Characterization of Boreal Toad Breeding Habitat in Utah

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February 2017
Utah Geological Survey
Utah Department of Natural Resources
Salt Lake City, UT
A contract deliverable for the Utah Department of Natural Resources,
Endangered Species Mitigation Fund

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Cover: Adult boreal toad swimming over the macroalgae *Chara* near the East Fork of the Bear River on the North Slope of the Uinta Mountains.

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Introduction

The Utah Geological Survey (UGS) coordinated with biologists at the Utah Division of Wildlife Resources (UDWR) in spring 2016 to facilitate collection of uniform data statewide at boreal toad (*Anaxyrus boreas*) survey sites. Recommendations for data collection were derived from research conducted by the UGS in 2015 at 16 active and no longer active ("recent") boreal toad breeding sites in northeastern Utah (Menuz, 2016). We found that active breeding sites were more likely to have submerged or floating aquatic vegetation than recent breeding sites and that qualitative habitat metrics derived from the Western (Boreal) Toad Ecological Integrity Table (Oliver, 2006) were effective at separating breeding sites from random wetland sites. We hypothesized that aquatic vegetation may directly provide habitat or food for boreal toad or may be an indicator of favorable conditions such as pH, temperature, nutrient levels, and water clarity. The 2015 study also found a trend towards more nutrients and higher turbidity at recent breeding sites that warranted further study.

The UGS developed a standardized field form in spring 2016 to determine whether trends in northeastern Utah applied statewide and to begin tracking site characteristics that may be useful for capturing future changes. The field form includes information on both general site characteristics and specific waterbodies (appendix A). General characteristics include the breeding status, chytrid status, population trend, stressors, site description, and a series of qualitative habitat metrics. Individual waterbody data include information about toads in each waterbody, waterbody type and size, distribution of water depths, presence of aquatic vegetation and algae, stressors immediately adjacent to the waterbody, and measurements of turbidity, pH, electroconductivity, and temperature. The goals of this report are to evaluate whether the 2015 trends hold up statewide and to summarize characteristics to provide a better understanding of breeding site attributes and condition.

Methods

The statewide boreal toad field form and instructions for use were developed by the UGS in spring 2016 (appendix A). Biologists for UDWR conducted a total of 78 surveys at 61 sites between May 19 and August 2, 2016. Most sites were only surveyed once, though 16% of sites, mostly in the central region, were surveyed two or three times. Both the site characteristic and waterbody data were usually collected at each survey when sites were surveyed multiple times, though the original intention of the protocol was for the general characteristics to be collected once per year. At a few sites, only one of the two data types was collected. At the end of the field season, we contacted UDWR biologist to verify the breeding status and chytrid status of each site. We also requested a complete list of all sites having documented breeding.

Sites were categorized into four breeding status categories: current, active, recent, and non-breeding. Collectively, the first three site types are referred to as breeding sites. Current sites had documented breeding in 2016, active sites had documented breeding between 2011 and 2015, and recent sites had documented breeding between 1997 and 2010. Non-breeding sites included sites with confirmed adult toad sites but no documented breeding, exploratory sites with no known toad populations, and four sites with breeding recorded over 20 years ago. We obtained survey data from 67% of the 21 current sites, 61% of 18 active sites, 47% of 30 recent sites, and 64% of the 36 non-breeding sites. We obtained data from 100% of the breeding sites in the two regions with the fewest sites and data from about 50% of the sites in the northern and southern regions, which each had about 30 breeding sites (table 1). Figure 1 shows regions and site locations discussed in this report.

Data were entered into a database by UGS employees and QA/QC'ed for consistency and completeness. Non-metric general site characteristic data were generated for sites with missing data and combined into a single record for sites having more than one record. ArcGIS and UDWR personnel inquiries were used to create the general characteristic data and address inconsistencies. Habitat metric data were collected at 52 sites and collected more than once at 10 of those sites. Waterbody data were collected at 60 sites; all but three of these sites had water quality measurements of temperature, pH, or

Table 1. Number of documented boreal toad breeding sites in Utah by breeding status and region, and percent of sites surveyed by the UDWR in 2016 following the standardized UGS protocol.

Regions	Current		Active		Recent	
	# sites	% Surveyed	# sites	% Surveyed	# sites	% Surveyed
Central Region	**3**	**100.0%**	**0**	**NA**	**4**	**100.0%**
Strawberry Reservoir	1	100.0%	0	NA	4	100.0%
Little West Fork	1	100.0%	0	NA	0	NA
Little Cottonwood Canyon	1	100.0%	0	NA	0	NA
Northern Region	**11**	**45.5%**	**5**	**60.0%**	**13**	**61.5%**
Bear River Range[1]	0	NA	1	0.0%	2	0.0%
Grouse Creek Mountains	6	33.3%	2	50.0%	1	100.0%
Monte Cristo Range	1	100.0%	2	100.0%	8	87.5%
Uinta Mountains[1]	4	50.0%	0	NA	2	0.0%
Southeastern Region	**1**	**100.0%**	**0**	**NA**	**0**	**NA**
East Mountain	1	100.0%	0	NA	0	NA
Southern Region	**6**	**83.3%**	**13**	**61.5%**	**13**	**25.0%**
Boulder Mountain	1	100.0%	1	100.0%	1	0.0%
Monroe Mountain[2]	1	100.0%	10	60.0%	6	33.3%
Paunsaugunt Plateau[3]	1	100.0%	1	0.0%	5	0.0%
Thousand Lake Mountain[2]	3	66.7%	1	100.0%	1	0.0%
Total	**21**	**66.7%**	**18**	**61.1%**	**30**	**46.7%**

[1]One active and two recent sites in the Bear River Range and one breeding and one recent site in the Uinta Mountains were surveyed by the UGS in 2015 using a slightly different protocol. These sites were not included in the percent surveyed.

[2]Recent sites include four sites on Monroe Mountain and one site at Thousand Lake Mountain that had breeding documented between 2000 and 2002 that have only been surveyed one or fewer times since; actual breeding status of these sites is unknown due to lack of survey data.

[3]Includes four recent sites that no longer have breeding habitat available due to decline of beaver in the area and resulting pond degradation.

electroconductivity from a multi-parameter meter. Data were collected from one waterbody per site at most sites, but 17 sites had data recorded for two to four waterbodies. Samples sizes for analysis varied due to missing data.

The following is a brief summary of findings of interest with a focus on the breeding sites, though two important caveats must be noted. *First, UDWR personnel received minimal instructions and training so there may be some regional and individual variation in how data were collected.* Personnel from each region received field instructions which included detailed directions for collecting field data, a link to directions for using a turbidity tube, cover class diagrams to assist with estimating aquatic vegetation cover, and a guide to identifying major aquatic vegetation and algae groups. However, personnel from each region never met with one another or with UGS personnel to conduct field training and calibrate qualitative portions of the protocol. *Second, breeding status classifications are based on memory, imperfect records, and variable site survey schedules, so some sites may be misclassified*. All

