cutting of the channel is believed to have been the result of water fluctuations from the Owyhee Dam operations. In addition, the stream width to depth ratio is too high in several places along Dry Creek (i.e., the stream channel is wider than potential for this reach) (USDI 2006). This portion of Dry Creek also shows signs of trailing and trampling from both current and historic livestock grazing. In addition, there is very little woody vegetation along the creek, outside of the Natural Exclosure (i.e., the second pinch), an area that is inaccessible to livestock.

Impacts to stream and riparian areas resulting from grazing depend on the intensity, duration, and timing of grazing activities (Platts *et al.* 1989), the capacity of a given watershed to assimilate imposed activities, and the pre-activity condition of the watershed (Odum 1981). Potential effects of livestock grazing on riparian and in-stream habitats include stream substrate compaction, undercut bank collapse, streambank destabilization, localized herbaceous and woody vegetation reduction or removal, streambank widening, pool frequency reduction, incised channel increase, and water tables lowering (Platts 1991; Henjum *et al.* 1994). All of these effects affect the amount and quality of habitat available to spotted frogs.

Moderate to heavy grazing affects the ability of the vegetation to reduce or prevent soil erosion. Streamside vegetation protects and stabilizes streambanks by binding the soil to resist erosion and trap sediment (Chaney *et al.* 1990). Plant roots in areas with light or no grazing are generally dense, heavily branched, spreading, and deeply penetrating. Under heavy grazing pressure, roots progressively develop fewer branches, and are shorter, sparser, and more concentrated in the top portion of the soil profile, thereby inadequate to provide sufficient soil and/or bank stabilization and protection (Vallentine 1990). When vegetation is removed from the banks and plant roots are inadequate to bind the soil, tension cracks can develop and lead to bank failure (Platts 1991). Additionally, many forbs and annual plants that frequently dominate early-seral plant communities, as a result of heavy grazing pressure, do not have the strong, deep root systems of the later seral perennials such as bunchgrasses, sedges, rushes, shrubs, and willows. When watersheds with primarily early-seral plants, or late-seral plants with reduced root systems, experience a flood event, they are more likely to suffer serious damage from erosion and mass wasting.

The most recent flood event on Dry Creek was during the winter of 2005-2006. A significant amount of precipitation fell in the area during December 2005 (WRRC 2010). Evidence this precipitation and subsequent high-flow event was observed during the 2006 spotted frog surveys where it was documented that the streambanks were folded back on themselves in many places (Engle 2006). As a result, very few areas along Dry Creek currently have overhanging banks or areas that could be used for overwintering sites.

Therefore, the current condition of Dry Creek may be limiting the number of suitable overwintering sites. In the winter, spotted frogs hibernate under water or in burrows and holes in the streambanks (Bull and Hayes 2002). Spotted frogs use areas where the water does not freeze and there is adequate oxygen levels for hibernating. Suitability of these overwintering sites may vary from year to year depending on the timing and intensity of grazing, timing and intensity of high-flow events, and water conditions. The limited number of overwintering sites along Dry Creek may be influencing the survival rate for spotted frogs along Dry Creek. Suitable breeding sites are widespread, but many are not being used; therefore, breeding sites are not considered a limiting factor. In addition, hibernacula in close proximity to breeding sites, and suitable migratory corridors with no barriers to movement are extremely important for the long-term survival of spotted frogs in Dry Creek. Spotted frogs have a relatively short, two week breeding window in the spring; thus, if individuals do not make it back to their natal sites within that time period, they may not reproduce that year.

Despite the disturbances to Dry Creek, there is evidence that portions of Dry Creek are slowly recovering from past management actions. Evidence of the recovery can be seen throughout the survey route. However, the most obvious recovery occurs between the second and third pinches. This section of the survey route generally receives less livestock use than the other portions, which may be affecting the rate of recovery of the riparian area. Figures 18 and 19 show the State transect between the second and third pinches (looking downstream). Figure 18 is a photo taken 2001 and Figure 19 is a photo taken in 2010. The yellow circle identifies a large boulder along the creek for comparison purposes. The 2010 photo shows a slightly more contiguous, slightly wider riparian area than in 2001. There is some evidence that riparian vegetation is starting to replace upland species, mid-seral and late-seral species are getting established, and vegetation is establishing itself in soil deposited along the banks. These are signs that the riparian area is widening, and the channel is narrowing and recovering (Prichard *et al.* 1998).

Figure 18. 2001 photo taken along Dry Creek, Malheur County, Oregon.

Figure 19. 2010 photo taken along Dry Creek, Malheur County, Oregon.

Figures 20 and 21 show this same portion of the State transect between the second and third pinches (looking upstream). Figure 20 is a photo taken 2001 and Figure 21 is a photo taken in 2010. Again, when the two figures are compared, the 2010 photo shows a more contiguous, slightly wider riparian width.

Figure 20. 2001 photo taken along Dry Creek, Malheur County, Oregon.

Figure 21. 2010 photo taken along Dry Creek, Malheur County, Oregon.

Figures 22 and 23 show a portion of the State transect below the third pinch (looking downstream). Figure 22 is a photo taken in 2001 and Figure 23 is a photo taken in 2010. The yellow circle identifies a boulder along the creek for comparison purposes. Comparing the two figures shows a narrowed stream channel in the 2010 photo. This type of channel narrowing is evident in other places along Dry Creek within the survey transect as well. Both channel narrowing and riparian width widening are example of a stream recovering from past management and/or natural events (Pritchard *et al.* 1998).

Figure 22. 2001 photo taken along Dry Creek, Malheur County, Oregon.

Figure 23. 2010 photo taken along Dry Creek, Malheur County, Oregon.

In addition, the BLM transect is showing signs of recovery. Within the BLM section there is evidence that riparian vegetation is starting to replace upland species and mid-seral species are beginning to establish themselves. There has also been a noticeable increase in the amount of frog habitat remaining and available in August (i.e., amount of residual water has increased through the life of the study). Another difference that has been noted on the BLM section is the total number of frogs (all life stages) observed along the transect has increased in the last few years of the study. The increase in frog numbers found within the BLM transect may be a result of higher survival rates or the frogs exploiting the more favorable habitat conditions.

More detailed studies should be conducted to determine what effect habitat conditions may have on the spotted frog population in Dry Creek.

4.2.1 Water Quality

Spotted frogs are sensitive to water quality because they rely on both aquatic and terrestrial environments for their life cycle. For this reason, water quality variables are often sampled in order to monitor effects from changes in water quality on amphibians. Water quality variables commonly sampled include pH, conductivity, dissolved oxygen and temperature.

