

# **INVENTORY OF AMPHIBIANS AND REPTILES IN THE POWDER RIVER BASIN AREA OF WYOMING**

YEAR TWO PROGRESS REPORT, 2009

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## ABSTRACT

Coal Bed Natural Gas (CBNG) development may impact amphibians and reptiles through changes in water quality, changes in water flow regimes, and increases in road densities and traffic volume. The Aquatic Task Group (ATG) is an inter-agency working group focused on studying and mitigating impacts of CBNG development in northeastern Wyoming and southeastern Montana. In 2008, the Buffalo Field Office of the BLM, a member of the ATG, provided support for the Wyoming Natural Diversity Database (WYNDD) to inventory and develop a monitoring plan for amphibians and reptiles in the Powder River Basin (PRB) in Wyoming. The goal of this project is to determine the current status of amphibians and reptiles in the PRB so that future monitoring can detect changes, if any, in species composition and occupancy rates due to CBNG development. We surveyed for amphibians and reptiles from 2008-2009 using visual encounter surveys of riparian reaches and standing water bodies, roadkill/basking surveys, nocturnal call surveys, and visual encounter surveys of rock outcrops. We also measured water quality and/or habitat characteristics at all sites. We documented 18 (6 amphibian, 12 reptile) of the 21 species expected to occur in the PRB, with species detection varying by survey method. Comparisons of results from nocturnal call and visual encounter surveys conducted by the Wyoming Game and Fish Department (WGFD) in 2006 and by WYNDD in 2008 and 2009 at the same sites show a possible decline in site occupancy for Northern Leopard Frogs in the PRB. Bullsnares were the most common road mortality and roadkill rates ranged from 0 to 6 dead reptiles/mile. Over 650 dead Tiger Salamanders were found during standing water body surveys. Laboratory analyses confirmed that salamanders tested had died of ranavirus infection. Recent Tiger Salamander die-offs also have been documented in Montana. Future research will hopefully determine if water quality influences susceptibility of salamanders to ranavirus infection. Chytrid infection rate was 23% in 2009 and prevalence of chytrid fungus in amphibians appears to be increasing in the PRB. Because potential impacts of CBNG development may be sublethal or vary between life stages, implementation of a long-term monitoring program in the PRB is necessary to determine population-level effects on local amphibians and reptiles.

## INTRODUCTION

The Powder River Basin (PRB) in northeastern Wyoming is an important area for the extraction of coal bed natural gas (CBNG). Over 18,000 CBNG wells currently exist in the PRB with numerous additional leases pending. CBNG development entails establishment of new roads, construction of wells and other infrastructure related to the extraction of CBNG, and the release of groundwater extracted from coal seams into surface streams, rivers, or holding ponds. In 2003, the Buffalo Field Office (BFO) of the Bureau of Land Management (BLM) prepared an Environmental Impact Statement (EIS) for CBNG development in Wyoming and Montana which outlines potential impacts to hydrology, wildlife, and other natural resources in the Powder River Basin (BFO BLM 2003). The EIS identified 2 primary areas of concern with respect to amphibians and reptiles; (1) changes in water quality and timing due to release of CBNG product waters into surface waters, and (2) road mortalities from increased vehicular traffic.

The Aquatic Task Group (ATG) is an inter-agency and inter-state working group focused on studying and mitigating impacts of energy development on aquatic ecosystems in northeastern Wyoming and southeastern Montana. In 2008, the Wyoming Natural Diversity Database (WYNDD), under the guidance of the ATG, began a 3-year study of amphibians and reptiles in the PRB. The ATG's Monitoring Plan (ATG 2006) provided the guidelines and objectives for this project. The majority of funding for this work was provided by the Buffalo Field Office of the BLM with some matching funds from WYNDD.

In general, little is known about the status and distribution of amphibians and reptiles in Wyoming and, until recently, few studies have examined species distribution in the Powder River Basin. However, increasing concern over potential impacts of CBNG development to amphibians and reptiles prompted the Wyoming Game and Fish Department (WGFD) to conduct a baseline inventory of reptiles and amphibians along the Powder River and its major tributaries from 2004-2006 (Turner 2007). The study provided an overview of species distribution, road mortality, and chytrid (*Batrachochytrium*) infection rates along the major rivers and streams within the PRB. Many of the WGFD's survey methods and some of the sampling reaches were incorporated into this project for consistency and long-term monitoring purposes; however the spatial extent of our work included upland and CBNG reservoir habitats in order to map distribution and study potential impacts across a broader area of the PRB.

### *Objectives*

This project had 4 overall objectives:

1. Complete a literature review of impacts to amphibians and reptiles from vehicular traffic and changes in water quality
2. Determine the general distribution and characterize the status and habitat of all amphibians and reptiles occurring in the PRB (below 1,370 m)

To do this, coordinates for all herptofauna observations will be combined with data from the WGFD (Turner, 2007) and WYNDD's database to produce a distribution map for each species. Overall site occupancy measures and current literature will be used to categorize species into general groups such as 'common in PRB', 'moderately abundant

in PRB', and 'rare in PRB'. Qualitative descriptions of habitat by species will be produced by combining standardized variables collected at survey sites (including water quality) and those presented in the literature.

3. Identify potential current and long-term impacts of CBNG activities on amphibians and reptiles and suggest possible mitigation measures. This will be achieved by measuring road mortality rates and water quality tolerance levels.

**Note:** The impact of CBNG activities on amphibians and reptiles can only be *roughly estimated* within the framework of this project.

4. Establish a long-term, repeatable monitoring protocol that can be used to track population trends and impacts from CBNG activities in the future.

The literature review (Objective 1) was completed in 2008, along with the first year of surveys to determine the distribution and habitat use of amphibians and reptiles in the PRB (Objective 2). This report details results from the second year of survey and inventory activities to map the distribution and habitat use of amphibians and reptiles in this region. Draft distribution maps for each species are included at the end of the report. Development of a long-term monitoring plan is in progress, with the first year of formal monitoring surveys to be conducted in the spring of 2010 if funding allows.

## METHODS

### *Study Area*

The Powder River watershed is located in northeastern Wyoming (Figure 1) and has an area of approximately 25,000 km<sup>2</sup>. The main stem of the river flows north into Montana where it joins the Yellowstone River. Within Wyoming, tributary streams that originate in the Bighorn Mountains to the west generally have perennial flow fed by snowmelt, whereas ephemeral tributaries originating in the plains to the south and east are characterized by short duration flows from rainstorms (Davis et al., 2006). The majority of CBNG development in the PRB is below 1,370 m elevation and, thus, defines the study area for this project. Topography is characterized by rolling hills and breaks. The climate is semi-arid and land cover is dominated by two ecological systems; Inter-mountain Basins Big Sagebrush Steppe and Northwestern Great Plains Mixed-grass Prairie. Riparian vegetation along rivers and streams is usually composed of cottonwoods and tall grasses but there are very few natural lentic (standing water) wetlands in the Basin. Twenty-one species of reptiles and amphibians potentially occur in the Powder River Basin of Wyoming (Table 1). Most of these species belong to the suite of Great Plains species whose far western range occurs in northeastern Wyoming. See Table 2 for a list of acronyms for species names used in this document.

Over 50% of land ownership in the PRB is private. Livestock grazing dominates land use with limited irrigated agriculture along perennial rivers (Davis et al. 2006). CBNG production has increased greatly in the last 10 years, especially in the eastern half of the PRB where natural gas is most easily recoverable. Gas field development often entails building and maintaining

extensive road networks to serve well pads, pipelines, and compression stations. Deep aquifer water is pumped to the surface and discharged into ephemeral drainages or reservoirs in order to release natural gas trapped in coal seams. The aquifer water is usually colder than surface water and often has higher concentrations of sodium bicarbonate and other salts (Davis et al. 2006). For more background information about the potential impacts of water quality and road network changes on amphibians and reptiles, see Griscom et al. (2009; Appendix A).

In 2009, the BFO requested that WYNDD also conduct surveys for amphibians and reptiles in the BLM Welch Management Area. The Welch Management Area is located on the Tongue River approximately 10 miles north of Sheridan, Wyoming and was acquired by the BLM in 2004 (Figure 2). Though only about 1,770 acres, the Welch Management Area is an ecologically important area that supports a diverse array of wildlife species and riparian communities. The BLM currently manages this area for recreation, wildlife habitat, cattle grazing, and hay production.

### *Surveys Protocols*

#### Nocturnal Call Surveys

We used nocturnal call surveys to survey for anurans (frogs and toads) during the 2009 breeding season. Males of all anuran species in the PRB vocalize under suitable weather conditions to attract females to breeding sites. Calls can be used to identify individuals to species and, depending on environmental conditions, can be heard up to an estimated 2 km away. Road-based nocturnal call surveys are an effective way of detecting species presence across relatively large distances without requiring physical access to adjacent land. Two types of nocturnal call surveys were conducted in 2009: 1) a method identical to that used by the WGFD (Turner, 2007) in 2006 along several of the same routes, and 2) a modified method established by WYNDD in 2008 that allows surveyors to cover larger distances.

Nocturnal call surveys involved a two person crew starting at a fixed location on a public road and driving a predefined distance to each subsequent listening point. All surveys were conducted after dark and detailed weather information was collected at the beginning and end of the survey (wind speed, barometric pressure, relative humidity, cloud cover, and air temperature). At each listening point, surveyors got out of the vehicle and listened for a predefined amount of time, recording the coordinates, species, calling intensity, direction and distance to caller(s), and ambient noise. Surveys along routes initially established by WGFD in 2006 were conducted along fixed 1.0 mile stretches, and surveyors stopped every 0.1 mi to listen for 2 minutes. The modified nocturnal call survey method was used along all other routes, with surveyors listening every 0.5 mi for 3 minutes.

#### Water Body and Riparian Surveys

We conducted visual encounter surveys (VES) along the banks of standing (lentic) and flowing water throughout the PRB. This survey method primarily targets amphibians, though reptiles are often found. Surveys followed protocols described in the ATG Monitoring Plan for Amphibians and Reptiles. Two surveyors searched at a consistent rate around the edge of lentic water bodies or along riparian reaches on either side of stream channels. In the case of routes

along the Powder River, however, both surveyors were on one side of the river (due to flooding and not being able to cross the river).

At each site, surveyors collected extensive data on habitat, water chemistry (pH, temperature, conductivity, TDS), species observed, and life stage. Surveys were timed to record search effort, and timers were stopped while animals were being processed. Dead amphibians were collected, labeled, and preserved in 95% ethanol for later analysis. All amphibians processed were also swabbed for chytrid fungus (*Batrachochytrium dendrobatidis*; see below).

Results from riparian and lentic water body surveys were used to produce a 'percent occupancy' estimate for each species (the number of water bodies occupied by a species divided by the number surveyed). This measure can be used to monitor changes across time, even if water bodies dry up or new ones are created. Site selection was not random but based primarily on where cooperative land owners and a high percentage of BLM surface ownership occurred. Lentic water bodies were located with the help of aerial photograph in ArcGIS. Although habitat characteristic were recorded, in most cases we were unable to determine if water bodies were impacted by CBNG development. Surveys in 2009 primarily targeted riparian areas along rivers and streams since surveys in 2008 focused heavily on lentic sites.

In an attempt to begin long-term monitoring efforts, we also surveyed fixed biotic monitoring reaches established by the USGS along the Powder River above and below confluences with major tributaries, some of which are known to be heavily impacted by CBNG product water. The USGS biotic monitoring reaches provide fixed stretches where fish, macroinvertebrates, algae, etc., are sampled during most years. Results from herpetological surveys combined with water quality and biotic variables collected at these monitoring reaches could provide valuable insight into ecological trends in the future.

### Rock Outcrop Surveys

Rocky outcrops are important landscape features for many reptiles because they provide protection from predators, basking surfaces, and shade from the midday sun, and are often used as hibernacula by multiple species of snakes. Therefore, we conducted visual encounter surveys for basking reptiles along south-facing rock outcrops. Rock outcrops were identified either opportunistically or with aerial photographs. Surveys were conducted primarily during morning hours, when reptiles are most likely to be basking. Surveys involved searching under and around rocks and organic debris. We photographed species encountered and described the general habitat in which the species was found. We recorded search effort by timing all surveys, stopping the timer during data recording and identification of species. We also recorded all non-reptile species observed during rock-outcrop surveys.

### Roadkill and Basking Surveys

Roads also serve as basking surfaces for reptiles and amphibians. Because animals basking on or crossing roads are often killed by vehicles, surveys along roads are commonly used to inventory local reptiles and amphibians (Heyer et al. 1994). Roadkill 'hotspots', where multiple individuals are found in a short distance, can signify proximity to hibernacula or migration corridors and the location of hotspots can be used to guide management plans. Encounter rates



or mortality rates along fixed stretches of road can also be calculated and compared across seasons or years.

We conducted roadkill/basking surveys along 1-mile fixed stretches of roads. We targeted different types of roads (paved, gravel, dirt, etc.) near or adjacent to rock outcrops or water bodies. Technicians walked on opposite sides of the road searching for dead or basking reptiles and amphibians. Animals found were photographed and their location was recorded. In addition to fixed roadkill surveys, technicians also recorded all incidental sightings of dead or basking reptiles and amphibians found while driving between survey sites.

### *Tiger Salamander Mortality*

In 2008, WYNDD technicians found over 600 dead or dying Tiger Salamanders (*Ambystoma tigrinum*) at several standing water bodies in the PRB. Samples showed no evidence of chytrid fungus and the cause of the die-off was not determined. In 2009, technicians were instructed to notify WYNDD zoologists immediately when dead or dying tiger salamanders were found so that specimens could be collected and sent to labs for necropsy and disease testing. Water quality measurements were taken and the BLM was notified as soon as dead salamanders were found so that landowners could be contacted.

### *Chytrid Analyses*

Chytrid fungus (*Batrachochytrium dendrobatidis*) has been implicated in amphibian declines around the world, especially in concert with other environmental stressors, and infected animals have been found in the PRB (Turner 2007, Griscom et al. 2009). To identify whether amphibians were infected with chytrid fungus, we collected epithelial tissue samples from a subset of all amphibians found at each site during surveys. Sample collection followed established procedures (Livo 2003). Amphibians were systematically swabbed with sterile cotton swabs to collect epidermal DNA. Swabs were immediately stored in sterile microcentrifuge tubes containing 95% ethanol and labeled with unique specimen numbers. We stored samples in a -20°F freezer until shipping. Samples were sent to Dr. John Wood at Pisces Molecular LLC in Boulder, Colorado, for analysis via PCR test to determine if the fungus was present.

## RESULTS & DISCUSSION

### *2009 Survey Results*

#### Nocturnal Call Surveys:

We conducted 16 nocturnal call surveys along roads in 2009 (Figure 3). Eight of the surveys were conducted along routes previously surveyed by the WGFD from 18-25 May, 2006 (Turner 2007) and were conducted with the same level of effort as WGFD surveys. Initial surveys were conducted 22 May – 6 June. We repeated surveys at the 4 most productive locations from 27-29

June. No amphibians were heard calling during repeat surveys and we concluded that breeding activities had ended for the season.

We detected both Boreal Chorus Frogs (*Pseudacris maculata*) and Plains Spadefoot Toads (*Spea bombifrons*) during nocturnal call surveys. Boreal Chorus Frogs and Plains Spadefoot Toads were heard at 56% and 25%, respectively, of nocturnal call surveys (Table 3). Results from WYNDD surveys in 2009 differed from results of WGFD surveys in 2006 for the same survey routes (Table 3). Most notably, Northern Leopard Frogs (*Lithobates pipiens*) were heard calling on 100% of the routes in 2006 but were never heard calling along any route in 2009. Woodhouse's Toads (*Anaxyrus woodhousii*) and Great Plains Toads (*A. cognatus*) also were heard calling on 25% and 13% of the routes in 2006 but were never heard calling in 2009. On the other hand, Plains Spadefoot Toads were heard calling on 50% of the WGFD routes in 2009 but were never heard calling along these routes in 2006. Similar results were observed when we compared site occupancy across the 13 total repeat WGFD sites surveyed by WYNDD in 2008 and 2009 (Figure 4). Most alarming again is the complete absence of Northern Leopard Frogs detected in 2008 and 2009 at sites where they were detected in 2006. In general, combined results from WYNDD surveys in 2008 and 2009 show that Boreal Chorus Frogs and Woodhouse's Toads currently have the highest site occupancy rates in the PRB based on nocturnal call surveys (Figure 5).

Because nocturnal call surveys detect calling by breeding amphibians, and weather is known to influence the timing and intensity of breeding efforts in amphibians (Heyer et al. 1994), survey results can vary annually despite efforts to synchronize survey dates (as seen above). Thus, results are not directly comparable for monitoring purposes without conducting multiple passes over several weeks, or correcting for differences in detectability due to covariates (weather, temperature, relative humidity, etc.) across years. Pulse breeders, such as the Plains Spadefoot Toad and Great Plains Toad, can be particularly difficult to monitor across years since breeding is restricted to very short periods of time following rainstorms. Thus, the differences in the occurrence of Plains Spadefoot Toads and Great Plains Toads between 2006 and 2009 surveys could be the result of timing of breeding events rather than changes in species abundance. However, the lack of Northern Leopard Frogs detected in 2008 and 2009 warrants further investigation, especially since this species is currently being petitioned for listing under the Endangered Species Act (ESA). Northern Leopard Frogs are not pulse breeders, though timing of breeding still varies with annual weather patterns.

#### Water Body and Riparian Surveys:

We conducted 39 VES surveys in riparian areas along streams and rivers, and 8 VES surveys at lentic sites including stockponds and CBNG ponds (Figure 3). We documented 2 species of amphibians and 4 species of snakes during riparian surveys. Northern Leopard Frogs were more common along rivers and streams and were documented at 46% of riparian sites and only 13% of lentic sites. Woodhouse's Toads and Wandering Garter Snakes (*Thamnophis elegans vagrans*) were the next most common species found during riparian surveys, both occurring at 15% of sites (Figure 6). Three species of amphibians were documented at lentic site but no reptiles were found during lentic surveys. Tiger Salamanders were the most common species observed at lentic sites, found at 63% of all lentic sites surveyed. Although turtles likely occurred at both riparian and lentic sites, probability of detecting them using VES surveys is relatively low. Use

of turtle traps is a more effective means of surveying for turtles (Turner 2007), but this technique is time consuming and should only be employed if management goals require monitoring trends in turtle populations at specific sites.

Northern Leopard Frogs were the most common amphibian found in the Welch Management Area and were documented at 2 of the 4 riparian VES surveys. Prairie Rattlesnakes (*Crotalus viridis*) and Wandering Garter Snakes were also found in the Welch Management Area during riparian VES surveys. In addition to individuals found during formal surveys, technicians also documented numerous incidental sightings in the Welch Management Area, including a Spiny Softshell Turtle (*Apalone spinifera*), an Eastern Yellowbelly Racer (*Coluber constrictor flaviventris*), two Prairie Rattlesnakes, and several Bullsnares (*Pituophis catenifer sayi*).

Combined VES survey results for 2008 and 2009 show that while some species, such as Woodhouse's Toads, are found in both riparian areas and standing water bodies, other species are more common in one or the other (Figure 6). In general, riparian sites had higher occupancy rates for Northern Leopard Frogs and garter snakes, while Tiger Salamanders were only found at lentic sites. Overall, Northern Leopard Frogs, Woodhouse's Toads, and Tiger Salamanders were the most common species found during VES surveys at water bodies (Figure 6). Interestingly however, comparisons between the 24 riparian VES sites surveyed by WGFD in 2006 and WYNDD in 2008 reveal a possible decrease in occupancy rates for Northern Leopard Frogs (Figure 7). WGFD documented Northern Leopard Frogs at over 16% of sites in 2006 but this species was not found during WYNDD surveys at the same sites (and at roughly the same time of year) in 2008. While these results are not directly comparable due to potential differences in weather, survey conditions, and timing of breeding across years, the absence of leopard frogs at these sites in 2008 is still concerning.

### Rock Outcrop Surveys

We surveyed 14 south-facing rock outcrops throughout the PRB in 2009 (Figure 3). Four species of reptiles (3 snakes, 1 lizard) were documented during surveys. Northern Sagebrush Lizards (*Sceloporus graciosus*) were observed at most rock outcrops (86%) and were typically found on rocks adjacent to clumps of yucca (*Yucca glauca*). Prairie Rattlesnakes were also commonly found along south-facing rock outcrops and were documented at 36% of sites. Bullsnares and Wandering Garter Snakes were observed during 7% of rock outcrop surveys. The single Wandering Garter Snake observed using this survey method was found at a rock outcrop adjacent to a river. Five of the 14 rock outcrop surveys were conducted in the Welch Management Area. Northern Sagebrush Lizards, Bullsnares, and Prairie Rattlesnakes were observed during surveys in this area and had similar site occupancy rates to the PRB. Trends in occupancy rates also were similar when survey results for 2008 and 2009 were combined (Figure 8). Non-reptile species found at rock outcropping included bushy-tailed woodrats (*Neotoma cinerea*), cottontail rabbits (*Sylvilagus* spp.), striped skunks (*Mephitis mephitis*), rock wrens (*Salpinctes obsoletus*), and scorpions (*Paruroctonus boreus*). Although technicians were specifically instructed to search crevices for roosting bats, no bats were found during surveys.

No evidence of snake hibernacula were found, however, timing of rock outcrop surveys was not ideal for observing snakes recently emerged from or about to enter hibernation. Snakes typically emerge from winter hibernacula, bask in the immediate vicinity of the hibernacula for

several days, and then disperse to their summer home ranges. Snakes typically do not return to hibernacula until fall, when they gather and bask near openings until cold weather forces them into hibernation (Bryce Maxell, personal communication). Thus, fall or early spring are the best times to survey specifically for hibernacula, but success still varies with weather patterns and size of the survey area.

### Roadkill and Basking Surveys

We conducted formal roadkill/basking surveys along 16 1-mile stretches of dirt, gravel, and paved roads throughout the PRB and Welch Management Area (Figure 3). A total of 17 reptiles were observed during formal roadkill/basking surveys, and all were dead. Bullsnares were the most common species found dead on roads (31% of sites), followed by Prairie Rattlesnakes (13%), Western Painted Turtles (*Chrysemys picta*) (13%), and Eastern Yellowbelly Racers (6%). Combined survey results for 2008 and 2009 (Figure 9) again showed similar trends to the 2009 data, with Bullsnares and Prairie Rattlesnakes being the most common species found on roads throughout the PRB. In addition to formal roadkill/basking surveys, we recorded all incidental occurrences of dead or basking reptiles and amphibians found while driving between surveys in the PRB. In 2009, 19 reptiles and amphibians were found on roadways, the majority of which (84%) were dead. Bullsnares were again the most common species found on roadways (74%) followed by Eastern Yellowbelly Racers (16%) and Prairie Rattlesnakes (11%).

Average roadkill rate for formal surveys was 0.74 dead reptiles/mile. Roadkill “hotspots,” where mortality rates of  $\geq 2$  dead reptiles/mile were documented, occurred on the Upper Powder River Road and in the Welch Management Area (Figure 10). The highest roadkill rates were along State Highway 338 in the Welch Management Area, where 2 different locations had roadkill rates of 6.0/mile and 4.0/mile on 5 June, 2009. Both of these roadkill “hotspots” were relatively close to the Tongue River. Interestingly, repeat surveys along the same stretches in late June revealed that roadkill rates had dropped to 0/mile and 2.0/mile, respectively. This drastic drop could result from seasonal changes in movement patterns, with increased movement occurring in early June as individuals disperse away from nearby hibernacula or to breeding sites. If managers are concerned about reptile and amphibian populations in the Welch Management Area, seasonal speed restrictions or increased signage warning motorists to watch for wildlife on roads may help to decrease the significant number of road mortalities in this area.

We documented an increase in average roadkill rate from 2006 to 2008/2009 along certain roads in the PRB. Average roadkill rates increased from 0.1 dead reptiles/mile in 2006 (Turner 2007) to 0.5 dead reptiles/mile in 2008 and 2009 along the same 10 stretches of roads (Table 4). While this trend could indicate an actual increase in frequency of vehicle mortalities from 2006 to 2009, results across years are not directly comparable due to annual differences in survey conditions and reptile activity patterns. The pattern, however, warrants further investigation and monitoring.

### *Species Results*

Using a variety of survey techniques in both 2008 and 2009, we were able to document all amphibian species thought to occur in the PRB. Based on results for surveys in 2009, Boreal Chorus Frogs, Woodhouse’s Toads, Tiger Salamanders, and Northern Leopard Frogs appear to

be relatively common throughout the PRB (Figures 11 and 12), though almost all Tiger Salamanders were found dead or dying. Boreal Chorus Frogs were primarily documented during nocturnal call surveys, but when observed during VES surveys they were found along rivers and streams as well as standing water bodies. Northern Leopard Frogs were best detected using VES surveys and were more common along riparian areas than lentic sites. Plains Spadefoot Toads and Great Plains Toads had the lowest occupancy rates for amphibians; however, detectability for these pulse breeders is notoriously low.

We summarized range of habitat types, habitat characteristics, and water quality parameters for each amphibian species documented in the PRB (Table 5). Based on the limited data currently available, Woodhouse's Toads appear to be the most tolerant species, found in a variety of habitat types and able to tolerate the widest range of water pH, TDS, conductivity, and salinity values. Due to low detectability and small sample sizes for several species, however, results are preliminary and not directly comparable across species. Larger sample sizes are needed for accurate comparisons across species.

We also documented most of the reptile species thought to occur in the PRB. Bullsnares and Prairie Rattlesnares were common in both upland and riparian habitats while garter snakes were primarily found near water bodies, particularly in riparian habitat (Figure 13). Wandering Garter Snakes were the most common of the garter snakes, Common Garter Snakes (*Thamnophis sirtalis parietalis*) were the least common. Eastern Yellowbelly Racers were not common, but could occasionally be found near water bodies and on roads. The Western Hog-nosed Snake (*Heterodon nasicus*) was the rarest species of snake observed during this study and was only detected once in the northern portion of the PRB in Wyoming in 2008. Northern Sagebrush Lizards were surprisingly common and were found at most rock outcrops surveyed in 2009 (Figure 14). We had few occurrences of turtles in the PRB in 2009 (Figure 15); however, survey techniques were not ideal for detecting turtles.

We generated draft species distribution maps (Appendix A) using coordinates of amphibian and reptile observations in the WYNDD database, which included data from Turner (2007) and this study. These distribution models are part of an ongoing project on Assessment of Wildlife Vulnerability to Energy Development (AWVED) being conducted by WYNDD's senior zoologist, Doug Keinath, and GIS specialist, Mark Andersen. This project is funded jointly through the Wyoming Landscape Conservation Initiative and WGF's State Wildlife Grants program. Maps provided in Appendix A are *DRAFT* distribution maps. Although most maps likely will not change significantly from draft maps for this group of species, some, such as the Tiger Salamander and Prairie Rattlesnake, are currently being re-run with adjusted model parameters. Species distributions were modeled statewide, not just based on data from the PRB. Statewide distribution maps were then clipped to the species known range in Wyoming and to the extent of the PRB for this report. Final distribution maps will be available by request from WYNDD. Exact methods used to generate distribution models will be detailed in the final AWVED report. Until then, questions regarding distribution maps can be directed to either Doug Keinath or Mark Andersen.

### *Tiger Salamander Mortality*

Tiger Salamander mortality was documented at 63% (5 of 8 sites) of standing water bodies in 2009, a marked increase from the 25% (9 of 36 sites) of sites found to contain dead salamanders in 2008 (Figure 16). Although fewer standing water bodies were surveyed in 2009, the high percentage of those sites found to contain dead salamanders is alarming. Over 650 dead salamanders were found in 2008 & 2009 combined. Two dead salamanders were sent to Dr. David E. Green at the National Wildlife Health Center in Madison, Wisconsin for diagnostic tests. Results showed that the cause of death in both salamanders was culture-confirmed ranavirus infection with both specimens showing external and internal symptoms of the infection (e.g. hemorrhaging).