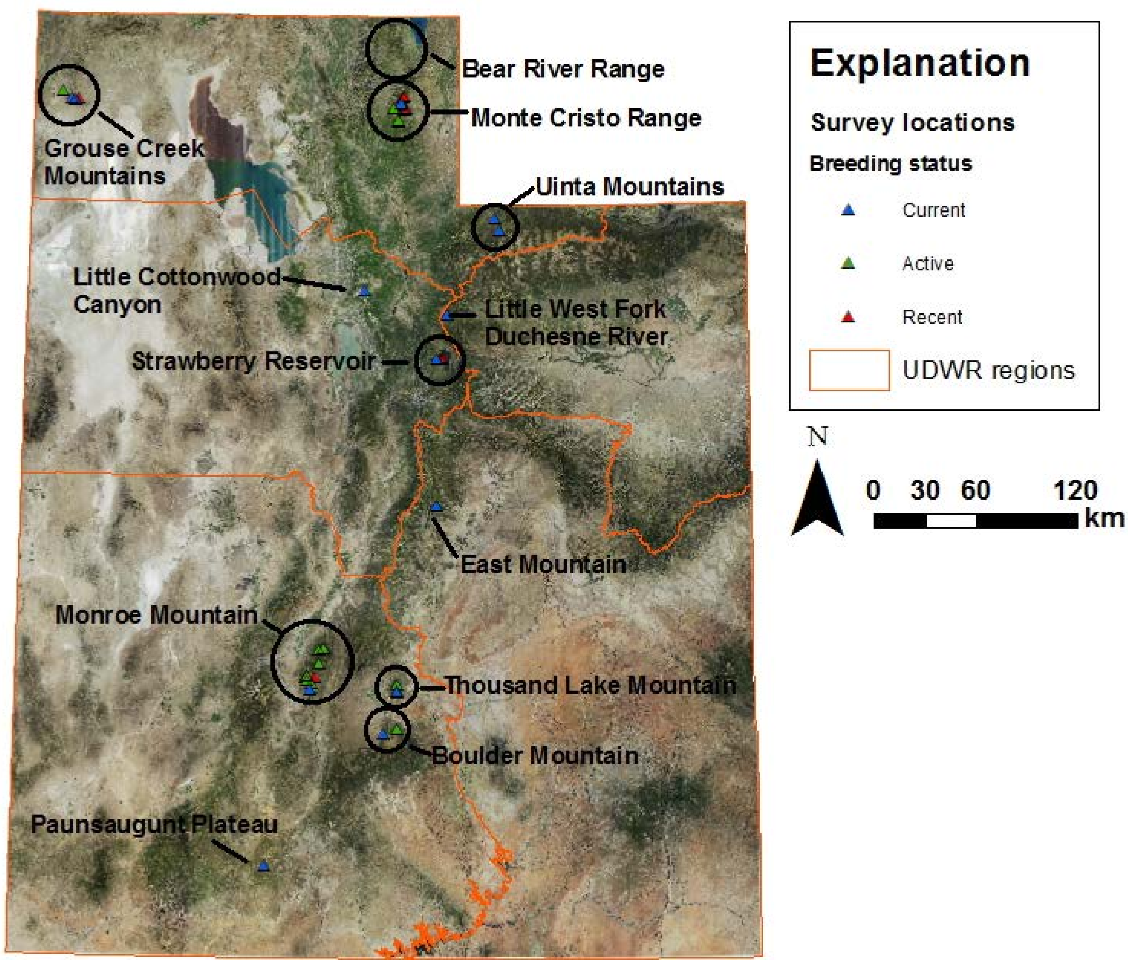

Figure 1. Overview map of survey regions referenced in table 1 within the Utah Division of Wildlife Resources (UDWR) regions. Sites surveyed by the UDWR following the uniform protocol in 2016 are shown for reference, though some points may be obscured due to clustering. The Bear River Range is shown despite a lack of surveyed sites because the region is mentioned in table 1.

current breeding sites should be correctly classified, but some active sites may actually have had breeding in 2016 and either were not surveyed that year or were not surveyed at the right time of year. Similarly, some recent breeding sites may be surveyed too infrequently to determine whether breeding has indeed been extirpated from the sites. At least five sites in the southern region fall into this latter category because they have only been surveyed once or less since breeding was originally documented in the early 2000s. Furthermore, the threshold separating active and recent sites is arbitrary; some active sites may now be extirpated and some recent sites may continue to have breeding. Despite these limitations, this research is an important first step towards creating uniform statewide data to assess boreal toad breeding habitat attributes and condition.

Results

Habitat Evaluation

Six habitat metrics were used to qualitatively rate different aspects of boreal toad habitat on a scale from A to D. Metrics evaluated waterbody type, presence of north shore, slope and water depth, hibernation features, presence of surrounding understory forming vegetation, and temperature. Surrounding vegetation was ranked separately for shrubs and for tall forbs, but combined to create the final vegetation metric. Sites having an overabundance of either shrubs or tall forbs were scored as the lowest ratings of the two measures and sites having an under-abundance of both were scored as the highest of the two ratings. The temperature metric was scored in the office using the highest recorded temperature value at each site with temperature thresholds from Oliver (2006). Alphabetical ratings were converted to numeric ratings; A = 5, B = 4, C =3, and D = 1. Values were averaged across site visits at sites where metric data were collected more than once. An overall habitat score was calculated by taking the mean value of all six metrics. Data from five sites surveyed by the UGS in 2015 using similar methods were included in analysis (see table 1).

The mean overall habitat score was 4.4 at current sites ($n = 13$), 4.2 at active sites ($n = 11$), and 4.1 at recent sites ($n = 17$, figure 2). We used one-sided t-tests to evaluate whether current sites had higher scores than active and recent sites and whether active sites had higher scores than recent sites. Current sites had higher scores than recent sites ($p = 0.002$); no other comparisons were significant. All current sites had scores of at least 4.0; 95% of all breeding sites had scores of 3.8 or higher.

Mean values for each individual metric at current sites was always higher than mean values at recent sites, though one-sided t-tests were only significant for hibernation features ($p < 0.001$). The mean hibernation metric value at current sites was 4.9 versus 4.2 at recent sites. The surrounding vegetation metric had the second largest difference in mean scores between current and recent sites (4.2 versus 3.8), though differences for this and all other metric comparisons were not significant. However, the overall habitat scores still differed between current and recent sites when the hibernation metric was dropped and the score recalculated ($p = 0.03$), suggesting that differences in the habitat score were not solely driven by the hibernation metric.

Potential Stressors

Stressors were recorded for the overall site and when a site was located within 30 m of a measured waterbody. Stressors were only evaluated for sites surveyed by UDWR in 2016. We tested for

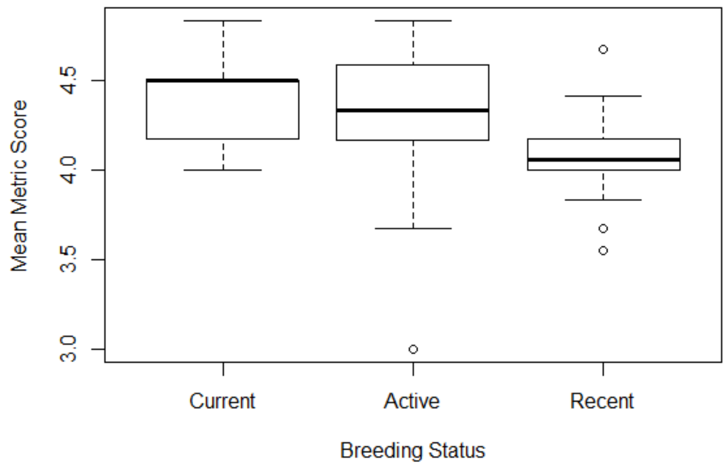

Figure 2. Mean habitat metric scores at current, active, and recent boreal toad breeding sites. Boxplot includes data collected in 2016 by UDWR and data collected in 2016 by the UGS

differences in the proportion of sites having each stressor at current and recent sites using the Fisher exact test. None of the overall site stressors differed significantly between current and recent sites. Common stressors at current and active sites include livestock grazing, roads, artificial berms, and potential predators (table 2). Surveyors also noted concerns regarding dewatering trends at three sites, including one in the Monte Cristo Range and two in the Grouse Creek Mountains. Recreational use in addition to adjacent trails was noted as a potential stressor at five sites.

Stressors within 30 m of waterbodies were recorded separately for each waterbody measured at a site. For our analysis, we used simple presence/absence information rather than estimating stressor prevalence. Recent sites were more likely to have turbid-appearing water than current sites ($p = 0.03$). The proportion of sites having other stressors adjacent to waterbodies did not significantly differ (table 3), though recent sites were more likely to have at least one sediment stressor (ATV track, road, unnatural bare soil) compared to current sites ($p = 0.04$). About two-thirds of sites had evidence of livestock grazing adjacent to at least one waterbody; grazed vegetation, deep tracks, and livestock manure were all relatively common. Other common waterbody stressors included ATV tracks, roads, unnatural bare soil, and potential predators.

We summarized stressor data for current and active breeding sites for regions that had at least two sites (Grouse Creek Mountains, Monte Cristo Range, Uinta Mountains, Boulder Mountain, Monroe Mountain, Thousand Lake Mountain) to better understand the spatial distribution of threats (tables 4 and 5). Hydrologic manipulations such as berms, control structures, and excavation were most common in the Grouse Creek Mountains, Monte Cristo Range, and Uinta Mountains and to a lesser degree Monroe Mountain. Sites in the Uinta Mountains and Grouse Creek Mountains were most likely to have roads within 30 m of waterbodies, and sites in the Monte Cristo Range and Uinta Mountains were most likely to have hiking trails and ATV tracks within 30 m of waterbodies. Over 50% of sites within each region were subject to livestock grazing; all of the sites in the Monte Cristo Range and Monroe Mountain had some evidence of grazing within 30 m of waterbodies. Predacious fish were observed at all sites in the Uinta Mountains, most at Monroe Mountain, and none elsewhere. Tiger salamanders were detected

Table 2. Percent of sites by breeding status with each potential overall site stressor.

Breeding status	Current	Active	Recent	Overall
Number of sites	**14**	**11**	**14**	**39**
Roads and Trails within 100 m				
Up-gradient dirt road	64.3%	36.4%	64.3%	56.4%
Up-gradient pavement	7.1%	0.0%	28.6%	12.8%
Non-motorized recreation trail	28.6%	9.1%	50.0%	30.8%
Livestock Grazing				
Livestock grazing	57.1%	72.7%	64.3%	64.1%
Unknown status of livestock grazing	21.4%	0.0%	21.4%	15.4%
Hydrologic Modification				
Excavation	28.6%	9.1%	0.0%	12.8%
Water level control structure	0.0%	18.2%	21.4%	12.8%
Artificial berm or dike	50.0%	45.5%	57.1%	51.3%
Ditching or draining	7.1%	0.0%	7.1%	5.1%
Potential Predators				
Fish or salamander known to occur	64.3%	81.8%	64.3%	69.2%
Predacious fish present	35.7%	45.5%	42.9%	41.0%
Tiger salamander present	35.7%	36.4%	21.4%	30.8%
Unknown tiger salamander status	42.9%	54.5%	57.1%	51.3%

Table 3. Percent of sites by breeding status having each potential stressor present within 30 m of at least one waterbody.