The results of the water quality (pH, conductivity, dissolved oxygen, and temperature) samples taken from 2001 to 2010 in Dry Creek are highly variable. This variation may be due to changes in vegetation, stream condition and grazing management over the life of the study. However, the results from this study are similar to the range of results Bull and Hayes (2000) encountered and may illustrate the range of water quality conditions spotted frogs can survive in. Unfortunately, the experimental design of this study renders the analysis of effects of water quality on the Dry Creek spotted frog population inconclusive. Further studies should be conducted to determine the effect of water quality in Dry Creek on the spotted frog population.

4.2.2 Habitat Ratings

Impacts to spotted frogs from livestock grazing are not well-understood. Howard and Munger (2003) found lower survival of spotted frog larvae in their high-livestock waste treatment, while others have found no significant impacts or short-term effects to spotted frogs from livestock grazing (Adams *et al.* 2009, Bull and Hayes 2000). However, further investigation is recommended in order to better understand livestock grazing and spotted frog interactions (Adams *et al*. 2009, Bull and Hayes 2000, Howard and Munger 2003).

For this study, streambank soil alteration (SSAR) and vegetation use by animals (VUBA) were recorded. The SSAR evaluates how far streambanks have moved away from optimum conditions for the respective aquatic habitat type (Platts 1987). The VUBA evaluation includes only vegetation disturbed (grazed and trampled) during the current growing season and potential plant growth that does not exist because of past disturbance of vegetation (i.e., cattle crossing, etc). The VUBA rating also only applies to recent vegetative use (Platts 1987).

Habitat ratings were found to fluctuate greatly, even within a given year, depending on the timing of livestock use. Additionally, determining SSAR and VUBA is relatively subjective and varies depending upon the surveyor; it is difficult to train observers to visualize the same optimum bank conditions (Platts 1987). Therefore, the ability to determine if a relationship exists between habitat ratings and population estimates is very limited and few conclusions can be made at this time. Again, the experimental design of this study renders the analysis of effects of livestock use on the spotted frog population inconclusive. Further studies should be conducted to determine the effects of livestock use along Dry Creek on the spotted frog population.

4.3 Exclosures

Three small exclosures were constructed to protect areas important to spotted frogs from grazing impacts in June 2006. Two of these exclosures (Campsite Oxbow and Barrel Springs) provide perennial water and overwintering habitat, while the third exclosure provides perennial water and breeding habitat for spotted frogs. Inside two of these exclosures (Campsite Oxbow and Barrel Springs) cattails and willows were transplanted in an attempt to diversify the existing habitat and increase vegetative cover.

Since 2006, vegetative cover within the three exclosures has increased from the exclusion of livestock grazing, providing frogs with suitable habitat to forage safely and elude predators. Vegetative cover has been found to provide suitable refugia from predators (Bull and Hayes 2000, Monello and Wright 1999, Bull and Marx 2002). These exclosures have also had consistent capture success over the life of the study. Surveyors have found numerous frogs inside the exclosures during both the mark-recapture and recruitment surveys. This was especially true when the areas outside the exclosures had been grazed, leaving the only vegetative cover inside the exclosures. However, the number of frogs that were found in the exclosures and the number of frogs that were found along the stream or in pools outside the exclosure could not be compared.

Vegetative cover has also been linked to spotted frog reproduction. Monello and Wright (1999) found a positive correlation between emergent vegetation and spotted frog reproduction. Bull and Marx (2002) found that emergent vegetation provides suitable egg laying habitat. Although all three exclosures provide emergent vegetation and vegetative cover, no spotted frog breeding has been documented in the Campsite Oxbow and Barrel Springs exclosures.

In addition, since the time the exclosures were built, the Dry Creek spotted frog population has seen dramatic increases in the total number of frogs. However, this increase may be a result of several factors (i.e., changes in precipitation levels and timing, habitat conditions, stream temperatures) and may not be directly related to the installation of the exclosures. Adams *et al.* (2009) did not find any short-term effects of cattle exclosures on spotted frog populations. Additionally, given the small size of the three exclosures, it is unlikely that the exclosures are the sole reason for such a dramatic increase in the spotted frog population. Unfortunately, the study design did not include a method to monitor the effects of these exclosures on the Dry Creek spotted frog population. Therefore, no conclusions can be made at this time regarding the effect of excluding important spotted frog habitat from livestock grazing. Further studies should be conducted to determine the effect of grazing exclosures on the Dry Creek spotted frog population.

4.4 Population Trends and Demography

Overall, there has been a dramatic increase in the number of frogs observed along the transect since the beginning of the study. This overall increase in the number total of frogs is believed to be a result of a combination of improving habitat conditions and favorable weather conditions in recent years. Since 2001, there have been over 2,536 spotted frogs PIT-tagged along Dry Creek. All life stages of spotted frogs have been observed and documented throughout the transect route; however, frog capture locations and egg mass locations have been concentrated between the second pinch and the east end of the state transect. Communal egg-laying sites have been documented; however, the number of egg masses at these sites is low. Similar sites in other spotted frog populations support 50 egg masses or more (Engle 2001). The largest communal site in Dry Creek contained seven egg masses in 2004, five egg masses in 2008 and eleven in 2010. Figure 24 shows all capture locations for each frog recorded on the survey route from 2001 to 2010 and Figure 25 shows egg mass locations for all survey years (2001-2010).

Deformities on subadult frogs have been documented in recent years (2008-2010). In addition, symptoms of disease have been observed in frogs along Dry Creek. However, causes of these malformations and effects of disease have not been investigated during this study.

4.4.1 Survivorship and Recruitment

Recapture data can be used to help evaluate survivorship of Dry Creek spotted frogs. Although 2,536 frogs have been PIT-tagged in the Dry Creek survey area over the ten year study period, only 230 have been recaptured in subsequent years (76 males and 154 females). This suggests the adult spotted frog survivorship in Dry Creek is relatively low. Specific reasons for low survivorship in Dry Creek are unknown. Reaser (2000) found recruitment and survivorship to vary significantly among sites and have no consistent pattern, but concluded that reasons for low survivorship include land use, weather and climate, predation, and other localized factors.

Due to the low adult survivorship in Dry Creek, it is important to monitor yearly recruitment (i.e., metamorophs) into the population. Turner (1960) found that mortality and emigration were off-set by yearly recruitment, at least in the short term. Table 4 shows the number of metamorphs observed along the transect in August of each year. Recruitment appears to be cyclic, with years of high recruitment coinciding with years of cooler, wetter summers and years of low recruitment generally coinciding with years of warmer, drier summers. In addition, years with high annual recruitment correlate with years of high overall numbers of frogs observed along the transect. The data collected during this study indicate that recruitment has increased dramatically, corresponding with the dramatic increase in the overall population of spotted frogs in Dry Creek.