Apparently healthy Northern Leopard Frogs and Woodhouse's Toads were documented at several sites where dead Tiger Salamanders were found. Although many types of ranavirus can affect multiple species of amphibians, *Ambystoma tigrinum* virus (or ATV) only affects Tiger Salamanders. Because other amphibians do not seem to be impacted by the virus, it is likely that the particular ranavirus infection sweeping the PRB in Wyoming and Montana is ATV. Tiger Salamanders are currently common throughout Wyoming, however, the rapid spread of ranavirus through populations in eastern Wyoming warrants monitoring Tiger Salamander populations to determine their ability to rebound from this lethal and highly contagious virus. At this point, it is unknown if the ranavirus outbreak is natural or if changes in water quality in the PRB due to CBNG development could be increasing susceptibility of Tiger Salamanders to the virus.

### *Chytrid Analyses*

We sampled 31 individual amphibians (6 Woodhouse's toads, 25 Northern Leopard Frogs) for chytrid fungus. Chytrid was detected in the PRB as well as the Welch Management Area (Figure 17). None of the Woodhouse's toads came back positive for chytrid. Seven (28%) Northern Leopard Frogs tested positive for chytrid. Overall chytrid infection rate for amphibians sampled in 2009 was 23% and was the highest reported in the PRB thus far. Turner (2007) reported a 14% infection rate and Griscom et al. (2009) reported an 18% infection rate. The perceived increase in chytrid infection rate could indicate an increase in the prevalence of chytrid fungus in the PRB. As with the ranavirus infection, however, sufficient data does not yet exist to determine if the increase is a result of natural spread or an increase in susceptibility of amphibians to the fungus due to changes in water quality.

## RECOMMENDATIONS

1. Road mortality for reptiles (and amphibians) appears to be greatest where roads are in close proximity to wetlands or riparian areas. Road mortality has been associated with significant declines in local anuran and turtle densities (Fahrig et al. 1995, Pope et al. 2000, Carr and Fahrig 2001) and can substantially decrease snake populations (Rosen and Lowe 1994) and, in certain cases, significantly increase probability of extinction (Row et al. 2007). Road mortality rates in the Welch Management Area along Hwy 338 near the Tongue River were particularly high in early June (up to 6 dead reptiles/mile) and could

threaten local snake populations. Managers should consider reducing speed limits or posting warnings on existing roads during key migration and dispersal time periods (spring and fall) and avoid placing new roads near wetlands, riparian areas, or rock outcrops.

2. Because chytrid fungus can decimate amphibian populations and cause local extinctions, we recommend implementing chytrid testing into any long-term monitoring program in the PRB. The consistently increasing rate of infection found in the PRB from 2006 to 2009 is a potential cause for concern, especially considering that Northern Leopard Frogs (which had the highest chytrid infection rate) are currently being petitioned for listing under the ESA.
3. Current survey efforts in the PRB have focused on mapping the distribution of amphibian and reptile species. While this data is extremely helpful for establishing baseline information, results are not directly comparable across years and do not allow managers to determine population trends. A repeatable monitoring protocol that incorporates detectability estimation and is carried out at the same sites across years is necessary to establish population trends. Because estimating abundance of amphibians is extremely time consuming and costly, experts strongly suggest using occupancy rates as opposed to abundance estimates (Heyer et al. 1994). We recommend that the ATG establish fixed monitoring sites where reptiles and amphibians can be surveyed using a standardized protocol that incorporates an efficient means of estimating probability of detection. Monitoring locations and types of surveys necessary will depend on:
  - a. Which species the ATG and the Buffalo Field Office decide should be included in monitoring efforts
  - b. If documentation of reproduction (i.e. egg mass, larvae, or juveniles) is important
  - c. If sampling of specimens for disease (such as chytrid fungus) is determined important.

Because egg mass and larvae life stages are most sensitive to changes in water quality and temperature, we strongly recommend a sampling scheme that, at the very least, incorporates documentation of reproduction for key species of amphibians. This is best accomplished using VES surveys along water bodies and incorporating use of dip nets at regular intervals to detect tadpoles in murky waters. VES surveys also allow for capture and sampling of individuals for disease testing.

## ACKNOWLEDGEMENTS

We would like to thank Guillermo Alba and Zackary Severino for conducting the field surveys for this project in 2009. William Turner generously provided WGFD data and routes. Bryce Maxwell, Zack Walker, Bill Ostheimer, and the Buffalo Field Office of the BLM provided much appreciated conceptual and logistical support.

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## TABLES AND FIGURES

**Table 1.** Species of amphibians and reptiles expected to occur in the Powder River Basin of Wyoming (Turner, 2007; Parker and Anderson, 2001).

Common Name	Scientific Name	Found by WGFD 2004-2006	Found by WYNDD 2008	Found by WYNDD 2009
Bullfrog*	<i>Lithobates catesbeianus</i>	Maybe	N	N
Milksnake*	<i>Lampropeltis triangulum</i>	N	N	N
Northern Prairie Lizard*	<i>Sceloporus undulatus garmani</i>	N	N	N
Boreal Chorus Frog	<i>Pseudacris maculata</i>	Y	Y	Y
Northern Leopard Frog	<i>Lithobates pipiens</i>	Y	Y	Y
Great Plains Toad	<i>Anaxyrus cognatus</i>	Y	Y	N
Woodhouse's Toad	<i>Anaxyrus woodhousii</i>	Y	Y	Y
Plains Spadefoot	<i>Spea bombifrons</i>	Y	Y	Y
Tiger Salamander	<i>Ambystoma tigrinum</i>	Y	Y	Y
Greater Short-horned Lizard	<i>Phrynosoma hernandesi</i>	Y	Y	Y
Northern Sagebrush Lizard	<i>Sceloporus graciosus</i>	Y	Y	Y
Eastern Yellowbelly Racer	<i>Coluber constrictor flaviventris</i>	Y	Y	Y
Prairie Rattlesnake	<i>Crotalus viridis</i>	Y	Y	Y
Western Hog-nosed Snake	<i>Heterodon nasicus</i>	Y	Y	N
Bullsnake	<i>Pituophis catenifer sayi</i>	Y	Y	Y
Wandering Garter Snake	<i>Thamnophis elegans vagrans</i>	Y	Y	Y
Plains Garter Snake	<i>Thamnophis radix</i>	Y	Y	N
Common Garter Snake	<i>Thamnophis sirtalis parietalis</i>	Y	Y	Y
Snapping Turtle	<i>Chelydra serpentina</i>	Y	Y	N
Western Painted Turtle	<i>Chrysemys picta</i>	Y	Y	Y
Spiny Softshell Turtle	<i>Apalone spinifera</i>	Y	N	Y

\* Indicates questionable occurrence in PRB due to lack of supporting documentation from field survey efforts.

**Table 2.** List of acronyms for species names used in tables and figures.

<b>BCF</b>	Boreal Chorus Frog	<b>PR</b>	Prairie Rattlesnake
<b>NLF</b>	Northern Leopard Frog	<b>WHS</b>	Western Hog-nosed Snake
<b>GPT</b>	Great Plains Toad	<b>BS</b>	Bullsnake
<b>WT</b>	Woodhouse's Toad	<b>WGS</b>	Wandering Garter Snake
<b>PSFT</b>	Plains Spadefoot Toad	<b>PGS</b>	Plains Garter Snake
<b>TS</b>	Tiger Salamander	<b>CGS</b>	Common Garter Snake
<b>SHL</b>	Short-horned Lizard	<b>ST</b>	Snapping Turtle
<b>NSL</b>	Northern Sagebrush Lizard	<b>SST</b>	Spiny Softshell Turtle
<b>EYR</b>	Eastern Yellowbelly Racer	<b>WPT</b>	Western Painted Turtle

**Table 3.** Results from nocturnal call surveys for breeding amphibians conducted in the Powder River Basin from 22 May – 6 June, 2009. Surveys highlighted in blue were conducted along previous WGFD survey routes using the same protocols. Results from WGFD surveys conducted 18-25 May, 2006 are also provided in the last column when appropriate.

Date	Route Name	Total time (min)	Last rain (days)	relative humidity	Wind (m/s)	temp (°C)	Distance btw stops (miles)	Species found by WYND in 2008	Species found by WGFD in 2006
5/29	BTNOC07	0:38	4	46.8	1.5	18.9	0.1	BCF, PSFT	BCF, NLF, WHT
5/27	BTNOC08	0:36	3	61.6	2	14.6	0.1	BCF	BCF, NLF, WHT
5/27	BTNOC09	0:36	3	59.5	3.3	15.1	0.1	BCF, PSFT	NLF
5/29	BTNOC10	0:28	4	48.5	0	16.7	0.1	-	NLF
5/27	BTNOC11	0:37	3	39.4	1	21.2	0.1	BCF, PSFT	BCF,NLF
5/29	BTNOC12	0:32	4	42.7	0.9	19.3	0.1	BCF	BCF, NLF
5/28	BTNOC13	0:38	4	41.7	0	19.7	0.1	-	NLF
5/28	BTNOC14	0:31	4	42.9	0	18.3	0.1	BCF, PSFT	BCF, GPT, NLF
5/22	NOC0901	1:06	N/A	46.1	1.1	20.7	0.5	BCF	n/a
5/26	NOC0902	0:46	2	50.2	0.9	15.2	0.5	-	n/a
5/26	NOC0903	0:43	2	46.5	3.1	15.1	0.5	BCF	n/a
5/26	NOC0904	0:43	2	52.3	4.3	13.6	0.5	-	n/a
6/1	NOC0905	0:33	1	76.7	7.5	10.5	0.5	-	n/a
6/1	NOC0906	0:33	1	81.6	11	10.4	0.5	-	n/a
6/1	NOC0907	0:35	1	87.5	6.1	12.1	0.5	-	n/a
6/6	NOC0908	0:34	1	69.1	4.7	11	0.5	BCF	n/a

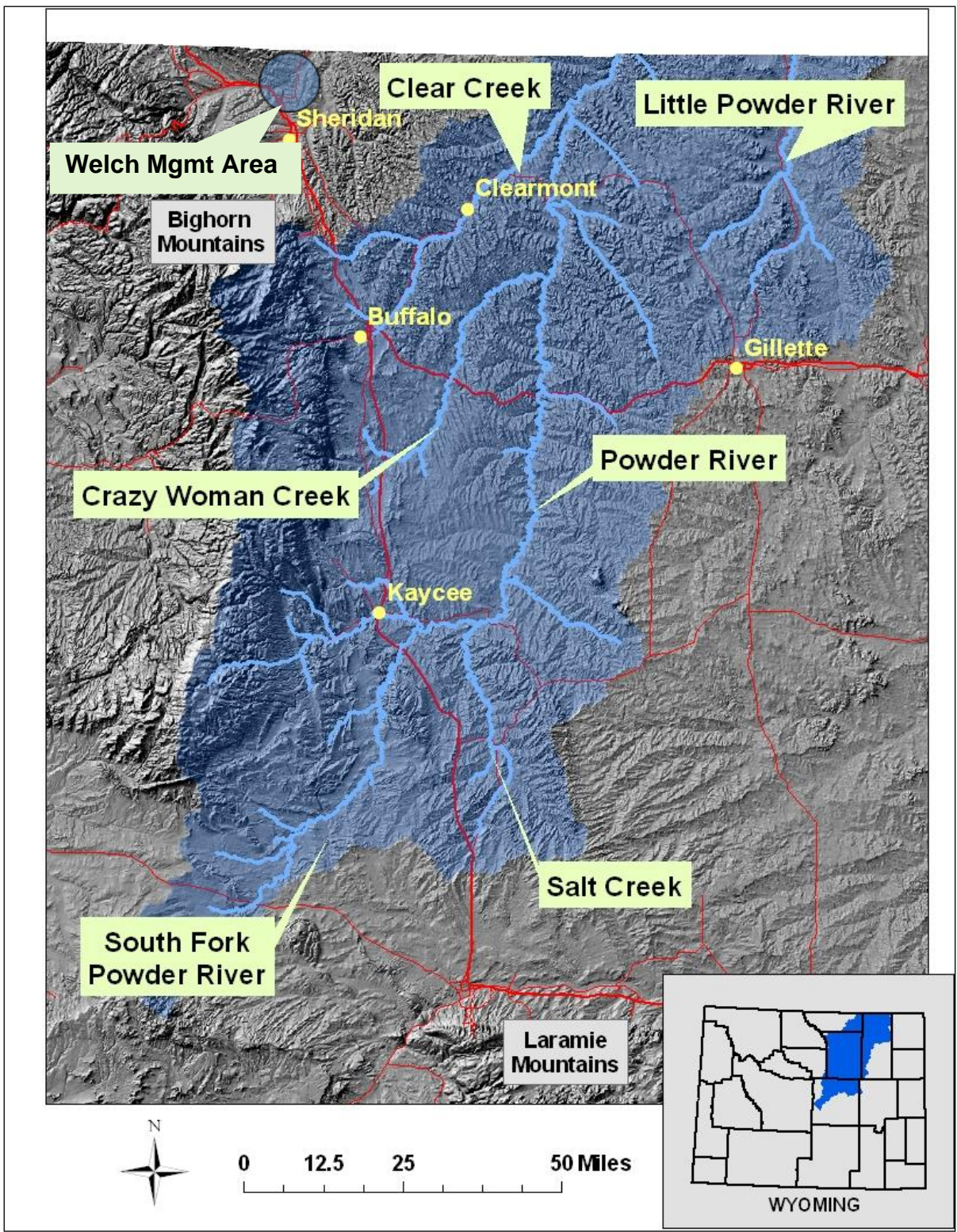
**Table 4.** Comparison between vehicle mortality rates documented for the same 1-mile stretches of road (n = 10) surveyed by WGFD in 2006 and by WYNDD in 2008 & 2009.

Route	WGFD Date	WYNDD Date	2006 mortality		2008/09 Mortality	
			Rate	2006 Species	Rate	2008/09 Species
BT08_01	5/15/2006	7/8/2008	0	-	0	-
BT08_02	5/30/2006	7/9/2008	0	-	0	-
BT08_03	6/6/2006	7/9/2008	0	-	1	1 Bullsnake (likely)
BT08_05	7/17/2006	7/11/2008	0	-	1	1 Prairie Rattlesnake
BT08_06	7/24/2006	7/11/2008	0	-	1	1 Bullsnake
BT09_03	5/22/2006	5/28/2009	0	-	0	-
BT09_04	5/22/2006	5/28/2009	1	1 Bullsnake	0	-
BT09_05	5/22/2006	5/29/2009	0	-	0	-
BT09_07	5/24/2006	5/27/2009	0	-	2	1 Prairie Rattlesnake 1 Bullsnake
BT09_12	5/30/2006	5/27/2009	0	-	0	-
<b>Avg. mortalities/mile</b>			<b>0.1</b>		<b>0.5</b>	

**Table 5.** Water quality characteristics for sites found to contain amphibians during riparian and lentic Visual Encounter Surveys (VES) in the Powder River Basin from 2008-2009. We recorded the number of sites where each species was found, the habitat type, the percent of the water body containing aquatic vegetation, and whether or not the water body was dammed. We also recorded minimum and maximum water temperature, pH, total dissolved solids (TDS), conductivity, and salinity.

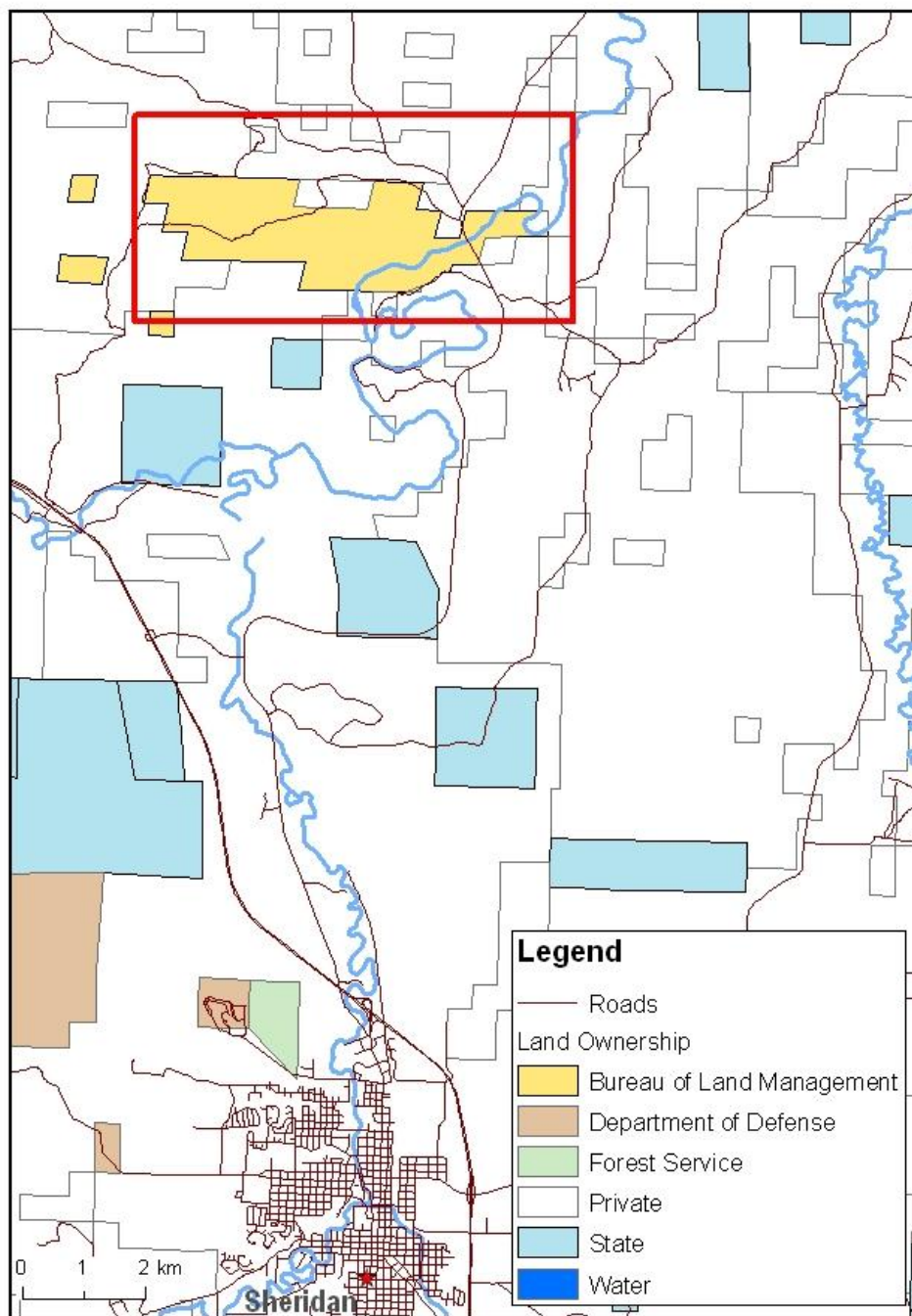
Species	Habitat Type	# of sites	% Aquatic Vegetation	Water Dammed?	Water Temp °C		Water pH		Total Dissolved Solids (g/L)		Conductivity (mS/cm)		Salinity (ppt)	
					Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
<b>Tiger Salamander</b>	Reservoir/stock pond	19	0-25	Y,N	14.1	29.4	7.3	<b>9.52</b>	0.13	4.92	0.21	6.66	0.1	4.2
<b>Boreal Chorus Frog</b>	Ditch/puddle, Stream channel, Reservoir/stock pond Ephemeral channel, Wetland/marsh	17	0-100	Y,N	12.4	30.1	7.1	7.9	0.08	6.17	0.12	<b>9.53</b>	0.1	<b>5.3</b>
<b>Northern Leopard Frog</b>	Stream channel, Reservoir/stock pond, Pond, Ephemeral channel	32	0-50	Y,N	11.3	30.1	7.1	<b>9.52</b>	0.13	<b>8.34</b>	0.16	3.38	0.1	1.8
<b>Woodhouse's Toad</b>	Stream channel, Reservoir/stock pond, Ephemeral channel	26	0-100	Y,N	12.9	29.9	7.1	<b>9.52</b>	0.10	<b>8.28</b>	0.16	<b>11.48</b>	0.1	<b>7.5</b>
<b>Plains Spadefoot Toad</b>	Reservoir/stock pond	2	1-50	N	24.9	30.1	7.4	7.9	0.13	0.13	0.20	0.21	0.1	0.1
<b>Great Plains Toad</b>	Reservoir/stock pond	1	1-25	N	24.9	24.9	7.4	7.4	0.13	0.13	0.21	0.21	0.1	0.1

**Figure 1.** Map of the Powder River Basin and Welch Management Area where amphibian and reptile surveys were conducted by WYNDD in 2008 and 2009.

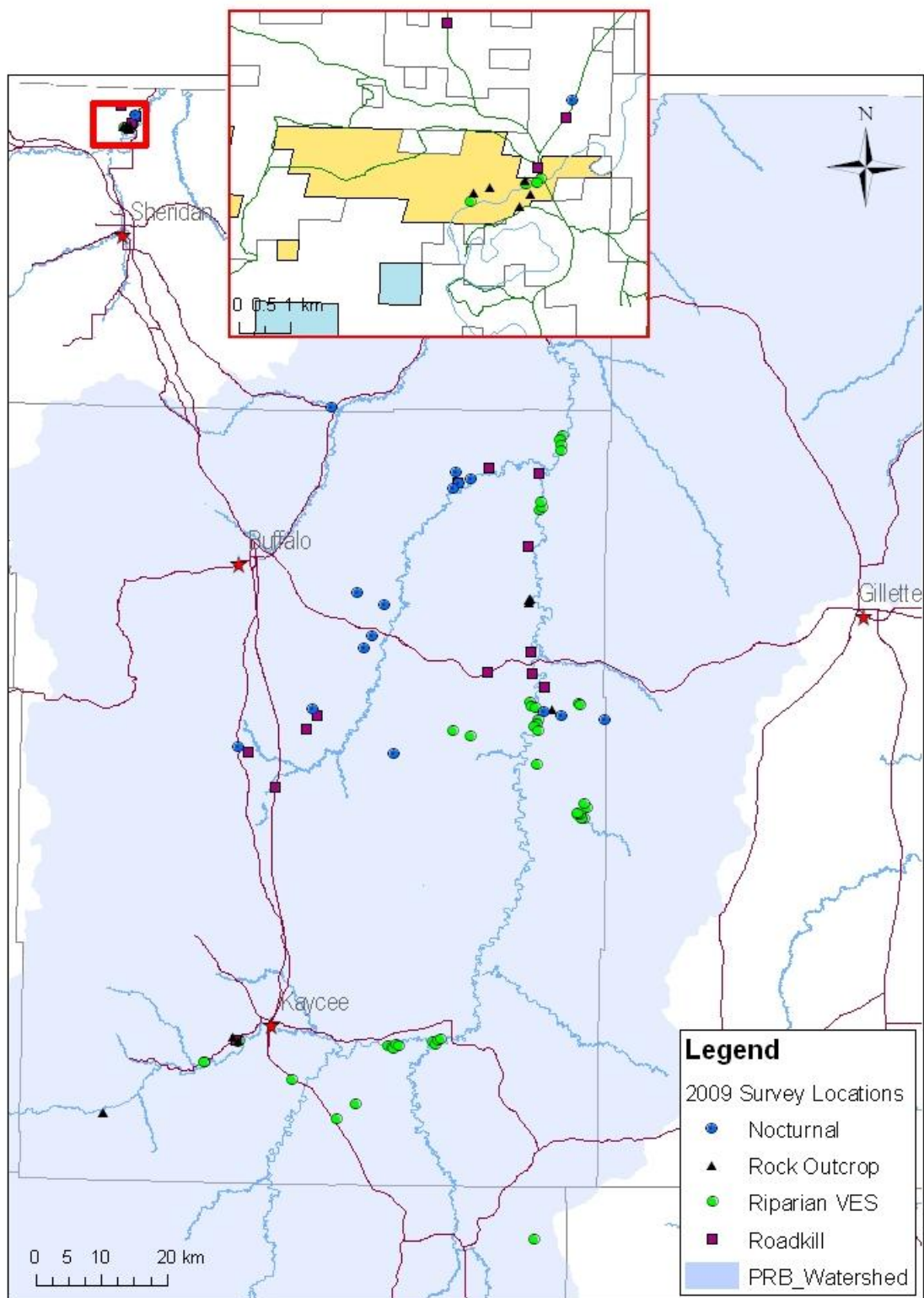




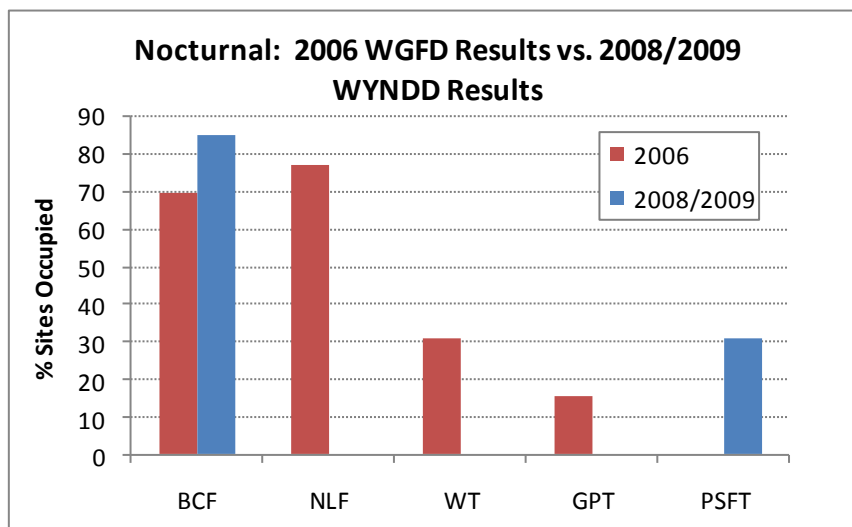
**Figure 2.** Enlargement of the Welch Management Area (highlighted in red) along the Tongue River north of Sheridan, Wyoming.



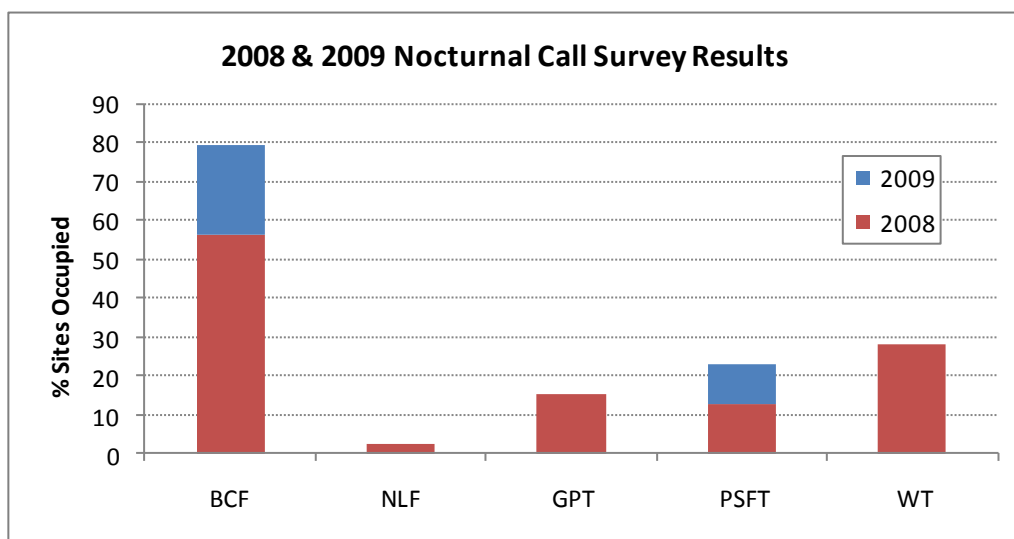
**Figure 3.** Location of amphibian and reptile surveys conducted in the Powder River Basin in 2009. Inset shows an enlargement of the Welch Management Area highlighted in red.



**Figure 4.** Percent occupancy of amphibian species for 13 sites surveyed in the Powder River Basin by WGFD in 2006 and by WYNDD in 2008 and 2009. Occupancy rates are shown for nocturnal call surveys (n = 13).