Stressor	Current	Active	Recent	Overall
Number of Sites	**14**	**11**	**14**	**39**
No stressors recorded	7.1%	9.1%	0.0%	5.1%
Hiking trail	14.3%	9.1%	42.9%	23.1%
Turbid-appearing water	7.1%	9.1%	50.0%	23.1%
Any sediment stressor (of 3 below)	64.3%	63.6%	100%	76.9%
ATV track	42.9%	27.3%	42.9%	38.5%
Road	57.1%	9.1%	71.4%	48.7%
Unnatural bare soil	28.6%	27.3%	50.0%	35.9%
Any livestock indicator (of 3 below)	**64.3%**	**72.7%**	**64.3%**	66.7%
Grazed vegetation	50.0%	54.5%	35.7%	46.1%
Tracks > 13 cm deep	64.3%	63.6%	35.7%	53.8%
Livestock manure	50.0%	63.6%	57.1%	56.4%
Any aquatic predator (of 2 below)	**50.0%**	**72.7%**	**57.1%**	59.0%
Predacious fish	35.7%	45.5%	42.9%	41.0%
Tiger salamander	14.3%	36.4%	14.3%	20.5%

Table 4. Percent of sites with potential overall site stressors, by region, for current and active breeding sites in regions having at least two records. The number of sites with data and total number of current and active breeding sites per region are indicated.

Region	Grouse Creek Mountains	Monte Cristo Range	Uinta Mountains	Boulder Mountain	Monroe Mountain	Thousand Lake Mountain
# of Sites with Data / Total # of Sites	**3/8**	**3/3**	**2/4**	**2/2**	**7/11**	**3/4**
< 100 m from road	66.7%	33.3%	100.0%	50.0%	71.4%	33.3%
Trail	33.3%	33.3%	50.0%	0.0%	0.0%	0.0%
Livestock	66.7%	100.0%	Unknown	50.0%	100.0%	66.7%
Predacious fish[1]	0.0%	0.0%	100.0%	0.0%	71.4%	0.0%
Tiger salamanders	0.0%[2]	100.0%	50.0%[3]	50.0%[4]	14.3%[3]	66.7%[3]
Berm	66.7%	100.0%	100.0%	0.0%	57.1%	0.0%
Excavation	100.0%	0.0%	100.0%	0.0%	28.6%	0.0%
Control structures	0.0%	0.0%	0.0%	0.0%	28.6%	0.0%

[1]Fish records listed as either present or unlikely to occur.
[2]One site listed as unknown status; two listed as unlikely to occur.
[3]Remaining site(s) listed as unknown status.
[4]Remaining site listed as unlikely to occur.

Table 5. Percent of sites with potential stressors within 30 m of waterbodies, by region, for current and active breeding sites in regions having at least two records. The number of sites that have data and total number of current and active breeding sites per region are indicated.

Region	Grouse Creeks Mountains	Monte Cristo Range	Uinta Mountains	Boulder Mountain	Monroe Mountain	Thousand Lake Mountain
# of Sites with Data / Total # of Sites	**3/8**	**3/3**	**2/4**	**2/2**	**7/11**	**3/4**
No stressors recorded	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%
Hiking trail	0.0%	66.7%	50.0%	0.0%	0.0%	0.0%
ATV track	33.3%	66.7%	100.0%	0.0%	28.6%	33.3%
Road	66.7%	33.3%	100.0%	0.0%	28.6%	0.0%
Turbid-appearing water	33.3%	0.0%	0.0%	0.0%	14.3%	0.0%
Unnatural bare soil	66.7%	66.7%	100.0%	0.0%	14.3%	0.0%
Any livestock presence	**33.3%**	**100.0%**	**50.0%**	**50.0%**	**100.0%**	**66.7%**
Grazed vegetation	33.3%	0.0%	0.0%	50.0%	100.0%	66.7%
Tracks > 13 cm deep	33.3%	66.7%	50.0%	50.0%	100.0%	66.7%
Livestock manure	33.3%	33.3%	50.0%	0.0%	100.0%	66.7%
Any predator	**0.0%**	**66.7%**	**100.0%**	**50.0%**	**71.4%**	**66.7%**
Predacious fish	0.0%	0.0%	100.0%	0.0%	71.4%	0.0%
Tiger salamander	0.0%	66.7%	0.0%	50.0%	14.3%	66.7%

at between half and two-thirds of sites in the Monte Cristo Range, Boulder Mountain, and Thousand Lake Mountain and were uncommon elsewhere.

Aquatic Vegetation, Turbidity, and Nutrients

Menuz (2016) found that current and active breeding sites were more likely to have submerged or floating aquatic vegetation than recent breeding sites and suggested further research into the potential impacts of turbidity and nutrient addition on boreal toad breeding. Submerged aquatic vegetation can be an indicator of water quality conditions; some species are sensitive to increases in turbidity (e.g., Wersal and others, 2006) and nutrients (e.g., Dennison and others, 1993). Furthermore, recent sites in the 2015 study were more likely than current and active breeding sites to have soil disturbance and turbidity within sites and to have adjacent sedimentation stress from roads, trails, and rangeland. Recent sites also showed a trend towards higher total nitrogen levels than current and active sites and were more likely to have nuisance algae or more severe livestock manure. Increased nutrients and turbidity can negatively impact tadpoles (Woods and Richardson, 2009), though findings related to nitrogen addition are inconsistent (Marco and others, 1999).

Surveyors in 2016 estimated the percent of each waterbody having submerged aquatic, floating, and emergent vegetation, surface algae, and the macroalgae *Chara*, using four broad cover classes: (none, <1%, 1–10%, and >10%). UGS surveyors in 2015 estimated the absolute percent cover of individual species; data were later summarized into functional groups and cover classes for the sake of comparison. We first looked at presence/absence of each "vegetation" class by calculating the percent of sites surveyed in 2015 or 2016 that had at least one waterbody during at least one site visit with a particular "vegetation" class recorded. A higher proportion of current and active sites had submerged aquatic vegetation and *Chara* than recent sites, and active sites were more likely to have floating vegetation than current and recent sites (table 6), though differences in vegetation were not significant based on Fisher exact tests. We next converted cover classes to the minimum value in the class; for example, 1 to 10% was converted to 1% and >10% was converted to 10%. Cover classes are more commonly converted to midpoints of each class, but we felt this was inappropriate due to the large range of the highest cover class. Using the most recent survey date, we used the mean values of all waterbodies to calculate mean minimum cover values at each site. Recent sites rarely had high cover of submerged aquatic vegetation, though differences by breeding status were not significant (figure 3).

Table 6. Percent of sites with particular classes of vegetation and algae present in at least one waterbody at site. Data combined from both UGS survey data in 2015 and UDWR survey data in 2016.

Characteristic	**Current**	**Active**	**Recent**	**Overall**
Vegetation Type	**n=15**	**n=12**	**n=17**	**n=44**
Submerged aquatic vegetation	71.4%[1]	83.3%	52.9%	67.4%
Floating vegetation	26.7%	66.7%	35.3%	40.9%
Chara	35.7%[1]	25.0%	17.6%	25.6%
Emergent	100%	100%	94.1%	97.7%
Surface algae	86.7%	75.0%	88.2%	84.1%

[1] Data available at only 14 sites due to missing data.

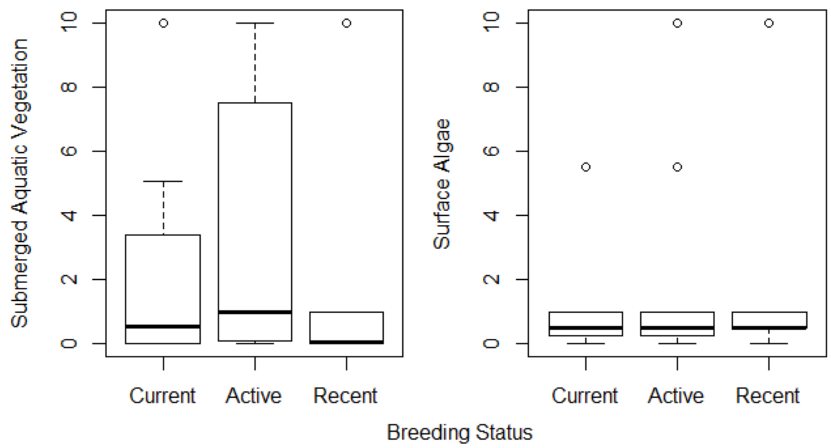

Figure 3. Mean minimum percent vegetation in water for current, active, and breeding sites. Cover class estimates were converted to the lowest value in the class and then mean values were taken across all waterbodies within the sites. For sites surveyed multiple times, only data from the most recent visit is shown.

