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Fish, Amphibian, and Reptile Inventory for
Bighorn Canyon National Recreation Area

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University of Wyoming
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by

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ABSTRACT

The Bighorn Canyon National Recreation Area (BCNRA) is located between the Pryor Mountains and Bighorn Mountains on the Montana-Wyoming border. A wide diversity of floral, faunal, and abiotic conditions exists within the BCNRA. Objectives of this study were to compile a list of fish, amphibian, and reptile species inhabiting the BCNRA, with information concerning their distribution, habitat associations, and relative abundance, as well as appropriate management recommendations. Standard fishery and herpetological survey methods were used. Forty-two fish, amphibian, and reptile species were documented, five of which were rare.

INTRODUCTION

The purpose of this study was to compile a list of fish, amphibian, and reptile species that inhabit the Bighorn Canyon National Recreation Area (BCNRA). Since a goal of the National Park Service is the management of the wildlife and natural resources within the BCNRA, baseline information on the species present and habitat associations will be useful to resource managers.

This study complements the survey of birds and mammals of the BCNRA conducted in 1984 by the Wyoming Cooperative Fishery and Wildlife Research Unit (Patterson et al. 1985). These two surveys provide basic biogeographic data on the vertebrate fauna of the BCNRA. A summary of the results of both surveys is provided in this report (see "Summary", page 30).

STUDY AREA

The BCNRA is 98 km long and encompasses 48,500 ha, including 5140 ha of Yellowtail Reservoir. It is situated 12 km northeast of Lovell, Wyoming and 40 km southeast of Billings, Montana.

The BCNRA is a highly diverse area. The north and south ends are wide, flat valleys, while the central portion is a rolling plain cut by the 335 m deep Bighorn Canyon. The BCNRA lies between the Big Horn Mountains to the east and the Pryor Mountains to the west. Elevation ranges from 1120 m above mean sea level near Fort Smith, Montana to 2355 m in the Pryor Mountains.

There is wide seasonal and geographic variation in temperature and precipitation. Temperature ranges from -26°C to over 38°C ($\bar{x} = 10^{\circ}\text{C}$). A precipitation gradient exists between Lovell, a desert with only 18 cm of precipitation per year, and Fort Smith, a grassland with over 50 cm of precipitation per year (National Park Service, 1981).

A wide diversity of habitats and vegetation types exists within and adjacent to the BCNRA (Jones et al. 1985, Myers 1985, Patterson et al. 1985, Cowardin et al. 1979). For example, emergent wetlands and heavily vegetated riparian zones can be found adjacent to barren rock and desert shrub zones. Vegetation types are highly localized and the boundaries between them are abrupt, resulting in many different habitat types within small areas (Jones et al. 1985).

Another important variable influencing animal distribution patterns is the fluctuating pool level in Yellowtail Reservoir. Although normal pool elevation is 1213 m, much variation occurs throughout the year as well as from one year to the next (National Park Service, 1981). Causes of this variation are complex, including weather, depth of snowpack in the mountains surrounding the Bighorn Basin and the Wind River Drainage, flow-rate adjustments made at Boysen and Yellowtail Dams, and evaporation rates. Changes in the surface area of the reservoir are minor at the north end because of the steep canyon walls, but at the south end the reservoir inundates large, shallow areas along the Bighorn and Shoshone Rivers (National Park Service, 1981). When the pool level is low, these floodplains dry up, greatly reducing the amount of wetlands present. In years of low precipitation and low pool levels, such as in 1985, water levels in the few permanent wetlands along the reservoir margins are very low.

Aquatic environments consist of various lacustrine, palustrine, and riverine types (see Appendix 1). The Bighorn and Shoshone Rivers are warm, silt-laden rivers upstream from Yellowtail Reservoir. Downstream from Yellowtail Dam the Bighorn River is a cold, clear river managed primarily for trout. Seventeen streams flow into Bighorn Canyon. These are mostly small coldwater streams that have downcut channels in steep, narrow canyons as they

flow from the Pryor and Big Horn Mountains. Yellowtail Reservoir is a deep, narrow lake throughout most of the BCNRA. Only at the south end does a shallow littoral zone exist. Large amounts of silt are deposited in this area by the Bighorn and Shoshone Rivers.

The geomorphology of the BCNRA is dominated by erosional features superimposed on the results of local and regional uplift. Most of the geologic formations present were formed by shallow seas in the Cretaceous and earlier periods. As mountain building started about 70 million years ago, the Bighorn River eroded downward through the Madison Limestone, forming the steep walls of Bighorn Canyon. Major anticlines influence topography near Sheep Mountain, Porcupine Creek, and the Bull Elk Basin. Fault-block uplifting of the Pryor Mountains resulted in steep cliffs and a series of springs located west of the canyon. The distinctive "redbed" outcrops of the Chugwater Formation are found near Horseshoe Bend and along the foothills of the Pryor Mountains. Most of the geologic formations in the southern part of the BCNRA are easily-weathered shales, silstones, and bentonites of volcanic origin, which form generally flat topography with occasional rock outcrops. Gravel and alluvium terraces deposited during the Pleistocene are found along the Bighorn River upstream and downstream from the reservoir (National Park Service, 1981).

Land use practices within the BCNRA include grazing, farming, mining, and recreational activities. Grazing is allowed in the area between Layout Creek and the Dry Head Range. Some grazing also occurs along the Shoshone and Bighorn River floodplains. Grazing is also a common practice on Crow tribal lands adjacent to the BCNRA. Bentonite mining occurs near the western boundary south of Horseshoe Bend and on adjacent acreage managed by the Bureau of Land Management. Two sand and gravel operations exist south of Highway

14A. There are 67 uranium claims on BCNRA land but none are active operations. Some farming involving irrigation occurs on the west side of the BCNRA. Recreational uses are primarily boating, fishing, camping, and hunting.

OBJECTIVES

This study had four objectives.

- 1) Compile a list of fish, amphibian, and reptile species that inhabit the BCNRA, using the BCNRA Wildlife Observation File, agency documents, previous observations by persons familiar with the BCNRA, and survey work conducted during the 1985 field season.
- 2) Describe the habitat associations and geographic distributions of the species present by interpretation of pertinent literature and observations within the BCNRA.
- 3) Estimate the abundance of species relative to the habitats in which they were found.
- 4) Provide management recommendations concerning the species present and their habitats.

METHODS

Standard biological sampling techniques were used during the 1985 field season. Active and passive techniques were used in both fisheries and herpetological field work. Various methods were employed in order to compensate for the biases inherent in particular techniques.

Sources of information other than our 1985 field work include publications of the Wyoming Game and Fish Department and the Montana

Department of Fish, Wildlife and Parks, the Wildlife Observation File at the National Park Service Visitor Center at Lovell, Wyoming, and personal communications from individuals who have worked in the BCNRA. General information on the presence and distribution of species was obtained from Baxter and Simon (1970), Brown (1971), Baxter and Stone (1985), and Stebbins (1985). Since detailed information concerning the reservoir fishery has been collected by Montana and Wyoming wildlife management agencies since 1967, no sampling was conducted on Yellowtail Reservoir.

Fishes

The following gear was used for sampling fish populations: backpack electroshocking units, seine, and minnow traps. Electrofishing was done between 20 June and 23 June, 1985, in twelve perennial streams in the BCNRA: Black Canyon Creek, Little Bull Elk Creek, Big Bull Elk Creek, Hoodoo creek, Dry Head Creek, Deadman Creek, Gyp Creek, Trail Creek (north and south forks), Layout Creek, Porcupine Creek, and Crooked Creek. In most streams, electrofishing began at the mouth of the creek and continued upstream until fish were no longer captured or the BCNRA boundary was reached. Layout Creek was sampled in a 200 m reach west of Highway 37. Captured specimens were immediately photographed and preserved in alcohol.

Streams where fish were captured were sampled for selected habitat parameters. Measurements were taken of wetted width, depth discharge, water temperature, alkalinity, gradient, and substrate over a representative 100 m reach. Indicators of the quality of the riparian zone such as the presence of undercut banks, overhanging vegetation and boulders, and woody debris were noted (Appendix 2).

The Bighorn River was sampled using a 5 m long, 5 mm mesh bag seine. Three 25 m long hauls were made in 0.7 m deep water over substrate of 8-12 cm diameter rounded cobble with some silt. The location was near Turtle Trap Site 1 (Appendices 3 and 4).

In addition to electrofishing and seining, passive capture techniques were employed. Minnow traps were set in pools and under overhanging boulders in streams (see maps in Appendix 4 and Appendix 3 for locations and dates) and on the bottom and within vegetative cover of emergent wetlands. Minnow traps were baited with dry dogfood, catfood, and invertebrates that were captured near the trap location, crushed, and put into perforated plastic bags along with intact specimens.

Amphibians and Reptiles

The following equipment was used in sampling of amphibians and reptiles: minnow traps, 1 m diameter 2.5 cm mesh hoop nets, 5 mm mesh dipnet, snake hook, fishing pole rigged with monofilament noose, and 20-liter buckets, green plastic mesh and surveyor's stakes (for drift fence).

Herpetological fieldwork was conducted throughout the BCNRA from 20 May to 22 September, 1985. Search efforts were concentrated on wetlands and riparian areas in May, June, and early July in order to coincide with the breeding seasons of most of the species present (Baxter and Stone 1985, Stebbins 1985), while searches for snake dens were conducted in late August and September along south-facing ridges (Duvall et al. 1985) near Sykes Mountain and East Pryor Mountain.

A variety of methods were used for herpetological sampling. Using habitat types previously defined and mapped (Jones et al. 1985, Patterson et al. 1985), intensive searches were conducted so that a habitat type in a

particular location was covered thoroughly on foot. Similarly, straight-line transects were walked in a variety of habitats. During these searches, rocks and logs were overturned (and replaced, since these are prime microhabitats for reptiles and amphibians in arid habitats). Rock outcrops were given special attention during searches for lizards and rattlesnakes. Springs, small upland ponds, riparian areas, and temporary standing water also received concentrated effort while searching for amphibians and snakes. In desert shrub habitat, tracking was attempted in an effort to follow movements of individual snakes (Stebbins 1985, Lillywhite 1982). Searches for turtles were conducted primarily in wetlands and along the Bighorn and Shoshone Rivers.

Three passive capture methods were used. For large turtles, hoop nets were baited with sardines, catfood, beef liver, chicken liver, and spinach. All turtle traps were set in the Bighorn River. For amphibians and small turtles, minnow traps were baited with beef or chicken liver, spinach, and invertebrates. Traps were set in wetland and riverine habitats (Appendices 3 and 4). For snakes and lizards, a combination of plastic mesh drift-fencing and 20-liter pitfall traps was employed. Animals encountering the fencing tend to move along it until falling into the pitfall traps. A 40 m fence with pitfall traps spaced 10 m apart on both sides of the fence was set along the southwest side of Sykes Mountain. The fence was oriented from northwest to southeast, parallel to the strike of the rock outcrops and perpendicular to the suspected vernal migration paths of rattlesnakes seen in that area (Duvall et al. 1985; Vogt and Hine 1982). The buckets were buried flush with the ground and partially covered to provide shade for trapped animals. The fencing was 45 cm wide, 5 mm mesh attached to surveyor's stakes, with 10 cm of the bottom edge buried. Traps were checked daily at 6:00 a.m., 7:00 p.m., and midnight.

Noosing, a standard technique for capturing lizards, was attempted in areas where thick vegetation prevented hand capture. A fishing pole with monofilament line rigged as an adjustable noose was used. Hand capture was used for all amphibian and reptile species except rattlesnakes.

Road cruising was used for sampling snake populations on both paved and unpaved roads (Campbell and Christman 1982). Highway 37 between Barry's Landing and Highway Marker #4 was the transect most often driven. The unimproved road from Barry's Landing north to the Dry Head Range was also driven, as well as the dirt and gravel roads south of Sykes Mountain. Driving was done at low speed (approximately 40 km/hour) and between one hour before sunset until 2:00 a.m. and in the early morning (5:00-6:00 a.m.) before scavengers found roadkills.

Because of the importance of environmental temperature to amphibians and reptiles, air and substrate temperature readings were taken at the exact location (microhabitat) of capture or observation. Air temperature was measured at a height of 30 cm directly above the point of capture or observation. Substrate temperature was measured on the ground surface at the point of capture or observation. All temperature readings were taken while shielding the thermometers from direct sunlight.

When animals were captured, cloacal temperature was measured with a Schultheis fast-reading thermometer within 15 seconds of capture. Snout-vent length was measured, and general body condition and distinguishing marks were noted. Sex was determined when possible. Animals were marked by clipping toes or scales to facilitate mark and recapture studies.

RESULTS

This section is organized in four parts. General results and effectiveness of methods are presented first, followed by sections discussing the three major taxa studied. At the end of the report are appendices which summarize the data and maps which show the localities at which animals were found.

Appendix 5 is a complete list of species that have been found in the BCNRA. This list was compiled from sampling data gathered by Wyoming Cooperative Fishery and Wildlife Research Unit personnel during the 1985 field season, and from publications of the Wyoming Game and Fish Department and the Montana Department of Fish, Wildlife, and Parks which summarized fisheries investigations conducted on Yellowtail Reservoir from 1967 to 1984 (see Definitions of Documentation Codes, Appendix 5).

Five species of fish were captured by electrofishing (Appendix 6). Fish were found in only six of twelve perennial streams: Black Canyon Creek, Big Bull Elk Creek, Dry Head Creek, Deadman Creek, Gyp Creek and Porcupine Creek. Only the four largest streams contained salmonids. Most fish were captured in riffles or in pools beneath overhanging boulders. Some fish may have been missed because deep pools could not be effectively electrofished. No fish were captured with minnow traps.

Twenty-three species were documented to occur in the reservoir or rivers entering the reservoir by the Wyoming Game and Fish Department and the Montana Department of Fish, Wildlife and Parks who routinely survey these waters (Appendix 5). Seventeen of the species found are native to the area.

Of the various methods employed for amphibians and reptiles, active, intensive searching within a given habitat type was most effective. Trapping methods were totally ineffective, regardless of the type of bait used.