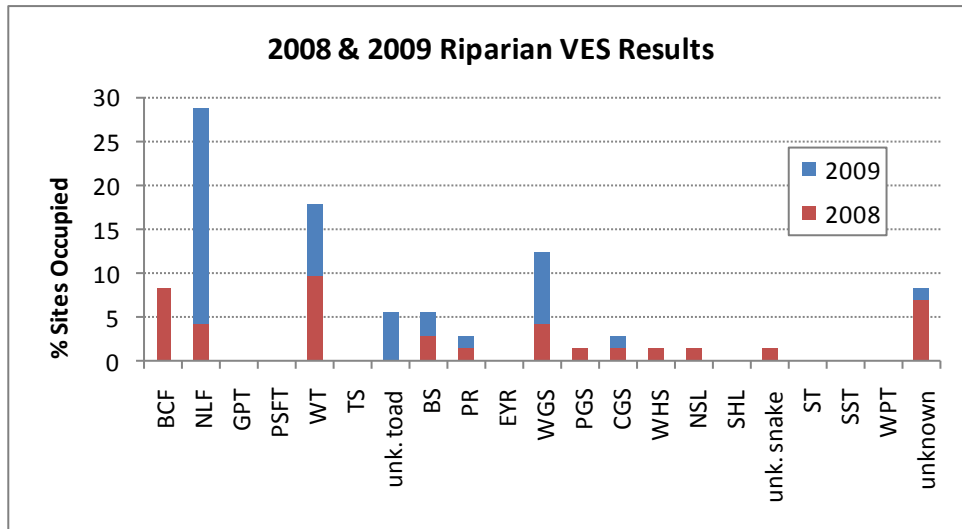
**Figure 5.** Percent occupancy of amphibian species at sites surveyed in the Powder River Basin from 2008-2009. Occupancy rates are shown for nocturnal call surveys (n = 39). Stacked columns display the relative contribution of each year to total occupancy rates.



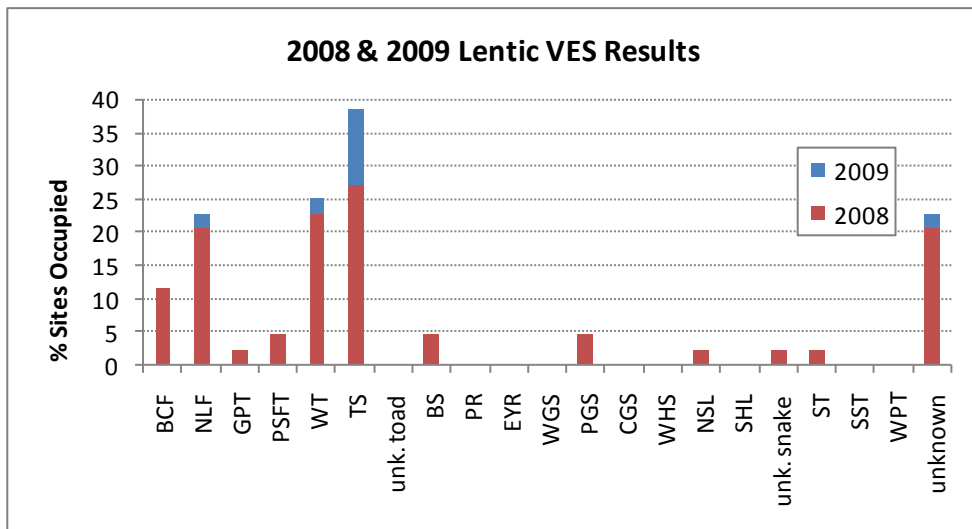


**Figure 6.** Percent occupancy of amphibian and reptile species for sites surveyed in the Powder River Basin from 2008-2009. Occupancy rates are shown for a) Riparian Visual Encounter Surveys (VES) (n = 73), and b) standing water body (Lentic) VES (n = 44). Stacked columns display the relative contribution of each year to total occupancy rates.

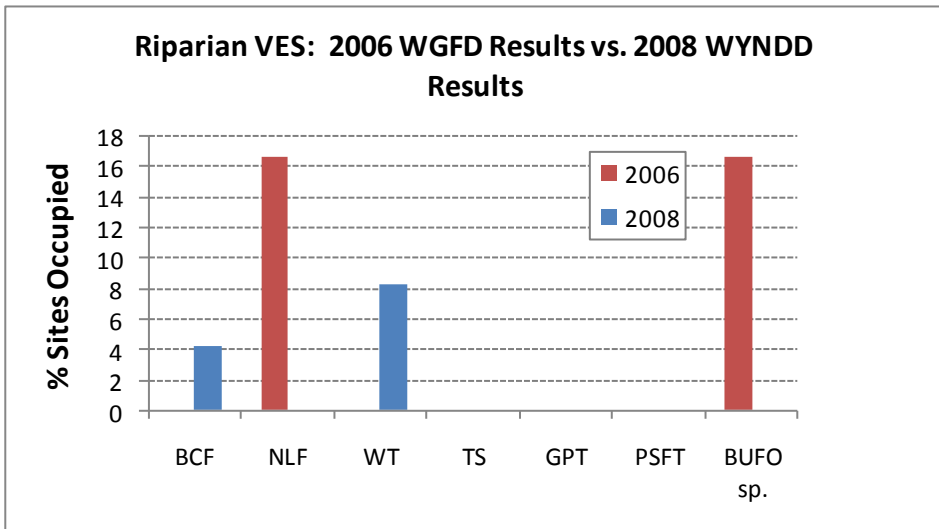
a)



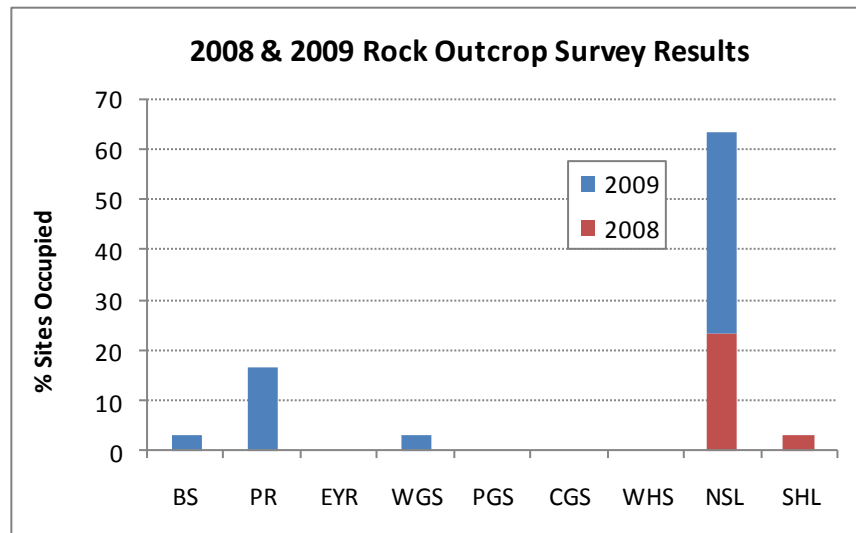
b)



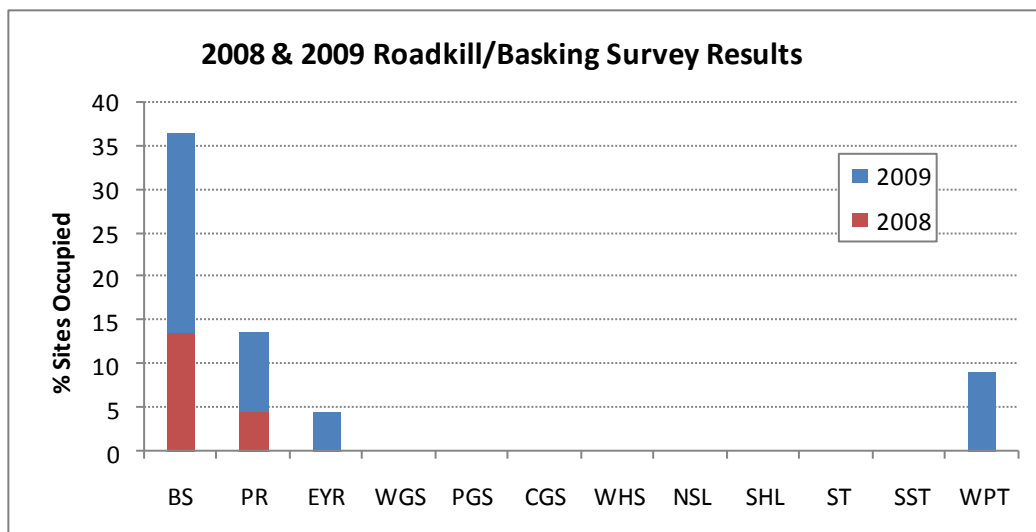
**Figure 7.** Percent occupancy of amphibian species for 24 sites surveyed in the Powder River Basin by WGFD in 2006 and by WYNDD in 2008. Occupancy rates are shown for Riparian Visual Encounter Surveys (VES) (n = 24).



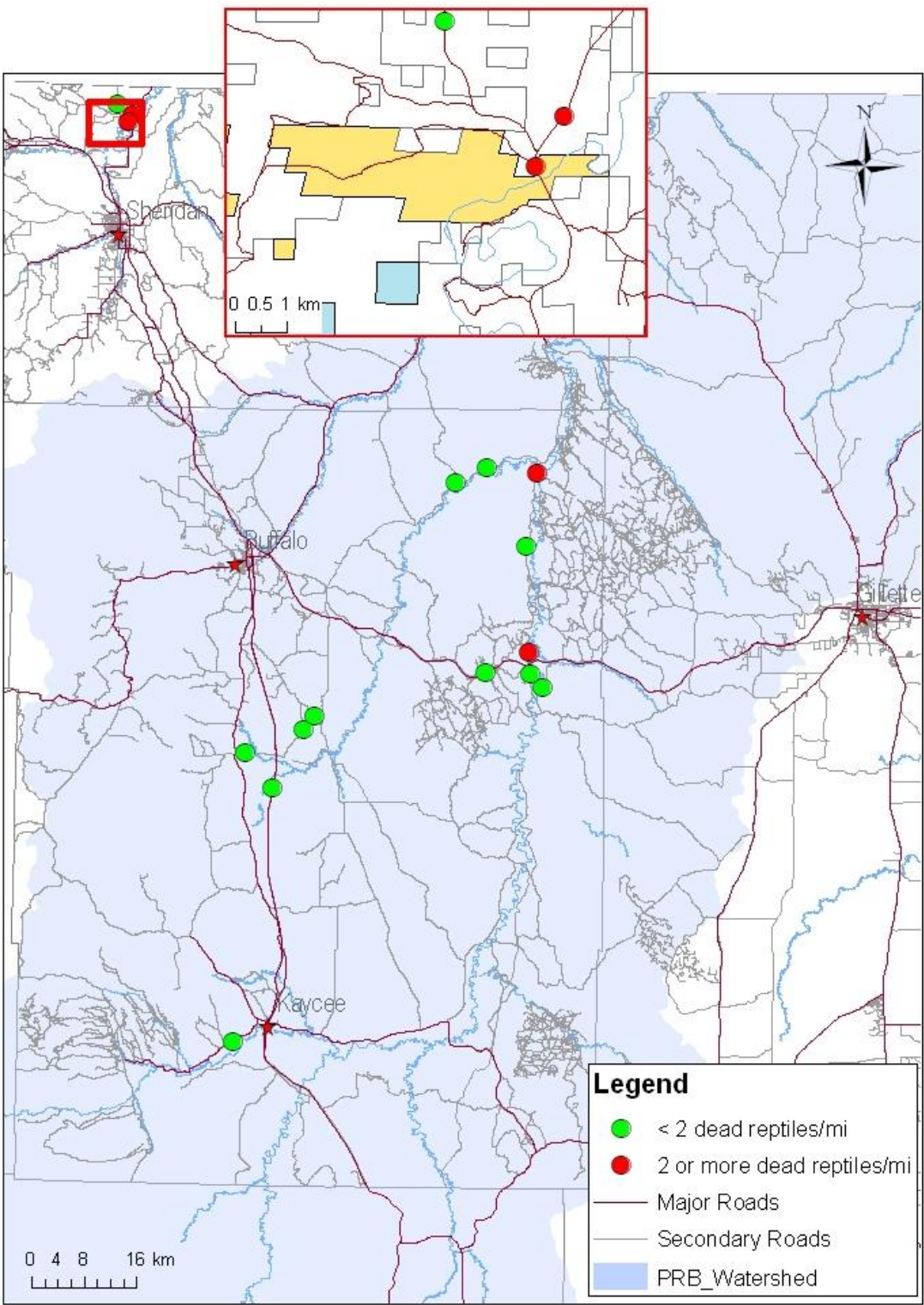
**Figure 8.** Percent occupancy of reptile species for sites surveyed in the Powder River Basin from 2008-2009. Occupancy rates are shown for rock outcrop surveys (n = 30). Stacked columns display the relative contribution of each year to total occupancy rates.



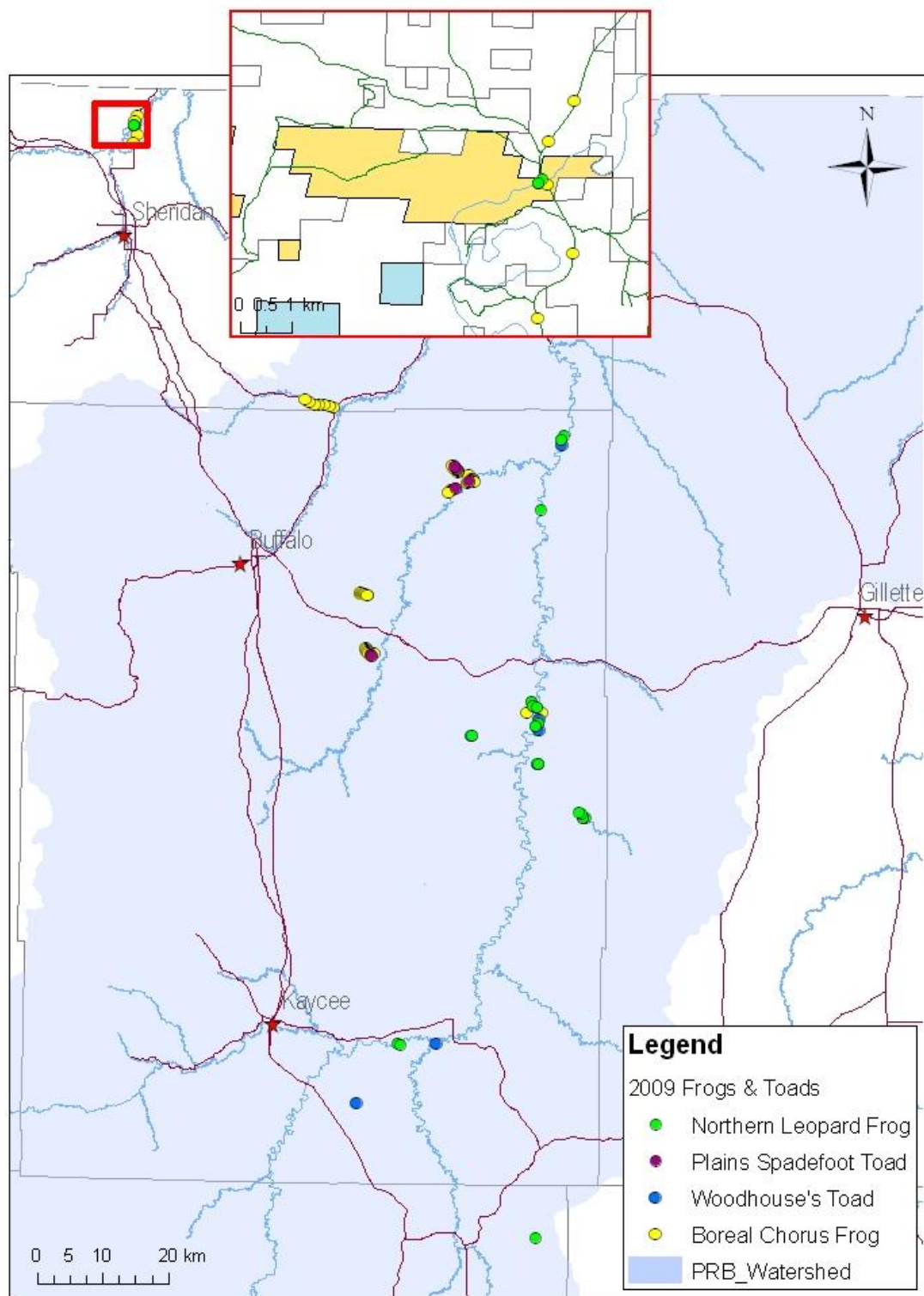
**Figure 9.** Percent occupancy of reptile species for sites surveyed in the Powder River Basin from 2008-2009. Occupancy rates are shown for roadkill/basking surveys (n = 22). Stacked columns display the relative contribution of each year to total occupancy rates.



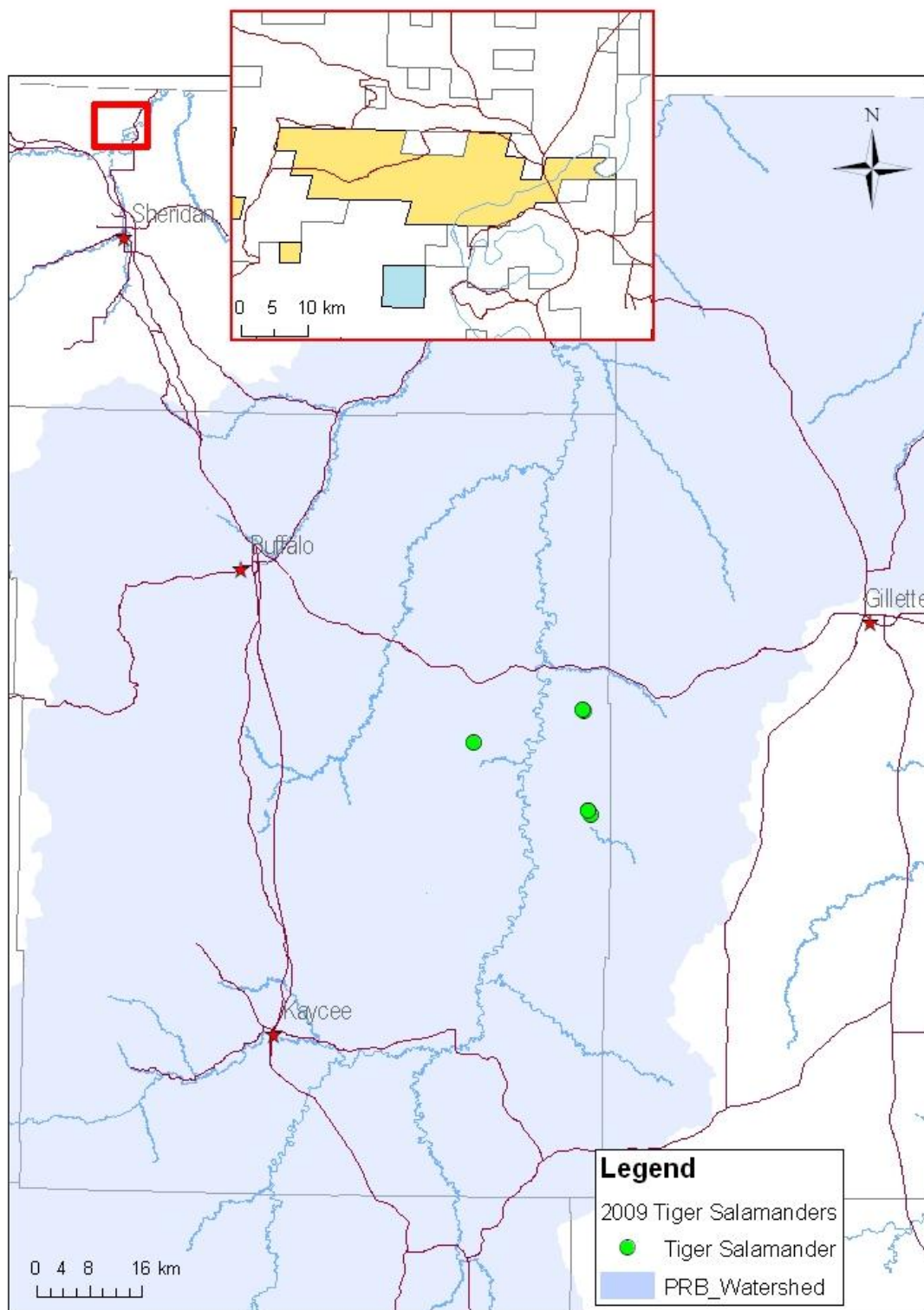
**Figure 10.** Location of roadkill “hotspots” for reptiles in the Powder River Basin and Welch Management Area, Wyoming, based on roadkill/basking surveys conducted in 2009 by WYNDD.



**Figure 11.** Locations of all occurrences for frogs and toads detected in 2009 during WYNDD field surveys in the Powder River Basin.

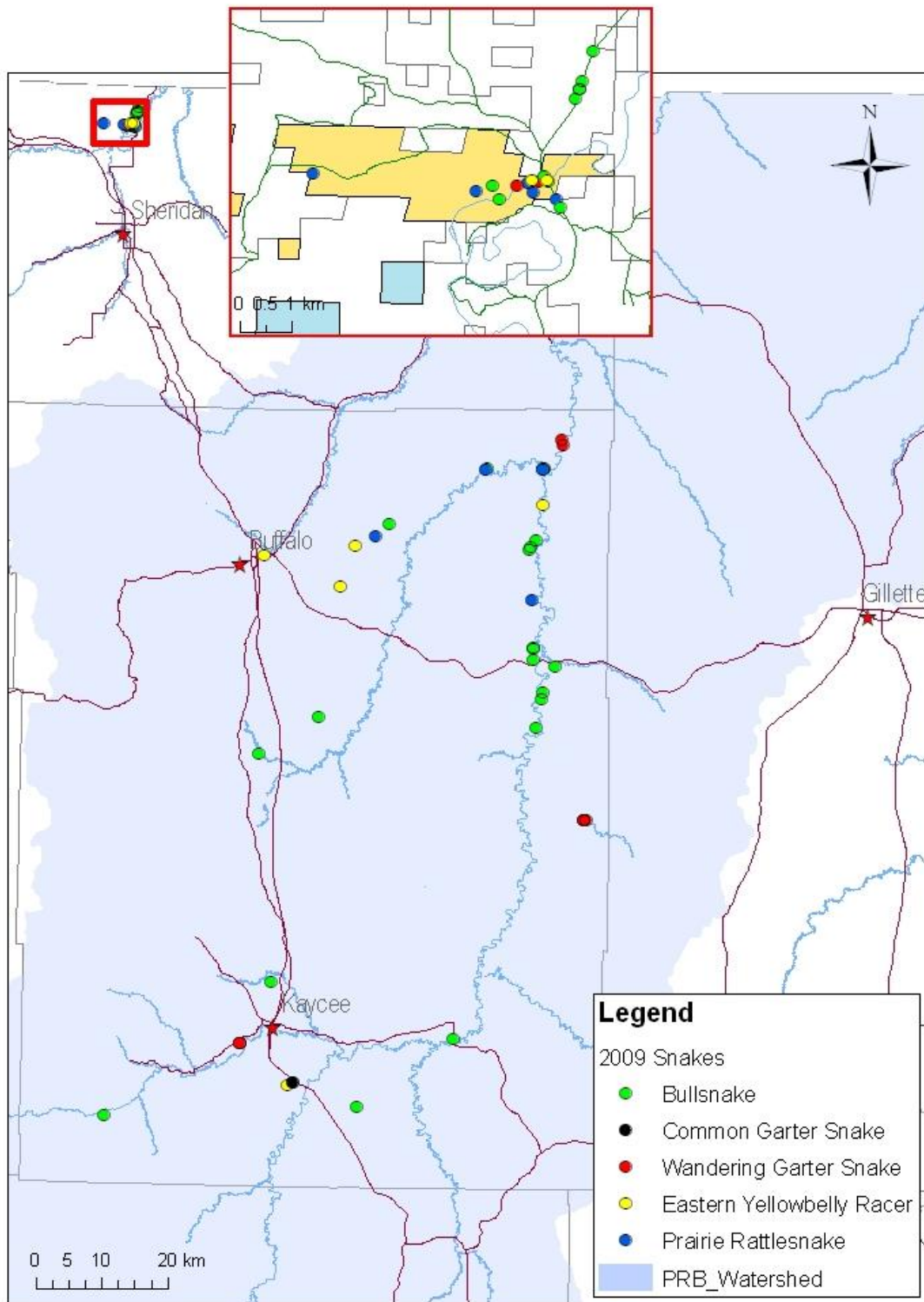


**Figure 12.** Locations of all occurrences for Tiger Salamanders detected in 2009 during WYND D field surveys in the Powder River Basin.

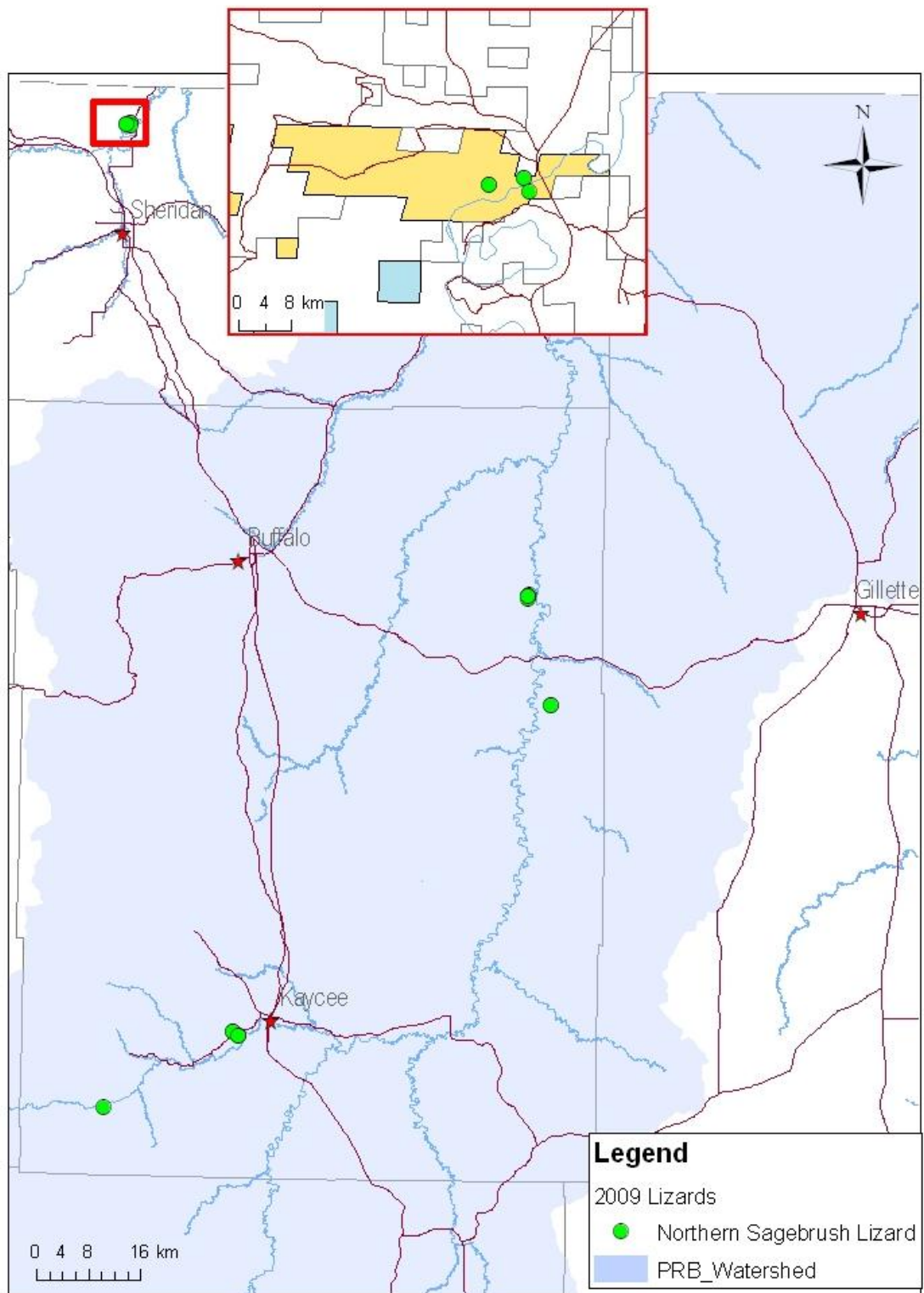




**Figure 13.** Locations of all occurrences for snakes detected in 2009 during WYNDD field surveys in the Powder River Basin.