We found some evidence that turbidity could be affecting breeding habitat, though turbidity effects may be confounded by regional differences. As discussed in the stressor section above, more recent sites had turbid-appearing water and potential sediment stressors near waterbodies than current breeding sites. Turbidity tube readings were taken at 16 sites in 2016 and 5 sites in 2015, sometimes more than one reading per site, for a total of 8 current, 4 active, and 9 recent sites. Most surveyors used tubes that could read up to 60 cm, so clarity could not be estimated beyond this threshold; 12.5% of current, 75% of active, and 77.8% of recent sites had at least one tube reading less than 60 cm. Some regions appear more affected by turbidity than others; half or more of the sites in all areas of the northern region except the Uinta Mountains had some evidence of turbidity, and turbidity was rarely noted in the southern region (turbidity tube measurements were not taken in this region).

There was no evidence of differences in nutrient levels affecting breeding habitat, though direct measures of water column nutrients were not taken. Similar proportions of current, active, and recent sites were adjacent to livestock manure (table 3), though measurements only noted presence/absence and not density. About 84% of all sites had at least some algae cover, with little difference in proportion by breeding status (table 6); most waterbodies had low algae cover (figure 3).

General Site Characteristics

We compiled chytrid status information for all current, active, and recent breeding sites in the northern, central, and southeastern regions and for sites surveyed in 2016 in the southern region. All tested sites in the Little West Fork of Duchesne River, Strawberry Reservoir, Monroe Mountain, and Paunsaugunt Plateau regions were positive for chytrid and all tested sites in Little Cottonwood Canyon, East Mountain, and Boulder Mountain regions were negative for chytrid. The Monte Cristo Range and Uinta Mountains have some positive and some negative sites. Of the tested sites on the compiled list, 41% of current sites, 50% of active sites, and 64% of recent sites tested positive (table 7). We have chytrid data for at least two-thirds of the current and active sites, but only 47% of the recent sites.

We used ArcGIS to classify breeding sites that were surveyed in 2016 into predominant site types, including stream segment (which sometimes included beaver ponds and small springheads), snowmelt and springhead ponds, wet meadows without any well-defined pools, and miscellaneous types. The majority of sites were composed of one or more small ponds that were either isolated (33.3%) or along small intermittent headwater drainages (23.1%). Ponds in the Grouse Creek Mountains and Monte Cristo Range were assumed to be predominantly spring-fed based on site names (e.g., Red Rock Springs) and site notes, and other ponds were assumed to be predominantly snowmelt-fed, though additional analysis would need to be conducted to determine actual origin of the water. About one-fourth of sites were classified as stream segment sites, including 43% of current breeding sites. Wet meadows and lakeshores (of Strawberry Reservoir) were less common (<10% of sites).

Surveyors recorded waterbody types that were present at each site they visited, regardless of whether they recorded data in a particular waterbody type. Waterbody types included active beaver pond, inactive beaver pond, stream/river backwater, springhead pool, temporary pool, permanent pond, and other. Current breeding sites frequently had more than one waterbody type listed per site and had the most sites with four or five listed types (table 8). Permanent ponds were the most common waterbody type, found at over 70% of sites. Beaver ponds and temporary pools were found at 43% and 36% of current breeding sites, respectively, and were somewhat less common at active and recent sites. Most recorded waterbodies had surface areas between 10 and 1000 m^2, though 20% of waterbodies were larger, including all of the waterbodies recorded on Monroe Mountain. Only four sites had waterbodies that were less than 10 m^2; these sites all had at least one larger waterbody as well. All waterbodies had at least some water that was <20 cm; shallow water was more prevalent at current and active sites than at recent sites (table 8). All but two sites had some water recorded that was greater than 20 cm in depth, and a little over half of the sites had at least some water with a depth more than 1 m.

We conducted exploratory analysis to look for regional trends in electroconductivity (EC) and pH because both water quality measurements are affected by bedrock geology and soil characteristics. We used only data from the latest site visit for sites that were visited multiple times and then took the mean value per site of each measurement. We included both breeding and non-breeding sites in this analysis. Boxplots of pH by region did not indicate any obvious regional differences for regions that had at least four measurements, whereas electroconductivity appeared to have more regional variation. We tested for differences in EC between regions for the four regions with the most sites (Monroe Mountain,

Table 7. Number of sites by chytrid and breeding status. All chytrid negative sites were tested within the last five years except for one breeding and four recent sites. Two breeding sites were tested in 2016, but results are not yet available. Data was not obtained for some sites in the southern region.

Breeding Status	Current	Active	Recent
Chytrid positive	7	6	9
Chytrid negative	10	6	5
Test results not available	3	1	5
Data not obtained	1	5	11

Table 8. Characteristics of waterbodies, by breeding status, including type, number of types per site, and waterbody size and depth.

Breeding Status	Current	Active	Recent	Overall
Number of sites	14	11	14	39
Number of waterbodies	34	14	23	71
Waterbody Types (Percent of all waterbodies)				
Active beaver pond	28.6%	0.0%	0.0%	10.3%
Inactive beaver pond	35.7%	27.3%	14.3%	25.6%
Beaver pond, any status	42.9%	27.3%	14.3%	28.2%
Stream backwater	28.6%	27.3%	21.4%	25.6%
Springhead pool	28.6%	18.2%	21.4%	23.1%
Temporary pool	35.7%	18.2%	7.1%[1]	20.5%
Permanent pond	71.4%	72.7%	78.6%	74.4%
Number of Waterbody Types Per Site (Percent of sites)				
One	42.9%	54.5%	71.4%	56.4%
Two to three	28.6%	45.5%	21.4%	30.8%
Four to five	28.6%	0.0%	7.1%	12.8%
Waterbody Size and Depth Characteristics (Percent of sites with characteristic)				
Largest waterbody <100 m^2	28.6%	30.0%[2]	50.0%	36.8%
Smallest waterbody >1000 m^2	14.3%	60.0%[2]	14.3%	26.3%
1+ waterbody 10 - 1000 m^2	85.7%	36.4%	85.7%	71.8%
Some water >1 m deep	57.1%	36.4%	71.4%	56.4%
1+ waterbody ≥20% of water <20 cm deep	71.4%	90.9%	57.1%	71.8%

[1]Includes one waterbody listed as other, seep or spring without pool.
[2]Only 10 sites with data available.

Strawberry Reservoir, Grouse Creek Mountains, and Monte Cristo Range) using analysis of variance and Tukey's Honest Significant Difference test to test for differences between region pairs ($p < 0.001$). EC values were highest in the Grouse Creek Mountains (mean = 586 uS, n = 4) and lowest on Monroe Mountain (mean = 60 uS, n = 11). Strawberry Reservoir (mean = 416 uS, n = 12) and Monte Cristo Range (mean = 308 uS, n = 11) sites differed from other sites but not one another. Although each region only had three sites or less sites to compare, EC measurements at Thousand Lake Mountain, Boulder Mountain, and Little Cottonwood Canyon trended towards lower values and measurements in the Uinta Mountains trended near the overall mean. We compared EC values at current and active breeding sites versus all other sites at Monroe Mountain and the Monte Cristo Range (figure 4). On Monroe Mountain, current/active sites had higher EC values than other sites based on a two-side t-test ($p = 0.03$). The current/active sites in the Monte Cristo Range had a non-significant trend towards higher EC values than other sites ($p = 0.13$).

We examined the distribution of mean electroconductivity and pH values from the most recent visit to sites by breeding status to better understand the range of conditions that may be suitable for boreal toad breeding. The distribution of EC and pH values did not differ significantly based on an analysis of variance test (p = 0.58 for pH and p = 0.21 for EC), though there was a slight trend towards higher EC values at current and recent breeding sites compared to active breeding sites (table 9, figure 5). This trend in EC is likely driven by the fact that over half of the active sites were located on Monroe Mountain, where EC values tended to be low, and half of the recent sites were located in the Monte Cristo Range, where EC values tended to be high. The median EC value for active and current sites was 231 uS, with 90% of the sites between 44 and 526 uS. The median pH value for active and current sites was 8.0, with 90% of the sites between 7.3 and 9.3. At the nine sites where measurements were taken directly adjacent to tadpoles or egg masses, mean pH values per site at those locations ranged from 7.3 to 9.9 with a median of 8.0 and mean EC values ranged from 44 to 407 with a median of 261 uS.

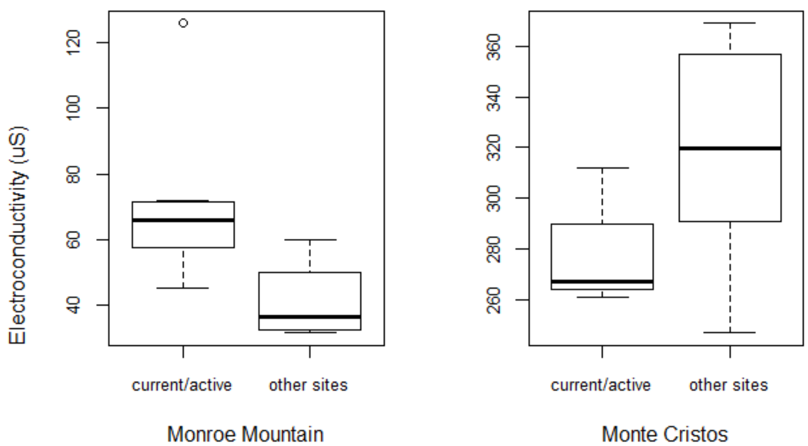

Figure 4. Electroconductivity values at Monroe Mountain and the Monte Cristo Range. Mean values were used at sites having more than one value recorded.