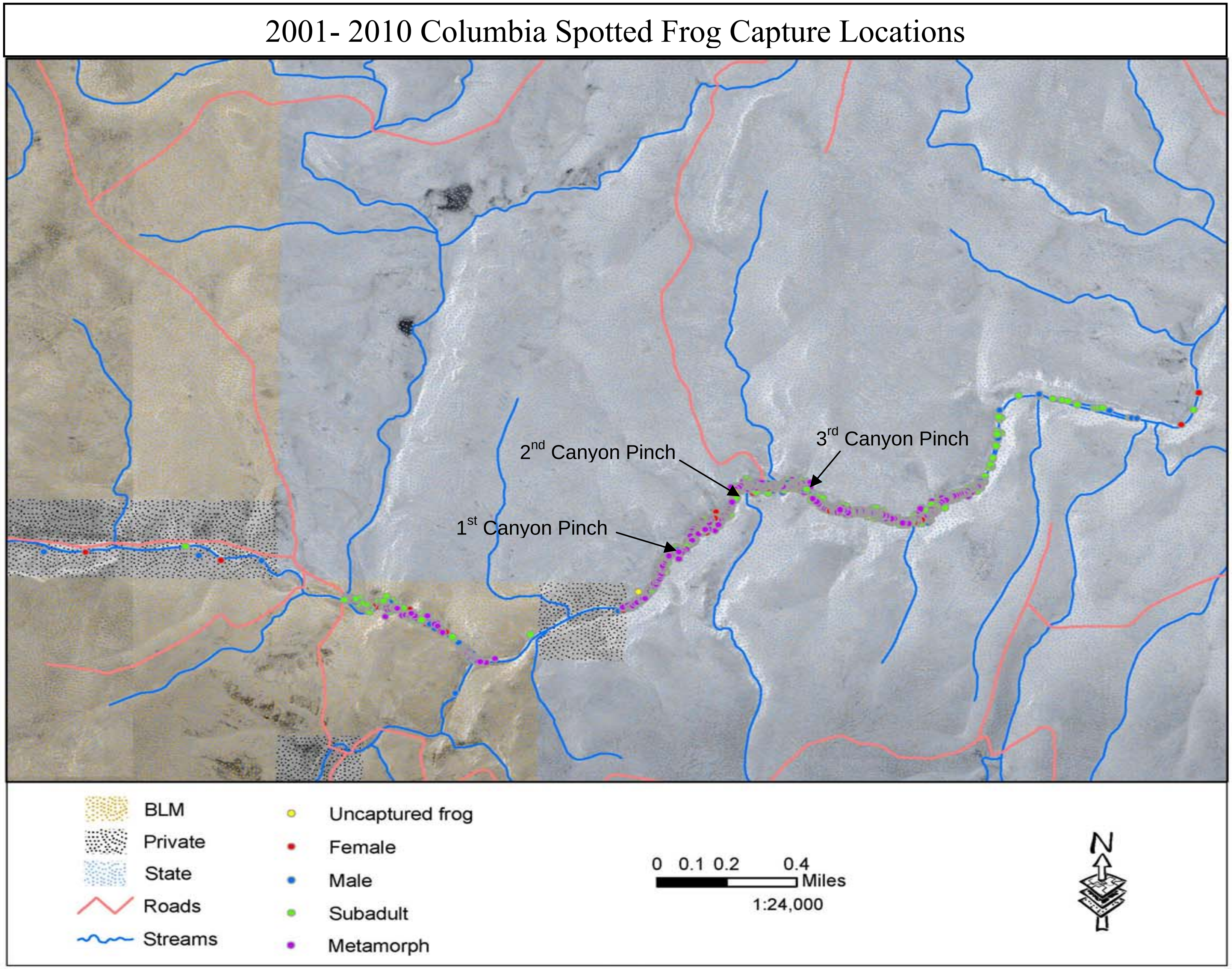

Figure 24. Columbia spotted frog capture locations (by gender and age class) from 2001 to 2010 along Dry Creek, Malheur County, Oregon.

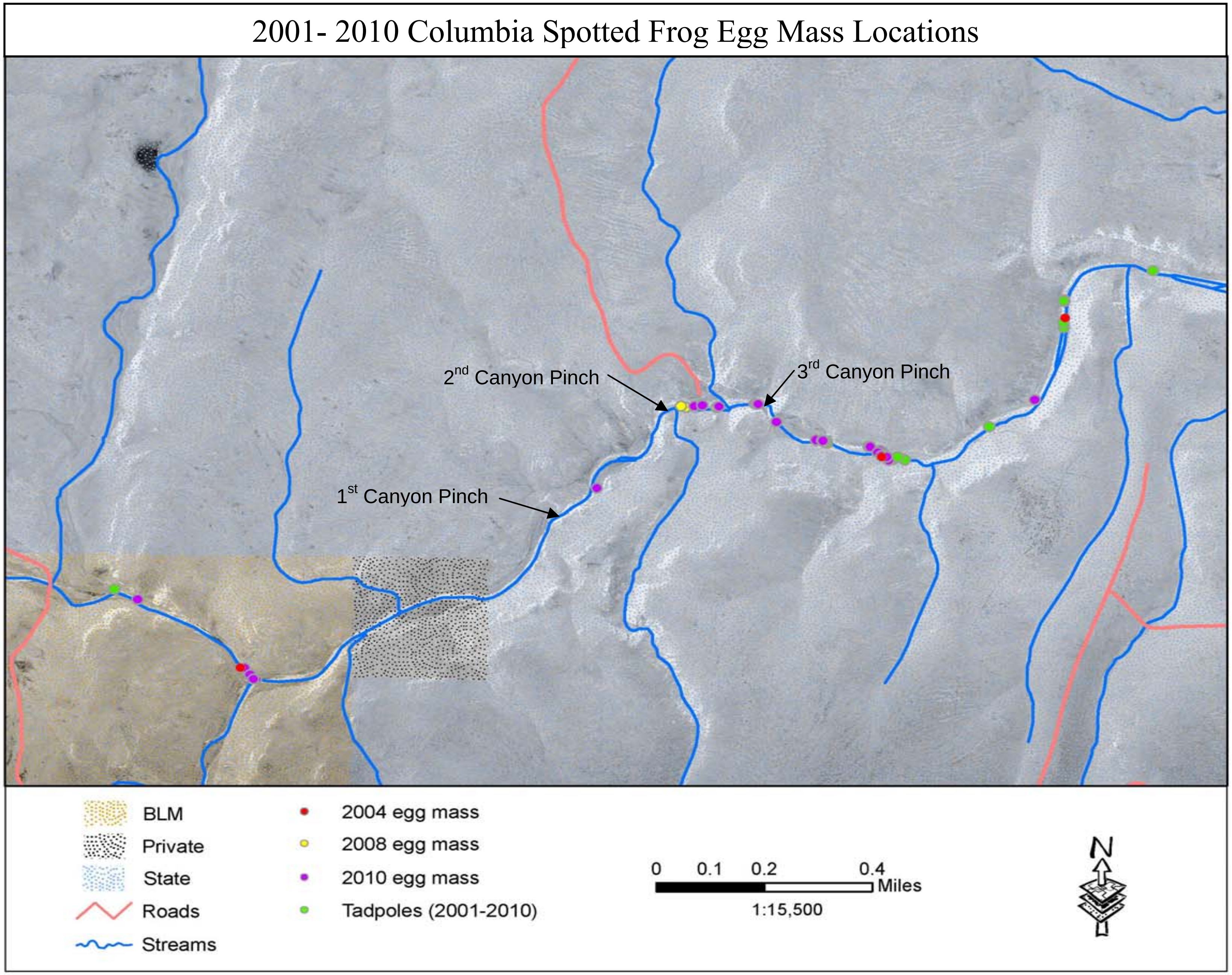

Figure 25. Egg mass locations from 2001 to 2010 along Dry Creek, Malheur County, Oregon.