Noosing of lizards was ineffective because of their extreme wariness, especially Sceloporus graciosus graciosus. Snake tracking also was ineffective because the soil surface formed a hard crust after thunderstorms and subsequent drying, obliterating tracks that might have been present and preventing track formation by all but the heaviest snakes. However, this technique did give good indications of rodent activity near burrows in areas where snakes were seen. Road cruising was most effective immediately after sunset, probably because greatest heat retention by paved surfaces coincided with the diurnal activity maxima of snakes.

Mark and recapture studies were inconclusive because of the low numbers of animals caught. No marked specimens were recaptured except for two S. g. graciosus at an abandoned dump site ("L" in Appendix 4). The population estimate for that local population was 5.3 ± 1.4 , using Bailey's version of the Lincoln-Petersen index corrected for small population size (Seber 1982).

All amphibians seen, heard, or captured were located in water or in microhabitats within 1 m of water. The low number of amphibians found was probably the result of the very restricted distribution of suitable wetland and riparian habitats which comprised only 1.7% of the area of the BCNRA (Appendix 7) and the below-average precipitation and temperatures during the 1985 breeding season.

Reptiles were seen and captured in a variety of habitats (Appendix 7). Greatest numbers were in four general habitat types: creek woodland/shrubland, grassland; wetlands, and rock/unvegetated. These four habitats comprised 12.7% of the land area. Juniper, desert shrub, mountain mahogany, and sagebrush habitats were also important for snakes (Appendices 7, 8 and 9). Crotalus viridis viridis and Pituophis melanoleucas sayi were the most widely distributed snakes in terms of habitat types. The species with

the most restricted preferences were Phrynosoma douglassi brevirostre (sagebrush and grasslands) Lampropeltis triangulum multistrata (creek woodland/shrubland), and Chrysemys picta belli (wetlands) (Appendices 7 and 8).

Summaries of length and temperature data are given in Appendix 10. No correlations were found between cloacal temperatures of amphibians and reptiles and either substrate or air temperatures. The cloacal temperature range within which reptiles were active was fairly narrow (22.2°C - 29.8°C), especially for Thamnophis elegans vagrans (22.2°C - 24.2°C).

The following paragraphs include information about the presence, abundance, habitat association, and distribution of fish, amphibian, and reptile species inhabiting the BCNRA. Terms describing relative abundance are defined in Appendices 5 and 7. Total numbers of animals captured are given in Appendix 10. Species not listed in Appendix 10 were not captured by Wyoming Cooperative Fishery and Wildlife Research Unit personnel during the 1985 field season. Species are listed by family using standard nomenclature (Robins et al. 1980, Stebbins 1985). Specimens deposited in the University of Wyoming Zoology Museum are listed in Appendix 11.

Fishes

Family Salmonidae

Brown Trout (Salmo trutta). This species of trout is not native to the Bighorn Canyon area (Baxter and Simon 1970, Brown 1971). It has been stocked in Yellowtail Reservoir. Its preferred habitat is slow-moving water in larger foothills streams that have thick cover and large rivers with low gradient and summer temperatures from 15-21°C (Baxter and Simon 1970). It does well in reservoirs but needs streams for spawning (Brown 1971). Two specimens were

captured in Dry Head Creek by electrofishing in June 1985. It is common in the BCNRA, especially in the reservoir.

Lake Trout (Salvelinus namaycush). This species is native to northwest Montana, but not to Wyoming or the BCNRA (Baxter and Simon 1970, Brown 1971). It has been stocked in Yellowtail Reservoir (Kent 1977, Montana Department of Fish, Wildlife and Parks 1985). It is limited to cold, deep lakes with rocky bottoms. It is uncommon in the BCNRA.

Rainbow Trout (Salmo gairdneri). This species was introduced to Wyoming and Montana from California (Baxter and Simon 1970). It has been stocked in Yellowtail Reservoir (Montana Department of Fish Wildlife and Parks 1985) and some of its tributaries (Kent 1977). It has wide habitat preferences, from cold lakes to rivers and farm ponds (Brown 1971). It is common in the BCNRA, especially in the reservoir.

Cutthroat Trout (Salmo clarki). This trout species is native to Montana and Wyoming streams east and west of the Continental Divide, including the Bighorn River Drainage. None were found in any of the streams in the BCNRA during the 1985 field season. Habitat preferences are mountain streams and lakes. If still present in the BCNRA, it is probably rare. It was stocked in the Shoshone River in 1978 (S. Yekel, Biologist, Wyoming Game and Fish Department, Cody, Wyoming, pers. comm. 1985).

Brook Trout (Salvelinus fontinalis). This species was transplanted into the Rocky Mountain region from the eastern United States (Baxter and Simon 1970). It was commonly found while electrofishing in the larger cold water streams of the BCNRA in June 1985 (Appendix 6). It prefers small, cold, spring-fed streams, beaver ponds and mountain lakes which have sand and gravel bottoms with vegetation (Baxter and Simon 1970, Brown 1971). Population status is common in the BCNRA.

Mountain Whitefish (Prosopium williamsoni). This is a native species to Wyoming and Montana. It is known from the Bighorn, Shoshone and Yellowstone Rivers (Baxter and Simon 1970, Brown 1971) and from Yellowtail Reservoir (Wyoming Game and Fish Department 1985). It prefers deep, fast water in large, cold rivers (Baxter and Simon 1970). It is uncommon in the BCNRA.

Family Cyprinidae

Common Carp (Cyprinus carpio). This species was introduced to Montana in the late 1800's (Brown 1971). It is now found in the Yellowstone, Bighorn and Shoshone Rivers and the Yellowtail Reservoir (Baxter and Stone 1970, Brown 1971, Kent 1977). Carp prefer warm, shallow water in streams, lakes, and reservoirs with muddy bottoms and thick aquatic vegetation. They are important forage fish in Yellowtail Reservoir (Kent 1977, Montana Department of Fish, Wildlife and Parks 1985). Population status in the BCNRA is abundant.

Lake Chub (Couesius plumbeus). This species has been recorded from the Bighorn and Shoshone Rivers and their tributaries (Baxter and Simon 1970, Brown 1971) and in Yellowtail Reservoir near Horseshoe Bend (Kent 1977). It prefers cool foothills streams and lakes (Baxter and Simon 1970). It is uncommon in the BCNRA.

Fathead Minnow (Pimephales promelas). This minnow is native to Montana and Wyoming east of the Continental Divide (Baxter and Simon 1970, Brown 1971). It is known from Yellowtail Reservoir (Wyoming Game and Fish Department 1985) and the Bighorn and Shoshone Rivers (Baxter and Simon 1970, Brown 1971, Kent 1977). While its habitat preferences range widely, it is usually found in slow, turbid, well-vegetated creeks in the plains (Baxter and Simon 1970, Brown 1971). It is common in Yellowtail Reservoir and uncommon in the Bighorn and Shoshone Rivers.

Longnose Dace (Rhinichthys cataractae). This fish is widespread in North America and is found in most major drainages in Wyoming and Montana (Baxter and Simon 1970, Brown 1971). In the BCNRA, it was found in Yellowtail Reservoir (Wyoming Game and Fish Department 1985), the Bighorn and Shoshone Rivers (Kent 1977), and in Porcupine and Gyp Creeks during our survey in June 1985. Longnose dace have very wide habitat preferences (Baxter and Simon 1970, Brown 1971). Specimens taken from Porcupine and Gyp Creeks were found under overhanging boulders and in riffles, respectively. Population status is common.

Flathead Chub (Hybopsis gracilis). This minnow is found in the Bighorn and Yellowstone Rivers and many of their small tributaries (Baxter and Simon 1970, Brown 1971). It is also in Yellowtail Reservoir (Kent 1977). In June, 1985, it was seined from a cobble-bottomed, fast-flowing reach of the Bighorn River near Turtle Trap Site 1 (Appendix 4). It prefers silty streams in the plains (Baxter and Simon 1970, Brown 1971). Population status is common in the Bighorn River and Yellowtail Reservoir.

Sturgeon Chub (Hybopsis gelida). In Montana this species is found only in restricted reaches of the Yellowstone River (Brown 1971). Although previously known from the Bighorn River, it was not found by Stewart in 1979 or from sampling during the 1985 field season. It was found 1.6 km upstream from Yellowtail Reservoir in 1981 by Wyoming Game and Fish Department personnel (Stewart 1981).

The sturgeon chub prefers turbid, fast-flowing water. It likes sand to rubble-size substrate in riffle zones. It is commonly associated with the longnose dace, flathead chub, and the plains and silvery minnows. When present, sturgeon chubs are usually a low percentage of the total fish

population. Its numbers have apparently been affected by dam construction which decreases turbidity. It is probably a rare species in the BCNRA.

Family Catostomidae

River Carpsucker (Carpoides carpio). This species is native to Montana (Brown 1971) and is found in the Bighorn River and Yellowtail Reservoir (Baxter and Simon 1970, Brown 1971, Wyoming Game and Fish Department 1985). It has wide habitat preferences including streams, rivers and reservoirs regardless of size, turbidity or velocity (Brown 1971). It is common in the BCNRA.

Shorthead Redhorse (Moxostoma macrolepidotum). This species is native in the eastern plains of Montana and Wyoming (Baxter and Simon 1970, Brown 1971). In the BCNRA, it is found in Yellowtail Reservoir (Wyoming Game and Fish Department 1985) and in the Bighorn and Shoshone Rivers (Kent 1977). It prefers shallow water in medium-sized, cool, clear streams with clean, rocky bottoms (Baxter and Simon 1970, Brown 1971). It is common in the BCNRA.

Longnose Sucker (Catostomus catostomus). This species ranges widely in the northern hemisphere (Baxter and Simon 1970). It is present in the Bighorn River, most of Montana, and Yellowtail Reservoir (Baxter and Simon 1970, Brown 1971, Wyoming Game and Fish Department 1985). It was captured in Porcupine Creek and in Deadman Creek in our 1985 survey. It prefers cold, clear streams and lakes (Brown 1971). It is common in the BCNRA.

White Sucker (Catostomus commersoni). This is a very common sucker east of the Continental Divide in Montana and Wyoming (Baxter and Simon 1970, Brown 1971). It has been captured in Yellowtail Reservoir (Montana Department of Fish, Wildlife and Parks 1981) and the Bighorn and Shoshone Rivers (Kent 1977). Preferred habitats are cold lakes and streams (Baxter and Simon 1970, Brown 1971). It is common in the BCNRA.

Mountain Sucker (Catostomus platyrhynchus). This fish is probably native in the Bighorn and Shoshone Rivers (Baxter and Simon 1970, Brown 1971). It is present in Yellowtail Reservoir (Kent 1977). Habitat preference varies widely from large rivers to mountain lakes and streams (Baxter and Simon 1970). It is uncommon in the BCNRA.

Family Ictaluridae

Channel Catfish (Ictalurus punctatus). This species is native to the Yellowstone and Bighorn Rivers in Montana (Brown 1971). It is found in Yellowtail Reservoir (Kent 1977, Montana Department of Fish, Wildlife and Parks 1985) where it has been stocked (Wyoming Game and Fish Department 1985). This fish prefers large reservoirs and rivers and is tolerant of turbidity (Baxter and Simon 1970, Brown 1971). It is common in the BCNRA.

Stonecat (Noturus flavus). This small catfish is native to Montana and Wyoming east of the Continental Divide (Brown 1971). It is known from the Yellowtail Reservoir (Wyoming Game and Fish Department 1985) and from the Bighorn, Yellowstone and Shoshone Rivers (Baxter and Simon 1970, Brown 1971). Its preferred habitat is rubble-bottomed streams with large rocks (Baxter and Simon 1970). It is uncommon in the BCNRA.

Family Gadidae

Burbot (Lota lota). This species is native to the rivers of Montana (Brown 1971) and the Bighorn River of Wyoming (Baxter and Simon 1970). It has been found in Yellowtail Reservoir and the Bighorn River (Kent 1977, Brown 1971). It prefers cold, deep lakes and rivers. It is uncommon in the BCNRA.

Family Cyprinodontidae

Plains Killifish (Fundulus zebrinus). This species is found predominantly in rivers of the Great Plains, but populations exist in the Bighorn River upstream and downstream from Yellowtail Dam (Baxter and Simon

1970, Brown 1971) but nowhere in the Yellowstone River. One specimen has been found in Yellowtail Reservoir near Horseshoe Bend (Wyoming Game and Fish Department 1985). This fish prefers shallow streams with sandy bottoms. It appears to be rare in the BCNRA.

Family Centrarchidae

Largemouth Bass (Micropterus salmoides). This fish is not native to Wyoming or Montana. The time and place of its introduction is unknown. Fry have been found during seining near Jim Creek (Kent 1977) and in the stomachs of walleye (Montana Department of Fish, Wildlife and Parks 1985). Its preferred habitat is large lakes, streams and ponds with summer temperatures above 24°C and abundant aquatic vegetation (Baxter and Simon 1970). It is uncommon in the BCNRA.

Green Sunfish (Lepomis cyanellus). This common and widely distributed species is not native to Wyoming or Montana (Baxter and Simon 1970, Brown 1971), but is now known from the Yellowstone and Bighorn Rivers (Baxter and Simon 1970, Brown 1971). It prefers small streams and warm lakes and ponds (Baxter and Simon 1970). It is an important forage fish in Yellowtail Reservoir (Montana Department of Fish Wildlife and Parks 1985, Kent 1977). Population status is common in the BCNRA.

Black Crappie (Pomoxis nigromaculatus). This species was introduced to Wyoming and Montana (Baxter and Simon 1970, Brown 1971). It is known from the Yellowstone and Bighorn Rivers and from Yellowtail Reservoir (Brown 1971, Montana Department of Fish, Wildlife and Parks 1985) and is an important forage fish for walleye, rainbow trout, lake trout, and burbot (Kent 1977). It prefers large, clear streams and reservoirs with a non-silty bottom. It has not done well in mountain streams. Population status is common in Yellowtail Reservoir.

Family Percidae

Walleye (Stizostedion vitreum vitreum). This species is not native to the BCNRA. Its presence and abundance is the result of stocking (Kent 1977). It is common in Yellowtail Reservoir and the Bighorn and Shoshone Rivers (Kent 1977, Montana Department of Fish, Wildlife and Parks 1985). Preferred habitats are large lakes and rivers with cold, clear water (Baxter and Simon 1970).