Table 9. Water quality parameter data by breeding status, including the minimum, median, maximum and 25th and 75th quantiles of data. Tadpole/egg mass sites are a subset of the current sites where measurements were taken directly at egg mass or tadpole locations.

Parameter	Breeding Status	# Sites	Quantiles of Data				
			Min.	25th	Median	75th	Max.
pH	Tadpole/egg mass	9	7.3	7.3	8.0	8.9	9.9
	Current	13	6.6	7.8	8.0	8.5	9.4
	Active	11	7.3	7.8	8.1	8.5	9.3
	Recent	13	7.6	7.7	7.9	8.1	8.4
EC (uS)	Tadpole/egg mass	9	44	129	261	331	407
	Current	13	20	126	318	335	547
	Active	11	45	65	72	269	726
	Recent	14	33	261	330	359	956

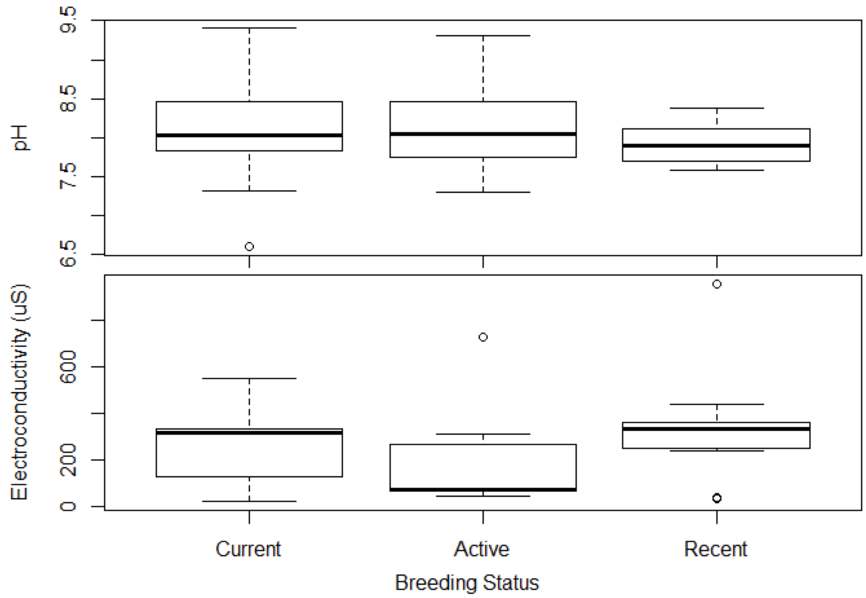

Figure 5. Mean pH and electroconductivity values per site, by breeding status. For sites surveyed multiple times, only data from the most recent visit is shown.

Discussion

The first goal of this report was to evaluate whether trends from the 2015 study held up statewide. We found support for the use of habitat metrics to evaluate potential breeding sites. While we did not evaluate breeding sites versus random sites in this study, we found that 95% of all breeding sites had mean habitat metric scores of 3.8 or higher, the same value as the first split in a classification tree model developed in the 2015 study that separated random sites from breeding sites (Menuz, 2016). We also found in this study that recent sites had lower scores than current sites. Sites may no longer support breeding because of declining habitat conditions or breeding may be less stable in sites that have always had poorer habitat conditions. However, it is also possible that differences in habitat scores between current and recent sites are driven by user-bias in metric scoring, since differences between site scores are low, or related to the regional clustering of recent sites (79% of recent sites were in the Monte Cristo Range or Strawberry Reservoir).

In contrast to the 2015 study, we did not find a significant difference between the presence of submerged aquatic and floating vegetation and site breeding status. Submerged aquatic vegetation was found at over three-quarters of current and active sites and over half of recent sites. By comparison, only 36% of 22 similarly situated randomly selected wetlands in the Jordan River watershed had submerged or floating vegetation (unpublished data). Surveys may have been timed too early to capture peak aquatic vegetation growth; six of the seven sites surveyed multiple times had higher submerged aquatic vegetation cover at later visits and all of the 2015 surveys were conducted later in the year than the 2016 surveys. Nonetheless, our results indicate that while aquatic vegetation may provide or indicate good habitat for boreal toad breeding, it does not appear to be necessary; and many sites that no longer support breeding still have submerged aquatic vegetation.

We found some support for the hypothesis that turbidity may negatively impact breeding sites and no support for a potential role of nutrients, though nutrient data were not directly measured. High levels of sediment addition can reduce boreal toad tadpole survival and growth rates (Woods and Richardson, 2009). More recent breeding sites had turbid-appearing water and potential sediment stressors near waterbodies than current breeding sites, though turbidity effects could be confounded by regional differences since most recent sites were in just two regions. High turbidity was very prevalent in the northern and central regions— the focal area of the 2015 study— and almost completely absent from the southern region, though personnel did not use a turbidity tube to take measurements in the southern region. Potential sediment stressors were also very common in the northern region, though they were particularly prevalent in the Uinta Mountains where none of the surveyed sites had high turbidity. Turbidity is likely to increase after recent rainfall or when there has been recent disturbance within a site. We recommend that turbidity measurements are made at each site visit to obtain better estimates of the prevalence of this stressor and to track changes at sites over time.

We summarized characteristics about waterbody features, aquatic vegetation and algae, water quality parameters, and stressors to better understand the range of conditions at breeding sites. A broad variety of waterbodies are found at sites utilized by boreal toad, though permanent ponds are the most common waterbody type and few breeding sites had very small (<10 m^2) waterbodies. Most waterbodies had shallow edges covering at least one-fifth of the surface; shallow water is favored for egg deposition (Oliver, 2006). Deep water (>1 m) does not appear to be necessary, and was found at only about half of the breeding sites, though water over 20 cm in depth was found at 95% of sites. Deeper water may provide protection from nighttime freezing in the summer. Emergent vegetation was growing in the water at virtually every site and submerged aquatic vegetation was also very common. Waterbodies at breeding sites had a broad range of electroconductivity values driven largely by regional differences. A field guide to amphibians in the western United States observed that boreal toads are usually found in water with pH greater than 8.0 (Koch and Peterson, 1995); we found that about half of the breeding sites had mean pH below this value. The range of pH and EC values at just the tadpole and egg mass locations was very similar to the range of conditions across all breeding sites. Unfortunately, it is unknown how many of the measured waterbodies in this study have ever supported boreal toad breeding. At sites with multiple waterbodies (about half of the surveyed sites), some waterbodies may never have been used for breeding, though the majority of measured waterbodies have probably supported breeding at some point in time.

Roads, livestock grazing, predators, and hydrologic modification were found at over half of all breeding sites, including half or more sites that had current breeding. The prevalence of these factors suggests that boreal toad can coexist with these stressors. In some cases, these stressors may actually be beneficial to the species. Hydrologic modifications such as artificial berms and excavation can create breeding habitat, and livestock grazing may help maintain areas of open water (Watson and others, 2003; Menuz, 2016), though high levels of grazing can increase mortality (McGee and Keinath, 2004). The stressor data collected for this project is limited to presence/absence information. More detailed information on abundance or severity of stressors could improve our understanding of boreal toad tolerance for disturbance.

We found strong regional differences in some site attributes, including electroconductivity, chytrid status, and common stressors; table 10 shows key attributes for each region. Rather than being

Table 10. Summary of regional breeding information. Site type and stressor data apply only to sites surveyed with the standard protocol in 2016.