Table 4. Number of Columbia spotted frog metamorphs observed along the entire transect on Dry Creek in August from 2001 to 2010, Malheur County, Oregon.

Date	Number of Metamorphs
August 4, 2001	37
August 11, 2002	71
August 9, 2003	98
August 20, 2004	223*
August 11, 2005	100
August 10, 2006	152
August 8, 2007	225
August 6, 2008	301
August 5, 2009	1,967*
August 10-11, 2010	2,941

*** entire transect was not completed due to time constraints**

Another measure of survivorship and recruitment success is to identify the number of metamorphs that survived their first winter and were observed the following year as subadults. Table 5 relates the number of subadults to the number of previous year's metamorphs. Turner (1960) found survival rates for all age classes after the metamorph stage to be close to 60 percent. For this study, the number and percent of metamorphs surviving to subadults has been highly variable, ranging from 30 percent to almost 92 percent (excluding the two years with over 100 percent survival). In 2008 and 2009, the survival rate is estimated at over 100 percent, presumably as a result of not all the metamorphs observed during the previous year's survey when an extremely large number of frogs were encountered. This high amount of variability is most likely caused by many localized factors including precipitation, temperatures, timing and magnitude of high-flow events, forage availability, summer habitat condition, and overwintering conditions, and possibly observer error.

Table 5. The relationship between the numbers of Columbia spotted frog metamorphs and subadults observed on Dry Creek in June from 2001 to 2010, Malheur County, Oregon.

Year	Number of Subadults	Number of Metamorphs (from previous year)	Percent of metamorphs surviving to subadults (%)
June 2001	41	-	-
June 2002	34	37	91.9%
June 2003	54	71	76.1%
June 2004	84	98	85.7%
June 2005	148	223*	**
June 2006	30	100	30.0%
June 2007	125	152	82.2%
June 2008	370	225	164.4%***
June 2009	684	301	227.2%***
June 2010	1187	1,967*	**

*** entire transect was not completed due to time constraints**
**** could not be calculated**
***** skewed estimate; presumably not all metamorphs observed the previous year due to extremely large number encountered**

To determine cohort survival along Dry Creek across years, it is important to determine age classes appropriately. Most frogs were captured first as subadults, and subsequently as adults (when gender could be determined). For the purposes of this report, "age" is defined as follows:

- 1st year: first calendar year of life (egg, tadpole, metamorph stages)
- 2nd year: second calendar year of life (previous year's metamorphs, now subadults)
- 3rd year: third calendar year of life (previous year's subadults, now adults)
- 4th year: fourth calendar year of life

Table 6 shows cohort survivorship through the life of the study. Due to individual variability in growth, size ranges cannot always predict age with certainty. However, it is safe to say that an 80 mm female is older than a 50 mm female in June of any given year. The breaks in age class in Table 6 are based upon recapture data for known subadults (when 2nd year could be assigned with certainty to a PIT-tagged individual), males and females caught along Dry Creek from 2001 to 2005 (Engle 2005). Figure 26 shows the average snout-vent length (SVL) (in mm) for frogs captured throughout the life of this study.

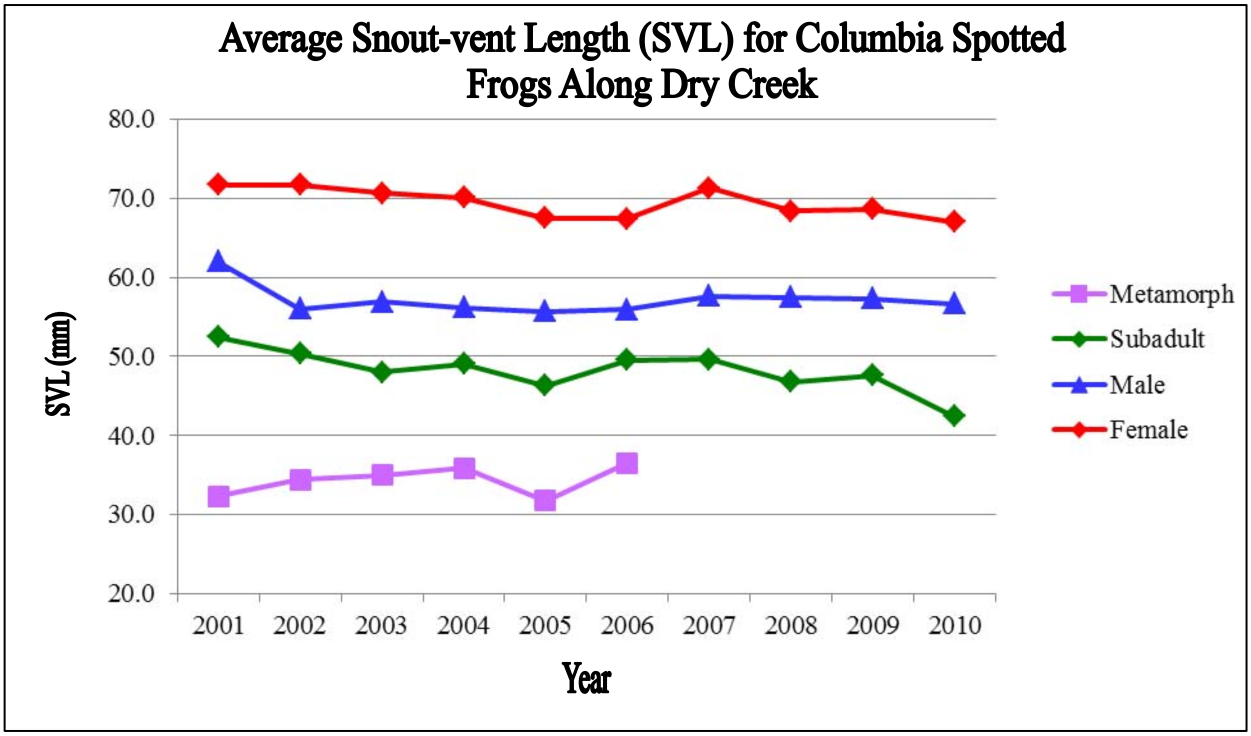

Figure 26. Columbia spotted frog cohort survivorship observed along the entire transect on Dry Creek from 2001 to 2010, Malheur County, Oregon.