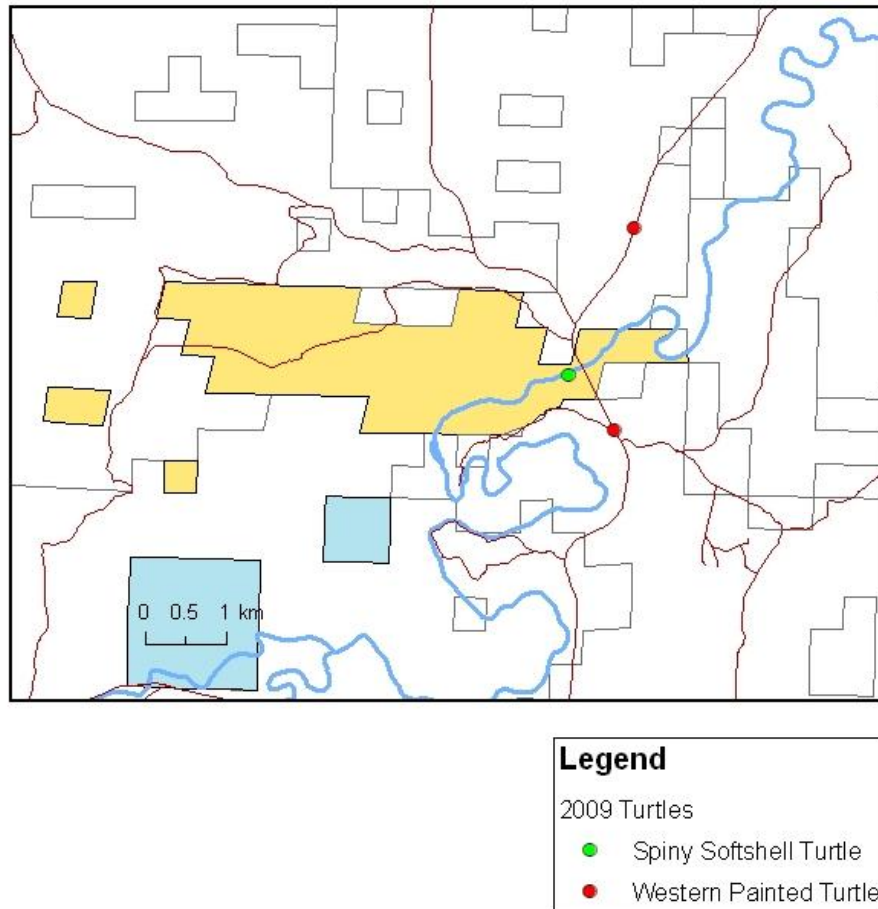


**Figure 14.** Locations of all occurrences for lizards detected in 2009 during WYNDD field surveys in the Powder River Basin.

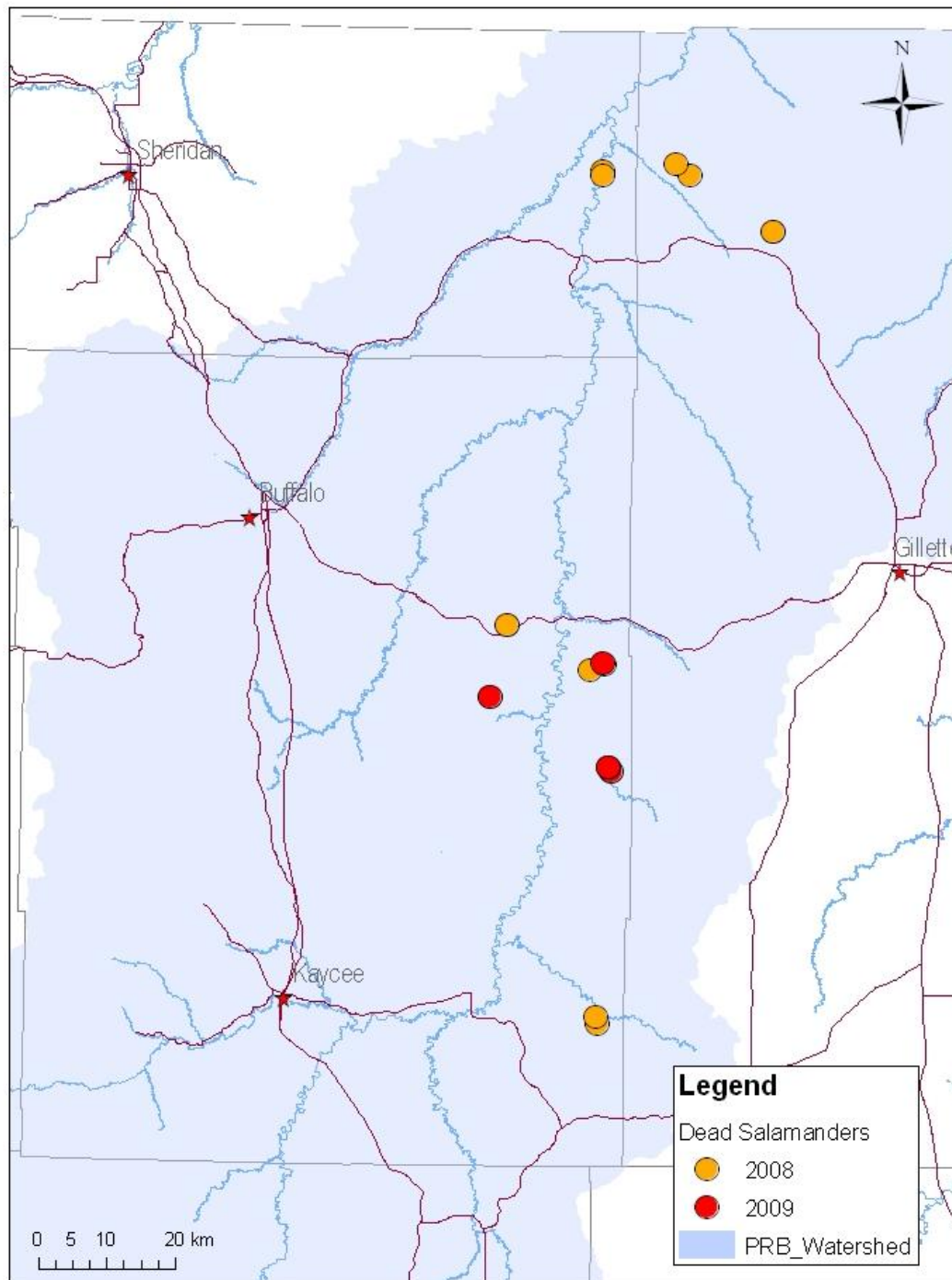




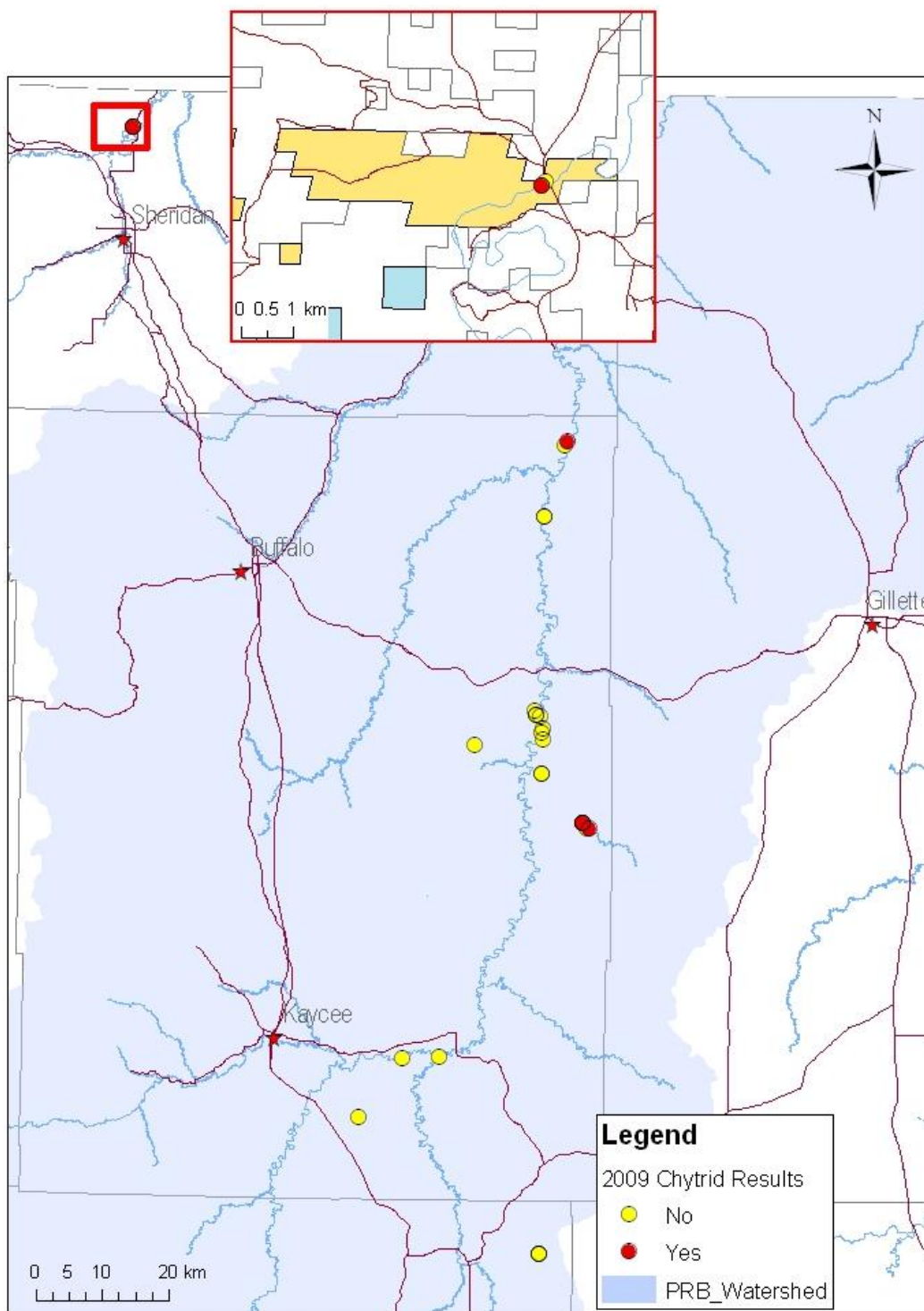
**Figure 15.** Locations of all occurrences for turtles detected in 2009 during WYNDD field surveys in the Powder River Basin. The only turtles documented in 2009 were in the Welch Management Area north of Sheridan, Wyoming.



**Figure 16.** Locations where dead Tiger Salamanders were found during Visual Encounter Surveys at standing water bodies in 2008 & 2009.



**Figure 17.** Locations of amphibian in the Powder River Basin area that tested positive for chytrid fungus in 2009.



APPENDIX A:

DRAFT DISTRIBUTION MAPS FOR AMPHIBIAN AND REPTILE  
SPECIES IN THE POWDER RIVER BASIN, WYOMING

Figure 1. Draft species distribution map for the Tiger Salamander (*Ambystoma tigrinum*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project. *Note: This distribution model is currently being re-run.*

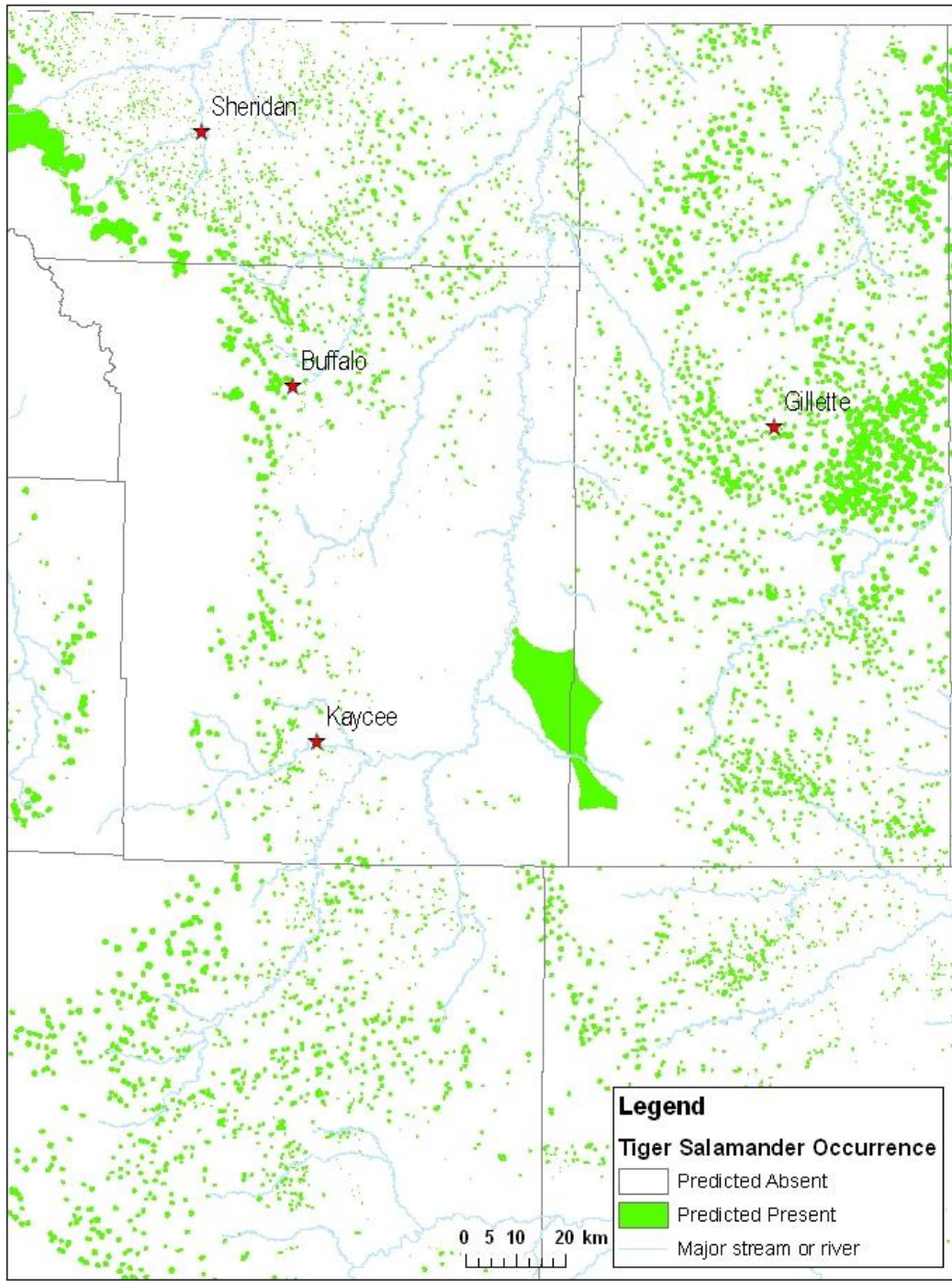




Figure 2. Draft species distribution map for the Tiger Salamander (*Ambystoma tigrinum*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project. *Note: This distribution model is currently being re-run.*

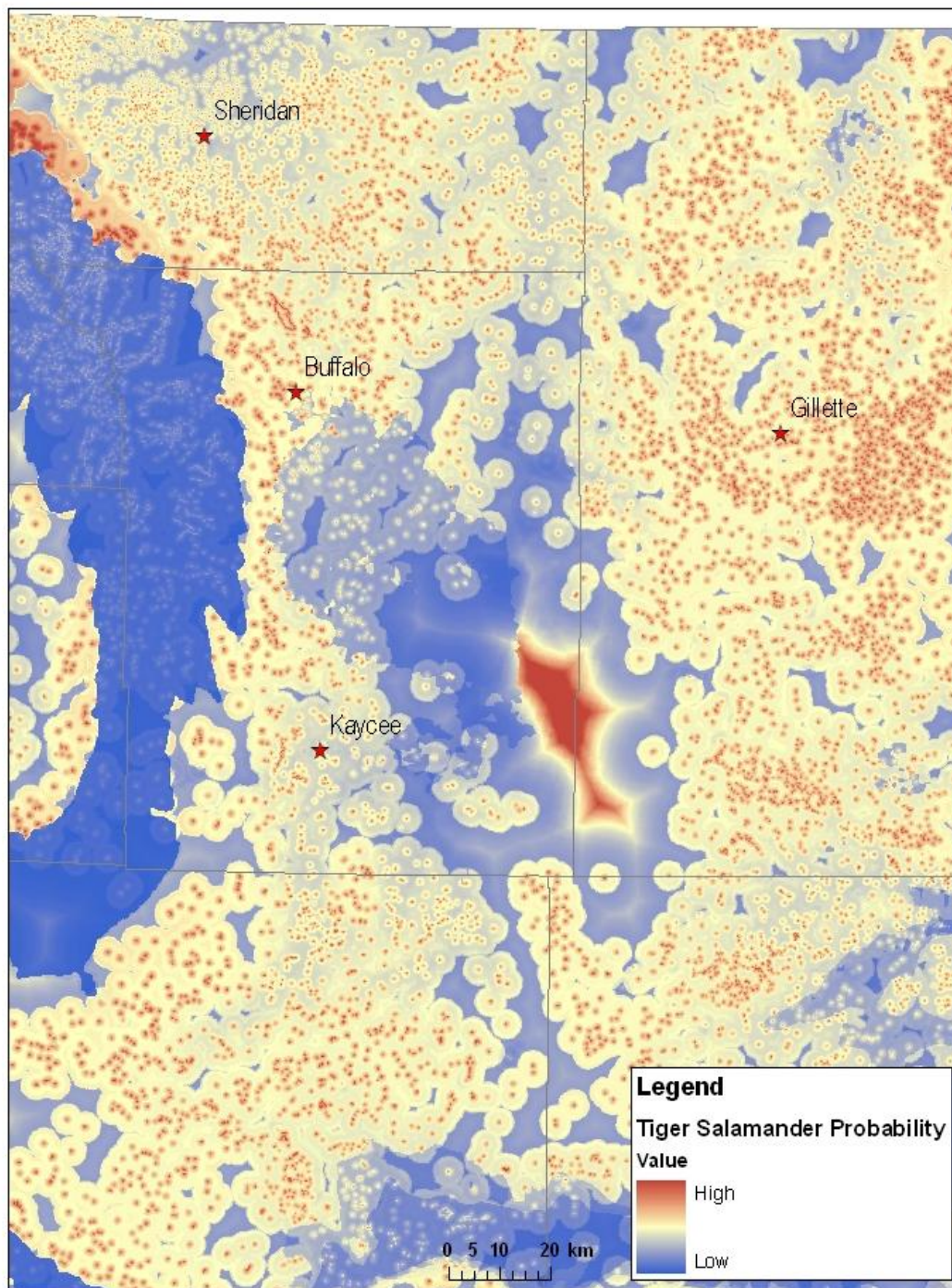


Figure 3. Draft species distribution map for the Boreal Chorus Frog (*Pseudacris maculata*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

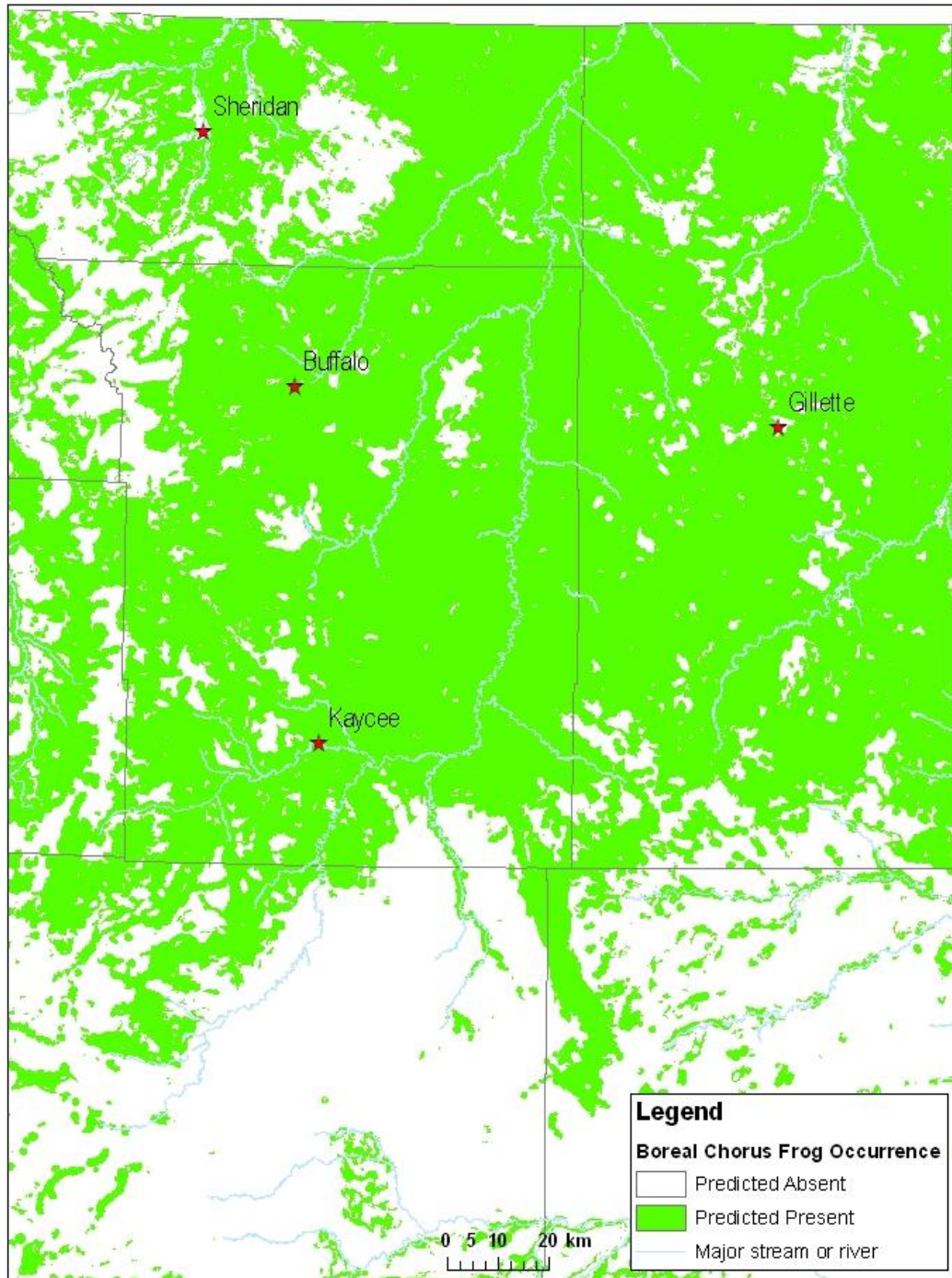




Figure 4. Draft species distribution map for the Boreal Chorus Frog (*Pseudacris maculata*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

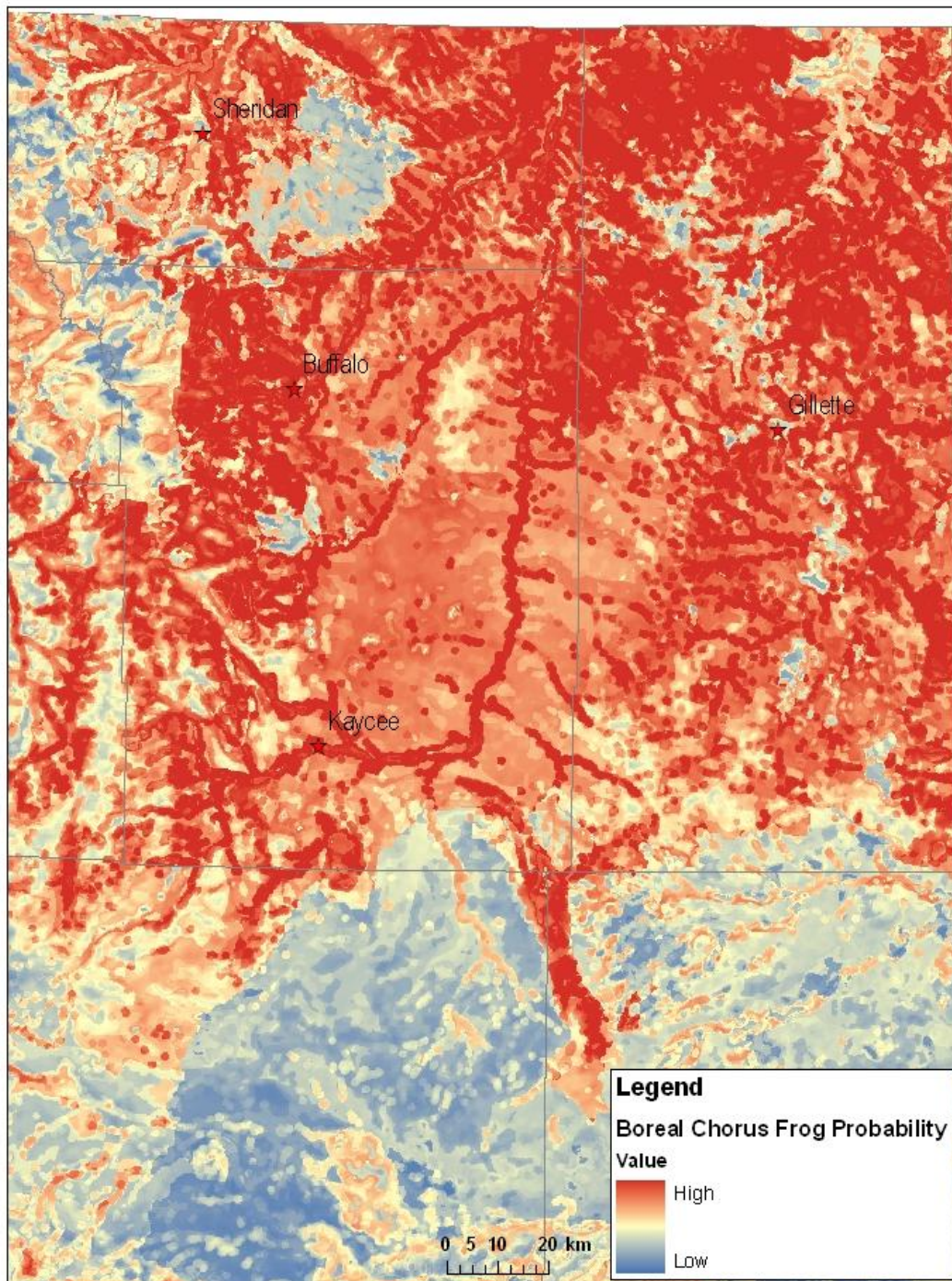




Figure 5. Draft species distribution map for the Northern Leopard Frog (*Lithobates pipiens*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