Sauger (Stizostedion canadense). This fish is native to Montana (Brown 1971). It was stocked in Yellowtail Reservoir, but has been found in the Bighorn and Shoshone Rivers (Kent 1977). Although it inhabits reservoirs and lakes, its preferred habitat is large, moderately-turbid rivers (Baxter and Simon 1970, Brown 1971). Population status is common.

Yellow Perch (Perca flavescens). This percid is not native to the BCNRA (Brown 1971). It inhabits Yellowtail Reservoir (Kent 1977) where it is common, but is uncommon in the Bighorn and Shoshone Rivers (Kent 1977, Montana Department of Fish, Wildlife and Parks). It prefers cool, clear lakes but can be found in well-vegetated, slow-moving streams (Brown 1971).

Amphibians

Blotched Tiger Salamander (Ambystoma tigrinum melanosticum). This species is known to occur in northern Wyoming and southern Montana (Baxter and Stone 1985, Stebbins 1985) and its presence in the BCNRA was documented in 1982 (BCNRA Wildlife Observation File). Only one specimen was seen during the 1985 field season. The tiger salamander is usually terrestrial as an adult and is found in moist habitats (Baxter and Stone 1985, Stebbins 1985). BCNRA personnel have seen salamanders near the residential area, afterbay, and sewage lagoons at Fort Smith and in the ponds at the Layout Creek ranger

Northern Leopard Frog (Rana pipiens). This species is widespread in Wyoming and Montana (Baxter and Stone 1985, Stebbins 1985) and within the BCNRA (BCNRA Wildlife Observation File). Adults and tadpoles were found during the 1985 field season.

Permanent aquatic environments such as beaver ponds and cattail marshes are the preferred habitats of this frog (Baxter and Stone 1985). In the Recreation Area, it has been recorded from lawns in Fort Smith, the Visitor Center Pond in Lovell, and along the Bighorn River (BCNRA Wildlife Observation File). During the 1985 field season, adults were observed in Black Canyon Creek, the Bighorn River, a small marsh between the Shoshone River and the Kane Causeway, and in a small pond west of the Bighorn River. Juveniles were captured in the Kane Cemetery Marsh, among rocks along the Bighorn River, and in Lower Kane Cave. Tadpoles were seen in all permanent emergent wetlands and in the Yellowtail Reservoir at the mouth of Big Bull Elk Creek. None were seen or heard along any of the small streams between the Bull Elk Basin and the south end of Yellowtail Reservoir. Population status is common.

Woodhouse's Toad (Bufo woodhousei woodhousei). This large toad is found throughout the Bighorn Basin (Baxter and Stone 1985), within Bighorn Canyon and north into Montana (Stebbins 1985). It lives in a variety of habitats but is usually near water. It prefers a dusty to sandy substrate with rocks or sage for cover. Lone adults were found partially buried in the dry silt and rocks near Black Canyon Creek and in the water of Big Bull Elk Creek. None were seen anywhere in the Recreation Area after June 22, although recently metamorphosed young were captured south of Lovell in late August (T. Peters, Resource Management Specialist, BCNRA, pers. comm. 1985).

Two adults in amplexus were found in shallow water along the rocky shoreline of the reservoir near the mouth of Big Bull Elk Creek on June 13. Water and cloacal temperatures were 19°C; air temperature was 32°C. The male

continued to grasp the female while measurements were taken and after release. A string of 12 eggs in the "zig-zag" pattern (Stebbins 1985, p. 250) was present on the posterior of the female. No eggs were found in the water. Subsequent visits to the area later in the summer revealed no tadpoles or transformed young.

Plains Spadefoot Toad (Scaphiopus bombifrons). This toad is found in the Bighorn Basin and the eastern counties of Wyoming and Montana (Baxter and Stone 1985, Stebbins 1985). Although its presence has been reported in the Jim Creek area (L. Stahl, Biologist, Wyoming Game and Fish Department Yellowtail Wildlife Habitat Area, pers. comm. 1985) in the summer of 1983, none were seen in that area or similar habitats during the 1985 field season.

This species prefers grassland and sagebrush habitats where the substrate is sufficiently loose and sandy to allow burrowing. Breeding occurs in temporary and permanent standing water. This toad was not found in the BCNRA during 1985. Population status is rare in the BCNRA.

Reptiles

Eastern Short-horned Lizard (Phrynosoma douglassi brevirostre). This species is found in most parts of Wyoming and in eastern and central Montana (Baxter and Stone 1985, Stebbins 1985). These lizards are known from the central and southern Bighorn Basin (Madsen et al. 1979). Previous sightings in the BCNRA were on the east slope of the Pryor Mountains (BCNRA Wildlife Observation File), in the Dry Head Range (L. Clark, Ranger, BCNRA, pers. comm. 1985, Patterson et al. 1985) and near Bighorn Cavern and the south rim of Devil Canyon. There are anecdotal accounts of its presence in the Horseshoe Bend and Sykes Mountain area. None were seen in the 1985 field season.

The preferred habitats of this lizard are grasslands and sagebrush with loose, sandy substrate. This species does not seem to be numerous in the BCNRA.

Northern Sagebrush Lizard (Sceloporus graciosus graciosus). This lizard is found below 2300 m in most of Wyoming and parts of southern and eastern Montana (Baxter and Stone 1985, Stebbins 1985). They are common throughout the BCNRA.

The preferred habitats for this species are dry, open areas with scattered vegetative cover or rock outcrops. In the BCNRA, they were most common on outcrops of the red, fine-grained rocks of the Chugwater Formation. Heat retention by these rocks might provide a longer growing season than other microhabitats (Baxter and Stone 1985, p. 122). Although these lizards were also found in relatively flat areas without dark red soil or rocks, population densities appeared to be lower than on the Chugwater Formation outcrops.

Bullsnake (Pituophis melanoleucas sayi). This species is found east of the Continental Divide in Wyoming and throughout Montana (Baxter and Stone 1985, Stebbins 1985). It is commonly seen in all parts of the BCNRA (BCNRA Wildlife Observation File). Live and roadkill specimens were common during the 1985 field season.

This species is known from various habitats such as desert, prairie, coniferous forest, and farmland (Stebbins 1985). In the BCNRA, it has been recorded from the residential area in Fort Smith, near Horseshoe Bend, and in the grass near the Layout Creek ranger station (BCNRA Wildlife Observation File). During the 1985 field season it was seen at the Layout Creek ranger station (T. Peters, Resource Management Specialist, BCNRA, pers. comm. 1985) and nearby riparian, prairie, sagebrush, and juniper habitats. It was

commonly found on Highway 37 near Crooked Creek and the northwest end of Sykes Mountain. It was most common near riparian habitats.

Yellow-bellied Racer (Coluber constrictor). The BCNRA is in the intergradation zone between the eastern and western subspecies according to Stebbins (1985), but Baxter and Stone (1985) list the eastern subspecies (C. c. flaviventris) as the only subspecies in the Bighorn Basin. Racers were seen, but not captured, during the 1985 survey in a mixed prairie south of the afterbay and in sand dunes south of the Bull Elk Basin. It is reported to be common in the Fort Smith area (P. Gordon, Chief of Interpretation, BCNRA, pers. comm. 1985; L. Clark, Ranger, BCNRA, pers. comm. 1985; BCNRA Wildlife Observation File). Patterson et al. (1985) mention its presence near the afterbay and in all areas north of the Bull Elk Basin. Madsen et al. (1979) did not find it in the southern Bighorn Basin. It is probably common north of the Bull Elk Basin, but uncommon in the south.

Pale Milk Snake (Lampropeltis triangulum multistrata). The BCNRA is on the northwest edge of the range of this species (Stebbins 1985, Williams 1978). It is known from the north and south ends of the Bighorn Basin (Baxter and Stone 1985). Within the BCNRA it has been seen at Ok-A-Beh (BCNRA Wildlife Observation File) and near Horseshoe Bend (Patterson et al. 1985). A den of hibernating milk snakes and bullsnakes was accidentally uncovered near the Mason-Lovell Ranch in 1982 (B. Harrison, Biologist, Wyoming Game and Fish Department, Yellowtail Wildlife Habitat Area, pers. comm. 1985).

Although this species lives in a wide variety of habitats throughout its range (Stebbins 1985), it seems to be confined to scarp woodlands in the plains and foothills zones in Wyoming (Baxter and Stone 1985). In the BCNRA, it has been observed only in or near riparian zones. Its population status is rare in the BCNRA.

Wandering Gartersnake (Thamnophis elegans vagrans). This snake is found in all areas of Wyoming (Baxter and Stone 1985) and in western and central Montana (Stebbins 1985). It was seen in most areas of the Recreation Area during the 1985 field season. This species is found in a wide variety of habitats but is usually near water (Baxter and Stone 1985, Stebbins 1985). In the BCNRA, wandering gartersnakes were most often seen in riparian zones, especially among rocks along streambanks and the reservoir shoreline. They often entered water to escape capture. Population status is common.

Prairie Rattlesnake (Crotalus viridis viridis). This subspecies of the western rattlesnake is found in the Bighorn Basin (Madsen et al. 1979), eastern and central Wyoming except for the high montane zones (Baxter and Stone 1985) and throughout Montana (Stebbins 1985). Its presence has been documented in the BCNRA (BCNRA Wildlife Observation File). It was often seen during the 1985 field season.

The prairie rattlesnake is found in a very wide variety of habitats (Stebbins 1985). In Wyoming it is most common in the plains and foothills zones, especially where rock outcrops provide shelter and thermally optimum environments (Baxter and Stone 1985, Duvall et al. 1985). In the BCNRA it was found in virtually all habitat types except emergent wetlands. This species was most common in the bentonite, shale and sandstone strata near Sykes Mountain, and in the riparian zones near Crooked Creek, Layout Creek, and both forks of Trail Creek. Its population status is common.

Turtles

According to Stebbins (1985), three species of chelonians inhabit the Bighorn Basin: the common snapping turtle (Chelydra serpentina serpentina), the western painted turtle (Chrysemys picta belli), and the western spiny softshell (Trionyx spiniferus hartwegi), but with the exception of one C. p.

belli found in the Visitor Center pond in Lovell, no turtles were observed or collected in the Recreation Area. Spiny softshells have been reported from various places along the Bighorn River in recent years (B. Harrison, Biologist, Wyoming Game and Fish Department, Yellowtail Wildlife Habitat Area, pers. comm. 1985; L. Pechacek, S. Yekel, Biologists, Wyoming Game and Fish Department, Cody, Wyoming, pers. comm. 1985; Madsen et al. 1979). Preferred habitat for these species is characterized by stagnant water with a sandy or muddy bottom and abundant plant growth. This habitat is not common in the BCNRA, especially in dry years.

Amphibian and Reptile Species Not Found

The boreal (western) toad (Bufo boreas) and the western plains gartersnake (Thamnophis radix haydeni) were both mentioned in the BCNRA Wildlife Observation File, but the information recorded is scant and the knowledge of the observers with regard to the species mentioned is uncertain. Neither species was reported or observed during the 1985 field season. One small specimen of what might have been a red-sided gartersnake (Thamnophis sirtalis parietalis) was seen on the road near Lime Kiln Creek, but because of the poor condition (flattened and desiccated) positive identification could not be made. The location of sighting of these three species (Fort Smith, Montana) does fall within the known ranges of these species (Stebbins 1985).

The rubber boa (Charina bottae) is a secretive snake and is seldom seen even in places where it is known to be fairly common. It prefers to be near water and thick cover in the lower montane and foothills zones (Baxter and Stone 1985). It is known from locations in the Bighorn Mountains and Yellowstone Park as well as Wind River Canyon (L. Pechacek, Biologist, Wyoming Game and Fish Department, Cody, Wyoming, pers. comm. 1985) but has not been found in the Bighorn Basin or in the BCNRA.

MANAGEMENT AND RESEARCH RECOMMENDATIONS

Fishes

- 1) Maintain water quality and preserve riparian zones associated with the four large, coldwater streams that contain trout (Appendix 2) through cooperation with the Crow tribe and private landowners. Grazing in the watershed might have contributed to the turbidity observed in Deadman Creek and the fine silt layer covering the bottom of Dry Head Creek. Silt can be detrimental to aquatic plants and invertebrates, thus reducing food sources for fish. Reduction of grazing, especially in the spring and early summer (Myers 1985), or elimination of grazing in the surrounding watersheds may be beneficial to fish populations (also see Patterson et al. 1985).
- 2) Most streams did not support trout, but some, such as Lime Kiln Creek, Layout Creek, and the south fork of Trail Creek, may have potential as trout streams. Stream flows and riparian zones in these watersheds should be protected.
- 3) Streams currently without fish could be used as "refuges" for rare native species. A survey of activities in watersheds, determination of annual stream flows and temperatures, etc. is needed to assess potential.
- 4) Some streams have little potential for supporting fish due to low summer stream flows, turbidity, high gradient, or lack of cover, but they may provide aquatic and riparian habitat needed by other vertebrate species (Gerhart 1982).
- 5) Although the reservoir and its tributaries are managed by state agencies primarily for sport fishing, the National Park Service can encourage management for native species which are not common, such as sturgeon chub,

lake chub, mountain sucker, stonecat, plains killifish, cutthroat trout and burbot.

- 6) Introduction of exotic species should be discouraged.
- 7) Survey the headwaters of the four trout streams for the presence of native cutthroat trout.

Amphibians and Reptiles

1) The National Park Service can encourage the Bureau of Reclamation to manage Yellowtail Reservoir for a normal (1213 m) and relatively constant pool level, especially in May and June. Since small changes in pool level around its normal value can result in large changes in the surface area of the reservoir, particularly at the south end, the amount of available wetland habitat can be greatly reduced in a dry year. Food, cover, and breeding sites for amphibians and reptiles are thereby diminished. The reservoir fishery can also be adversely affected because small fish and eggs are stranded on exposed substrate.

2) The preservation and enhancement of existing wetland and riparian habitats should be a high priority. All amphibians require water for reproduction and many reptiles prefer moist habitats for cover and foraging. Most amphibians in the BCNRA were found in wetlands that persisted through the summer. Importantly, these wetlands showed no sign of grazing.