In addition, the following criteria, based upon capture data, can be used to infer survivorship trends:

- Uncaptured subadults and adults are not included since there is a possibility that they may be captured and counted another time in any given year;
- Uncaptured metamorphs are included because they are only viewed once (in the last survey of the year);
- Recaptured frogs are only counted on the first capture of the year (when it is easiest to determine subadult age class);
- Frogs 42 mm and under in August are considered metamorphs; and
- Females captured in August are adjusted for annual growth; males caught in August are not adjusted for annual growth. Females will continue to grow rapidly between June and August. Males do not have as fast of growth rate between June and August; therefore, males do not need to be adjusted for annual growth in August.

Table 6. Columbia spotted frog cohort survival across years observed on Dry Creek from 2001 to 2010, Malheur County, Oregon. Note: Data in table only includes frogs captured along the normal transect route.

Life Stage		Cohort/"Birth" year												
		1998 cohort	**1999 cohort**	**2000 cohort**	**2001 cohort**	**2002 cohort**	**2003 cohort**	**2004 cohort**	**2005 cohort**	**2006 cohort**	**2007 cohort**	**2008 cohort**	**2009 cohort**	**2010 cohort**
1st year of life	**Egg masses**	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	**12 masses**, at least 6,000 individuals	Unknown	Unknown	Unknown	**13 masses**, at least 6,500 individuals	Unknown	**70 masses**, at least 35,000 individuals
1st year of life	**Metamorph** (Gosner stage 47 to 45mm in August)	Unknown	Unknown	Unknown	(2001 survey) **37**	(2002 survey) **71**	(2003 survey) **98**	(2004 survey) **223***	(2005 survey) **100**	(2006 survey) **152**	(2007 survey) **225**	(2008 survey) **301**	(2009 survey) **1967***	(2010 survey) **2,941**
2nd year of life	**Subadult** (39-60mm in June; no males over 53mm; females to 69mm in August)	Unknown	Unknown	(2001 survey) **41**	(2002 survey) **34**	(2003 survey) **54**	(2004 survey) **84**	(2005 survey) **148**	(2006 survey) **30**	(2007 survey) **125**	(2008 survey) **370**	(2009 survey) **684**	(2010 survey) **1,187**	
3rd year of life	**Adult** (females 61-75mm in June; females 70-75mm in August; males 54-57mm)	Unknown	(2001 survey) 3 females 0 males **3**	(2002 survey) 7 females 3 males **10**	(2003 survey) 11 females 3 males **14**	(2004 survey) 18 females 8 males **26**	(2005 survey) 16 females 6 males **22**	(2006 survey) 19 females 11 males **30**	(2007 survey) 8 females 8 males **16**	(2008 survey) 42 females 24 males **66**	(2009 survey) 93 females 46 males **139**	(2010 survey) 98 females 94 males **192**		
4th + year of life	**Adult** (females 76+ mm; males 58+ mm)	(2001 survey) 4 females 3 males **7**	(2002 survey) 1 female 1 male **2**	(2003 survey) 0 females 3 males **3**	(2004 survey) 1 female 1 male **2**	2005 survey) 0 females 0 males **0**	(2006 survey) 1 females 4 males **5**	(2007 survey) 2 females 6 males **8**	(2008 survey) 3 females 17 males **20**	(2009 survey) 16 females 36 males **52**	(2010 survey) 11 females 44 males **55**			

*** entire transect not surveyed due to time constraints**

Using the data from Table 6, a graph can show the survivorship of cohorts across years and the life stages where mortality is greatest for all age classes. Figure 27 shows cohort survival between age classes for the life of the study. However, only seven cohorts (i.e., 2001 through 2007) can be tracked from the metamorph through the 4+ adult age class because the survey has only ten years of data.

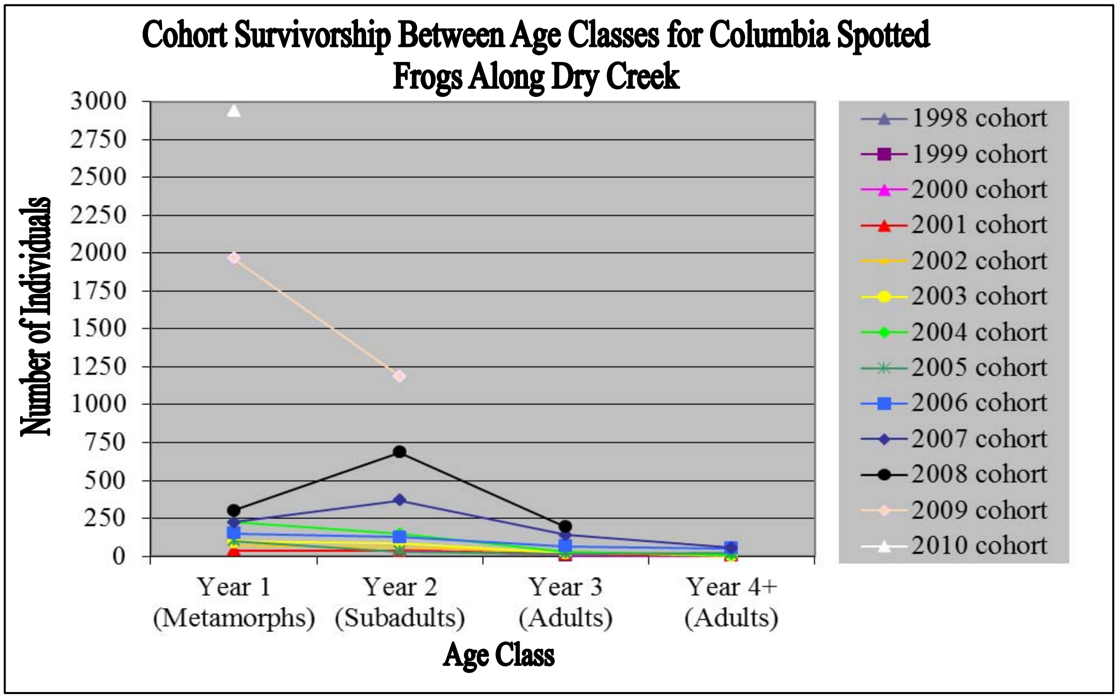

Figure 27. Columbia spotted frog cohort survivorship observed along the entire transect on Dry Creek from 2001 to 2010, Malheur County, Oregon.