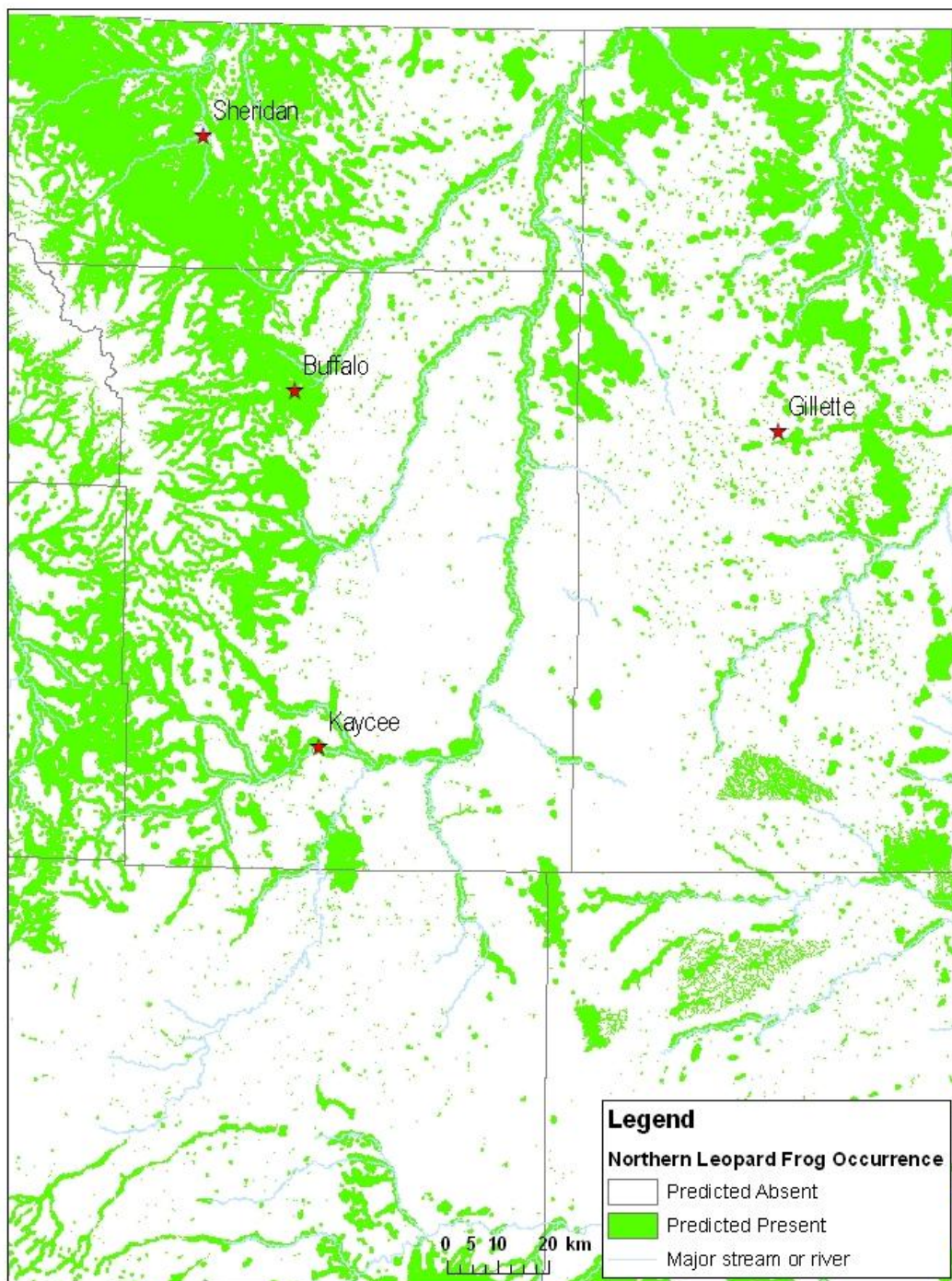




Figure 6. Draft species distribution map for the Northern Leopard Frog (*Lithobates pipiens*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

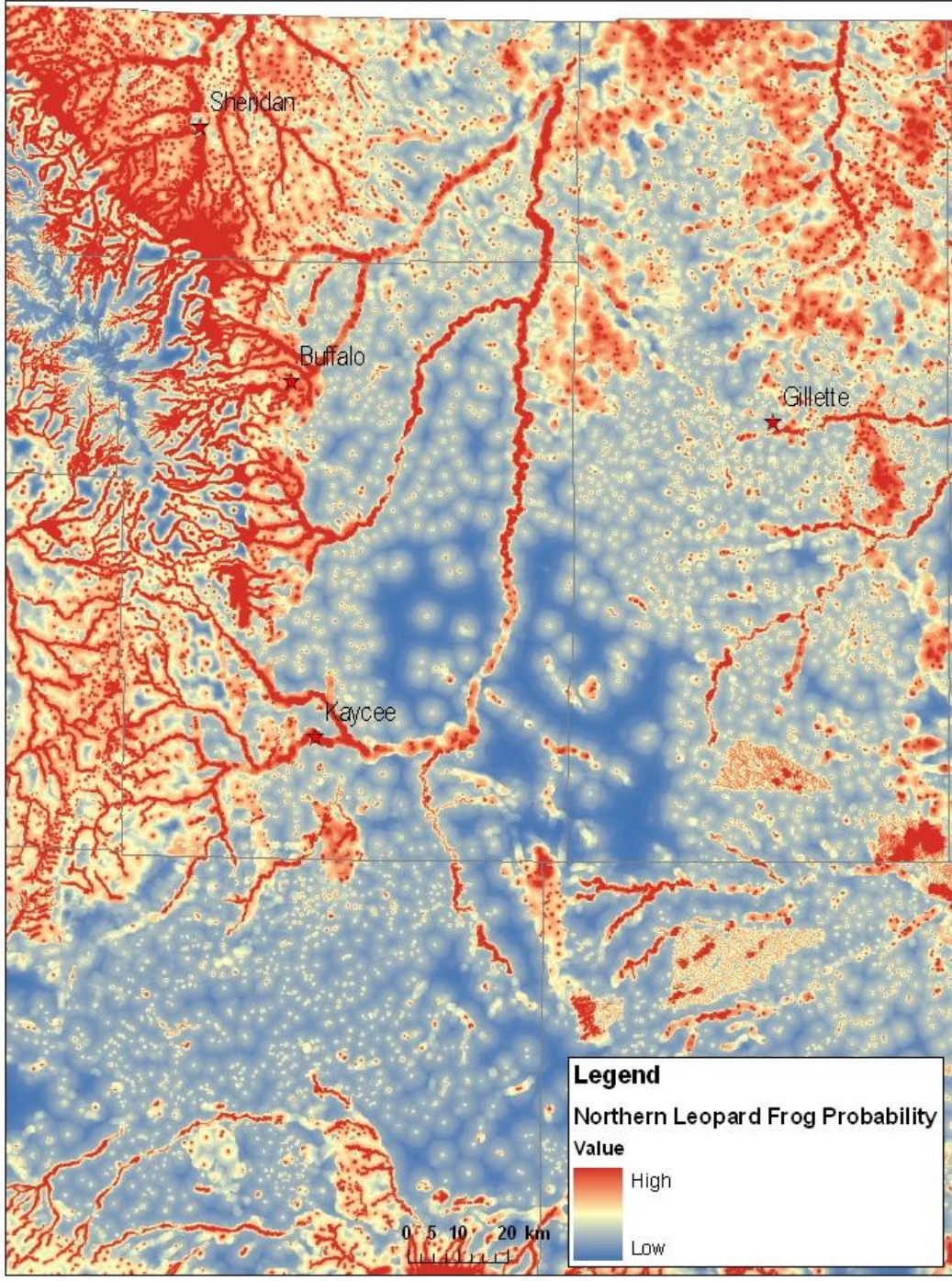


Figure 7. Draft species distribution map for the Great Plains Toad (*Anaxyrus cognatus*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

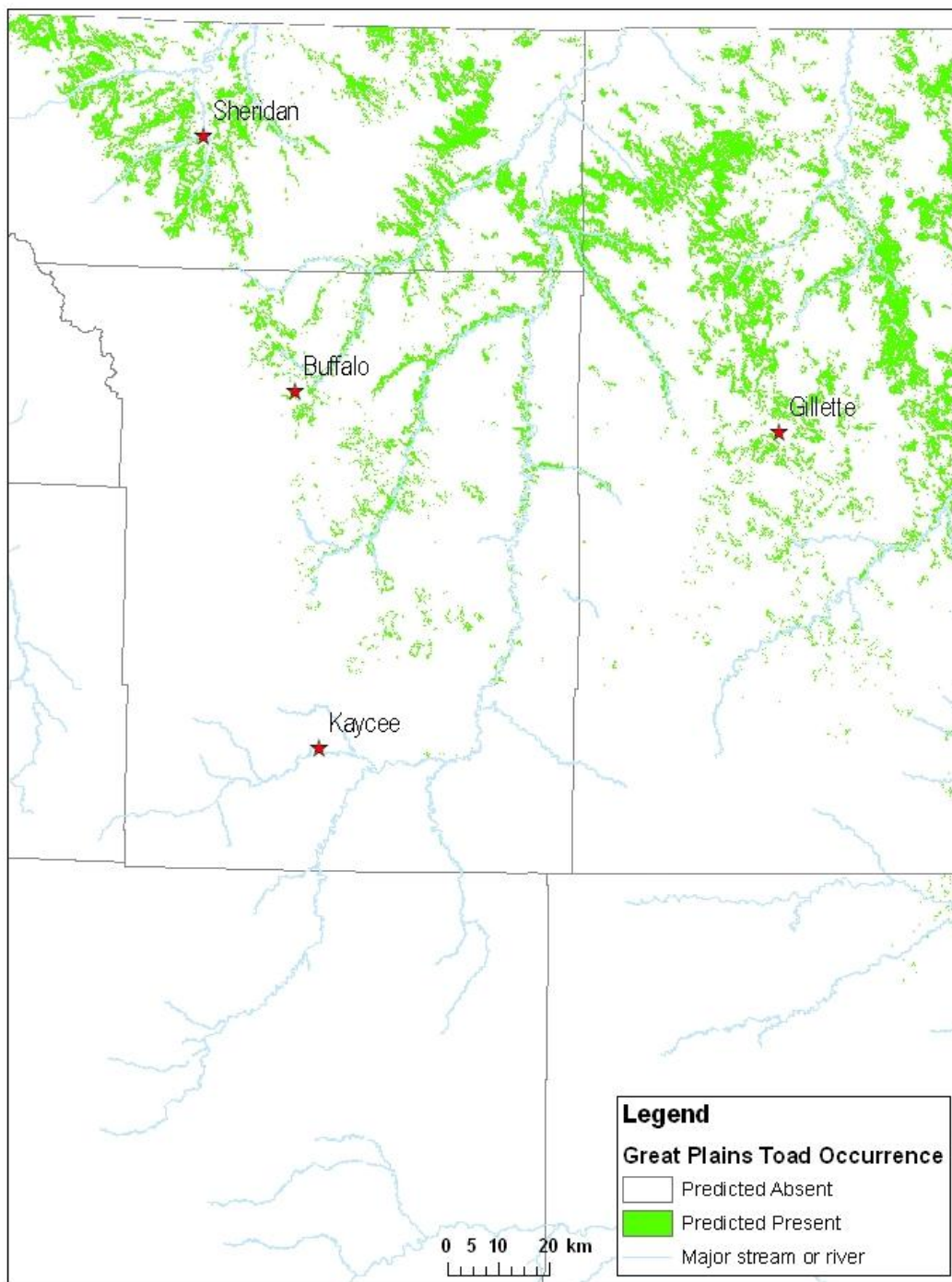




Figure 8. Draft species distribution map for the Great Plains Toad (*Anaxyrus cognatus*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

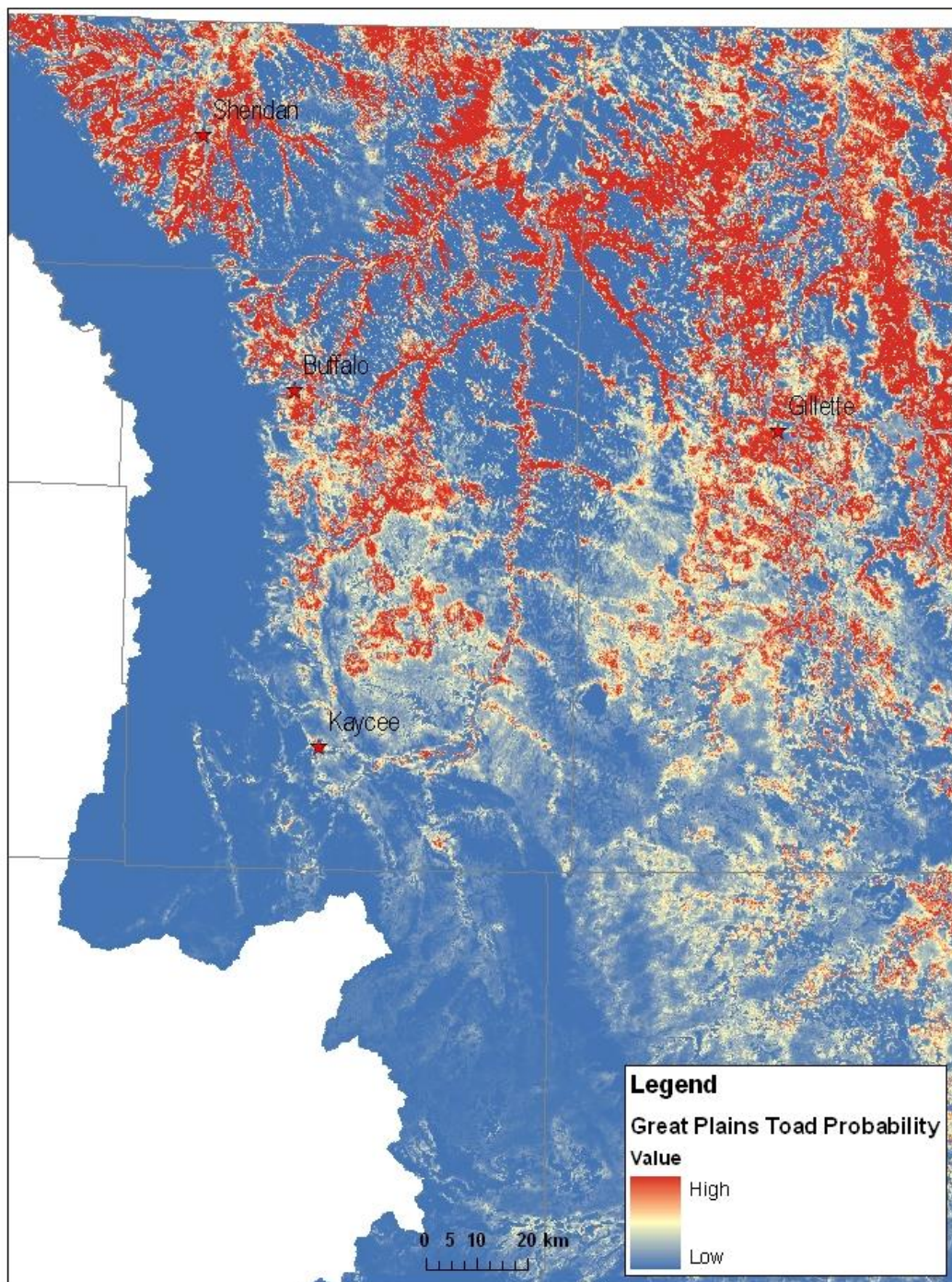


Figure 9. Draft species distribution map for the Woodhouse's Toad (*Anaxyrus woodhousii*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

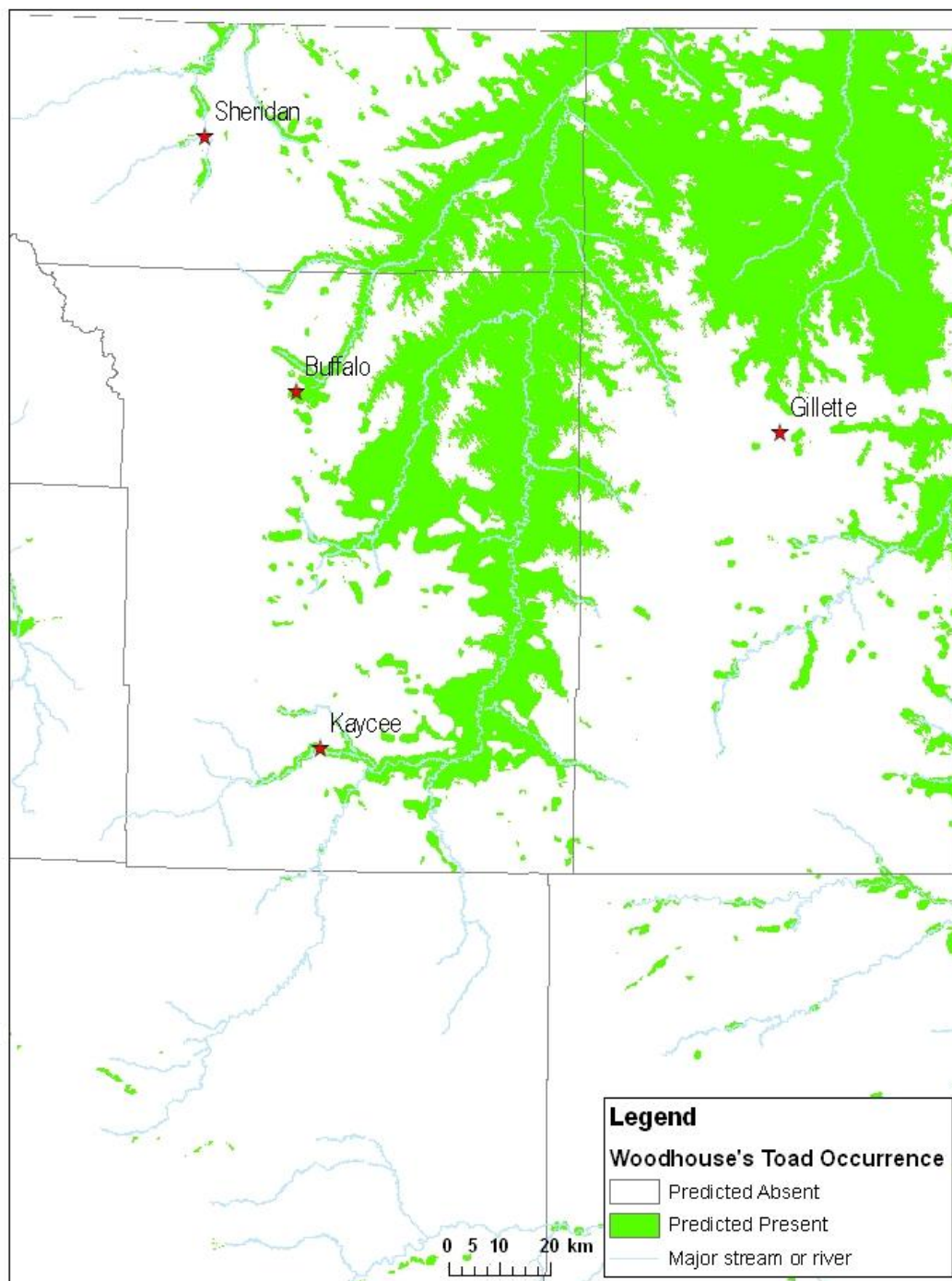




Figure 10. Draft species distribution map for the Woodhouse's Toad (*Anaxyrus woodhousii*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

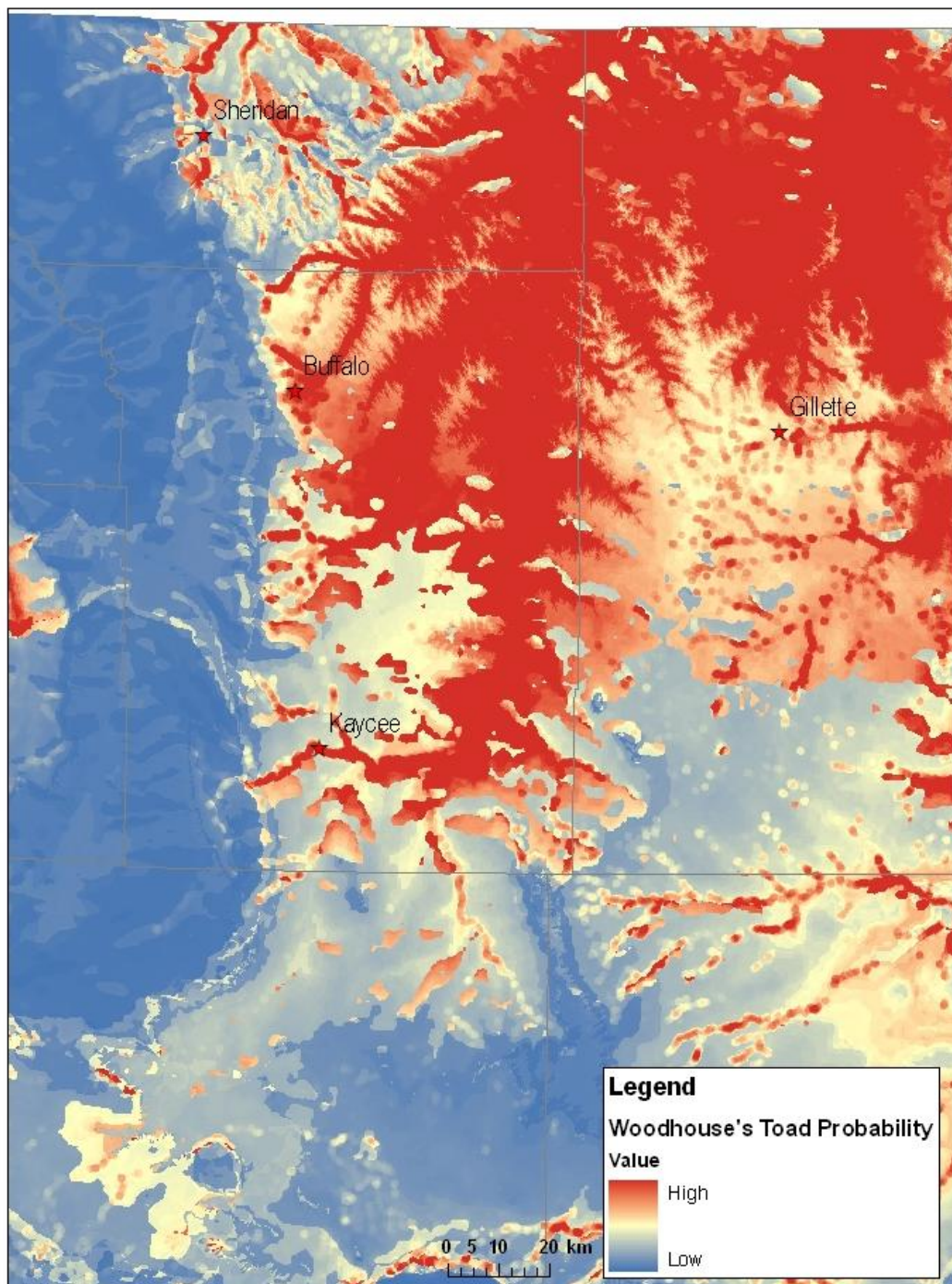




Figure 11. Draft species distribution map for the Plains Spadefoot (*Spa bombifrons*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD’s ongoing AWVED project.

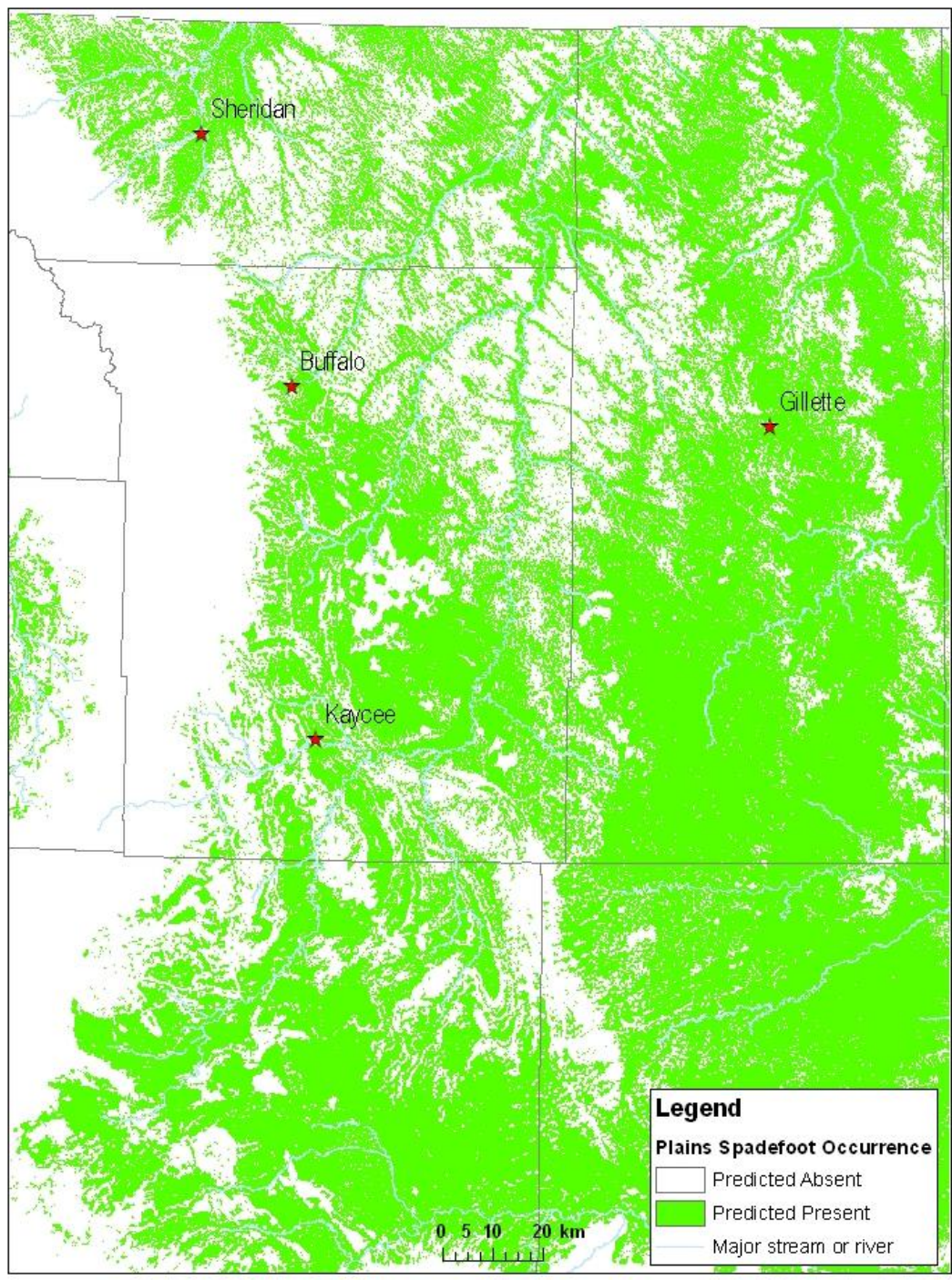




Figure 12. Draft species distribution map for the Plains Spadefoot (*Spea bombifrons*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