Riparian habitat is of special importance to the rare pale milk snake. Crooked Creek, Layout Creek, and Trail Creek deserve special attention with regard to this species. The Layout Creek Canyon above the ranger station and the coniferous forest near the Black Canyon campground are the most likely habitats for the rare rubber boa. Turtle habitat was greatly restricted by the scarcity of palustrine wetlands. The marsh along the east side of the

Bighorn River near Five Springs Creek would be excellent turtle and amphibian habitat if increased inflow from Five Springs Creek could be accomplished.

The reliance of amphibians, some reptiles, and other species including birds and mammals on moist habitats emphasizes the extreme importance of these wetland and riparian zones in a generally arid landscape, despite the small area that these habitats occupy (Patterson et al. 1985; Gerhart 1982; also see Appendix 8). The location of future campgrounds, road construction, and other disturbances to important habitats (National Park Service 1981) should be carefully considered in this regard.

3) Various measures to minimize human impact on snake populations should be considered. Rattlesnakes in particular are deliberately killed, sometimes in large numbers if their dens are found. Although no dens were located during the 1985 field season, their existence within the BCNRA is certain. If discovered, their location should be kept confidential to discourage poaching. Closure of unimproved roads in the vicinity of den sites during the spring and fall aggregations might be considered. Education of the public about the importance of reptiles in natural ecosystems through printed materials, campfire programs, and Visitor Center displays, for instance, might diminish human impact on these species.

Human use of an area, agriculture and grazing in particular, is associated with the decline of rattlesnake populations (Klauber 1972). Bentonite mining on land managed by the Bureau of Land Management near Sykes Mountain probably has adverse effects on snake populations that den in the BCNRA because of the destruction of foraging habitat and increased vehicular traffic. Reclamation of this area should be encouraged.

The proposed extension of Highway 37 north from Barry's Landing through the Dry Head Range and Crow tribal lands would probably result in increased

human impact on snake populations. Access would increase in areas not now affected by visitor activity. Additional vehicular traffic would result in increased mortality (roadkills) throughout the western portion of the BCNRA.

SUMMARY

A total of 306 vertebrate species are known to inhabit the BCNRA. Enumeration by class is as follows: 28 fish, 6 amphibians, 13 reptiles (Appendices 5 and 7), 212 birds, 47 mammals (Patterson et al. 1985). Five additional species of amphibians and reptiles are possible inhabitants of the BCNRA, but their presence has not been observed (see text, p. 25). Of the 28 fish species, 17 are native (Appendix 5). Two fish species (plains killifish, sturgeon chub) are rare. Insufficient data exist to evaluate the abundance of two stocked species (cutthroat trout, white crappie). Brown trout and the common carp are exotic species. All amphibian and reptile species present are native to the area. One amphibian species (plains spadefoot toad) and one reptile species (pale milk snake) are rare. Another rare reptile (rubber boa) is known from the surrounding region and might be present in the BCNRA. Rarity probably results from the greatly restricted area of suitable habitats within the BCNRA. The bald eagle is the only endangered species known in the BCNRA; rare avian species include the cattle egret, snowy egret, black-crowned night heron, white faced ibis, tundra swan, and the snow goose (Patterson et al. 1985). Rare mammals in the BCNRA are the spotted bat and Merriam's shrew (Patterson et al. 1985).

Many, but not all, habitat types are occupied by at least one herptile species (Appendices 5, 7, and 8). All habitats were occupied by at least one bird or mammal species (Patterson et al. 1985). Wetland and creek woodland habitats were found to be most important for amphibian (Appendix 8), avian and mammalian species diversity (Patterson et al. 1985). The greatest numbers of reptilian species were found in creek woodland, sagebrush, grassland, wetland, and rock/unvegetated habitat types (Appendix 8). Our study and that of

Patterson et al. (1985) conclude that management objectives should be concentrated on the preservation of unique and restricted habitat types, especially wetland and riparian habitats. Recreational and land use practices, especially grazing, should be restricted or prohibited in areas where rare species exist or where unique biological activities occur, such as the heronry and cormorant rookery at the south end of the BCNRA (Patterson et al. 1985). More study is needed concerning the tributaries flowing into Bighorn Canyon and their capacity as trout or non-game fish habitat. Non-game species of all kinds merit more research.

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Appendix 1. List of types of habitat, vegetation and special features in the Big Horn Canyon National Recreation Area modified from Cowardin et al. (1979), Myers (1985), and Jones et al. (1985).

1.0 Coniferous forest--Ustic Vegetation

- 1.1 Douglas fir
- 1.2 Limber Pine
- 1.3 Ponderosa Pine/Douglas fir
- 1.4 Ponderosa Pine
- 1.5 Douglas fir/Juniper
- 1.6 Limber Pine/Juniper

2.0 Deciduous Forest--Floodplain Forest--Creek Woodland

- 2.1 Riparian/Plains cottonwood/Understory shrubs
- 2.2 Riparian/Plains cottonwood
- 2.3 Riparian/Lanceleaf cottonwood/Understory shrubs
- 2.4 Riparian/Boxelder/Water birch/Choke Cherry

3.0 Woodland Chaparral--Aridic and Semi-aridic Vegetation

- 3.1 Juniper
- 3.2 Juniper/Grassland
- 3.3 Juniper/Sagebrush
- 3.4 Juniper/Mountain Mahogany
- 3.5 Mountain Mahogany

4.0 Basin--Prairie Shrub--Aridic Vegetation

- 4.1 Sagebrush Grassland
 - 4.2 Greasewood/Rabbitbush
 - 4.3 Greasewood
 - 4.4 Mixed
-
- 5.0 Mountain--Foothills Shrub--Steppe--Semi-aridic Vegetation
 - 5.1 Sagebrush/Grassland
 - 5.2 Mountain Mahagony
 - 5.3 Mixed
-
- 6.0 Riparian Shrub
 - 6.1 Willow
 - 6.2 Skunkbush
 - 6.3 Chokecherry
 - 6.4 Wild Plum/Chokecherry/Wood Rose
 - 6.5 Buffalo Berry
 - 6.6 Russian Olive
 - 6.7 Mixed
 - 6.8 Tamarisk
-
- 7.0 Grasslands--Semi-aridic vegetation
 - 7.1 Mixed Prairie
 - 7.2 Wet-Moist Meadow
 - 7.3 Thickspike/Western Wheatgrass/Needle and Thread
 - 7.4 Annual Forb
-
- 8.0 Disturbed Areas

8.1 Roadside

8.2 Urban/Residential

9.0 Riverine/Lower Perennial

9.1 Riverine/Lower Perennial/Rock Bottom

9.2 Riverine/Lower Perennial/Unconsolidated Bottom

9.3 Riverine/Lower Perennial/Aquatic Bed

9.4 Riverine/Lower Perennial/Unconsolidated Shore

10.0 River/Upper Perennial

10.1 River/Upper Perennial/Rocky Shore

10.2 Riverine/Upper Perennial/Unconsolidated Shore

11.0 Lacustrine

11.1 Lacustrine/Limnetic/Rock Bottom

11.2 Lacustrine/Limnetic/Unconsolidated Bottom

11.3 Lacustrine/Littoral/Rock Bottom

11.5 Lacustrine/Littoral/Unconsolidated Bottom

11.6 Lacustrine/Littoral/Unconsolidated Shore

12.0 Palustrine

12.1 Palustrine/Rock Bottom

12.3 Palustrine/Aquatic Bed

12.4 Palustrine/Unconsolidated Shore

12.5 Palustrine/Emergent

12.6 Palustrine/Forested

12.7 Palustrine/Scrub/Shrub

13.0 Special Features

13.1 Caves

13.2 Cliffs (Canyons, Mountains)

13.3 Rock Outcrop/Rock Piles

13.4 Talus Slope

13.5 Shoreline

13.6 Sand dunes

13.7 "Fellfield" (Myers 1985)

Appendix 2. Physical parameters of six perennial streams¹ in the Bighorn Canyon National Recreation Area in which fish were captured by electrofishing.

| Stream Name | Date Sampled | Mean Width (m) | Mean Depth (cm) | Discharge (m ³ /sec) | Gradient (%) | Water Temperature (°C) | Substrate ² Type | Comments |
|--------------------|--------------------|----------------|-----------------|---------------------------------|--------------|------------------------|-----------------------------|------------------------------------------------------------------------------------------------------|
| Black Canyon Creek | 6/22/85 | 12.60 | 14.90 | 0.57 | 2 | 16 | G-B | Large creek, clear water, some pools, no overhanging banks or vegetation. |
| Big Bull Elk Creek | 6/22/85 | 3.75 | 63.60 | 0.96 | 6 | 12 | B | Very clear water, some deep pools and overhanging boulders, no vegetation. |
| Deadman Creek | 6/20/85 | 1.68 | 5.30 | 0.15 | 4 | 18 | S-B | Turbid with much woody debris, no overhanging banks or vegetation, all fish within 25 m below falls. |
| Gyp Creek | 6/20/85 | 2.45 | 7.40 | 0.39 | 4 | 16 | S-B | Clear water, mostly bedrock, no overhanging banks, little overhanging vegetation. |
| Dry Head Creek | 6/20/85 6/21/85 | * | * | 0.30 | 3 | * | S-R | Clear water, but fine sediment covered substrate, extensive overhanging vegetation, numerous pools. |
| Porcupine Creek | 6/23/85 | * | * | * | 2 | * | G-B | Clear water, numerous pools and overhanging boulders little vegetation. |

* - Missing data.

¹ - Measurements were taken at 10m intervals beginning at the mouth of the streams. Elevation of the stream mouths was 1206 m during the period of 6/20/85-6/23/85.

² Substrate Codes:

S - silt and sand

G - gravel (1-10 cm)

R - rubble/cobble (10.1-40 cm)

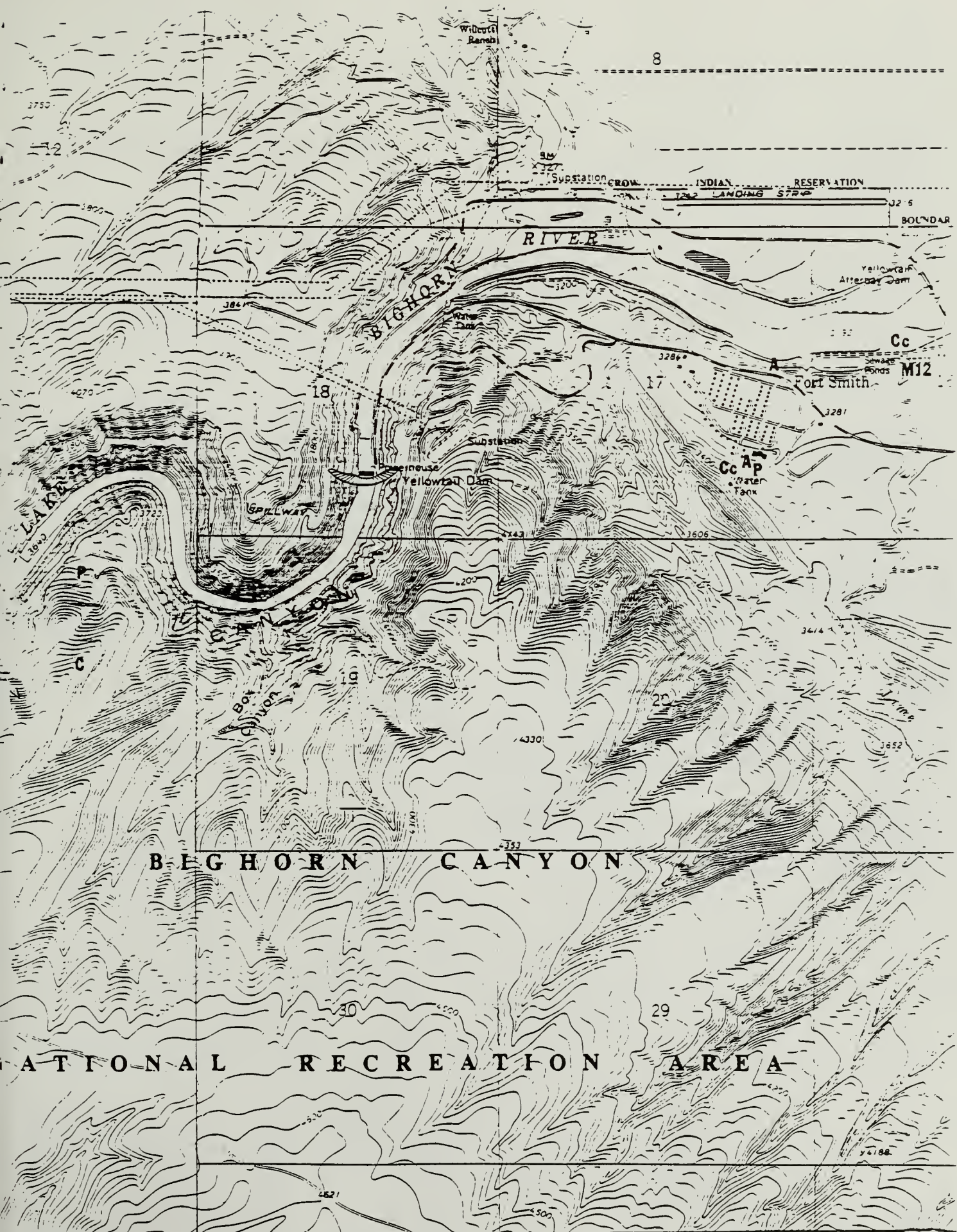
B - boulder/bedrock (>40 cm)

Appendix 3. Type and number of turtles, salamander, and minnow traps set in the Bighorn Canyon National Recreation Area during 1985, with locations, map codes, dates during which traps were baited and checked, and total number of trap-days at each location.