This study indicates low adult survivorship for spotted frogs in Dry Creek, with an increasingly lower survival rate as the cohort ages and an extremely low number of frogs surviving to the 4+ adult age class. The adult survival is also highly variable, ranging from 0 percent to almost 79 percent (excluding one year with 125 percent survival). The variability in the survivorship of cohorts is again most likely caused by factors such as precipitation, temperatures, and habitat conditions (both summer and overwintering habitats) (Reaser 2000).

4.4.2 Longevity

The lifespan of spotted frogs can be seven to nine years (Engle 2001). Turner (1960) found the lifespan of spotted frogs to be nine years for males and up to twelve years for females. Data from this study indicate the oldest captured male survived to at least five years of age and the oldest female captured survived to at least seven years of age (exact ages could not be determined since both frogs were adults at first capture). The number of frogs reaching these ages in extremely low. Of the 2,536 spotted frogs captured and PIT-tagged throughout the life of the study, nine percent reached adulthood (three years of age or older). Only a total of 230 frogs have been documented to be at least three years of age throughout the life of the study. This is a minimum estimate, however, because not all adults are captured each year. Figure 28 depicts the number of frogs reaching the three and older age class for the life of the study.

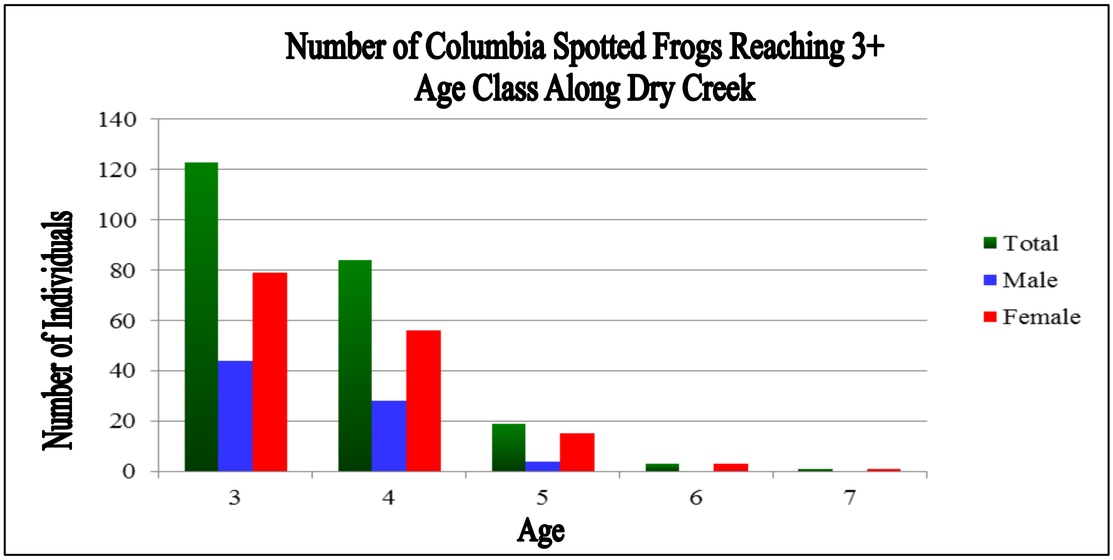

Figure 28. Number of Columbia spotted frogs, by gender, reaching three years of age and along Dry Creek from 2001 to 2010, Malheur County, Oregon.

In addition, Engle (2001) documented the earliest breeding age for Great Basin spotted frogs to be age three for males and age four for females in the Owyhee Uplands. Given the few spotted frogs that survive to breeding age, it is important to manage for increasing adult survivorship in order to ensure the long-term persistence of spotted frogs in Dry Creek.

Figure 29 shows each age class and gender present in the population (all frogs recorded along survey routes) each year. In most years, more females have been recorded along the transect route than males. These data are similar to the results Turner (1960) found in Wyoming where older females outnumbered older males by a ratio of 3.5 to 1, although the results of this study show an average of 1.6 times more females than males documented each year.

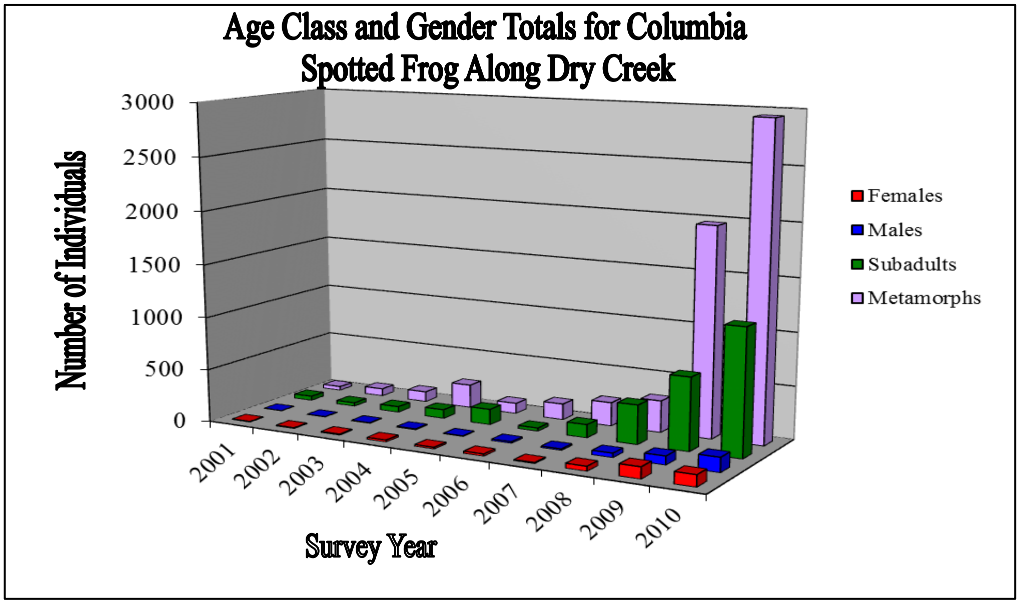

Figure 29. The total of each age class present in the Columbia spotted frog population along Dry Creek from 2001 to 2010, Malheur County, Oregon.

4.5 Predation

Populations can also be influenced by predation. The most common predators of spotted frogs include bass (*Micropterus*), non-native salmonid species (*Oncorynchus*, *Salmo* and *Salvelinus*), American bullfrogs (*Rana catesbeiana*), common carp (*Cyprinus carpio*) and other non-native species (USDI 2010). However, garter snakes are also among the known predators for spotted frogs. Effects of predation are difficult to document, although negative effects of predation on frog populations have been documented (Knapp and Matthews 2000, Pilliod and Peterson 2001, Knapp 2005, Reaser 2000, Bull and Hayes 2000).

Snake numbers have been documented during the mark-recapture surveys each year since 2001 in an attempt to determine if predation is an important factor in spotted frog survival along Dry Creek. The results of this study indicate that predator numbers are cyclic and do not appear to be closely related to spotted frog numbers. However, using the data collected from this survey effort, very few, if any, conclusions can be made as to the effect snake numbers may have on the spotted frog population in Dry Creek.