Region	Number of Sites (% with 2016 Data)			Site Types	Chytrid Status (Number of Tested Sites)	Stressors at ≥50% of Current/Active Breeding Sites[1] and Notes About Dewatering and Turbidity	Additional Site Notes
	Current	Active	Recent				
Little West Fork	1 (100%)	0	0	stream segment	positive (1)	predacious fish	Livestock grazing status at site unknown. No turbidity tube data collected.
Strawberry Reservoir	1 (100%)	0	4 (100%)	stream segments; Strawberry Reservoir lakeshore	positive (1)	predacious fish; trails, roads (≤30 m); livestock grazing (≤30 m); higher turbidity at some of the recent sites	
Little Cottonwood Canyon	1 (100%)	0	0	snowmelt pond	negative (1)	trails	No turbidity tube data collected.
Bear River Range[2]	0	1 (0%, 1 surveyed in 2015)	2 (0%, 2 surveyed in 2015)	springhead ponds	negative (1)	excavation; roads (≤30 m); livestock grazing (≤30 m); higher turbidity at one active and one recent site	
Grouse Creek Montains	6 (33.3%)	2 (50%)	1 (100%)	springhead ponds; wet meadow	negative (8)	berms; excavation; roads (≤30 m); livestock grazing, unnatural bare soil (≤30 m); dewatering concern mentioned at one site; higher turbidity at one current and one active site	Active sites have much higher electroconductivity (EC) than current breeding sites; region has higher EC than all other regions.
Monte Cristo Range	1 (100%)	2 (100%)	8 (87.5%)	springhead ponds	positive (2); negative (5)	tiger salamanders; berms; trails (≤30 m); ATV tracks (≤30 m); livestock grazing (≤30 m); unnatural bare soil (≤30 m); dewatering concern mentioned at one site; higher turbidity at all measured sites except one current and two recent sites	One of the active sites, with last documented breeding in 2011, was noted to have a declining population trend. Areas with active/current breeding tend to have lower EC values than other sites.
Uinta Mountains	4 (50%, 1 surveyed in 2015)	0	2 (0%, 1 surveyed in 2015)	pond along stream	positive (4); negative (1)	predacious fish; berms; excavation; ATV tracks (≤30 m); roads (≤ 30 m); unnatural bare soil (≤30 m)	Livestock grazing status unknown.
East Mountain	1 (100%)	0	0	wet meadow	negative (1)	tiger salamanders; berms; roads (≤30 m); ATV tracks (≤30 m); livestock grazing; increased turbidity at current site	
Boulder Mountain	1 (100%)	1 (100%)	1 (0%)	snowmelt pond; stream segment	negative (2)	none	No turbidity tube data collected.
Monroe Mountain	1 (100%)	10 (60%)	6 (33.3%)	snowmelt ponds; stream segments	positive (9)	predacious fish; berms; roads; livestock grazing (≤30 m); no turbidity tube data collected; water marked as turbid at one active site	No turbidity tube data collected. Region has lower EC values than other regions, though current/active sites had somewhat higher values than other sites in region. Unsurveyed recent sites have not been surveyed in >10 years; true status unknown.
Paunsaugunt Plateau	1 (100%)	1 (0%)	5 (0%)	stream segment	positive (1)	predacious fish	No turbidity tube data collected. Four of the recent sites no longer have breeding habitat available due to decline of beaver in the area.
Thousand Lake Mountain	3 (66.7%)	1 (100%)	1 (0%)	wet meadow	negative (2)	tiger salamanders; livestock grazing (≤30 m)	No turbidity tube data collected. The active site is likely declining due to sedges filling in water. The recent site has not been surveyed in >10 years; true status unknown.

[1]Note made when trails, ATV tracks, roads, livestock grazing, or unnatural bare soil was found within 30 m of measured waterbody.
[2]Data on site types and stressors derived from 2015 survey data, which did not have the same list of stressors at other sites.

caused by one uniform factor, boreal toad population declines may need to be understood on a region by region or site by site basis. For example, declining beaver habitat on the Paunsaugunt Plateau, disappearing open water on Thousand Lake Mountain, and turbidity in the Monte Cristo Range are all reasonable hypotheses to explain why some sites no longer support breeding. We recommend continuing to monitor as many current, active, and recent breeding sites as possible to better track changes in condition at sites and understand regional population drivers.

Acknowledgments

This project relied heavily on aquatic biologists at the Utah Division of Wildlife Resources, who collected all the field data in 2016 and spent their time looking through old records to help fill in data gaps as needed. Paul Badame, Chance Broderius, Chris Crocket, Jordan Detlor, Daniel Kellor, Cody Edwards, Sam McKay, Jake Mecham, and Kevin Wheeler were critical to this project, along with many seasonal employees that assisted with data collection. Paul Chase, former biologist with the Uinta-Wasatch-Cache National Forest, provided information on the location of sites in the Bear River Range and Claudia Stout and Elliott Casper conducted field surveys for the UGS in 2015. Peter Josten helped with data management and analysis for a preliminary version of the data. This manuscript was improved by helpful comments from Peter Josten, Hugh Hurlow, and the Utah Geological Survey technical review team. This project would not have been possible without the support of Chris Keleher and funding from the Utah Department of Natural Resources' Endangered Species Mitigation Program.

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Appendix A: Field Form and Protocol

Observer Initials:_______________________________ Survey Date:______________________
Site Name:_____________________________________

Region (Major Range): __________________________

UTME (NAD83):___ ___ ___ ___ ___ ___ UTMN (NAD83): ___ ___ ___ ___ ___ ___ ___ Elevation (m):________

Boreal Toad Status

Breeding Status (select one): ___Active (between 2011- 2015) ___Recent (past 6-20 years) ___Historic (>20 years) ___Status Unknown

Breeding status notes (particularly if unknown):

Population trend has been (select one): __relatively stable __increasing __in decline __unknown

Population trend notes:

Chytrid status (select one):

____Not tested/Unknown ____Chytrid positive ____Chytrid negative (tested within past 5 years)
____Chytrid negative (tested over 5 years ago) ____ Tested/will be tested in 2016, results unknown

Breeding Habitat Features Present at Site: (select one or more)

____active beaver ____inactive beaver ____stream/river backwater ____springhead pool
____temporary pool/pond ____permanent pond/lake ____other (list):

Describe area encompassed by site (i.e., is site a single springhead pond, a stretch of stream between two tributaries, a beaver pond plus adjacent meadow with shallow pools, etc.)

Stressors (circle one)

Distance to nearest motorized vehicle road? <100 m 100-500m 500-1000 >1000m

Are any breeding ponds within 100 m of a non-motorized recreation trail? Yes No

Is there an up-gradient dirt road within 100 m of sites that may run-off to waterbodies: Yes No

Is there an up-gradient pavement within 100 m that may run-off to waterbodies: Yes No

Site typically subject to livestock grazing: Yes No Unknown

Tiger Salamander: Known to occur Unlikely to occur Unknown status

Potentially predacious fish: Known to occur Unlikely to occur Unknown status

Bullfrog: Known to occur Unlikely to occur Unknown status

Hydrologic manipulations at site (select one or more)**:**

Artificial berms/dikes ditching/draining excavation of feature water level control structures other:_____________________________

Other stressors:

Are there any recent (past 5-10 years) changes in site status that are known to the observer that may affect boreal toad populations, such as new water diversions, changes in grazing regimes, etc.? If so, describe:

Rank	Waterbody Type
A	lentic and large enough not to dry up and deep enough not to freeze solid at night during summer including lakes, ponds (especially beaver ponds), and large pools (including artificially created ponds and pools).
B	lotic: low-velocity, low-gradient streams or springs.
C	lotic: rivers, streams OR lentic but very small or uniformly shallow: temporary pools, small puddles.
D	No surface water typically present at site.
Rank	**Presence of North Shore (Long Axis of Waterbody)**
A	Ample north shore present. Long axis of waterbod(ies) arranged E-W and/or waterbod(ies) with ample shoreline along both axes (i.e. rounded pond).
B	Moderate amount of north shore present. Long axis of waterbod(ies) arranged NE-SW or NW-SE or may be N-S if minor axis almost as long as major axis (i.e., wide oval pond).
C	Minor amount of north slope present. Long axis of waterbod(ies) may be NNE-SSW or NNW-SSE or arranged N-S with moderately wide minor axis (if pond) or some meandering (if stream) creating some north shore.
D	Little or no north shore present. Long axis of waterbod(ies) north to south with little shoreline along minor axis (typically narrow waterbodies such as a stream).
Rank	**Slope and Water Depth Near Shore**
A	Mostly gentle slopes and/or large area, esp. along north shores, with gentle slopes; water <10 cm common.
B	Mixture of gentle and steeper slopes with some areas with <10 cm deep water; gentle slopes common but not predominant and not occupying the majority of the north shores.
C	Gentle slopes present, but uncommon. Few areas with water <10 cm deep.
D	All shorelines with steep slopes. Water <10 cm not present.
Rank	**Hibernation Features (within 100 m of waterbodies)**
A	Features such as burrows (esp. ground squirrels), interstices of beaver dams, old beaver lodges, overhanging stream banks, rocky chambers near streams, cavities under boulders or tree roots, loose soil, and/or woody debris piles common and connected to summertime habitat.
B	Above features present but not abundant. Some area with features may be disconnected from summertime habitat due to low use roads or other low severity fragmentation, but some connected features present.
C	Above features present but rare and/or only present on very steep slopes or disconnected from summertime habitat by busy roads, development, or other severe fragmentation.
D	None of the above features present.