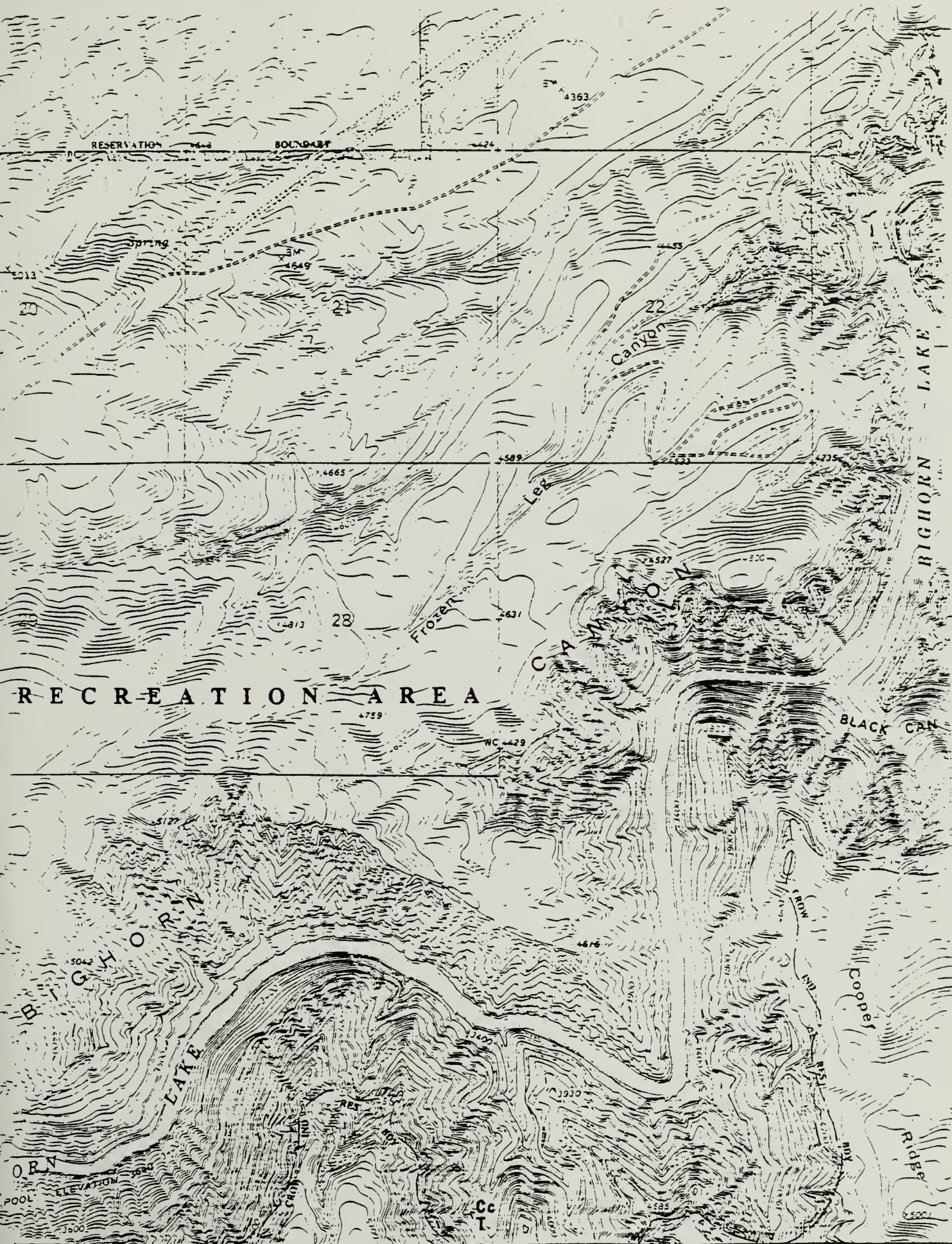
| | Number of traps set | Location | Map ¹ Codes | Dates (1985) | Total Trap-days |
|-------------------|------------------------|----------------------------------------|---------------------------|--------------|--------------------|
| Turtle traps: | 1 | Kane Cemetery marsh | T1 | 6/6 - 6/30 | 14 |
| | 1 | Bighorn River | T2 | 6/6 - 6/30 | 14 |
| | 1 | Bighorn River | T3 | 6/30 - 7/9 | 9 |
| | 1 | Bighorn River | T4 | 8/11 - 8/24 | 13 |
| Salamander traps: | 2 | Bighorn River ponds | S1, S2 | 5/25 - 7/8 | 84 |
| | 2 | Kane Cemetery marsh | S3, S4 | 6/6 - 7/8 | 62 |
| | 1 | Bighorn River | S5 | 6/16 - 6/30 | 14 |
| | 1 | Sorensen Ranch pond | S6 | 7/20 - 7/24 | 4 |
| | 1 | Five Springs Creek marsh | S7 | 8/11 - 8/13 | 2 |
| Minnow traps: | 4 | Trail Creek (North and South Forks) | M1, M2, M3, M4 | 6/1 - 6/6 | 20 |
| | 1 | Layout Creek | M5 | 7/20 - 7/24 | 4 |
| | 1 | Black Canyon Creek | M6 | 7/20 - 7/24 | 4 |
| | 1 | Big Bull Elk Creek | M7 | 7/20 - 7/24 | 4 |
| | 1 | Dry Head Creek | M8 | 7/20 - 7/24 | 4 |
| | 1 | Porcupine Creek | M9 | 7/20 - 7/24 | 4 |
| | 1 | Big Bull Elk Creek | M10 | 8/23 - 8/26 | 3 |
| | 1 | Dry Head Creek | M11 | 8/23 - 8/26 | 3 |
| | 1 | Lime Kiln Creek | M12 | 8/8 - 8/10 | 2 |
| | | | | | |

¹Map codes denote exact locations of traps as marked on topographic maps in Appendix 4.

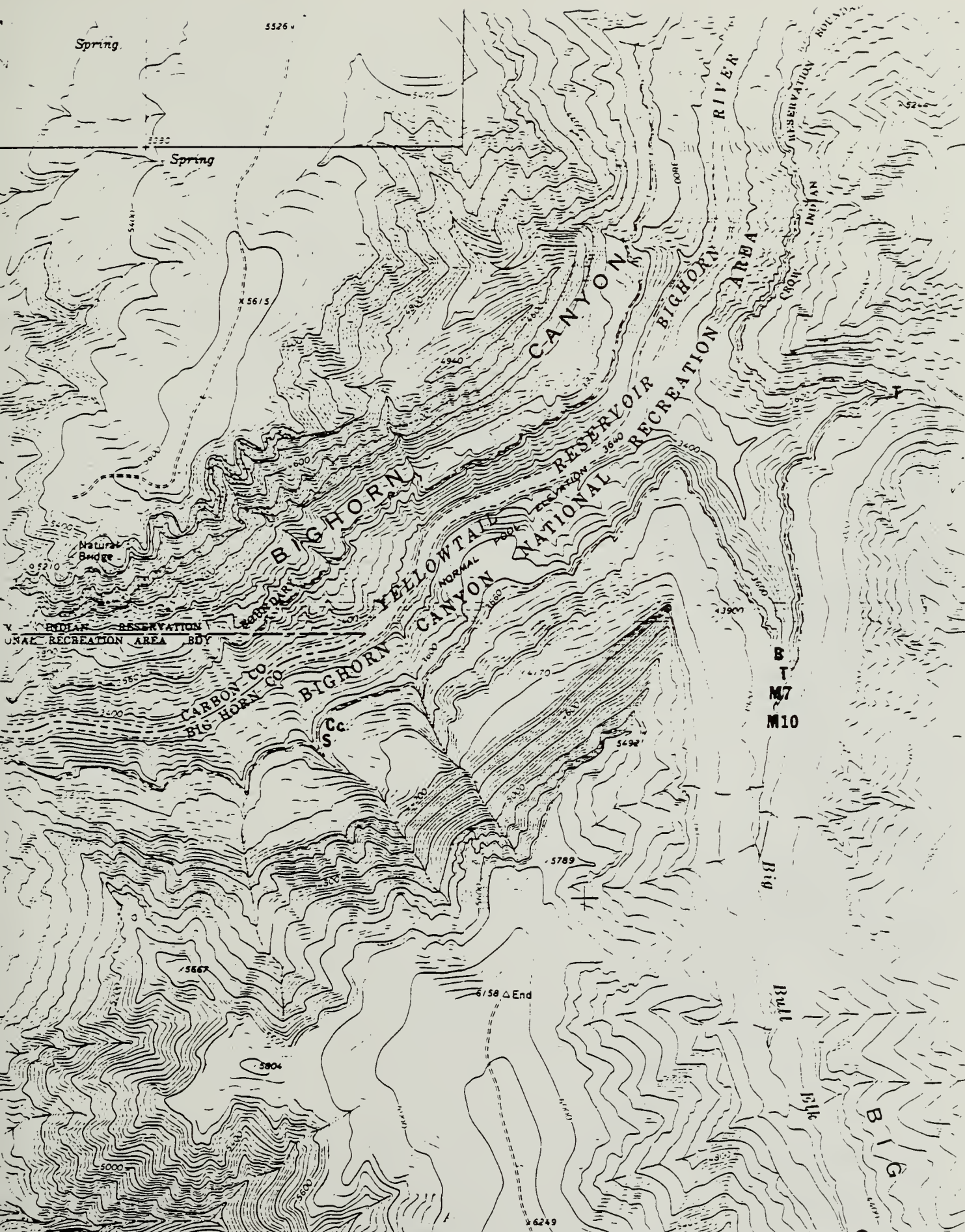
APPENDIX 4. Locations of species sighted and traps set between 20 May-22 September, 1985, in bighorn Canyon National Recreation Area, MT-WY. All maps are 7.5 minute series topographic maps published by the U.S. Geological Survey. The following information is listed on each map legend: name of quadrangle, latitude-longitude, publication date, map codes for species and traps.



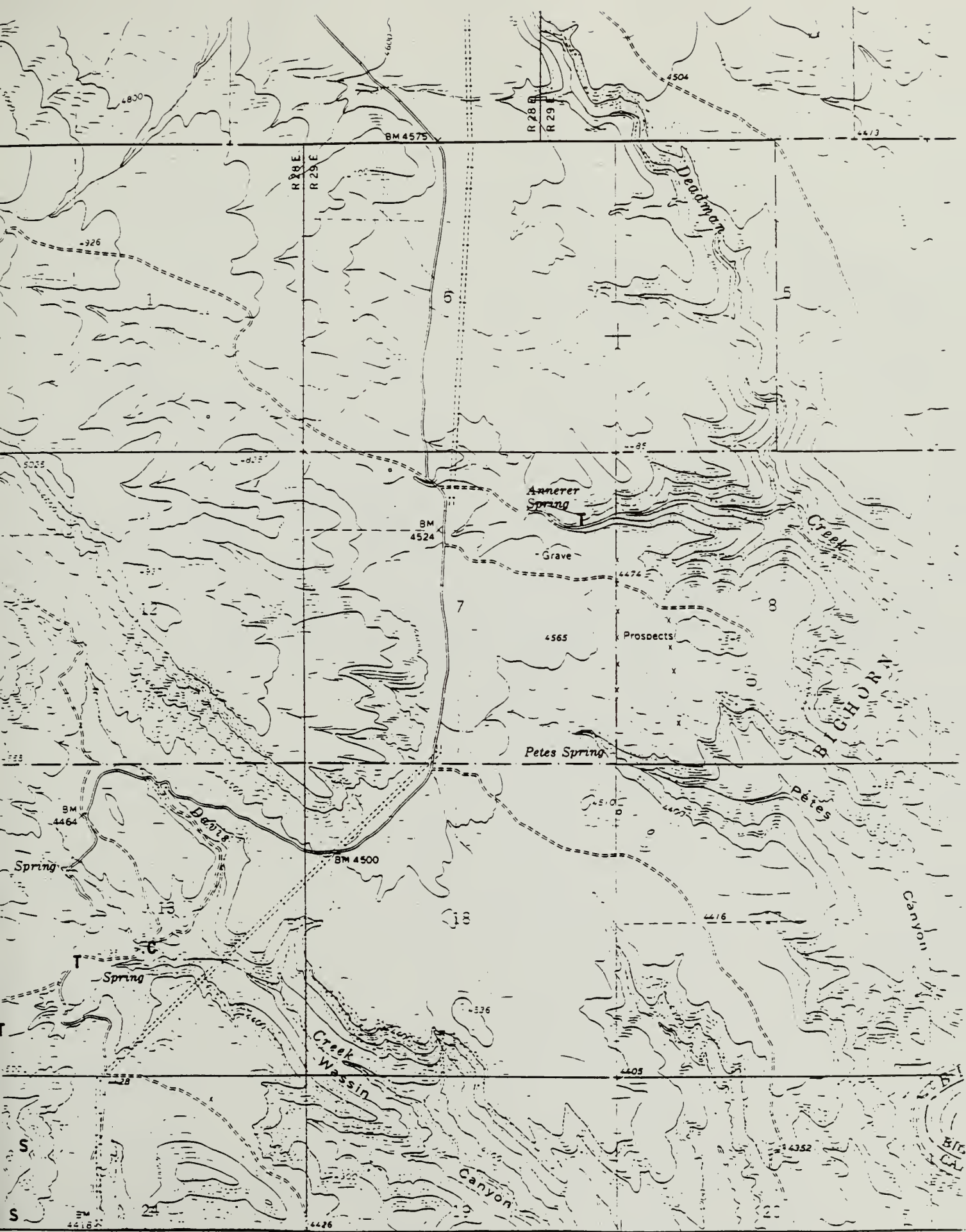
Yellowtail Dam, Mont., N4513--W10752.5, 1964, A - Ambystoma tigrinum, C - Crotalus viridis, Cc - Coluber constrictor, P - Pituophis melanoleucas, M12 - Minkow Trap 12.