4.6 Movement Patterns

Spotted frogs have been documented to migrate between seasonal habitats and for dispersal reasons. These movements vary with elevation, season, age and gender. Movement occurs both during the day (foraging and basking) and at night (dispersal and migration) (Tait 2007). Movement distances of spotted frogs have been documented up to 6,500 m; however, most movements are less than 100 m (Engle 2001). Therefore, it is important to determine movement characteristics of a given population to avoid unintentional impacts from management actions (Tait 2007). Results of this study show that while, 2,536 individual frogs have been PIT-tagged over the life of the study, no PIT-tagged frogs have been documented outside the annual survey route.

4.6.1 Movement Within the Annual Transect

Recapture data can also be used to help evaluate movement patterns of Dry Creek spotted frogs. Since 2001, there have been 230 frogs that have been captured in multiple years along the transect route. Of those frogs, only 61 frogs have been captured across three or more years. Based on straight line distances between GPS points, distances traveled varied from 0 m to 733 m for both males and females. Males traveled up to 617 m, with an average distance traveled of 62 m. Females traveled up to 733 m, with an average distance traveled of 61 m.

Of the 230 recaptured frogs, 71 individual frogs were documented to move over 100 meters during the life of the survey, indicating spotted frogs can, and do, travel upstream and downstream along Dry Creek. However, when extended surveys were completed in 2006 and 2008, no frogs that were originally captured along the annual transect were detected outside the annual survey transect. Therefore, the distances adult spotted frogs move in Dry Creek are most likely a result of traveling between breeding, foraging and overwintering sites rather than dispersal distances. The extent to which out-migration occurs across different age class, if at all, is unknown.

4.6.2 Movement Outside the Annual Transect

Extended surveys were conducted in 2006 and in 2008 to document presence of PIT-tagged frogs outside the annual transect. Figure 30 shows the extended survey locations.

The 2006 extended surveys were conducted in June on Butte Creek and reaches of Dry Creek immediately upstream and downstream of the annual survey transect. Butte Creek (tributary to Dry Creek) was surveyed until the channel no longer had surface flow and was isolated from potential frog habitat upstream (approximately 0.5 miles). Although there were several pockets of suitable-looking habitat along Butte Creek, only one spotted frog was observed and it was not PIT-tagged. Six frogs were captured during the survey of an approximate one-mile reach immediately upstream from the BLM transect. None of these frogs had been PIT-tagged. This section of Dry Creek had narrow stream channels with alternating shallow to deep pools; similar habitat to the annual transect.

In addition, twenty-eight frogs were captured (none previously PIT-tagged) and a breeding site was confirmed during the extended survey downstream from the State transect for approximately one mile. The habitat downstream of the annual transect was much different (in better condition) than that observed in the survey area, possibly due to a different grazing regime. The effects of the high water event were not as evident in this section of Dry Creek, the floodplain did not show signs of scour and there was more dense vegetation. In some areas, boulders were found across the valley floor, similar to that found in the State transect, but oxbow pools were not created from diverted energy. This reach contained good spotted frog habitat conditions for breeding and summer use; however, few potential overwintering sites were observed. In addition, the water was clear and frogs were more abundant than any other reaches surveyed in 2006.

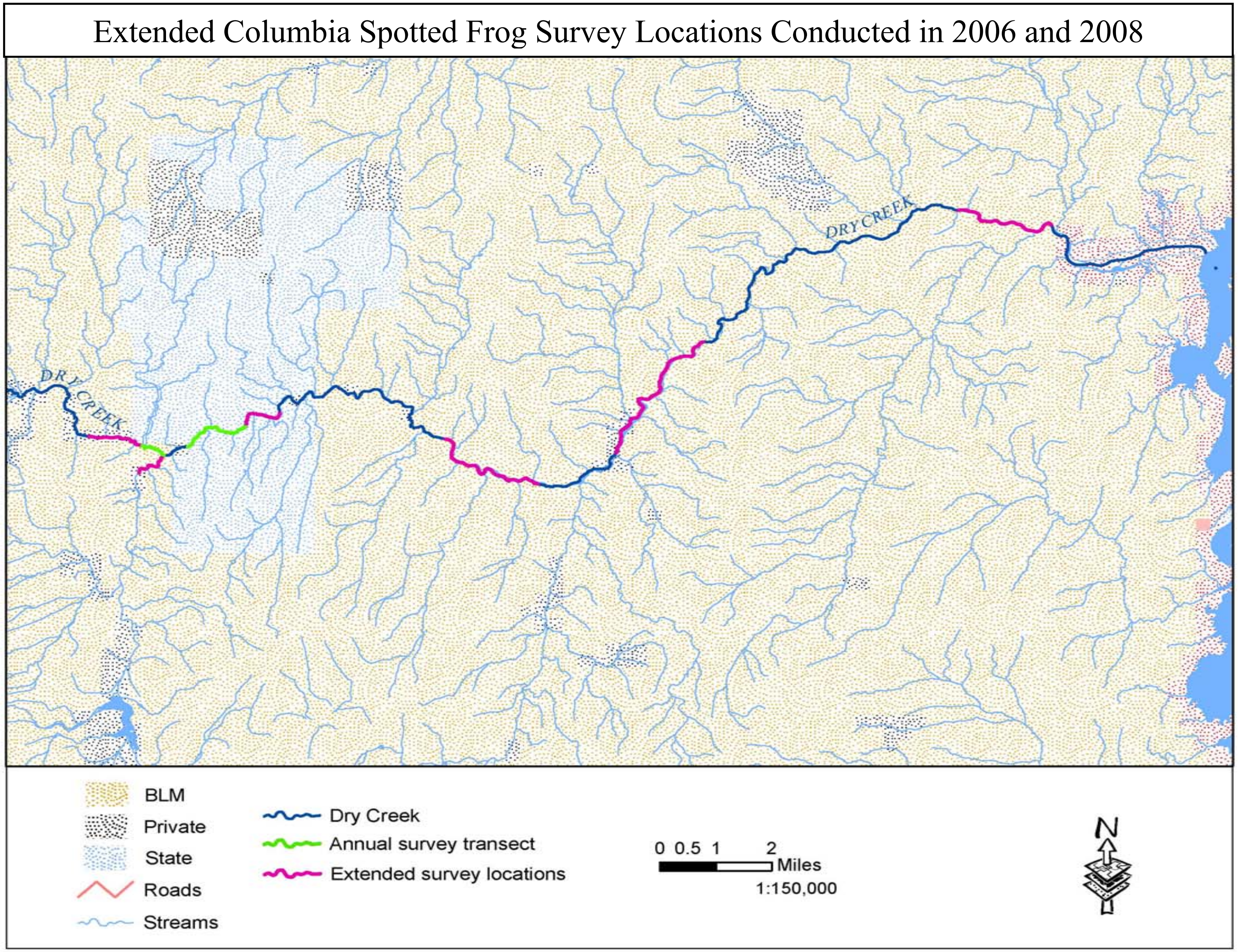

Figure 30. Columbia spotted frog extended survey locations for 2006 and 2008 along Dry Creek, Malheur County, Oregon.