Observed Hibernation Features (circle one or more feature):
None observed Burrows Beaver Dam Beaver Lodge Undercut Stream Bank Boulders Loose Soil Woody debris piles

Rank for Shrubs	Rank for Tall Forbs	**Understory-Forming Shrubs or Tall Forbs (e.g., goldenrod, coneflower);** Evaluate along stream floodplain or in valley bottom within 100 m of waterbod(ies). Cover estimates pertain to area without standing water.
A	A	Ample cover near waterbodies. Generally this will entail 33 to 60% of the area along a stream floodplain or valley bottom near a pond or lake with moderate to dense cover of understory-forming species.
B	B	Moderate cover near waterbodies, with approximately 21 to 33% of area with moderate/dense cover, or cover abundant, but very patchy
C1	C1	Low cover near waterbodies, with approximately 5 to 20% of area with moderate/dense cover.
C2	C2	Overly abundant cover near waterbodies. Between 60% and 80% of non-water area along stream floodplain or valley bottom with understory species. Little basking habitat present
D1	D1	No or only a few scattered areas with cover present (<4% cover)
D2	D2	Extremely abundant cover near waterbodies. Over 80% of non-water area along stream floodplain or valley bottom with understory cover. Basking habitat extremely rare.
	NA	Tall forb cover could not be evaluated at site due to time of year when site was surveyed

Habitat metric notes

Observer Initials:________________ Date:___________ Site Name: __________________

Boreal Toad Documented? (circle all) None Egg strand Tadpoles Metamorph Juvenile Adult

Survey Start Time: ________ (24-hr time) **End Time:** ________ (24-hr time)

Current Weather (circle): Clear (0% cloud) Mostly Clear (<25%) Partly Cloudy (25-50%) Mostly Cloudy (50-99%) Overcast (100%) Light rain Heavy rain Snow **Rainfall estimate in last 72 hours[1]:** none <0.1'' 0.1-1'' >1'' **Wind:** Calm Light Strong

Waterbody 1 **Set Feature?** Y N **Waterbody Name/Comments:**

Toads (circle and add approx. #): None Egg strand(____) Tadpole(____) Metamorph(____) Juvenile(____) Adult(____)

Feature Type: active beaver pond inactive beaver pond stream/river backwater springhead pool temporary pool/pond permanent pond/lake other:______________________ **Size of wetted area[2]:** <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m²

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (should add up to 100%)

Turbidity Tube Measurement (take at location at least 20 cm in depth): Visibility is (circle one) *greater than* or *equal to* ______ cm

Cover Estimates in Water: *Cover Classes* a: not observed/0%; b: <1%, c: 1-10%, d: >10%

Surface algae: a b c d **Chara:** a b c d **Floating:** a b c d **SAV:** a b c d **Emergent:** a b c d

List SAV and floating species if known:

Check Stressors within 30 m of Waterbody and Then List Other Observed Stressors or Noticeable changes in Blank Space Below:

Livestock Grazing		Tracks/Roads		Species		Other	
	Grazed vegetation		Hiking trail		tiger salamander		turbid-appearing water
	Livestock manure		ATV track		predacious fish		unnatural bare soil
	Tracks >13 cm deep		Road		bullfrog		broken fence

Waterbody 2 **Set Feature?** Y N **Waterbody Name/Comments:**

Toads (circle and add approx. #): None Egg strand(____) Tadpole(____) Metamorph(____) Juvenile(____) Adult(____)

Feature Type: active beaver pond inactive beaver pond stream/river backwater springhead pool temporary pool/pond permanent pond/lake other:______________________ **Size of wetted area[2]:** <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m²

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (should add up to 100%)

Turbidity Tube Measurement (take at location at least 20 cm in depth): Visibility is (circle one) *greater than* or *equal to* ______ cm

Cover Estimates in Water: *Cover Classes* a: not observed/0%; b: <1%, c: 1-10%, d: >10%

Surface algae: a b c d **Chara:** a b c d **Floating:** a b c d **SAV:** a b c d **Emergent:** a b c d

List SAV and floating species if known:

Check Stressors within 30 m of Waterbody and Then List Other Observed Stressors or Noticeable changes in Blank Space Below:

Livestock Grazing		Tracks/Roads		Species		Other	
	Grazed vegetation		Hiking trail		tiger salamander		turbid-appearing water
	Livestock manure		ATV track		predacious fish		unnatural bare soil
	Tracks >13 cm deep		Road		bullfrog		broken fence

Water Quality Measurements Take at least one measurement at egg strand or suitable-appearing breeding spot.

WB #	Shore (N, NE, E, etc.)	Egg Strand Point?	Standing or Flowing?	Depth of Water (cm)	pH	EC (uS)	Temp. (°C)	Other Notes About Location (plant species, unusual characteristics, etc.)
		Y N	S F					
		Y N	S F					
		Y N	S F					

Waterbody 3 **Set Feature?** Y N **Waterbody Name/Comments:**

Toads (circle and add approx. #): None Egg strand(____) Tadpole(____) Metamorph(____) Juvenile(____) Adult(____)

Feature Type: active beaver pond inactive beaver pond stream/river backwater springhead pool temporary pool/pond permanent pond/lake

other:_______________________ **Size of wetted area²:** <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m²

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (should add up to 100%)

Turbidity Tube Measurement (take at location at least 20 cm in depth): Visibility is (circle one) *greater than* or *equal to* ______ cm

Cover Estimates in Water: *Cover Classes* a: not observed/0%; b: <1%, c: 1-10%, d: >10%

Surface algae: a b c d **Chara:** a b c d **Floating:** a b c d **SAV:** a b c d **Emergent:** a b c d

List SAV and floating species if known:

Check Stressors within 30 m of Waterbody and Then List Other Observed Stressors or Noticeable changes in Blank Space Below:

	Livestock Grazing		Tracks/Roads		Species		Other
	Grazed vegetation		Hiking trail		tiger salamander		turbid-appearing water
	Livestock manure		ATV track		predacious fish		unnatural bare soil
	Tracks >13 cm deep		Road		bullfrog		broken fence

Waterbody 4 **Set Feature?** Y N **Waterbody Name/Comments:**

Toads (circle and add approx. #): None Egg strand(____) Tadpole(____) Metamorph(____) Juvenile(____) Adult(____)

Feature Type: active beaver pond inactive beaver pond stream/river backwater springhead pool temporary pool/pond permanent pond/lake

other:_______________________ **Size of wetted area²:** <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m²

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (should add up to 100%)

Turbidity Tube Measurement (take at location at least 20 cm in depth): Visibility is (circle one) *greater than* or *equal to* ______ cm

Cover Estimates in Water: *Cover Classes* a: not observed/0%; b: <1%, c: 1-10%, d: >10%

Surface algae: a b c d **Chara:** a b c d **Floating:** a b c d **SAV:** a b c d **Emergent:** a b c d

List SAV and floating species if known:

Check Stressors within 30 m of Waterbody and Then List Other Observed Stressors or Noticeable changes in Blank Space Below:

	Livestock Grazing		Tracks/Roads		Species		Other
	Grazed vegetation		Hiking trail		tiger salamander		turbid-appearing water
	Livestock manure		ATV track		predacious fish		unnatural bare soil
	Tracks >13 cm deep		Road		bullfrog		broken fence

Water Quality Measurements Take at least one measurement at egg strand or suitable-appearing breeding spot.

WB #	Shore (N, NE, E, etc.)	Egg Stand at Point?	Standing or Flowing?	Depth of Water (cm)	pH	EC (uS)	Temp. (°C)	Other Notes About Location (plant species, unusual characteristics, etc.)
		Y N	S F					
		Y N	S F					
		Y N	S F					
		Y N	S F					
		Y N	S F					
		Y N	S F					
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Boreal Toad Breeding Habitat Field Assessment Instructions

Before you begin:

1. Assign each observer a unique three letter combination. Usually this can be their initials, but may need to be something else if there are many people with the same initials (use x, q, or z as substitute middle initial if need be).
2. Determine which sites will be surveyed using this protocol and make sure each site is referred to by a standardized site name so that the site can be tracked over time.
3. Decide if you will use *set waterbody features* at each survey or if waterbodies will change at each site visit. A site with a single springhead pool will have one set waterbody feature. At a site with a series of beaver ponds, you can either visit the same pond each time or visit different ponds. If you do the former, make sure it is clear which feature is associated with each waterbody number.
4. It may be useful to create a site map to evaluate some of the toad metrics and to label the set waterbody features on. It would be helpful to have a map that showed the breeding waterbodies and a buffer around 100 m from each waterbody.

On First Site Visit- Collect Data on First Field Form (Some Data May Be Recorded in Office):

First Page: Introductory Information

1. Record observer initials, site name, and survey date. Also record the major region where the site is located, such as the Monte Cristos, Paunsaugunt Plateau, etc. This will help the data be organized into region for later analysis. Record site UTMs and elevation from your GPS.
2. Record what is known about boreal toad population status at each site. In many cases, the breeding status and population trend may be too difficult or time consuming to estimate or figure out from existing data; in these cases just mark unknown. It is okay to mark your best guess if you have an educated guess, such as marking active if you remember that breeding was documented in 2010 or 2011 or marking in decline without good population estimates.
3. Record waterbody types present at site that may be used for breeding.
4. Describe the site to provide a general idea of how large and complex of an area the site encompasses.
5. Answer questions regarding site stressors. These stressors are probably relatively permanent and can be answered based on GIS or institutional knowledge rather than site surveys if need be. Do not spend time surveying for tiger salamanders, bullfrogs, and predacious fish. Instead record a response based on previous experience at site.