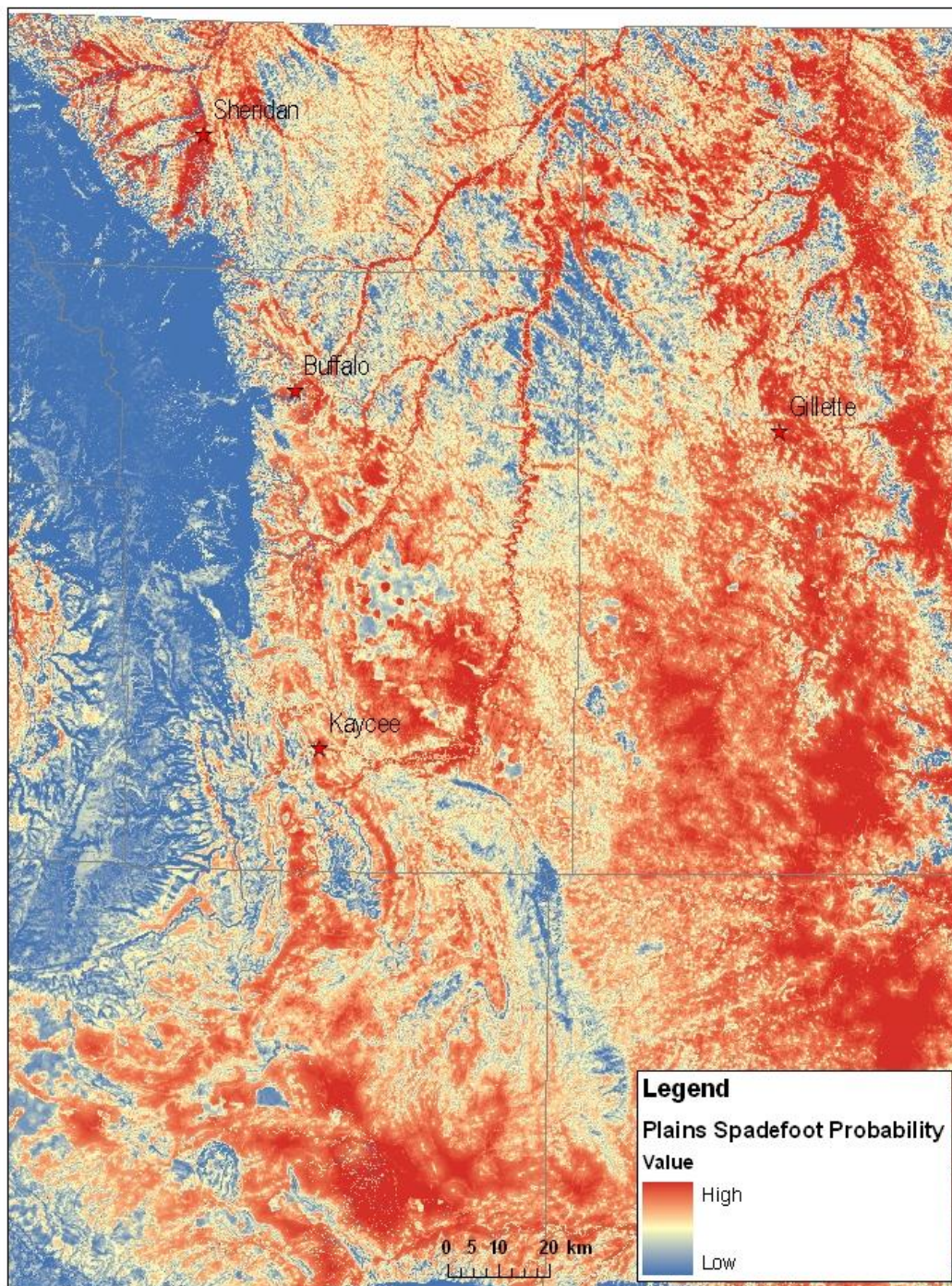




Figure 13. Draft species distribution map for the Greater Short-horned Lizard (*Phrynosoma hernandesi*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

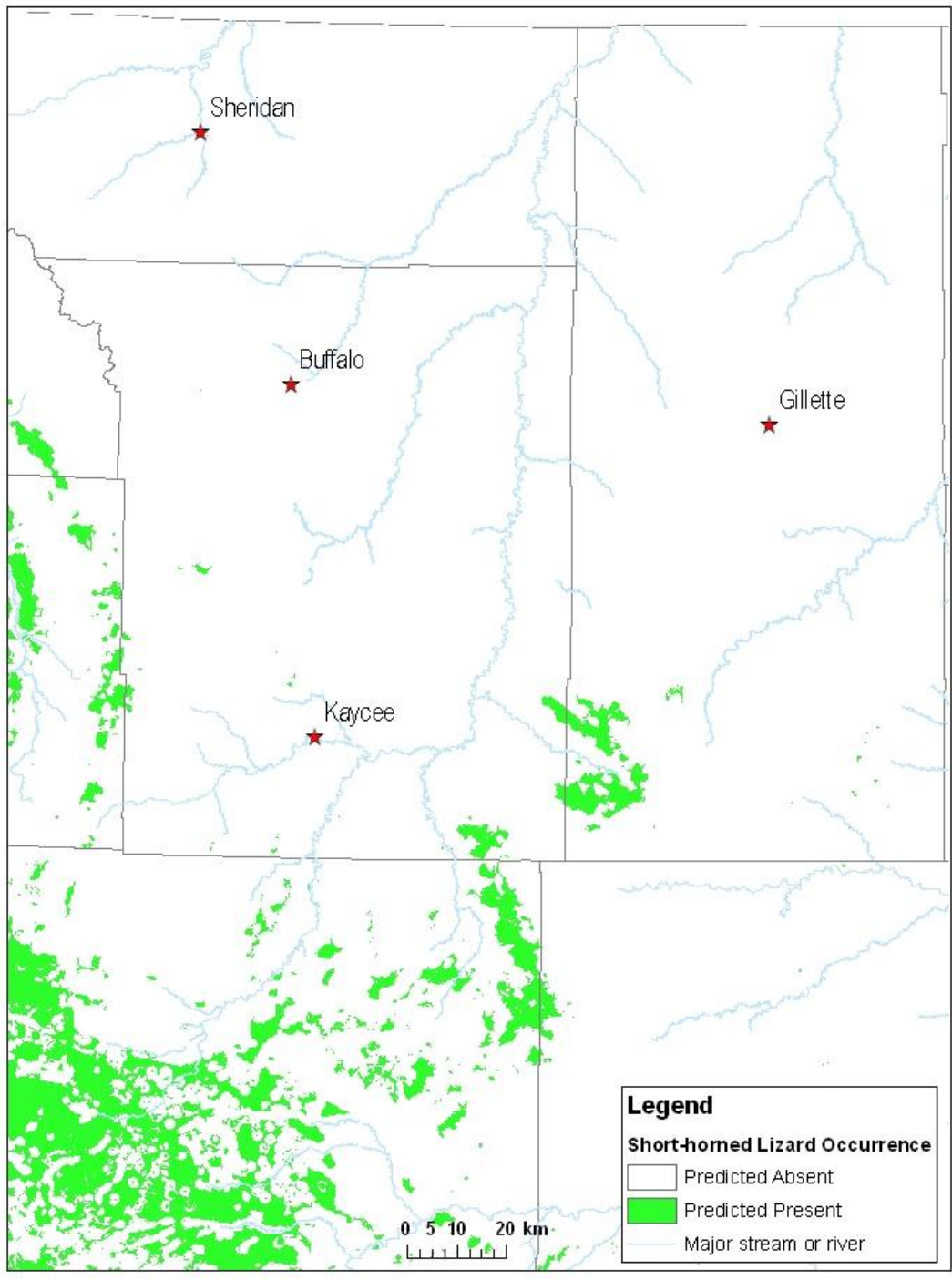


Figure 14. Draft species distribution map for the Greater Short-horned Lizard (*Phrynosoma hernandesi*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

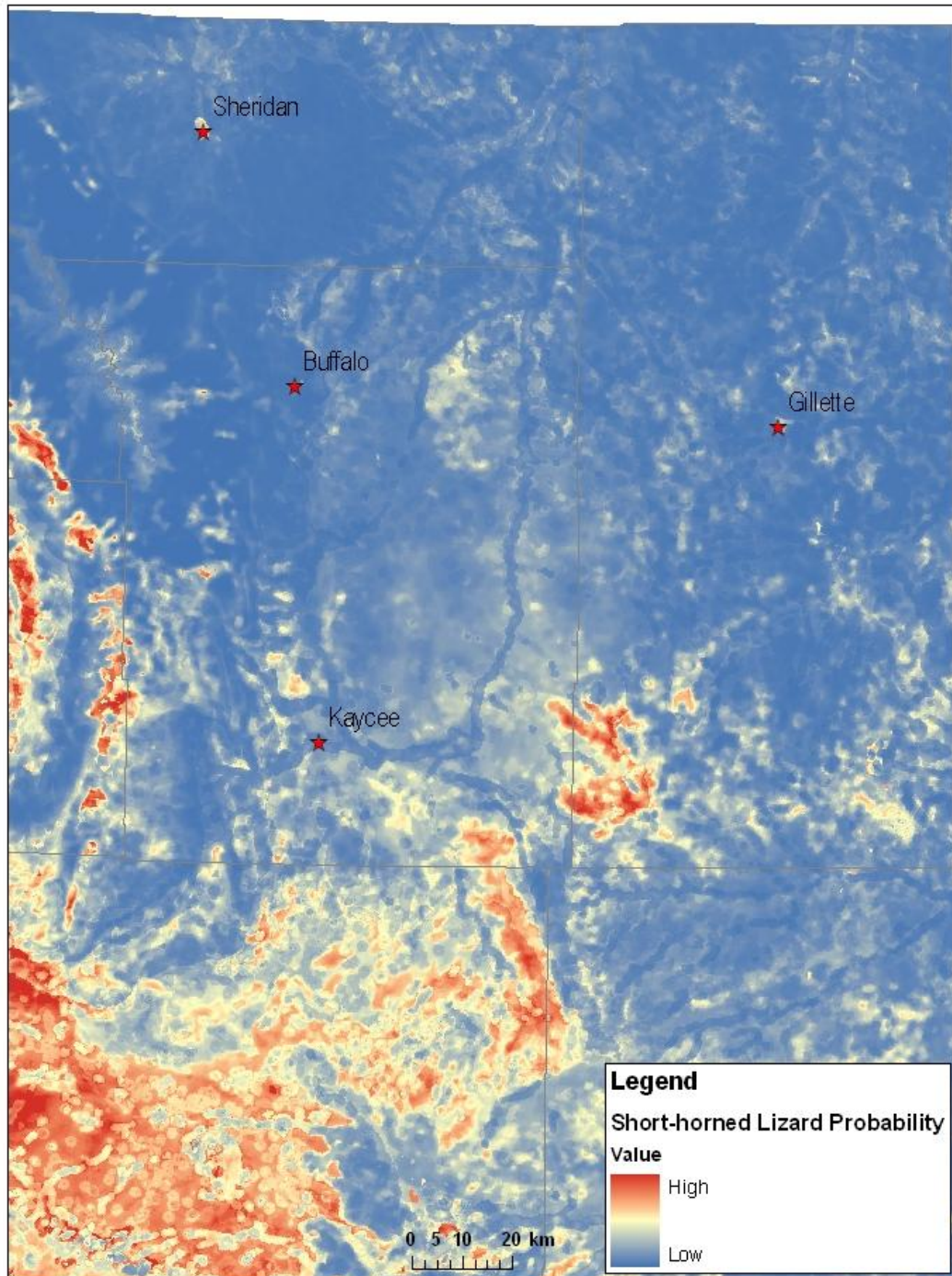


Figure 15. Draft species distribution map for the Northern Sagebrush Lizard (*Sceloporus graciosus*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

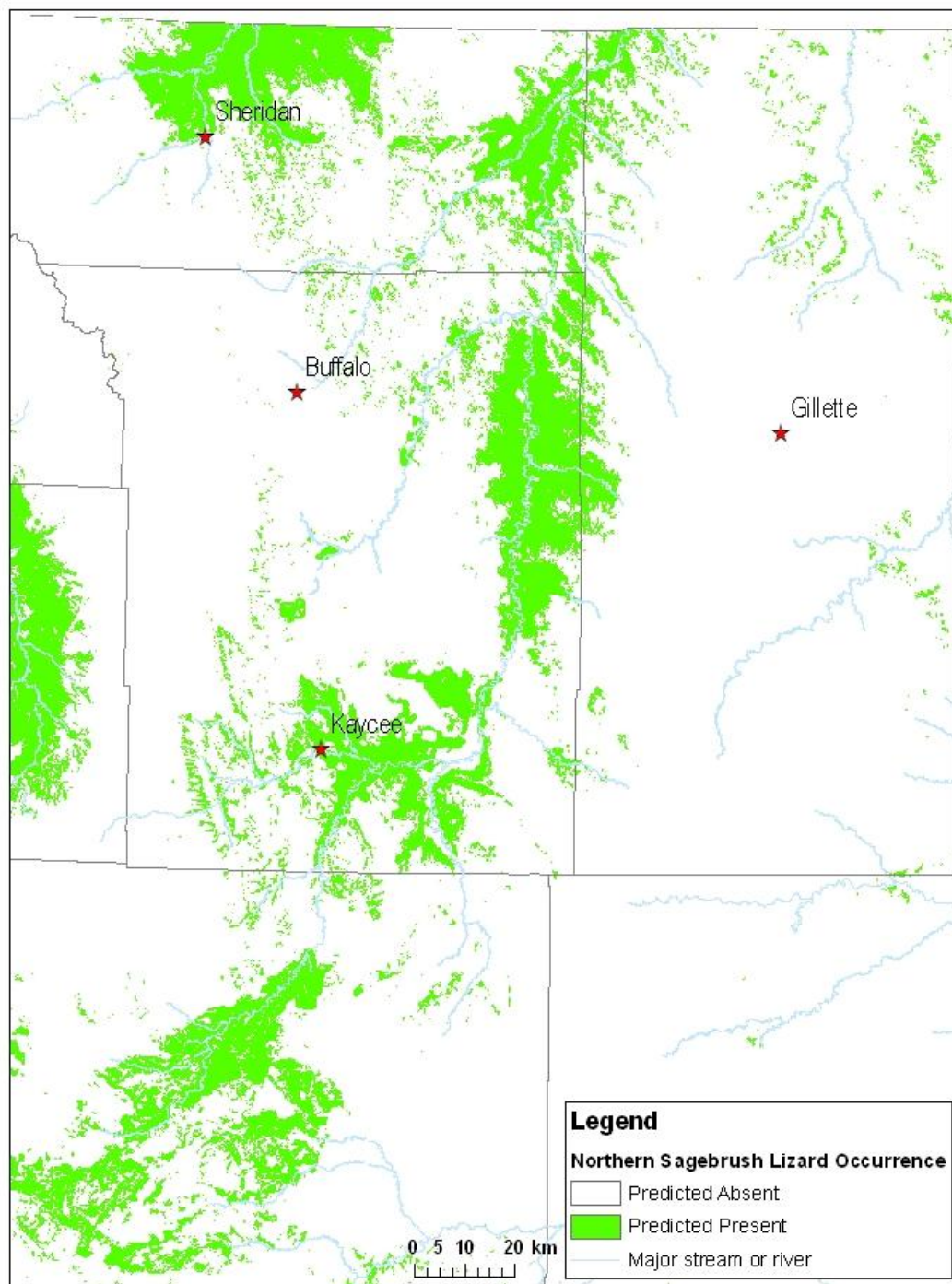




Figure 16. Draft species distribution map for the Northern Sagebrush Lizard (*Sceloporus graciosus*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

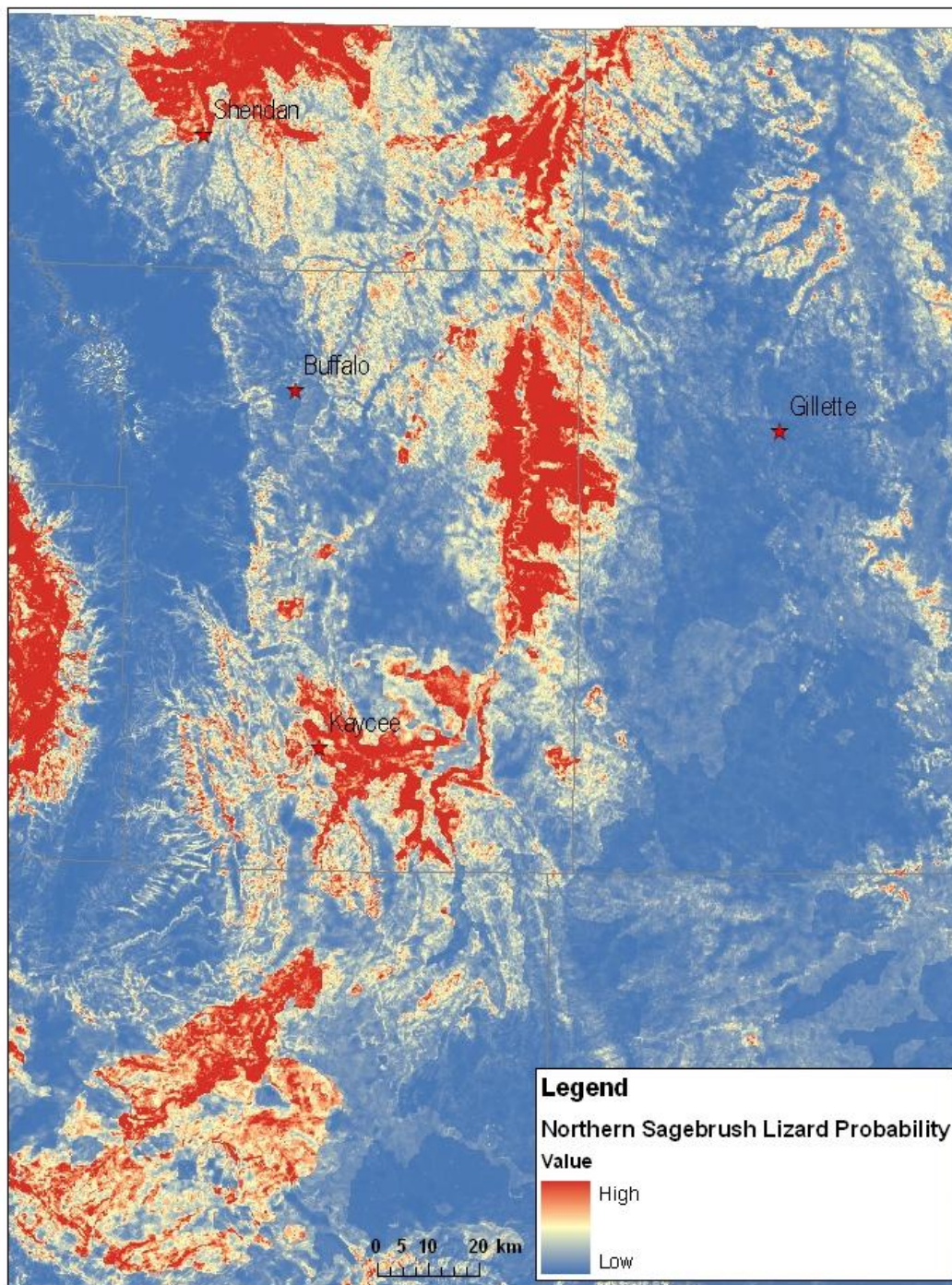




Figure 17. Draft species distribution map for the Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

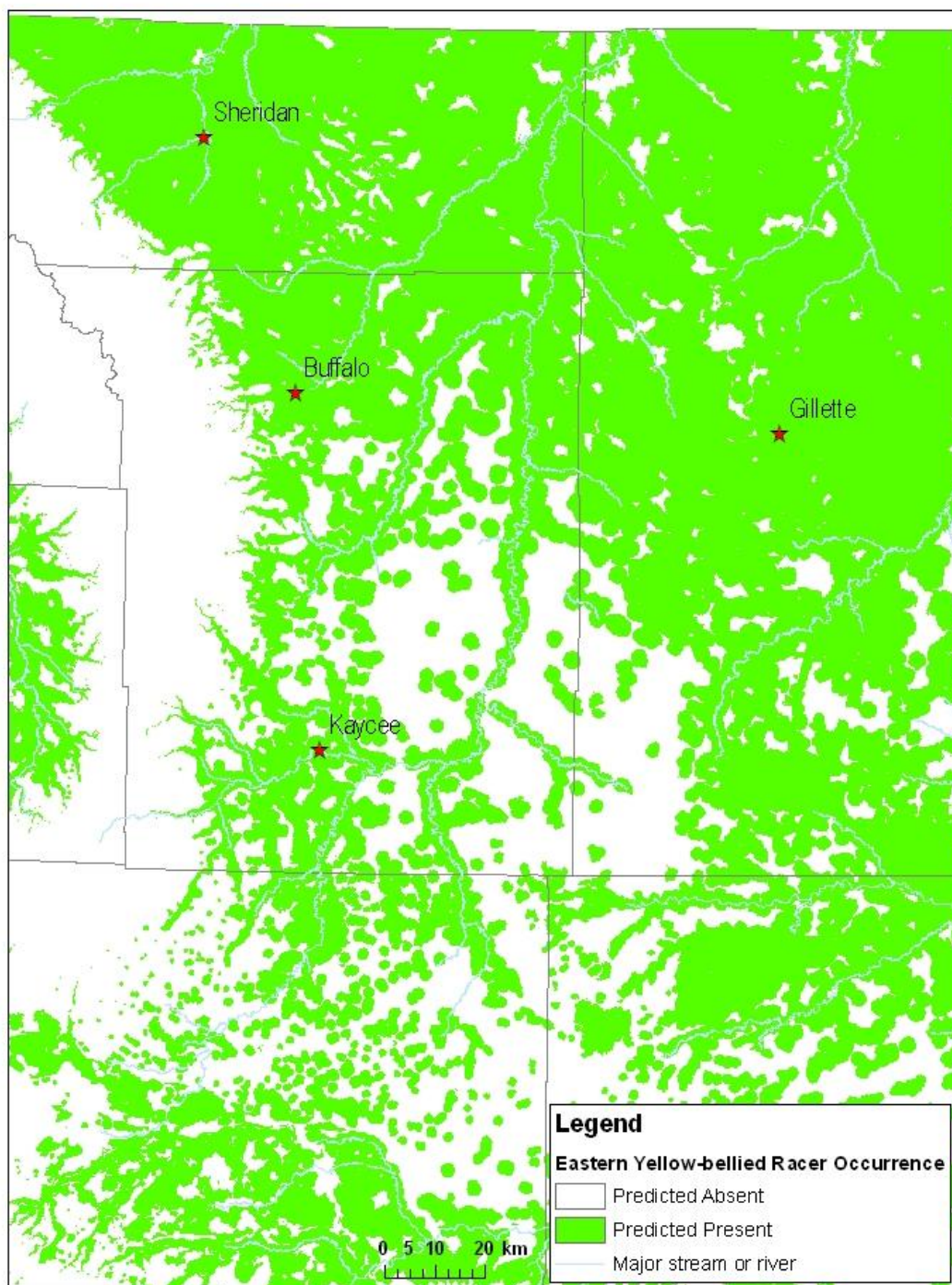




Figure 18. Draft species distribution map for the Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

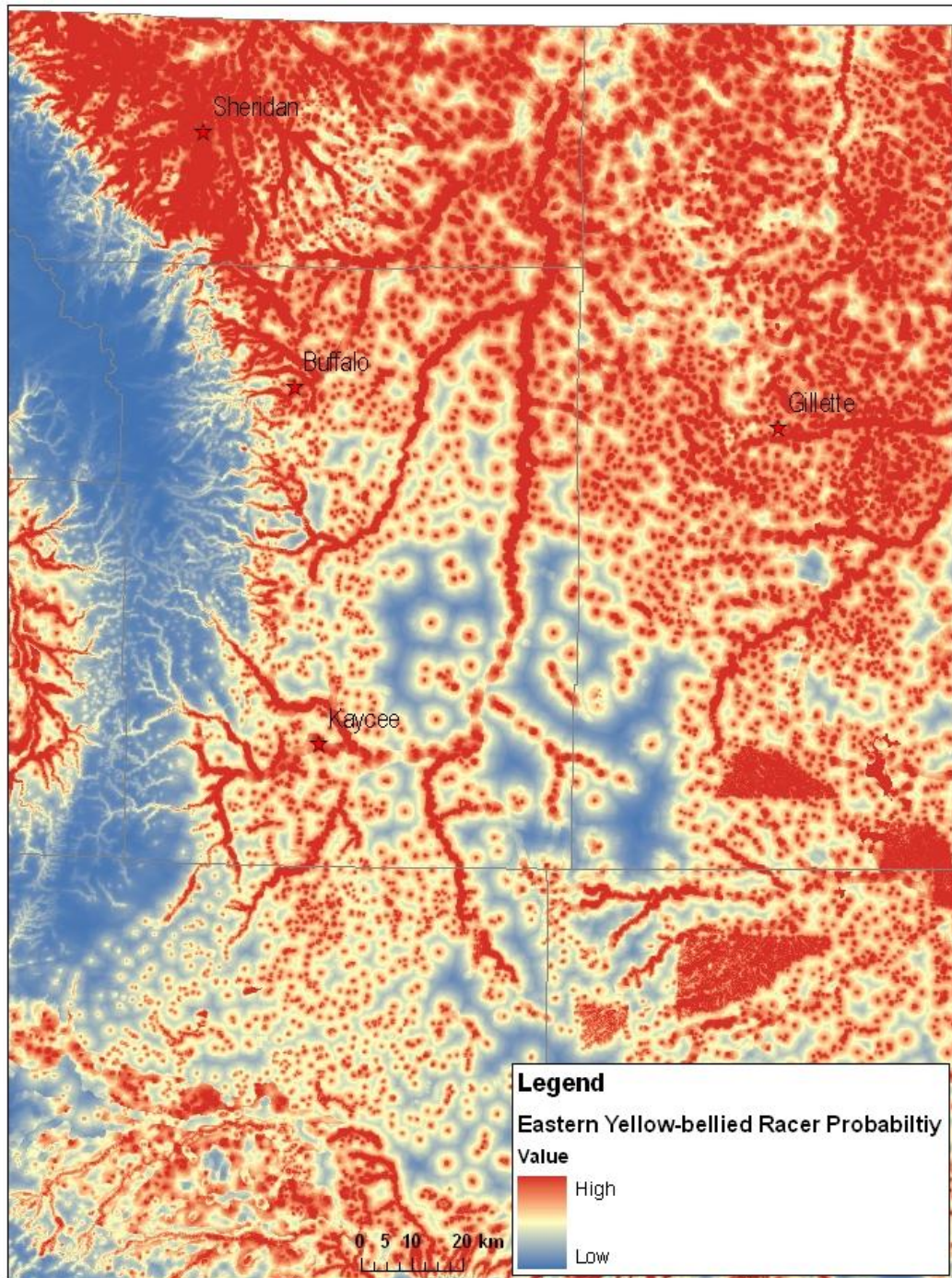


Figure 19. Draft species distribution map for the Prairie Rattlesnake (*Crotalus viridis*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project. *Note: This distribution model is currently being re-run.*

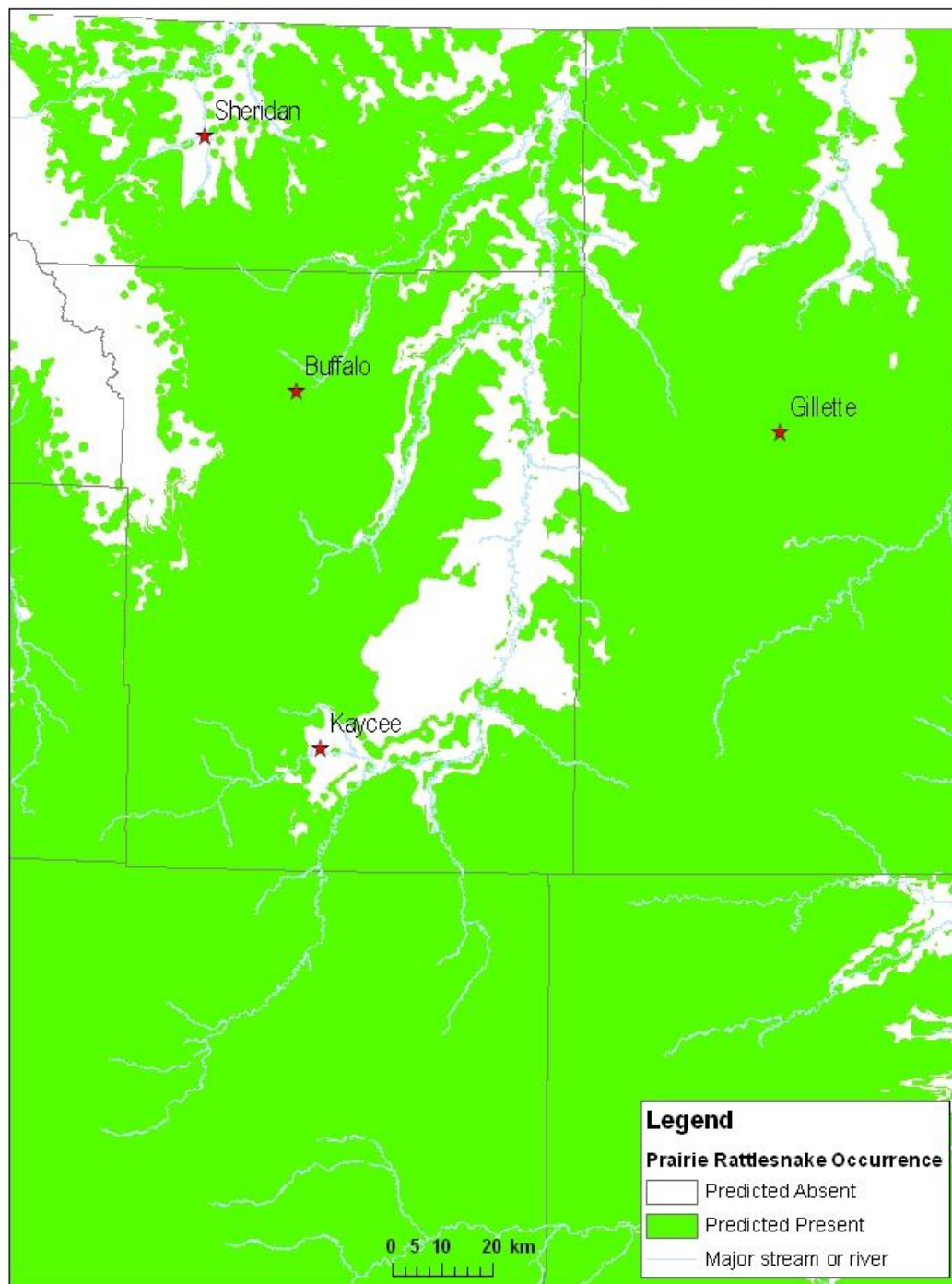




Figure 20. Draft species distribution map for the Prairie Rattlesnake (*Crotalus viridis*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project. *Note: This distribution model is currently being re-run.*