In June 2008, additional extended surveys were conducted (along three separate reaches) to document presence of spotted frogs along lower portions of Dry Creek. The stream reach from Indian Trails (just below the Gorge) downstream for approximately two miles contained good spotted frog habitat conditions for breeding and summer use; however, few potential overwintering sites were observed. Aquatic habitat was uniform and well-connected. A total of 123 frogs were observed during the survey (8 females, 106 subadults, and 9 uncaptured frogs). Spotted frog tadpoles were also documented within this reach of Dry Creek. However, no PIT-tagged frogs were observed or captured during this survey.

The reach of Dry Creek, starting at Hurley Springs and continuing downstream approximately three miles, also contained good breeding and summer use habitats and few potential overwintering sites. Aquatic habitat was uniform and well-connected throughout this reach, as well. A total of 19 spotted frogs were observed during the survey (2 males, 12 subadults, and 5 uncaptured frogs). No PIT-tagged frogs were observed or captured during this survey.

A third reach from The Corrals on Dry Creek upstream for approximately 1.5 miles was also surveyed. No spotted frogs or tadpoles were documented along this stretch of Dry Creek. Large carp were present in most pools along this stretch of stream; carp were the only fish documented. Additionally, there was no algae present along this stretch of stream to act as hiding cover for spotted frogs. Stream flows along this section of Dry Creek are very minimal in late July and August, making poor habitat condidtions for spotted frogs.

In conclusion, although several frogs have been documented to move over 100 meters with the annual survey transect, no frogs that were originally captured along the annual transect have been detected outside the annual survey transect. This suggests that frogs captured on the BLM and State transects, remain within those transects. More studies should be conducted to determine if frogs stay in the transect area as a result of more favorable habitat conditions within the transect or from other factors.

5. Conclusions

This study indicates that the Dry Creek spotted frog population may be cyclic. The cycle is most likely a result of many factors working together, including precipitation amounts, timing of precipitation, condition of the habitat, the habitat's ability of the habitat to withstand disturbances. Additionally, overwintering sites are limited along Dry Creek. The current condition of Dry Creek may be limiting the number of suitable overwintering sites and the suitability of these overwintering sites may vary from year to year depending on the timing and intensity of grazing, timing and intensity of high-flow events, and other factors. Suitable breeding sites are widespread, but many are not being used; therefore, breeding sites are not considered a limiting factor.

This study also indicates low spotted frog adult survivorship, with an increasingly lower survival rate as the cohort ages. An extremely low number of frogs survive to the 4+ age class and the breeding age. Variability in the survivorship of cohorts is most likely caused by factors such as summer and overwintering habitat conditions, precipitation, and temperature.

Another factor that may be affecting the Dry Creek population, but was not analyzed in this study is Chytridiomycosis (Chytrid fungus). Chytrid fungus was found to be present in the Dry Creek population in 2006 (Engle 2006), but the extent of this outbreak was not studied.

In conclusion, the population trend of spotted frogs in Dry Creek is unknown at this time. It is unclear whether there is an overall increasing trend in the frog population or if the recent increase in the number of spotted frogs is a peak in the overall population cycle. The likelihood of long-term persistence of spotted frogs in Dry Creek is also unclear at this time given the low adult survivorship and the number of frogs that survive to the breeding age. More survey years are needed to infer trend and long-term persistence. Additional years of monitoring population levels and trends would be beneficial to determine a stronger link between climate variables and survival.

The following are recommendations to be considered for future years:

1. Continue monitoring the Dry Creek spotted frog population. Changes in study design may be needed to address questions on effects of weather, land management, disease and other remaining questions.

2. Consider enlargements of the exclosures if the current, small exclosures appear to be beneficial and create diverse and reliable frog habitat.

3. Change the grazing management along Dry Creek if improvements in the condition of the stream and related riparian habitat are needed (e.g., winter-use grazing has proven beneficial along Dry Creek on BLM-managed lands downstream).

4. Conduct additional, and more frequent, egg mass surveys to document breeding sites (as weather permits).

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APPENDIX I
Habitat Ratings
FROM:

Platts W. S. 1987. Methods for evaluating riparian habitat with applications to management. USFS Intermountain Forest and Range Experiment Station. Ogden, Utah. GTR INT-221.

Streambank stability rating (SSAR)

Rating (%)	Description
0	Streambanks are stable and are not being altered by water flows, animals, or other factors.
1-25	Streambanks are stable, but are being lightly altered along the transect line. Less than 25% of the streambank is receiving any kind of stress and if stress is being received, it is very light. Less than 25% of the streambank is false, broken down, or eroding.
26-50	Streambanks are receiving only moderate alteration along the transect line. At least 50% of the streambank is in a natural stable condition. Less than 50% of the streambank is false, broken down, or eroding. False banks are rated as altered. Alteration is rated as natural, artificial, or a combination of the two.
51-75	Streambanks have received major alteration along the transect line. Less than 50% of the streambank is in a stable condition. Over 50% of the streambank is false, broken down, or eroding. A false bank that may have gained some stability and cover is still rated as altered. Alteration is rated as natural, artificial, or a combination of the two.
76-100	Streambanks along the transect line are severely altered. Less than 25% of the streambank is in a stable condition. Over 75% of the streambank is false, broken down, or eroding. A past damaged bank, now classified as a false bank, that has gained some stability and cover is still rated as altered. Alteration is rated as natural, artificial, or a combination of the two.

Vegetation use by animals (VUBA)

Rating (%)	Description
0-25 (light)	Vegetation use is very light or none at all. Almost all of the potential plant biomass at present stage of development remains. The vegetative cover is very close to that which would occur naturally without use. If bare areas exist (i.e., bedrock), they are not because of loss of vegetation from past grazing use.
26-50 (moderate)	Vegetation use is moderate and at least one-half of the potential plant biomass remains. Average plant stubble height is greater than half of its potential height at its present stage of development. Plant biomass no longer on site because of past grazing is considered as vegetation that has been used.
51-75 (high)	Vegetative use is high and less than half of the potential plant biomass remains. Plant stubble height averages over two inches. Plant biomass no longer on site because of past grazing is considered as vegetation that has been used.
76-100 (very high)	Use of the streamside vegetation is very high. Vegetation has been removed to two inches or less in average stubble height. Almost all of the potential vegetative biomass has been used. Only the root system and part of the stem remains. That potential biomass that is now non-existent because of past elimination but grazing is considered vegetation that has been used.