Second Page: Ecological Integrity Table Metrics

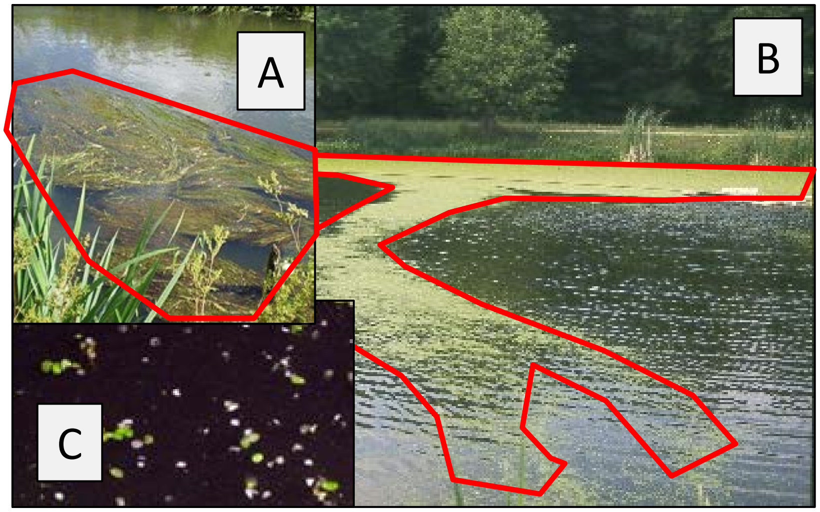
6. Determine what types of waterbodies are present at site. You may need to walk around site to select waterbody type, but in many cases this information will be known a priori.
7. If possible, use a map to help determine how much north shore is present at site. If no map is available, use a compass to determine the major orientation of streams or waterbodies at site.
8. As you survey site for boreal toad breeding, pay attention to the near shore waterbody slopes and then fill out the metric appropriately.

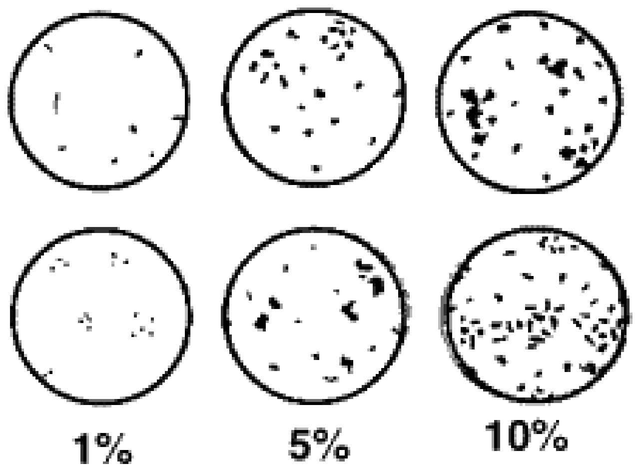
9. Spend about 10 minutes searching for potential hibernation features in area about 100 m from waterbody, circle features found, and then rate metric. OR if you are walking through area as part of boreal toad surveys, pay attention to features and mark when found.
10. Estimate the amount of cover of either shrubs or tall understory-forming forbs in the stream floodplain or valley bottom within 100 m of waterbodies. You may use a site map to help with estimates.

<u>During First and All Subsequent Site Visits</u>

Third and Fourth Pages: Waterbody Information

1. Record observer initials, date and site name
2. Record whether boreal toad were documented anywhere at site during survey
3. Record the survey start time and end time using the 24 hour format.
4. Record an estimate of the current cloud cover and wind speed. If possible, estimate recent rainfall either using the provided website or based on field observations.
5. Record waterbody data for at least one waterbody per site. If waterbody is the same feature that is visited at every survey, circle Y for Set Feature. Otherwise circle N
6. Record data on any toad observations within waterbody. Circle none if no observations were made; otherwise write in an approximate number of each boreal toad observation.
7. Circle the waterbody feature type.
8. Estimate the size of the wetted area. See the size comparisons at the bottom of the data sheet for reference.
9. Estimate the percent of the waterbody in each depth class. It may be helpful to draw out your estimates on a map. You can use the turbidity tube to help with depth estimates.
10. Take a turbidity tube measurement somewhere within the waterbody at least 20 cm in depth if possible (to avoid getting bottom sediment). Avoid collecting data in areas where you have disturbed the sediment and be careful to keep duckweed and algae out of the tube.
    See http://extension.usu.edu/utahwaterwatch/htm/videos#Turbidity for instructions.
11. Estimate the cover class for each algae and vegetation class. For dense vegetation, such as the pondweed in A and the duckweed in B, you can generalize to assume entire area inside red polygon in vegetated. For very sparse vegetation, such as in C, you may want to use the cover class diagram below to help with estimates. It is often useful to visually divide waterbody into quarters or other segments to obtain a cover estimate.





12. Check off any stressors observed within 30 m of the waterbody.
13. For at least one point within the waterbody, record water quality data. Record data at a location with an egg strand present if possible. Otherwise, record data at a potentially suitable egg strand location. If reasonable, select a site between 5 and 20 cm deep on the north shore of the waterbody. However, you can select another location if the north shore is inaccessible or very deep.
    a. Record the waterbody number as 1 if associated with waterbody one on the data form, 2 if waterbody 2, etc.
    b. Record the shore. Consult a map or compass if at all possible.
    c. Circle yes or no for whether egg strand is at point.
    d. Circle S if water appears to be standing or F if water is noticeably flowing.
    e. Record the depth of water from the surface to substrate. Use the turbidity tube to help measure this if you do not have a measuring tape.
    f. Record the water pH. If you remove water from the waterbody with a cup for the measurement, rinse some of the water over the pH probe before taking a measurement. Otherwise, make sure you swirl the probe around in the water before taking a measurement. You may want to take several measurements close to one another to make sure they are consistent; record an average or typical value.
    g. Record electroconductivity. Be sure to measure in uS or to convert from mS by multiplying by 1000.
    h. Record water temperature.
    i. Record any additional notes about the location of interest.
14. Record additional water quality data if desired. For example, you could record additional values at other egg strands or you could record values at two distinct locations within waterbody, such as at a flowing area and a stagnant area.
15. Record data for additional waterbodies if desired if site is composed of more than one main waterbody. Select waterbodies where breeding has occurred or is likely to have occurred in the past.

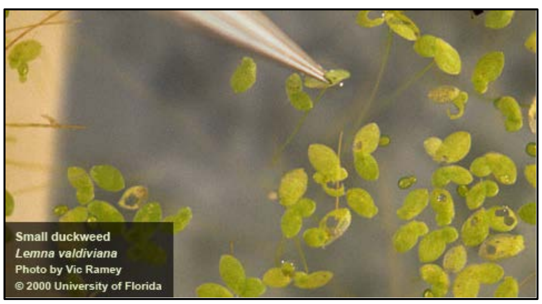
Major Aquatic Vegetation Groups

Filamentous Surface Algae

Algae growing in long chains, threads, or filaments growing on or near the water surface (not attached to rocks or other structures).

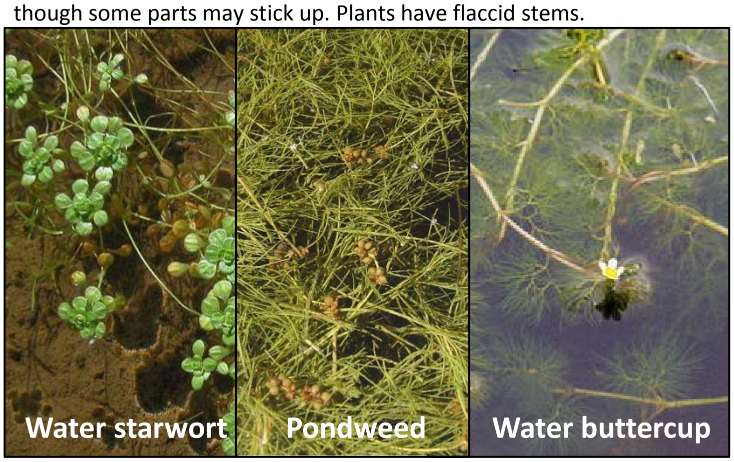
Floating

Aquatic plants that are not attached to the bottom. Duckweed is the most commonly encountered example of this; bladderwort and mosquitofern can also be encountered in Utah.



Submerged Aquatic Vegetation (SAV)

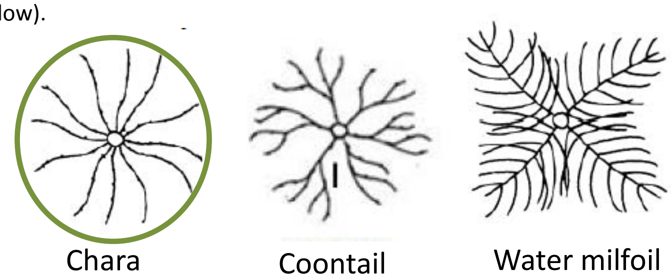
Rooted plants with most of their leaves and stems below water, though some parts may stick up. Plants have flaccid stems.



Photos from luirig.altervista.org, www.biopix.com, and gobotany.newenglandwild.org

Chara/Muskgrass

Multicellular algae that is easy to confuse with submerged aquatic vegetation. Chara often has a musky odor and gritty texture due to mineral deposits and has a distinct leaf cross section compared to SAV species that may be encountered in Utah (see cross sections below).



Emergents

Rooted herbaceous plants often found on shorelines that stand above the surface of the water and have somewhat stiff or firm stems.