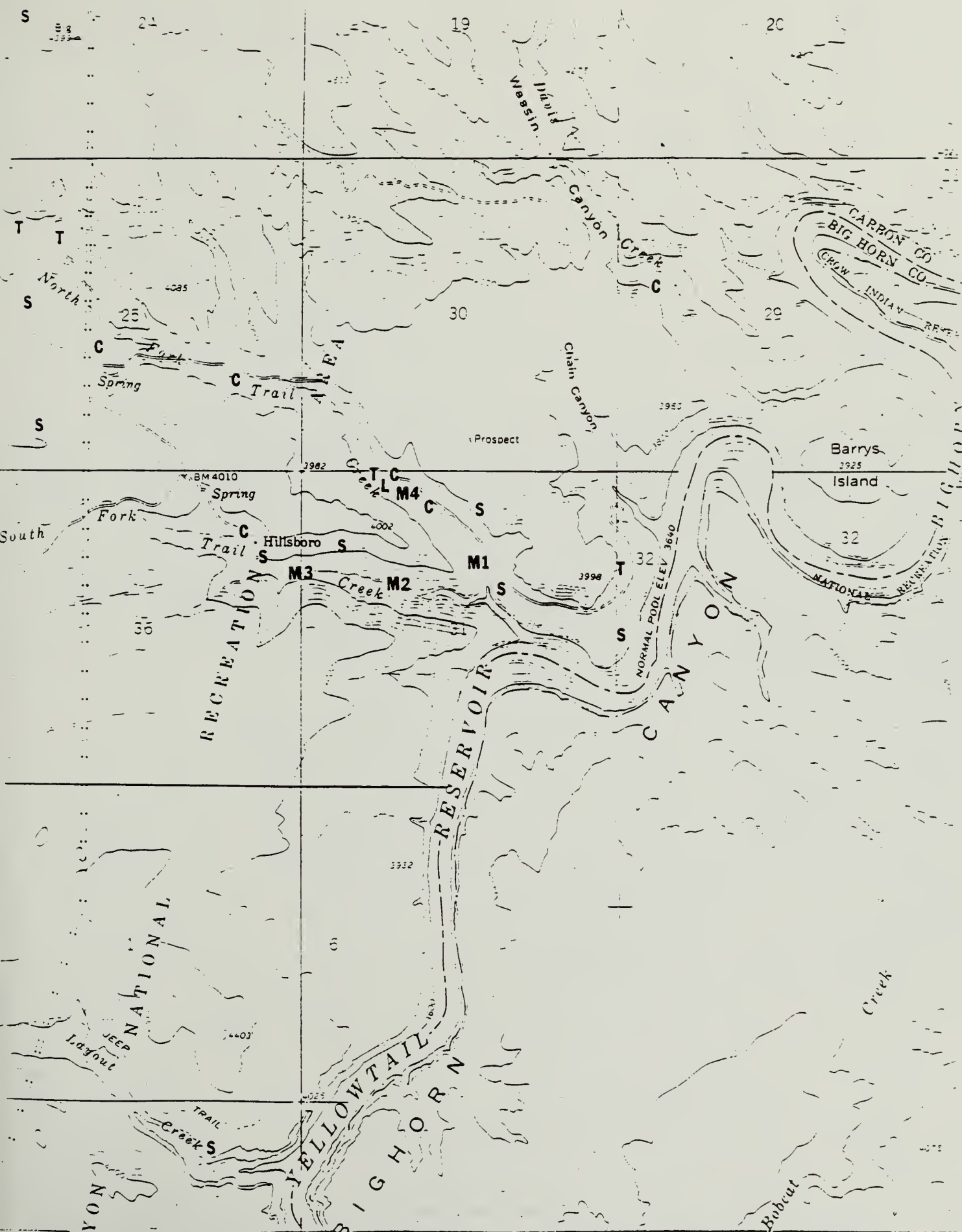
Grapevine Dome, Mont., N4515--W10800, 1964, Cc - Coluber constrictor, T - Thamnophis elegans



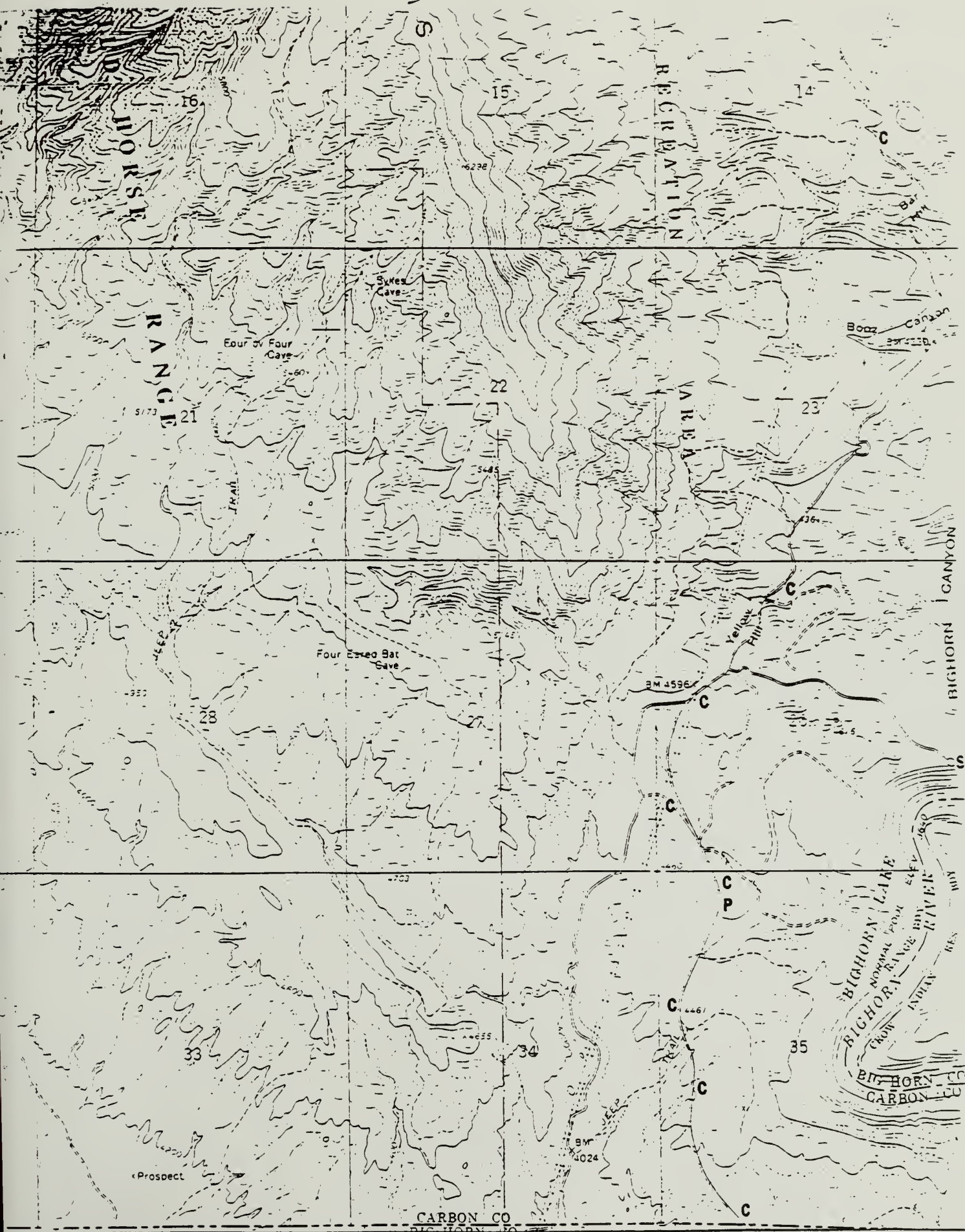
Little Finger Ridge, Mont., N4507.5—W10800, 1964, B - Bufo woodhousei, Cc - Coluber constrictor, S - Sceloporus graciosus, T - Thamnophis elegans, M7, M10 - Minnow Traps 7 and 10.



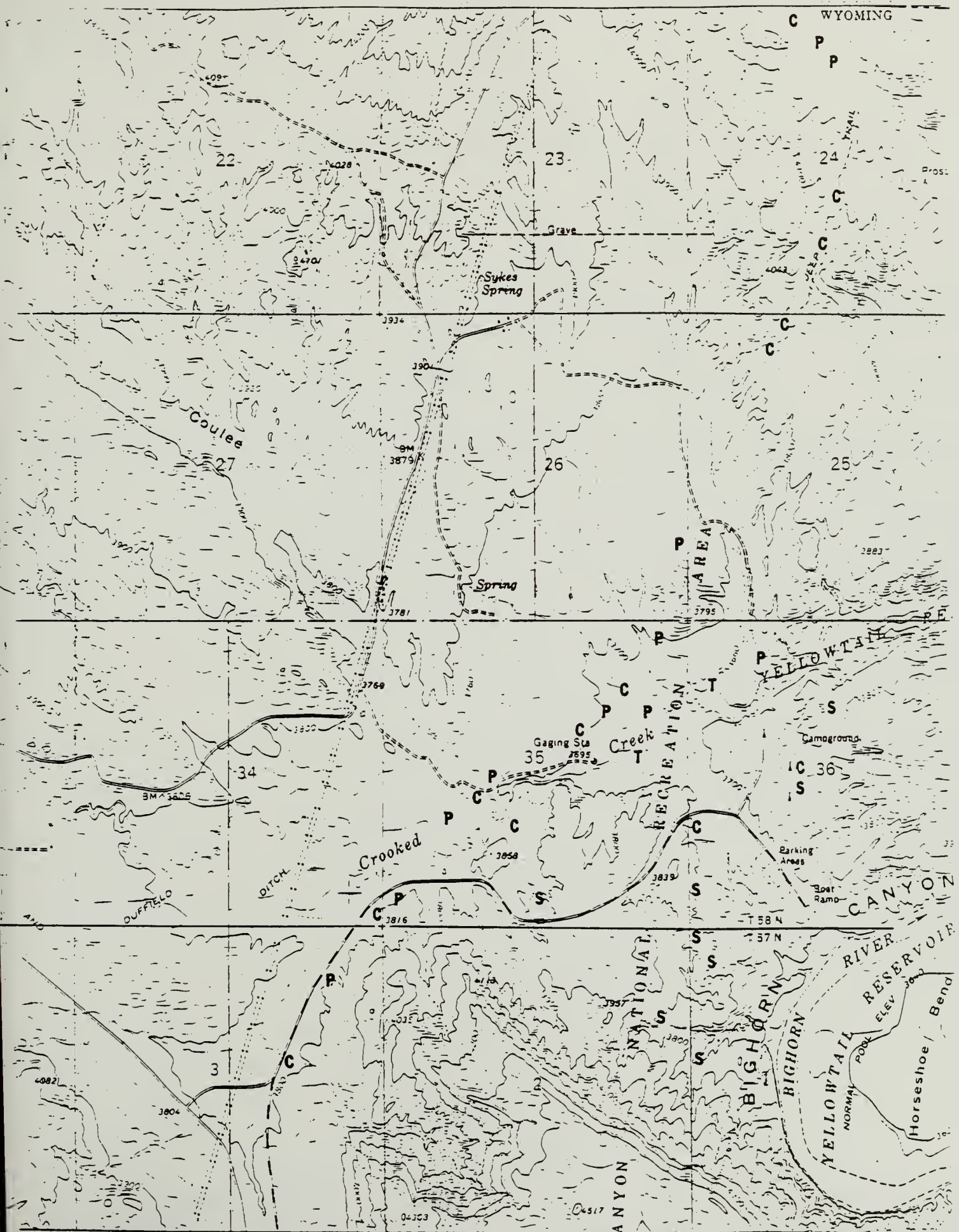
Dead Indian Hill, Mont., N4507.5--W10807.5, 1964, C - Crotalus viridis, S - Sceloporus graciosus, T - Thamnophis elegans, MS, M11 - Minnow Traps 8 and 11.



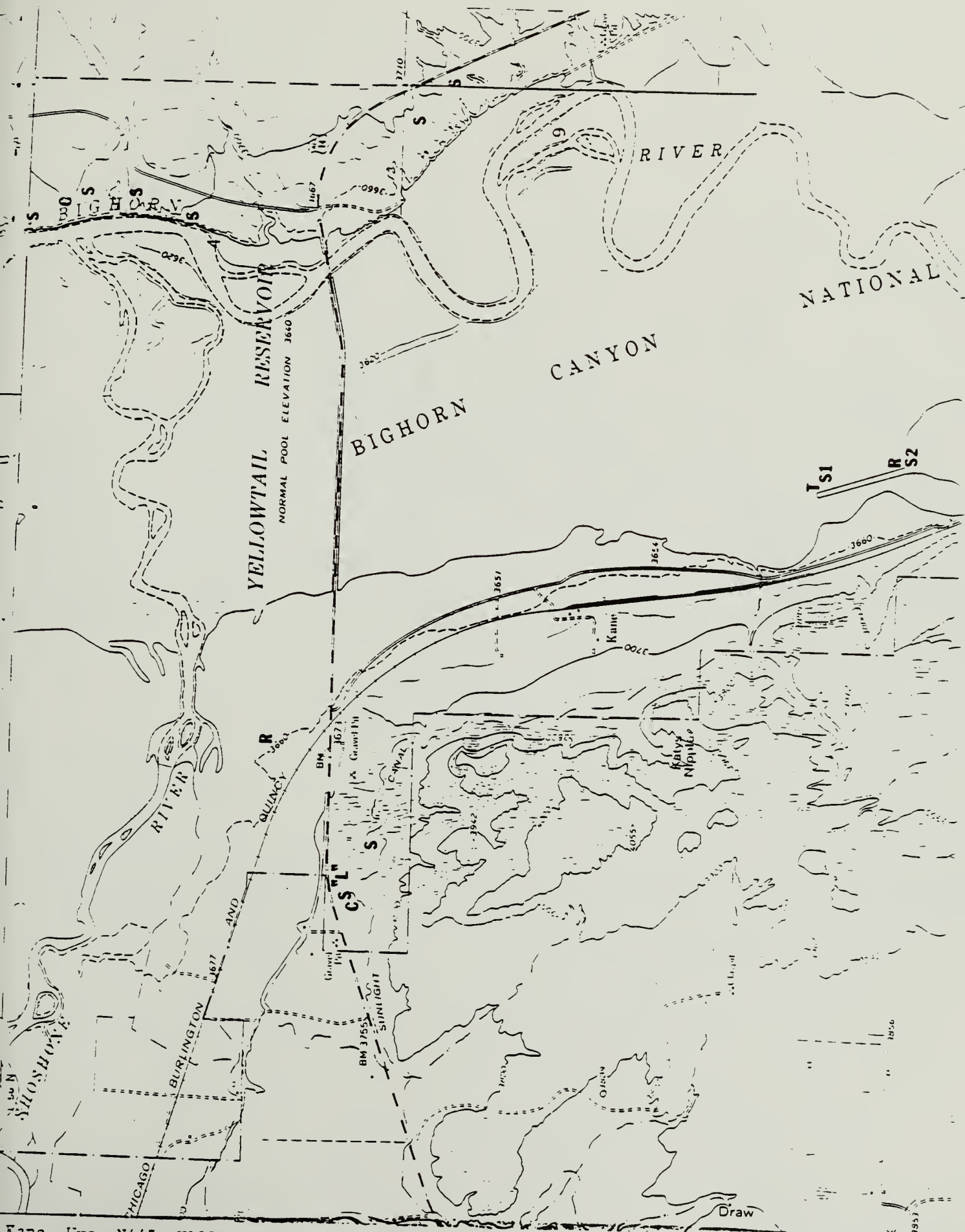
Hillsboro, Mont.-Wyo., N4500-W10807.5, 1964, C - Crotalus viridis, L - Lampropeltis triangulum, S - Sceloporus graciosus, T - Thamnophis elegans, M1 - M4 - Minnow Traps 1-4