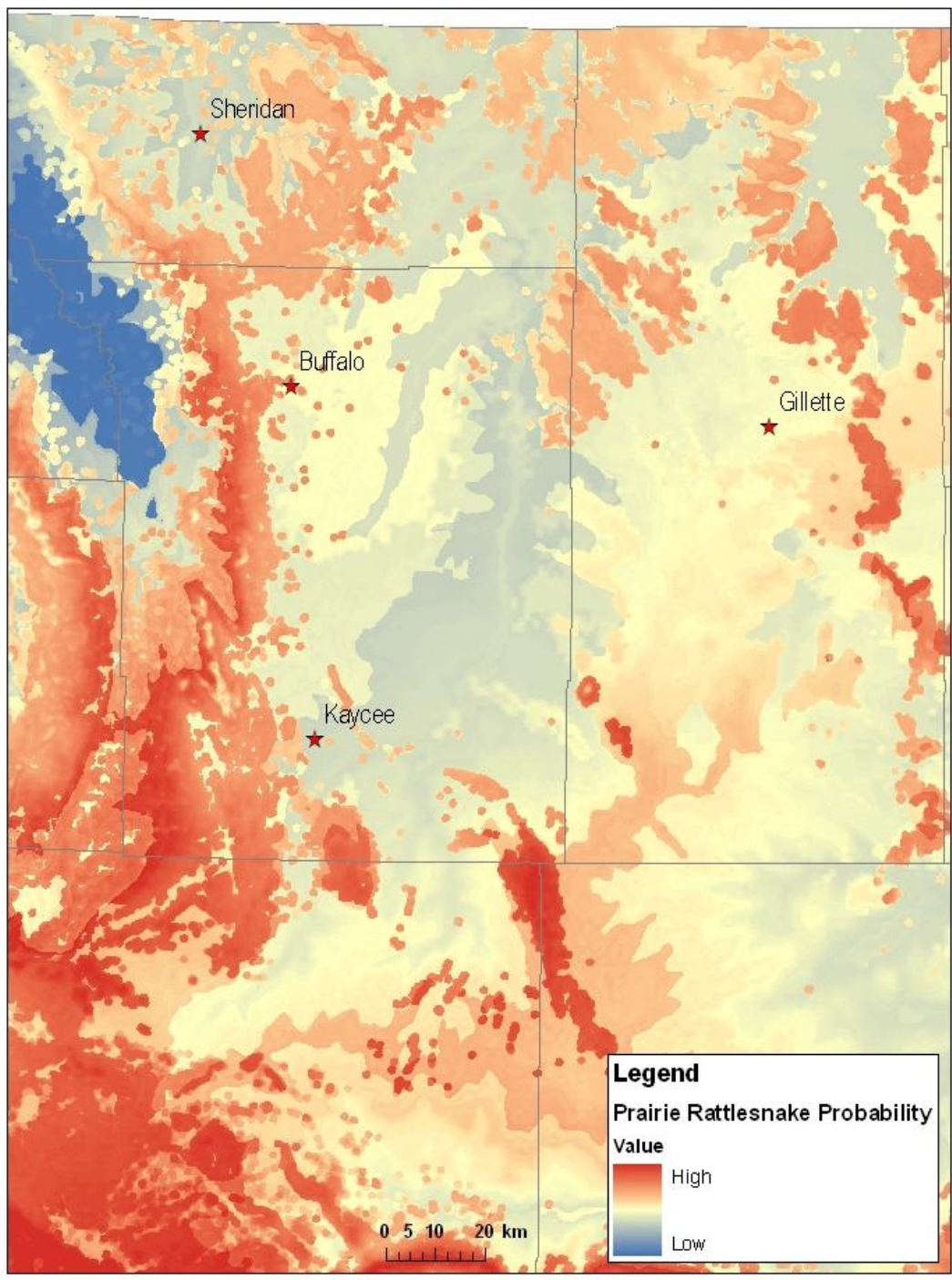


Figure 21. Draft species distribution map for the Western Hog-nosed Snake (*Heterodon nasicus*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

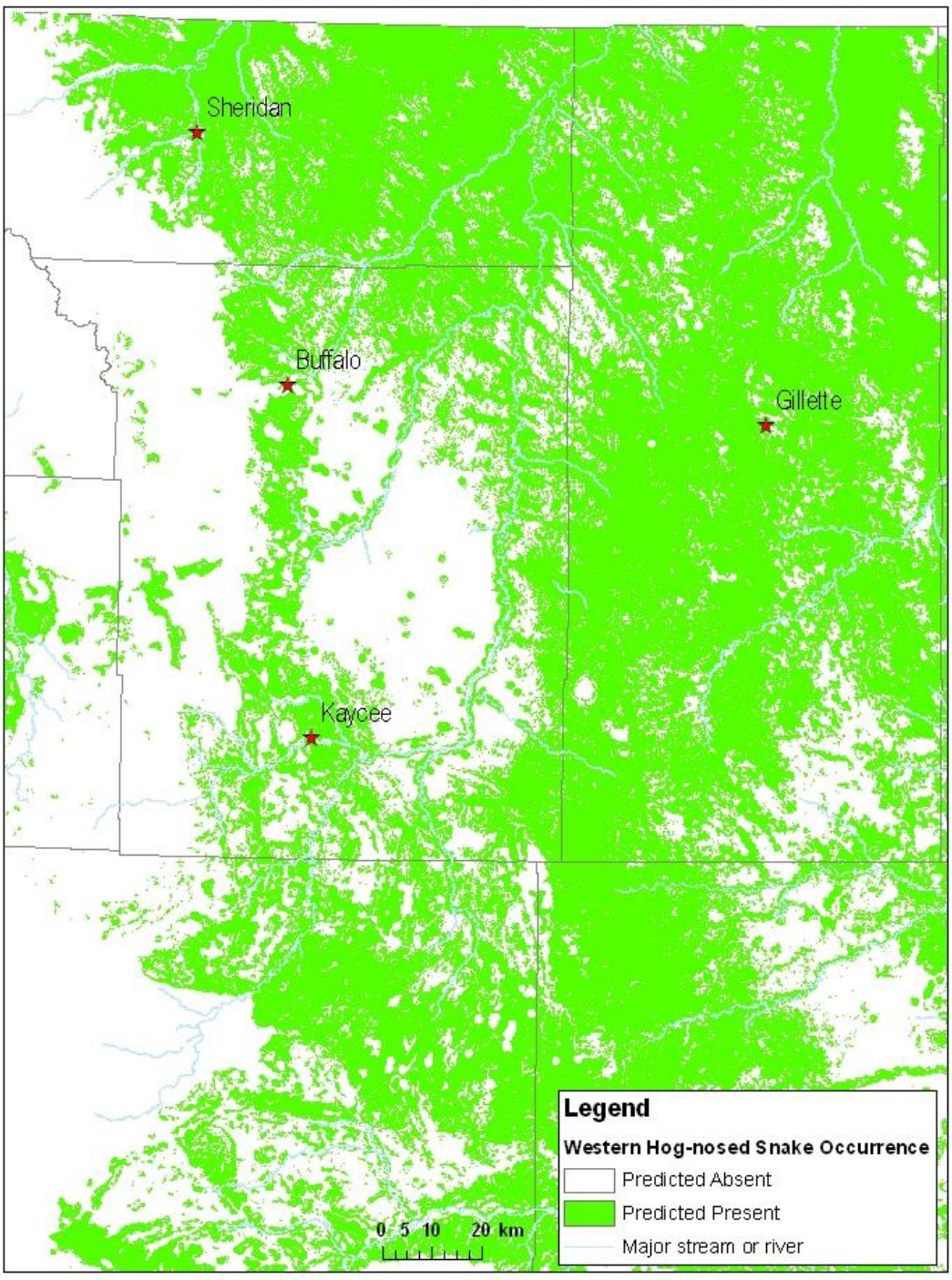




Figure 22. Draft species distribution map for the Western Hog-nosed Snake (*Heterodon nasicus*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

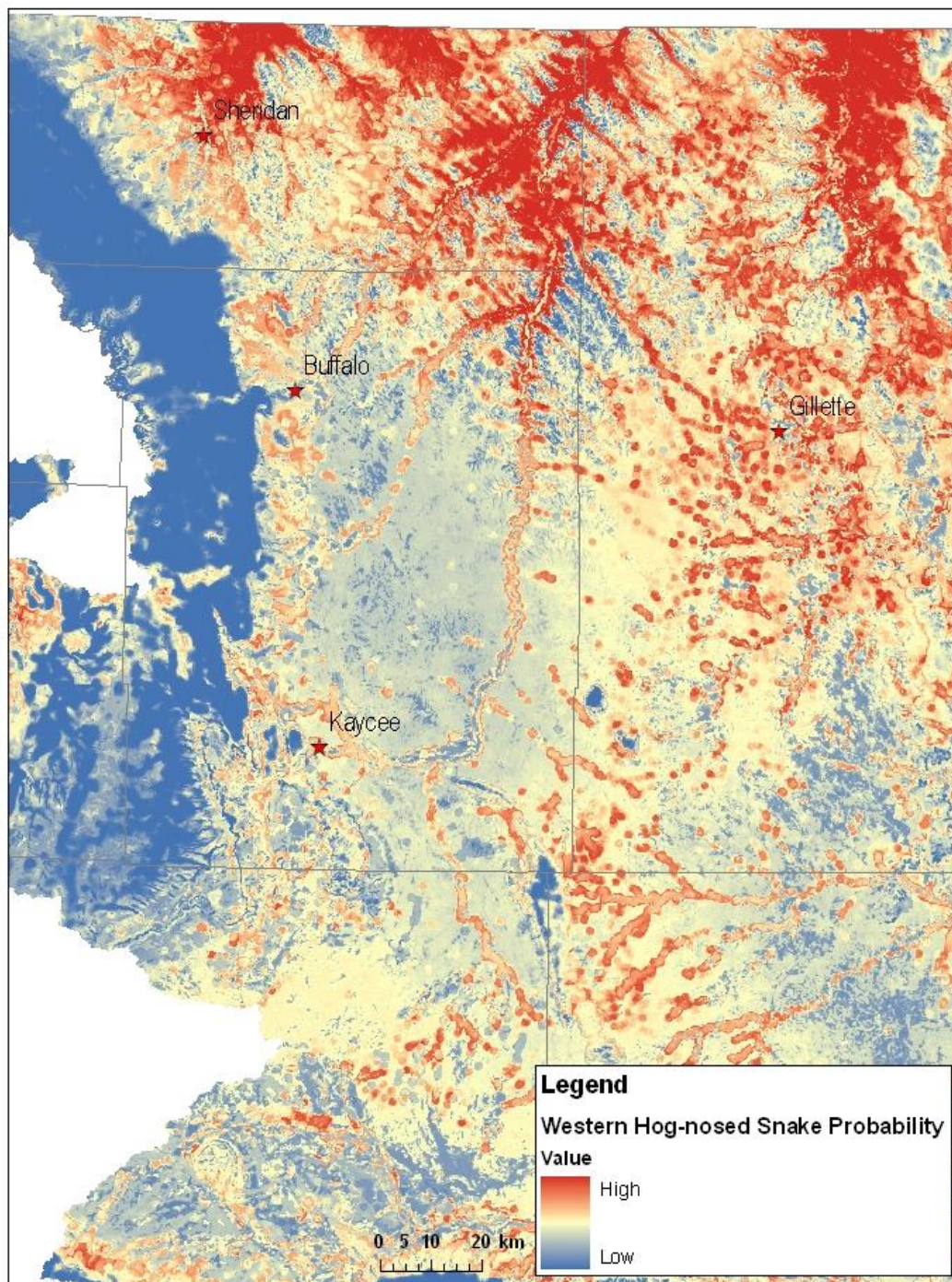




Figure 23. Draft species distribution map for the Bullsnake (*Pituophis catenifer sayi*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWWED project.

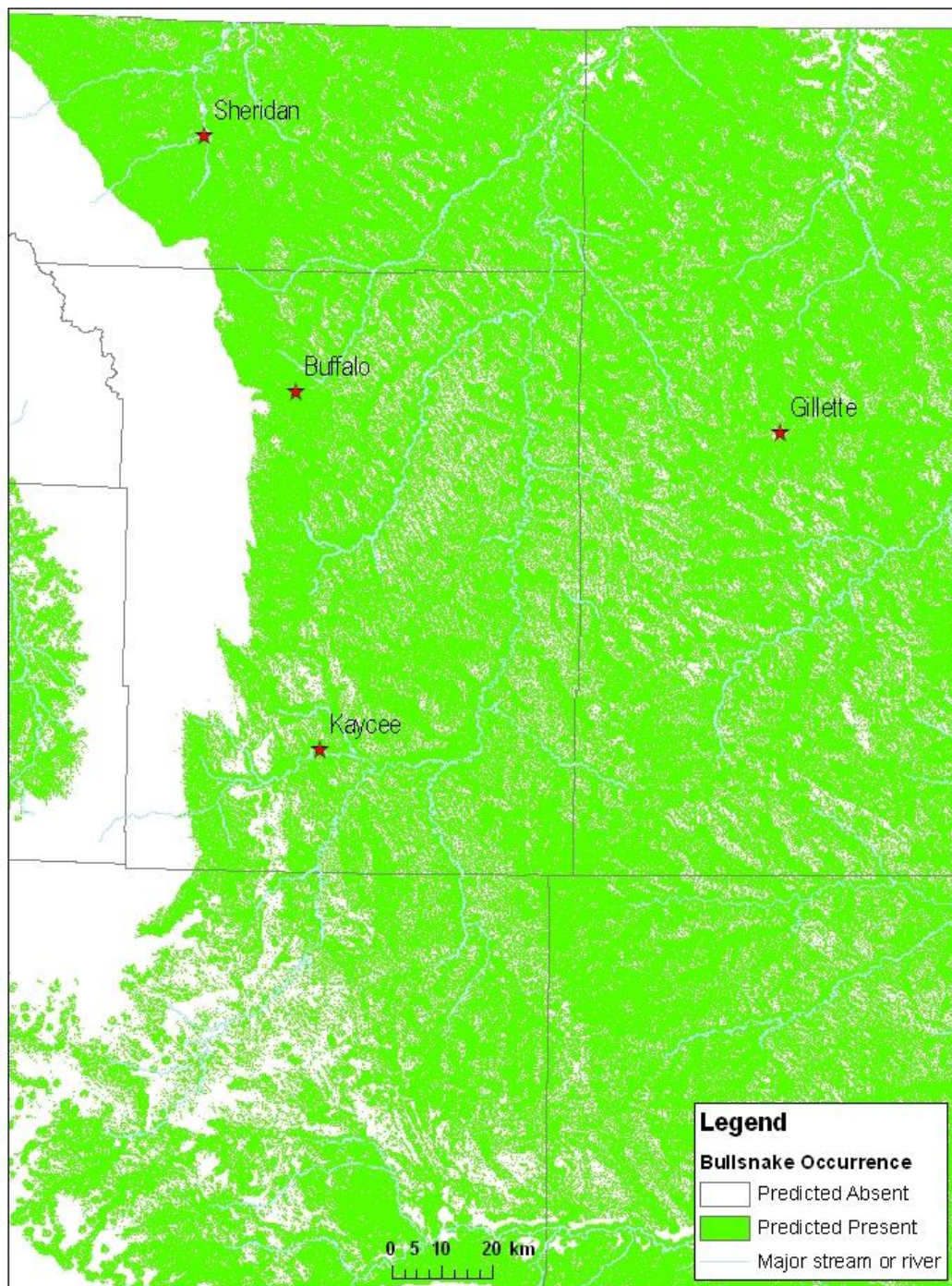




Figure 24. Draft species distribution map for the Bullsnake (*Pituophis catenifer sayi*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

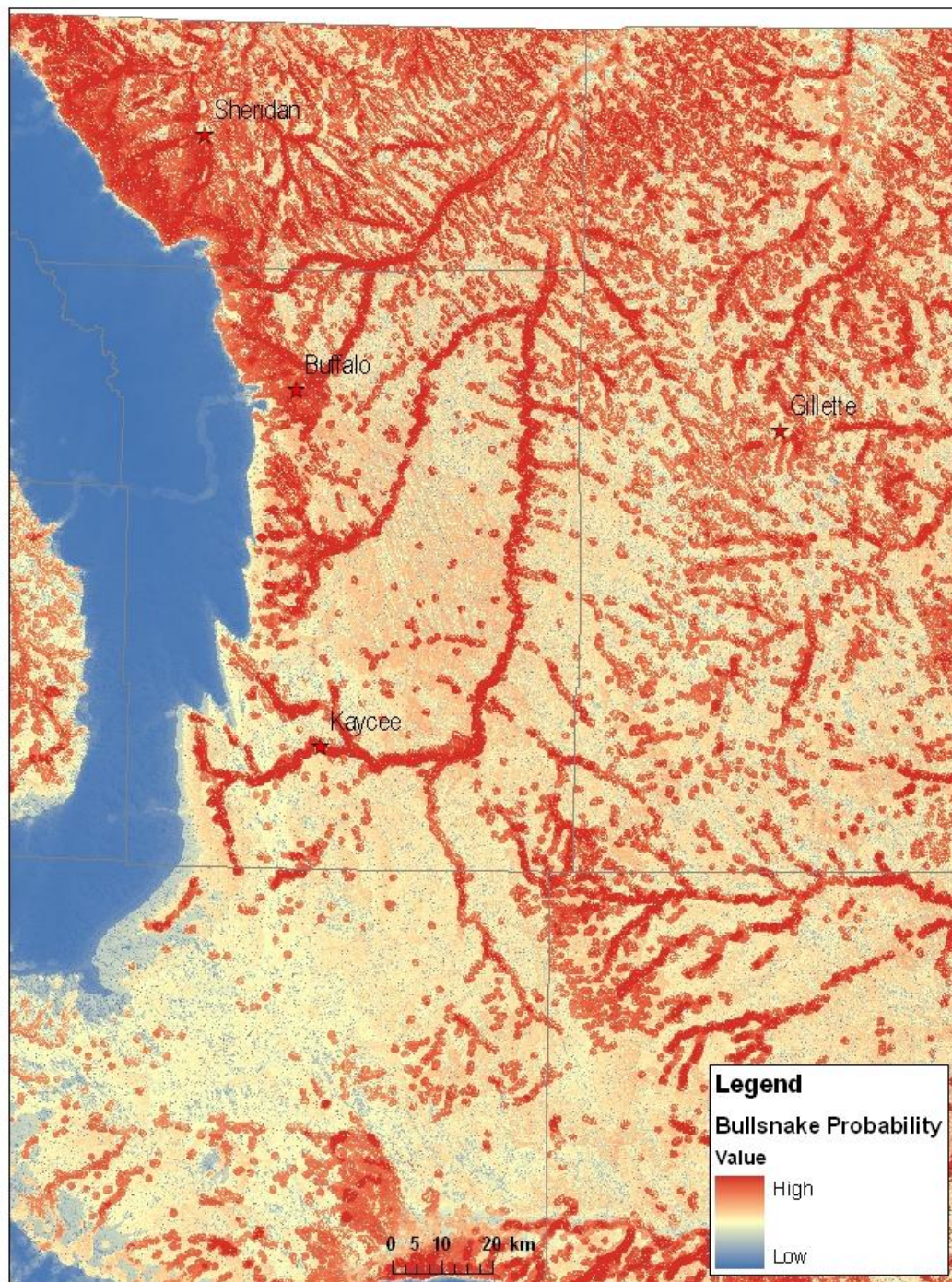




Figure 25. Draft species distribution map for the Wandering Garter Snake (*Thamnophis elegans vagrans*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

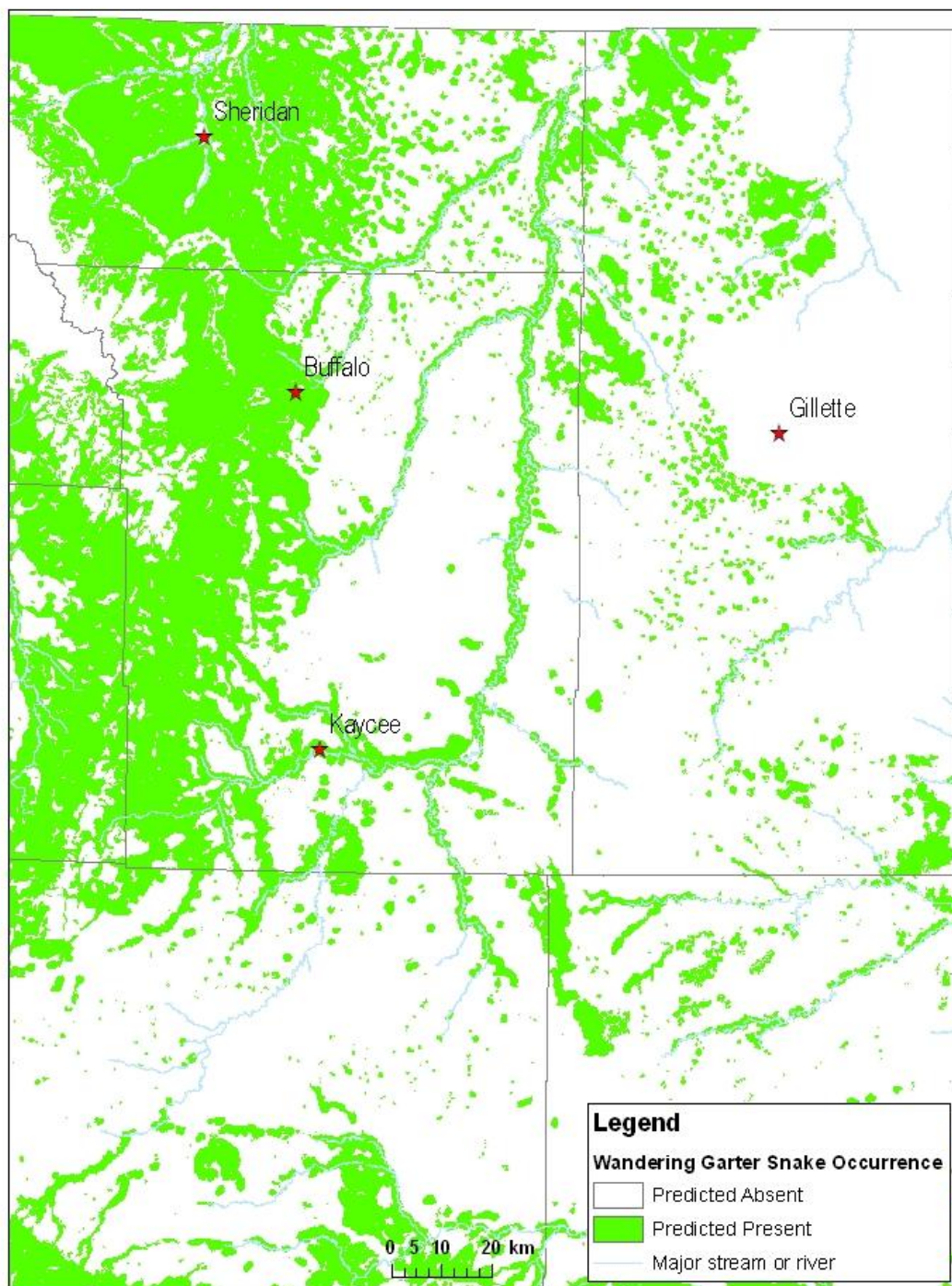


Figure 26. Draft species distribution map for the Wandering Garter Snake (*Thamnophis elegans vagrans*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

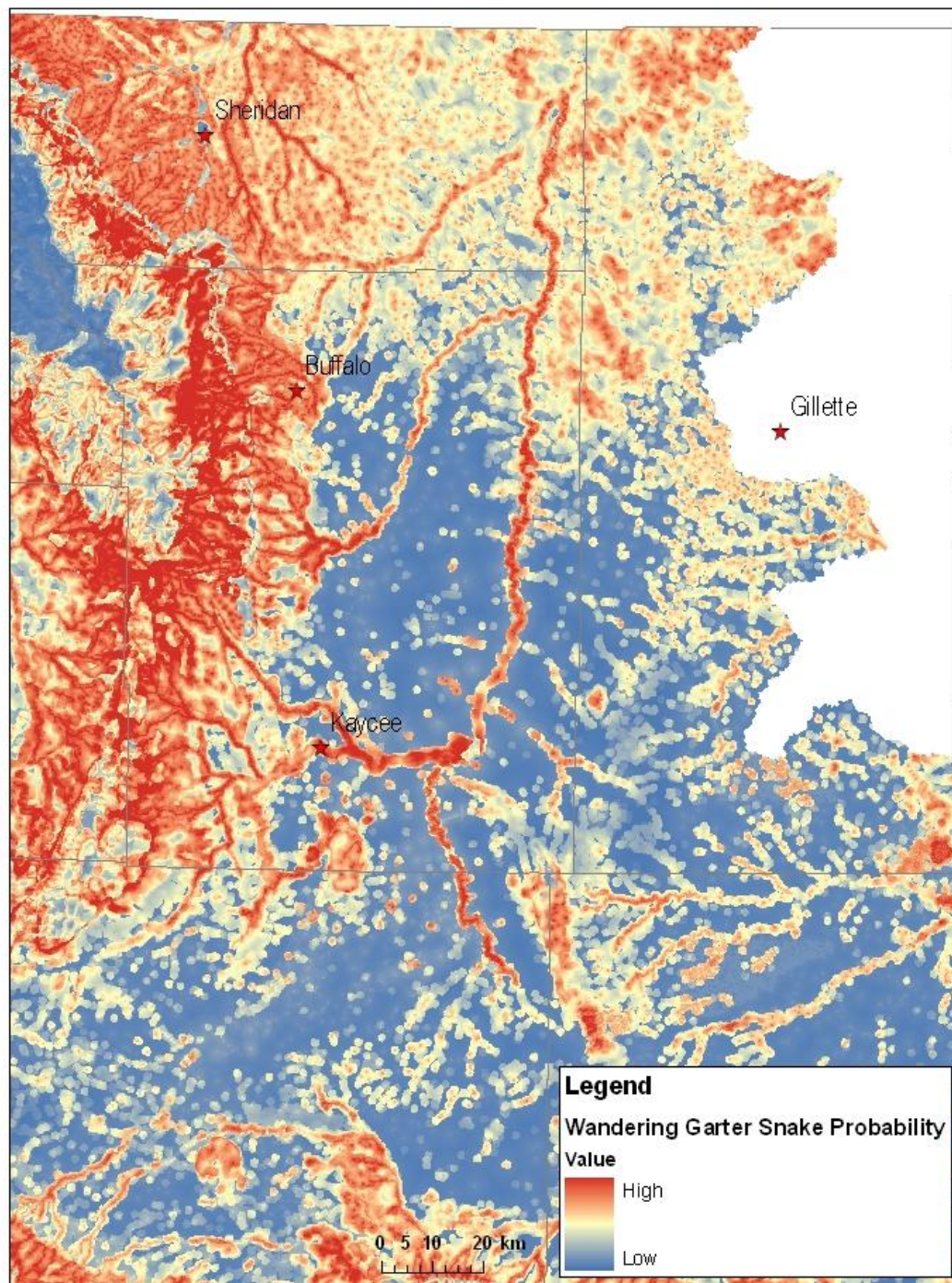




Figure 27. Draft species distribution map for the Plains Garter Snake (*Thamnophis radix*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