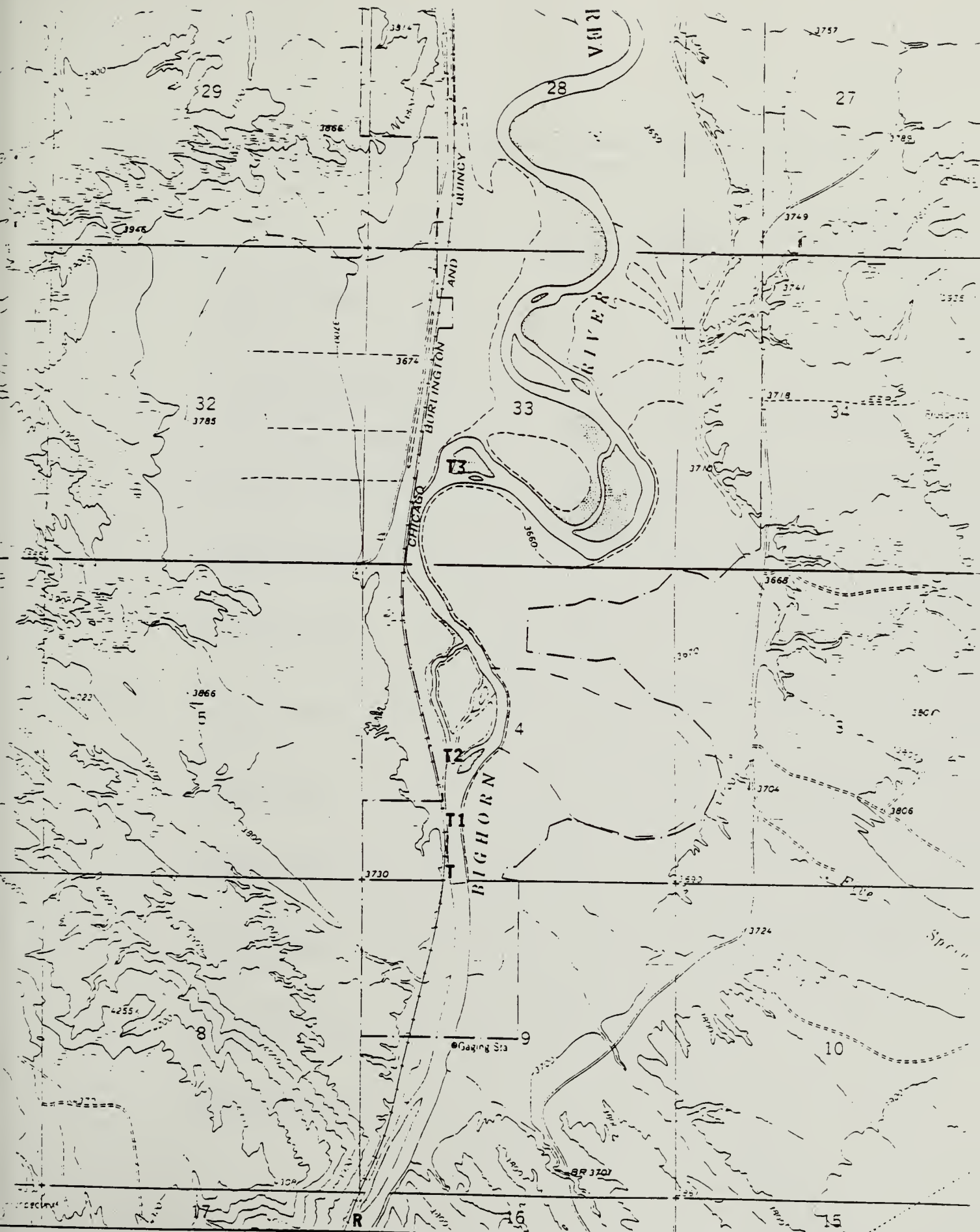
Mystery Cave, Mont.-Wyo., N4500-W10815, 1964, A - Ambystoma tigrinum, C - Crotalus viridis, L - Lampropeltis triangulum, P - Pituophis melanoleucas, S - Sceloporus graciosus, T - Tamias elegans, M5 - Minnow Trap 5.



Sykes Spring, Wyo., N4452.5--W10815, 1964, C - *Crotalus viridis*, P - *Pituophis melanoleucas*, R - *Rana piñiens*, S - *Sceloporus orcutti*, T - *Thamnophis elegans*



Kane, Wyo, N445--W10807.5, 1964, C - *Crotalus viridis*, R - *Rana pipiens*, S - *Sceloporus graciosus*, T - *Thamnophis elegans*, "L" - Location of *S. graciosus* population mentioned in text; S1, S2--Salamander Traps 1 and 2. T1, T2, T3 - Turtle Traps 1, 2, and 3.



ne, Wyo, N445--W10807.5, 1964, C - Crotalus viridis, R - Rana pipiens, S - Sceloporus
acidosus, T - Thamnophis elegans, "L" - Location of S. graciosus population mentioned in
 text; S1, S2--Salamander Traps 1 and 2. T1, T2, T3 - Turtle Traps 1, 2, and 3.

Appendix 5. Fish species found in the Bighorn Canyon National Recreation Area with codes for native status, relative abundance, habitat associations, and documentation.

| Family | Species | Native (N) Status | Relative ¹ Abundance | Habitat ² Association | Documentation ³ |
|------------|------------------------------------------------------------------|----------------------|------------------------------------|-------------------------------------|------------------------------------|
| Salmonidae | Mountain Whitefish <u>Prosopium williamsoni</u> (Girard) | N | U | L, R | 1, 9 |
| | Cutthroat Trout <u>Salmo clarki</u> Richardson | N | ? (S) | S | 5, 16 |
| | Rainbow Trout <u>Salmo gairdneri</u> Richardson | | C (S) | L, S | 5, 7, 9, 11, 15 |
| | Brown Trout <u>Salmo trutta</u> Linnaeus | | C (S) | L, S | 1, 5, 9, 11, 14, 15, 18 |
| | Brook Trout <u>Salvelinus fontinalis</u> (Mitchill) | | C | S | 18 |
| | Lake Trout <u>Salvelinus namaycush</u> (Walbaum) | | U (S) | L | 5 |
| Cyprinidae | Lake Chub <u>Couesius plumbeus</u> (Agassiz) | N | U | L, R, S | 3 |
| | Common Carp <u>Cyprinus carpio</u> (Linnaeus) | | A | L, R | 1, 2, 3, 4, 6, 7, 9, 10, 12, 14 |
| | Sturgeon Chub <u>Hybopsis gelida</u> (Girard) | N | U-R | R | 17 |
| | Flathead Chub <u>Hybopsis gracilis</u> (Richardson) | N | C | L, R, S | 1, 2, 3, 4, 7, 9, 10, 18 |
| | Fathead Minnow <u>Pimephales promelas</u> Rafinesque | N | C | L, R | 2, 4, 9, 10 |
| | Longnose Dace <u>Rhinichthys cataractae</u> (Valenciennes) | N | C | L, R, S | 2, 3, 4, 9, 10, 18 |

| | | | | | |
|-----------------|--------------------------------------------------------------------|---|-------|---------|--------------------------|
| Catostomidae | River Carpsucker <u>Carpoides carpio</u> (Rafinesque) | N | C | L, R | 1, 2, 3, 4, 6, 7, 10 |
| | Longnose Sucker <u>Catostomus catostomus</u> (Forster) | N | C | L, R, S | 1, 6, 9, 10, 14, 18 |
| | White Sucker <u>Catostomus commersoni</u> (Lacepede) | N | C | L, R | 1, 2, 3, 6, 9, 10, 14 |
| | Mountain Sucker <u>Catostomus platyrhynchus</u> (Cope) | N | U | L | 2, 6, 9, 10 |
| | Shorthead Redhorse <u>Moxostoma macrolepidotum</u> (Lesueur) | N | C | L, R | 1, 3, 6, 10, 14 |
| Ictaluridae | Channel Catfish <u>Ictalurus punctatus</u> (Rafinesque) | N | C | L, R | 5, 8, 14 |
| | Stonecat <u>Noturus flavus</u> (Rafinesque) | N | U | L, R | 1 |
| Gadidae | Burbot <u>Lota lota</u> (Linnaeus) | N | U | L, R | 8, 10, 14 |
| Cyprinodontidae | Plains Killifish <u>Fundulus zebrinus</u> Jordan and Gilbert | N | R | L | 2 |
| Centrarchidae | Largemouth Bass <u>Micropterus salmoides</u> (Lacepede) | | U | L | 3, 12 |
| | Green Sunfish <u>Lepomis cyanellus</u> Rafinesque | | C | L | 3, 12, 13 |
| | Black Crappie <u>Pomoxis nigromaculatus</u> (Lesueur) | | C | L, R | 3, 11 |
| | White Crappie <u>Pomoxis annularis</u> Rafinesque | | ? (S) | L | 19 |

| | | | | | |
|----------|---------------------------------------------------------------------|---|-------|------|-----------------------------------|
| Percidae | Yellow Perch <u>Perca flavescens</u> (Mitchill) | | C | L, R | 1, 2, 3, 7, 10, 11, 12, 14, 18 |
| | Sauger <u>Stizostedion canadense</u> (Smith) | N | C (S) | L, R | 1, 7, 10, 11, 14 |
| | Walleye <u>Stizostedion vitreum</u> <u>vitreum</u> (Mitchill) | | A (S) | L, R | 1, 5, 7, 8, 10, 11, 14, 18 |

¹Relative Abundance Code Definitions (see Documentation Code Definitions below for sampling information).

- A - Abundant: More than 15% by number in at least one sample.
- C - Common: Between 5-15% by number in at least one sample.
- U - Uncommon: Between 1-5% by number in at least one sample.
- R - Rare: One specimen found; not reported in recent years.
- S - Stocked: Abundance has been affected by stocking programs.
- ? - Unknown: Data are insufficient for determination of relative abundance.

²Habitat Association Code Definitions.

- L - Lake (Yellowtail Reservoir).
- R - River (Bighorn River, Shoshone River).
- S - Stream (tributaries of Bighorn River, Yellowtail Reservoir).

³Definition of Documentation Codes.

- 1 - Gillnetting, Yellowtail Reservoir between Montana-Wyoming stateline and Chugwater Gap, May 14-16, 1984 (Wyoming Game and Fish Dept. 1985).
- 2 - Minnow seine, Yellowtail Reservoir, Horseshoe Bend area, June 11 and July 10, 1984 (Wyoming Game and Fish Dept. 1985).
- 3 - Minnow seine, Yellowtail Reservoir, Crooked Creek Bay, June 11 and July 10, 1984 (Wyoming Game and Fish Dept. 1985).
- 4 - Minnow seine, Yellowtail Reservoir, Jim Creek area, July 10, 1984 (Wyoming Game and Fish Dept. 1985).
- 5 - Fish stocking, Yellowtail Reservoir, 1965-69 (Kent 1977).
- 6 - Gillnetting, Yellowtail Reservoir, 1967-1977 (Kent 1977).
- 7 - Purse seine, Yellowtail Reservoir, Devil's Canyon to Horseshoe Bend, July 1975 (Kent 1977).
- 8 - Trap net, Shoshone River, May, 1969 (Kent 1977).
- 9 - Electrofishing, lower Shoshone River, April 9-12, 1973 (Kent 1977).
- 10 - Electrofishing, lower Bighorn River, April 9-12, 1973 (Kent 1977).

- 11 - Creel census, Yellowtail Reservoir, April - September, 1983. (Montana Dept. of Fish, Wildlife, and Parks, 1985).
- 12 - Stomach contents of walleye, Yellowtail Reservoir between Yellowtail Dam and Barry's Landing, May - September 1984 (Montana Dept. of Fish, Wildlife and Parks 1985).
- 13 - Minnow traps, Yellowtail Reservoir, 1984 (Montana Dept. of Fish, Wildlife and Parks 1985).
- 14 - Gillnetting, Yellowtail Reservoir, October 3-6, 1983 and November 7-9, 1984 (Montana Dept. of Fish, Wildlife and Parks 1985).
- 15 - Fish stocking, Afterbay and Bighorn River, 1968-1985 (Montana Dept. of Fish, Wildlife and Parks 1985).
- 16 - Fish Stocking, Shoshone River, 1978 (S. Yekel, Biologist, Wyoming Game and Fish Dept., Cody, Wyoming, pers. comm. 1985).
- 17 - Lower Bighorn River, 19 (Stewart 1981).
- 18 - Captured or observed by Wyoming Cooperative Fish and Wildlife Research Unit personnel during 1985 field season (see Appendix 6).
- 19 - Fish Stocking, Yellowtail Reservoir, 1984 (Wyoming Game and Fish Dept. 1985).

Appendix 6. Permanent streams surveyed in the Bighorn Canyon National Recreation Area in 1985. Species are identified in streams where fish were found.¹ Numbers of fish found are indicated in parentheses.

| | |
|--------------------------|--------------------------------------------------------------|
| Lime Kiln Creek | No fish found |
| Black Canyon Creek | Brook Trout (7) |
| Corral Creek | No fish found |
| East Cabin Creek | No fish found |
| Little Bull Elk Creek | No fish found |
| Big Bull Elk Creek | Brook Trout (11) |
| Hoodoo Creek | No fish found |
| Dry Head Creek | Brown Trout (2) |
| Deadman Creek | Longnose Sucker (7) |
| Gyp Creek | Longnose Dace (2) |
| Davis Creek | No fish found |
| Trail Creek - North Fork | No fish found |
| Trail Creek - South Fork | No fish found |
| Layout Creek | No fish found |
| Porcupine Creek | Brook Trout (13) Longnose Dace (1) Longnose Sucker (2) |
| Cottonwood Creek | No fish found |
| Bighorn River | Flathead Chub (4) |

¹ Fish were captured by electrofishing in all streams except the Bighorn River, in which seining was used.

Appendix 7. Species of amphibians and reptiles inhabiting the Bighorn Canyon National Recreation Area, with codes for relative abundance, habitat associations and documentation.

| Species | Relative Abundance ¹ | Habitat Association ² | Documentation ³ |
|----------------------------------------------------------------------------|------------------------------------|---------------------------------------------------|----------------------------|
| Blorched Tiger Salamander (<u>Ambystoma tigrinum melanosticum</u>) | C | 2.3-.4, 13.1 | OBS, NPS, PC |
| Boreal Chorus Frog (<u>Pseudacris triseriata maculata</u>) | C | 12.3-.5 | OBS, NPS, PC, WGFY |
| Northern Leopard Frog (<u>Rana pipiens</u>) | C | 8.2, 10.1, 11.3-.6 12.3-.7, 13.1, 13.5 | OBS, NPS, PC |
| Woodhouse's Toad (<u>Bufo woodhousei woodhousei</u>) | C | 6.7, 8.2, 9.0, 11.3, 12.3, 13.3 | OBS, NPS, PC |
| Plains Spadefoot Toad (<u>Scaphiopus bombifrons</u>) | R | 4.1 | WGFY |
| Boreal (Western) Toad (<u>Bufo boreas boreas</u>) | ? | 8.2 | NPS*, GB |
| Eastern Short-horned Lizard (<u>Phrynosoma douglassi brevirostre</u>) | U | 3.0, 4.1, 4.4, 5.0 | OBS, NPS, PC |
| Northern Sagebrush Lizard (<u>Sceloporus graciosus graciosus</u>) | C | 3.0, 4.0, 5.0, 8.0, 13.2-.4, 13.6 | OBS, NPS, PC |
| Bullsnake (<u>Pituophis melanoleucas savi</u>) | C | 2.3-.4, 3.0, 4.0, 5.0 7.1-.2, 8.0, 13.3 | OBS, NPS, PC |
| Yellow-bellied Racer (<u>Coluber constrictor</u>) | C | 7.1, 8.1, 13.6 | OBS, NPS, PC |
| Pale Milk Snake (<u>Lampropeltis triangulum multistrata</u>) | R | 2.3, 4.4, 5.3, 8.1 | OBS, WGFY, NPS, PC |
| Wandering Gartersnake (<u>Thamnophis elegans vagrans</u>) | C | 2.0, 6.3-.4, 6.7, 7.2, 8.0, 9.0, 10.0, 13.3-.5 | OBS, PC |
| Western Plains Gartersnake (<u>Thamnophis radix havdeni</u>) | ? | ? | NPS, GB |
| Red-sided Gartersnake (<u>Thamnophis sirtalis parietalis</u>) | ? | 8.1 (2.4)** | OBS*, GB |

| | | | |
|---------------------------------------------------------------------|---|------------------------------------------|-------------------|
| Prairie Rattlesnake (<u>Crotalus viridis viridis</u>) | C | 2.3, 3.0, 4.0, 5.0, 7.0, 8.0, 13.2-.4 | OBS, NPS WGFY, PC |
| Rubber Boa (<u>Charina bottae</u>) | | | GB |
| Western Painted Turtle (<u>Chrysemys picta belli</u>) | U | 12.3 | OBS, GB |
| Common Snapping Turtle (<u>Chelydra serpentina serpentina</u>) | ? | ? | GB |
| Spiny Softshell Turtle (<u>Trionyx spiniferus hartwegi</u>) | U | 9.0 | WGFY, GB |

*Identification uncertain

**Habitat nearest the road (see text)

¹Relative Abundance Code Definitions (Modified from Patterson et al. 1985)

A--Abundant: A species that inhabits much of the preferred habitat within its range; the species or its sign can be seen in numbers on any outing by a skilled observer during the proper season.

C--Common: A species that inhabits much of the preferred habitat within its range; the species or its sign can be seen more than once on an outing by a skilled observer during the proper season.

U--Uncommon: A species that is common only in small areas within its range or a species that is found throughout its range in relatively low densities; usually requires intensive searching to be seen by a skilled observer.

R--Rare: A species that occupies only a small percentage of the preferred habitat within its range or a species that is found throughout its range in extremely low densities; cannot always be found by a skilled observer even during intensive survey work.

?--Unknown: Insufficient information available for determination of relative abundance.

²Habitat Association Code Definitions--see Appendix 1.

³Documentation Code Definitions--

OBS--Species was observed during surveys.

NPS--National Park Service Wildlife Observation Card File

WGFY--Wyoming Game and Fish Department Yellowtail Wildlife Habitat Management Area Personnel

PC--Personnel communication by a reliable observer working in BCNRA.

GB--Guidebooks.

Appendix 8. General types of habitats in the Bighorn Canyon National Recreation Area percentages and number of hectares of each type (from Jones et al. 1985) number and species of amphibians and reptiles present in each, and hours and percentages of search time.

| Habitat Type | Habitat Area | | Amphibia | | Reptilia | | Search Time | |
|-------------------------------|--------------|------|----------|----------------------|----------|------------------------------|-------------|-------|
| | Hectares | % | Numbers | Species ¹ | Numbers | Species ¹ | (hr) | % |
| Coniferous Forest | 108.8 | 6.0 | 0 | | 0 | | 19.5 | 4.8 |
| Deciduous/Flood Plain Forest | 77.2 | 4.2 | 2 | At, Ptm | 2 | Tev, Pms | 31.5 | 7.7 |
| Floodplain Shrub (Salt Cedar) | 177.6 | 9.8 | 0 | | 0 | | 20.0 | 4.9 |
| Creek Woodland/Shrubland | 8.4 | 0.5 | 3 | At, Rp, Ptm | 6 | Tev, Cvv, Pms, Ltm, Tsp, Sgg | 68.5 | 16.3 |
| Juniper/Sagebrush/Grassland | 538.1 | 29.6 | 0 | | 3 | Cvv, Pms, Sgg | 29.0 | 7.1 |
| Juniper/Mountain Mahogany | 34.4 | 1.9 | 0 | | 4 | Cvv, Pms, Sgg, Tev | 16.5 | 4.0 |
| Mountain Mahogany | 154.7 | 8.5 | 0 | | 2 | Cvv, Sgg | | |
| Sagebrush | 332.1 | 18.2 | 1 | Sb | 5 | Cvv, Pms, Sgg, Tev, Pdb | 32.0 | 7.9 |
| Grasslands | 93.2 | 5.1 | 0 | | 6 | Cvv, Pms, Sgg, Pdb, Cc, Tev | 22.5 | 5.5 |
| Wetlands | 21.8 | 1.2 | 4 | At, Rp, Bww, Ptm | 5 | Cvv, Pms, Tev, Cpb, Tsp | 54.0 | 13.2 |
| Desert Scrub | 122.7 | 6.7 | 0 | | 3 | Cvv, Pms, Sgg | 62.0 | 15.2 |
| Rock/Unvegetated | 106.7 | 5.9 | 0 | | 5 | Cvv, Pms, Sgg, Cc, Tev | 41.5 | 10.2 |
| Unclassified/Miscellaneous | 44.1 | 2.4 | | | | | 4.1 | 1.0 |
| Total | 1820.8 | 100 | | | | | 408.0 | 100.0 |

¹Species Codes:

At - Ambystoma tigrinum

Bww - Bufo woodhousei woodhousei

Cc - Coluber constrictor

Cpb - Chrysemys picta belli

Ltm - Lampropeltis triangulum multistrata

Pdb - Phrynosoma douglassi brevirostre

Ptm - Pseudacris triseriata maculata

Sgg - Sceloporus graciosus graciosus

Cvv - Crotalus viridis viridis

Tev - Thamnophis elegans vagrans

Tsp - Thamnophis sirtalis parietalis

Appendix 9. Road transect data--Habitat types, with lengths¹ and total lengths², crossed by Highway 37 between Mile Marker 4 and Barry's Landing; snake species and number of each found, with estimates of relative density (Seber 1982) in each habitat type (number of snakes seen per kilometers of road driven). Total number of transects driven = 121.

| Habitat Type | H(km) ¹ | Hab-total ² | % ³ | C.v. viridis | | P.m. sayi | | T.e. vagrans | | Total | |
|--------------------------------------|--------------------|------------------------|----------------|--------------|---------|-----------|---------|--------------|---------|--------|---------|
| | | | | Number | Density | Number | Density | Number | Density | Number | Density |
| Saltbush Desert Shrub | 7.7 | 931.7 | 25.6 | 8 | 0.00859 | 2 | 0.00215 | 0 | 0 | 10 | 0.01073 |
| Big Sage Desert Shrub | 0.2 | 24.2 | 0.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Big Sage/Greasewood/ Desert Shrub | 0.6 | 72.6 | 2.1 | 1 | 0.01377 | 0 | 0 | 0 | 0 | 1 | 0.01377 |
| Greasewood | 3.1 | 375.1 | 10.3 | 4 | 0.01066 | 4 | 0.01066 | 1 | 0.00267 | 9 | 0.02399 |
| Marsh | 0.6 | 72.6 | 2.1 | 2 | 0.02755 | 2 | 0.02755 | 0 | 0 | 4 | 0.0551 |
| Juniper | 3.4 | 411.4 | 11.3 | 2 | 0.00486 | 0 | 0 | 1 | 0.00243 | 3 | 0.00729 |
| Juniper/Mountain Mahogany | 8.1 | 980.1 | 26.9 | 10 | 0.0102 | 4 | 0.00408 | 0 | 0 | 14 | 0.01428 |
| Mountain Mahogany | 1.4 | 169.4 | 4.7 | 2 | 0.01181 | 0 | 0 | 0 | 0 | 2 | 0.01181 |
| Prairie | 2.7 | 326.7 | 9.0 | 2 | 0.00612 | 0 | 0 | 0 | 0 | 2 | 0.00612 |
| Creek Woodland | 0.2 | 24.2 | 0.7 | 2 | 0.08264 | 1 | 0.04132 | 1 | 0.04132 | 4 | 0.16529 |
| Big Sage Shrubland | 2.1 | 254.1 | 7.0 | 3 | 0.01181 | 4 | 0.01574 | 1 | 0.00394 | 8 | 0.03148 |
| Totals | 30.1 | 3400.1 | 100 | 36 | | 17 | | 4 | | 56 | |

¹ Length of each habitat type crossed when driving one transect.

² Length of each habitat type crossed per transect multiplied by total number of transects driven.

³ Percentage of transect covered by each habitat type.

Appendix 10. Fish, amphibian, and reptile species captured, number of individuals, mean snout-vent length, total lengths (fish), mean cloacal temperature, mean substrate and air temperatures with ranges of values.

| Species | n | $\bar{SV}(\text{mm})$ | $\bar{T}_b(^{\circ}\text{C})$ | $\bar{T}_s(^{\circ}\text{C})$ | $\bar{T}_a(^{\circ}\text{C})$ |
|---------------------------|----|-----------------------|-------------------------------|-------------------------------|-------------------------------|
| Tiger Salamander | 1 | 64 | - | - | - |
| Leopard Frog | 3 | 72 | 25.6 21.0-32.2 | 24.7 20-32 | 27.3 24-33 |
| Woodhouse's Toad | 5 | 90 | 20.8 19.0-22.4 | 18.4 12-24 | 28.2 22-32 |
| Northern Sagebrush Lizard | 19 | 43.4 | 25.3 23.6-29.8 | 27.6 17-36 | 23.4 17-33 |
| Wandering Gartersnake | 21 | 39.3 | 22.3 22.2-24.2 | 22.5 16-35 | 24.7 20-30 |
| Bullsnake | 9 | 912 | 25.3 22.4-27.8 | 24.9 22-28 | 26.0 20-32 |
| Pale Milk Snake | 2 | 46.2 | - | - | - |
| Prairie Rattlesnake | 28 | 467 | - | 26.0 18-39 | 26.8 7-38 |

| | n | $\bar{SV}(\text{mm})$ | Total Length |
|-----------------|----|-----------------------|--------------|
| Brook Trout | 31 | 40.1 | 1244 |
| Flathead Chub | 5 | 119.2 | 596 |
| Longnose Dace | 4 | 59.8 | 239 |
| Longnose Sucker | 7 | 116.6 | 816 |

Appendix 11. List of specimens collected in Bighorn Canyon National Recreation Area that have been deposited in the University of Wyoming Zoology Museum, with cataloging numbers. Number in parentheses indicates number of specimens in a particular species.

| Species | U.W. Number |
|--------------------------------------------------------------|------------------|
| <u>Salvelinus fontinalis</u> (Mitchill) (31) | 1361, 1364, 1365 |
| <u>Hybopsis gracilis</u> (Richardson) (5) | 1368 |
| <u>Rhinichthys cataractae</u> Valenciennes) (4) | 1363, 1366 |
| <u>Catostomus catostomus</u> (Forster) (7) | 1362, 1367 |
| <u>Bufo woodhousei woodhousei</u> (Girard) (1) | 0599 |
| <u>Sceloporus graciosus graciosus</u> (Baird and Girard) (1) | 0598 |
| <u>Thamnophis elegans vagrans</u> (Baird and Girard) (2) | 0591, 0600 |
| <u>Pituophis melanoleucas sayi</u> (Schlegel) (3) | 0594, 0595, 0596 |
| <u>Lampropeltis triangulum multistrata</u> (Kennicott) (1) | 0592 |
| <u>Crotalus viridis viridis</u> (Rafinesque) (1) | 0597 |