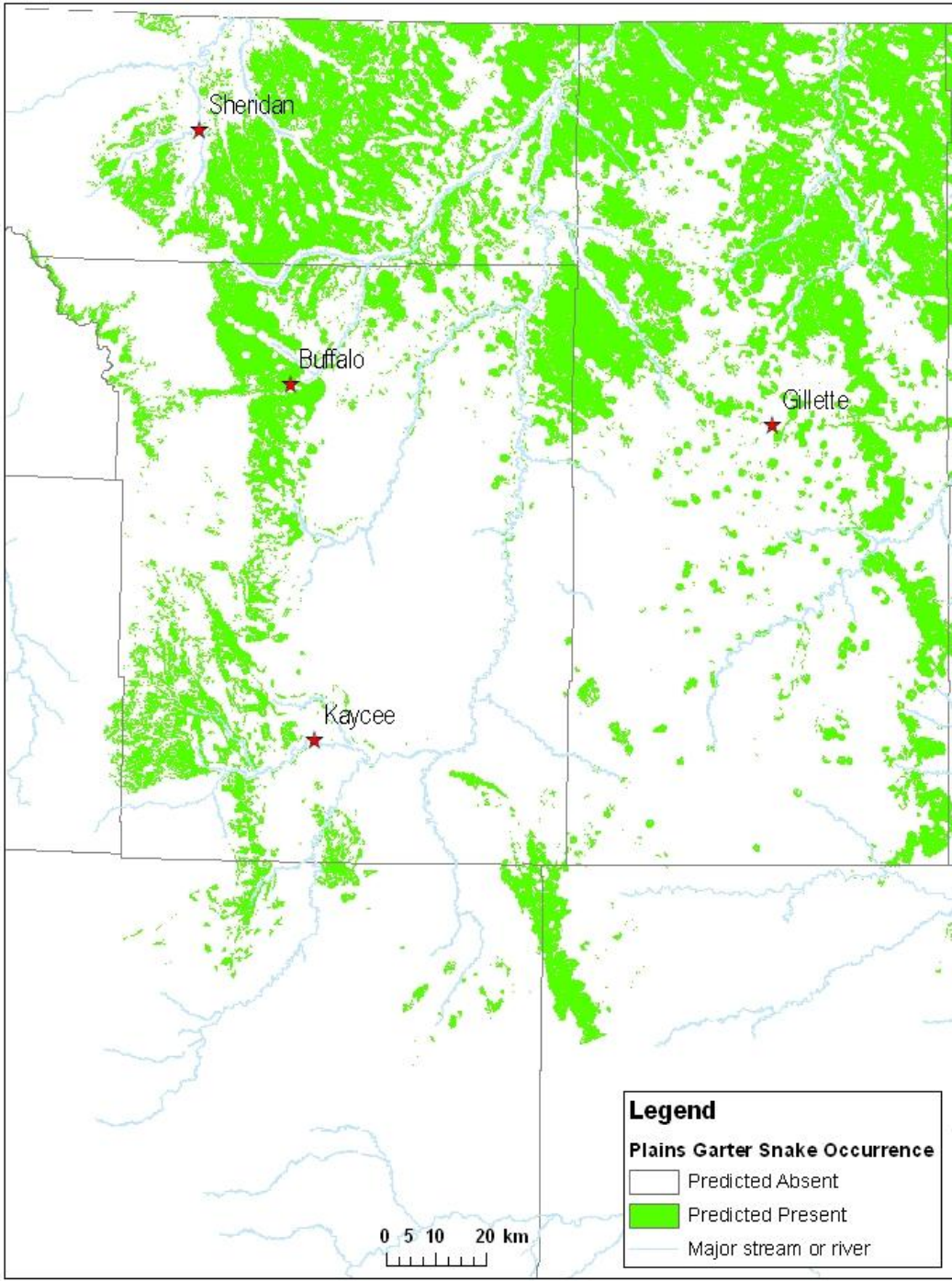




Figure 28. Draft species distribution map for the Plains Garter Snake (*Thamnophis radix*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

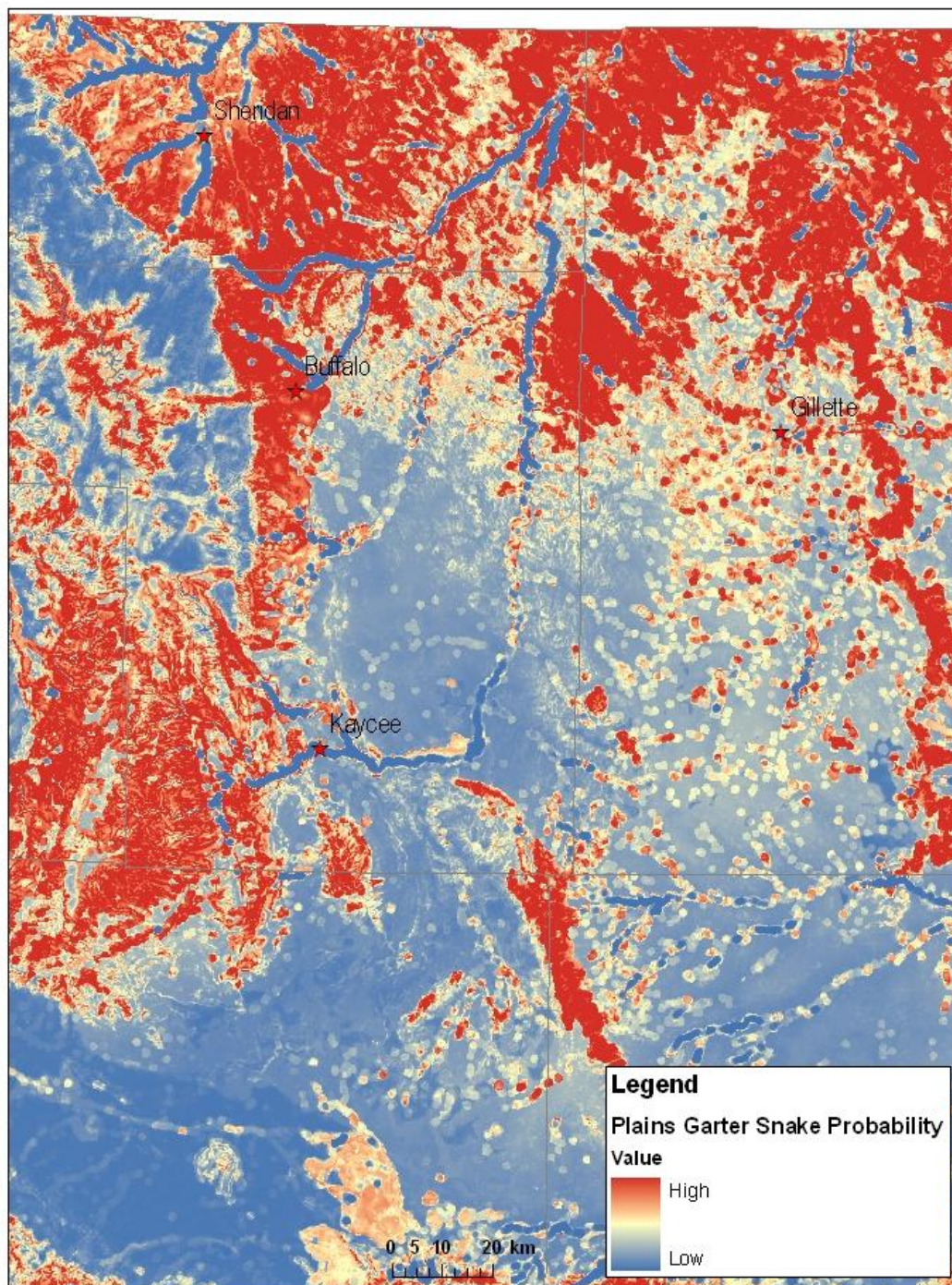




Figure 29. Draft species distribution map for the Common Garter Snake (*Thamnophis sirtalis parietalis*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

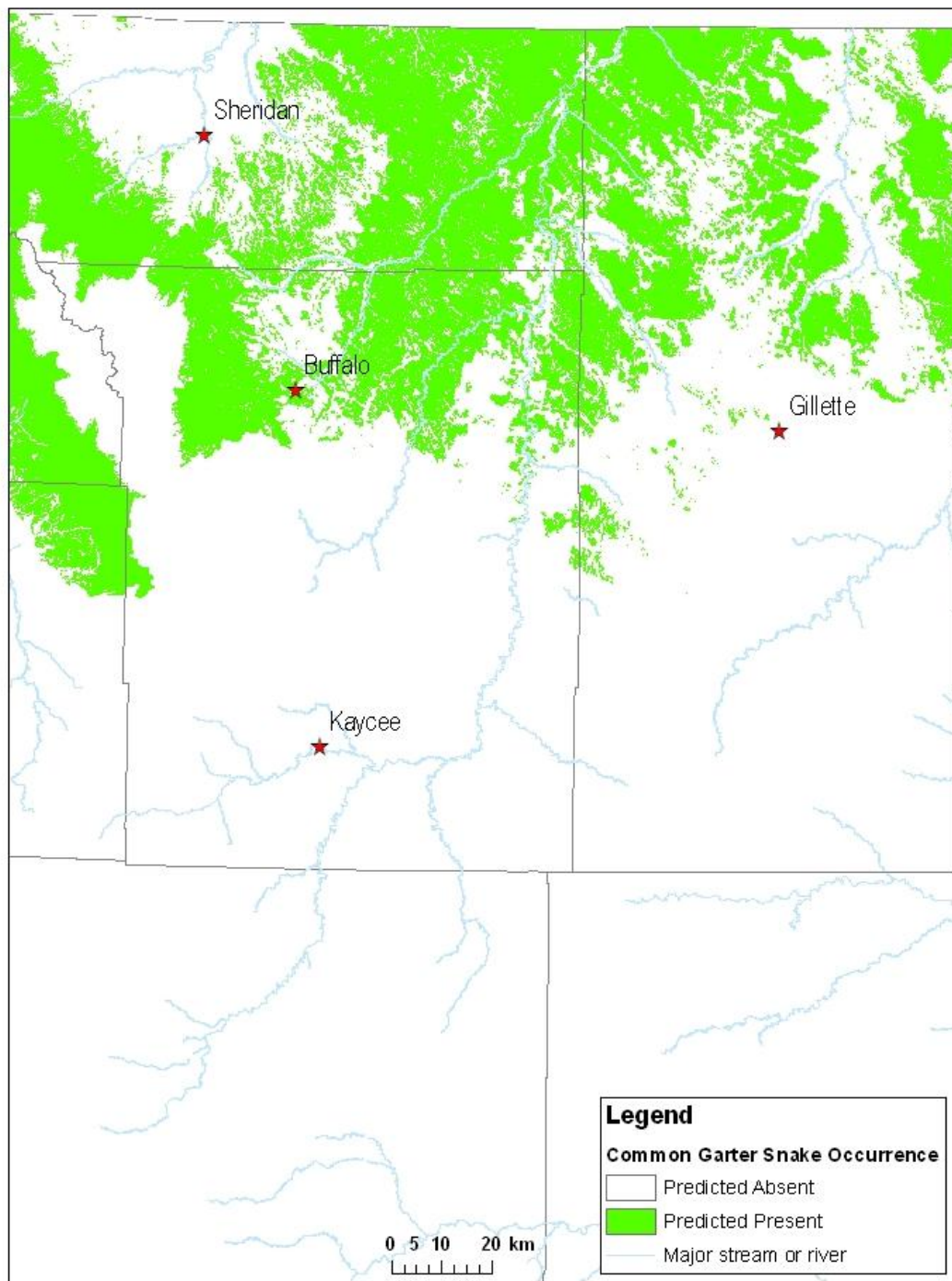


Figure 30. Draft species distribution map for the Common Garter Snake (*Thamnophis sirtalis parietalis*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

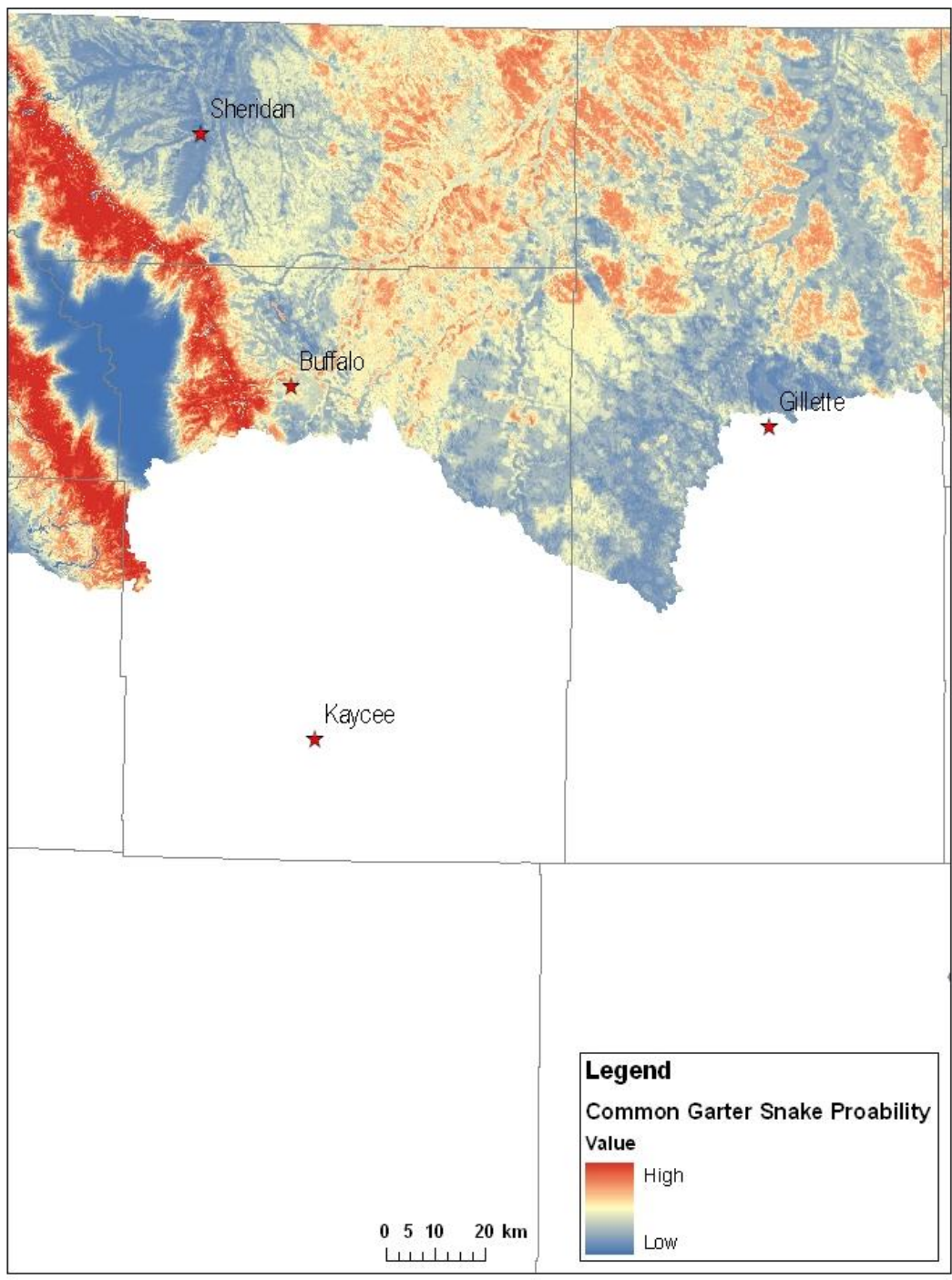




Figure 31. Draft species distribution map for the Western Painted Turtle (*Chrysemys picta*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

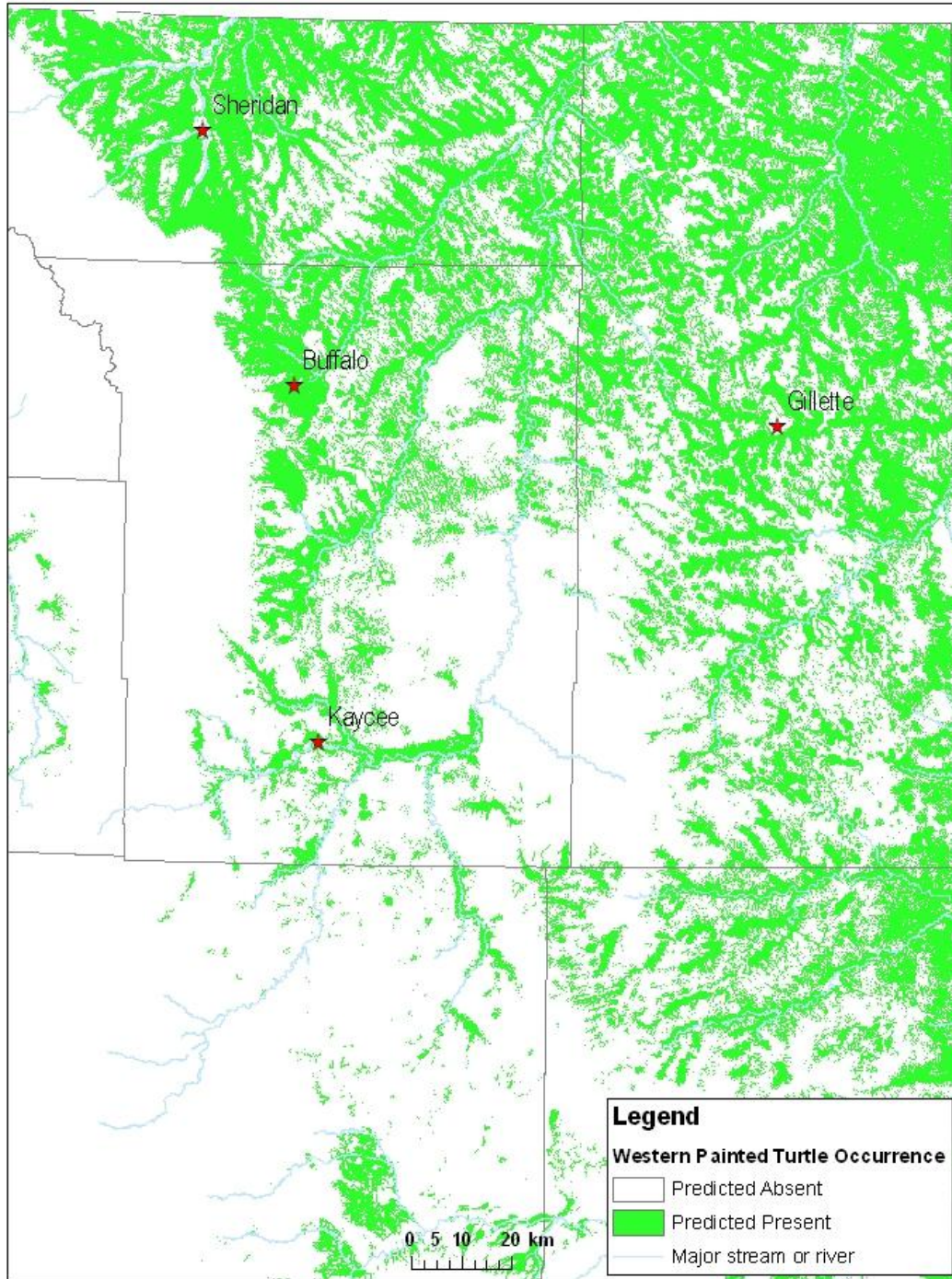




Figure 32. Draft species distribution map for the Western Painted Turtle (*Chrysemys picta*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

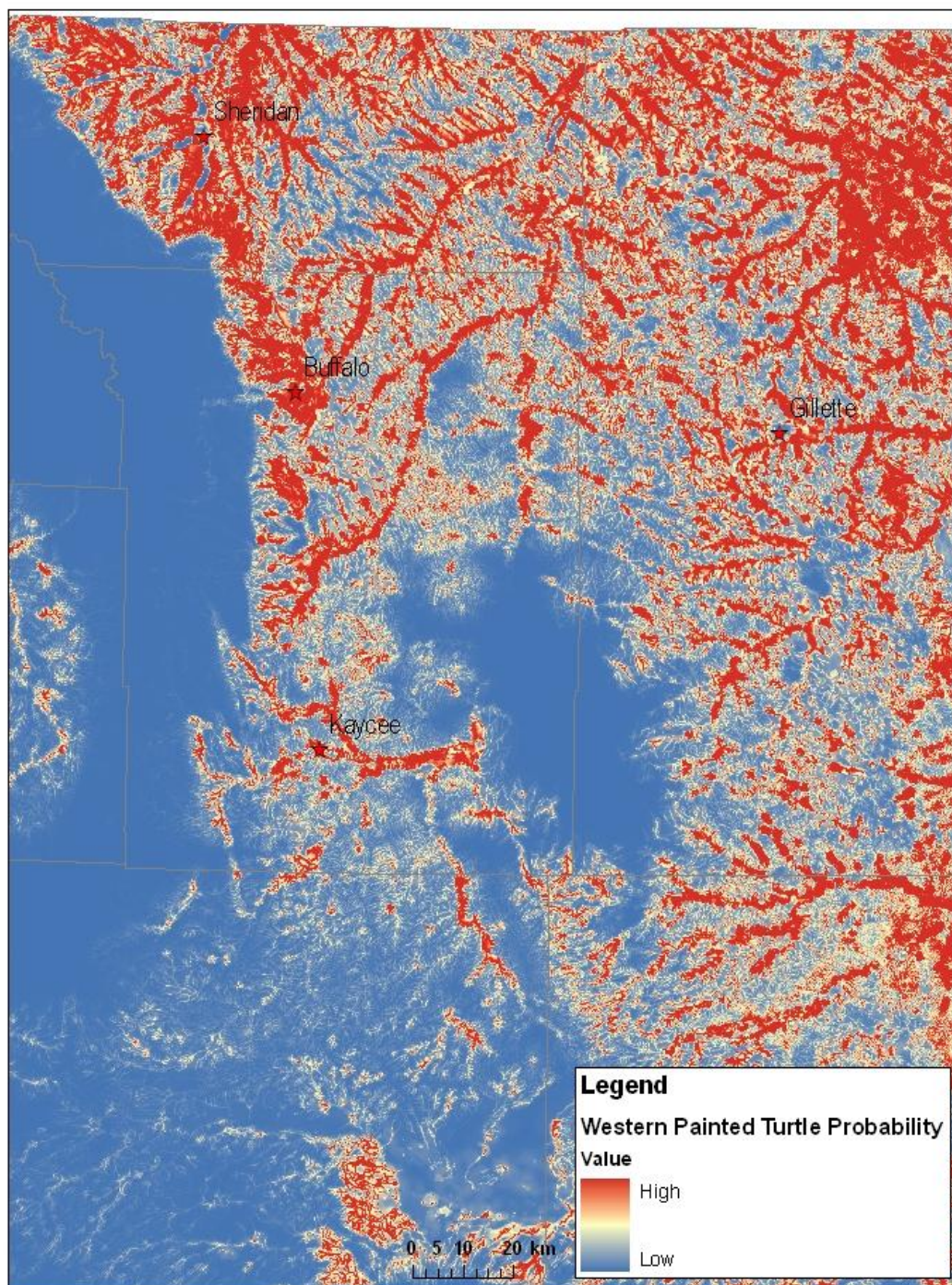


Figure 33. Draft species distribution map for the Spiny Softshell Turtle (*Apalone spinifera*) showing predicted occupancy (present/absent) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

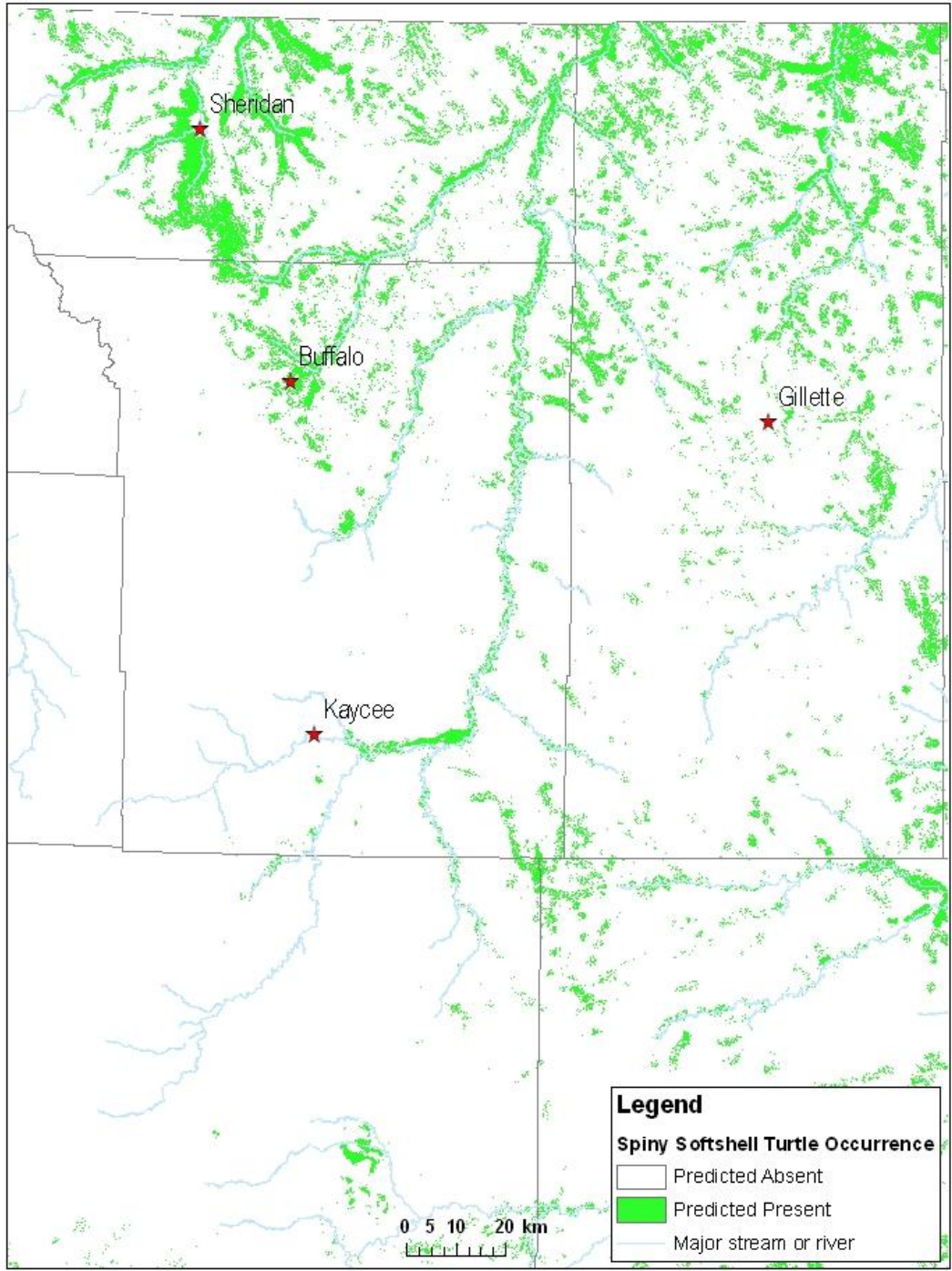




Figure 34. Draft species distribution map for the Spiny Softshell Turtle (*Apalone spinifera*) showing probability of occupancy (high to low) in the Powder River Basin, Wyoming. The map is based on results from a statewide species distribution model generated for WYNDD's ongoing AWVED project.

