Department of the Interior
National Park Service
Yellowstone National Park

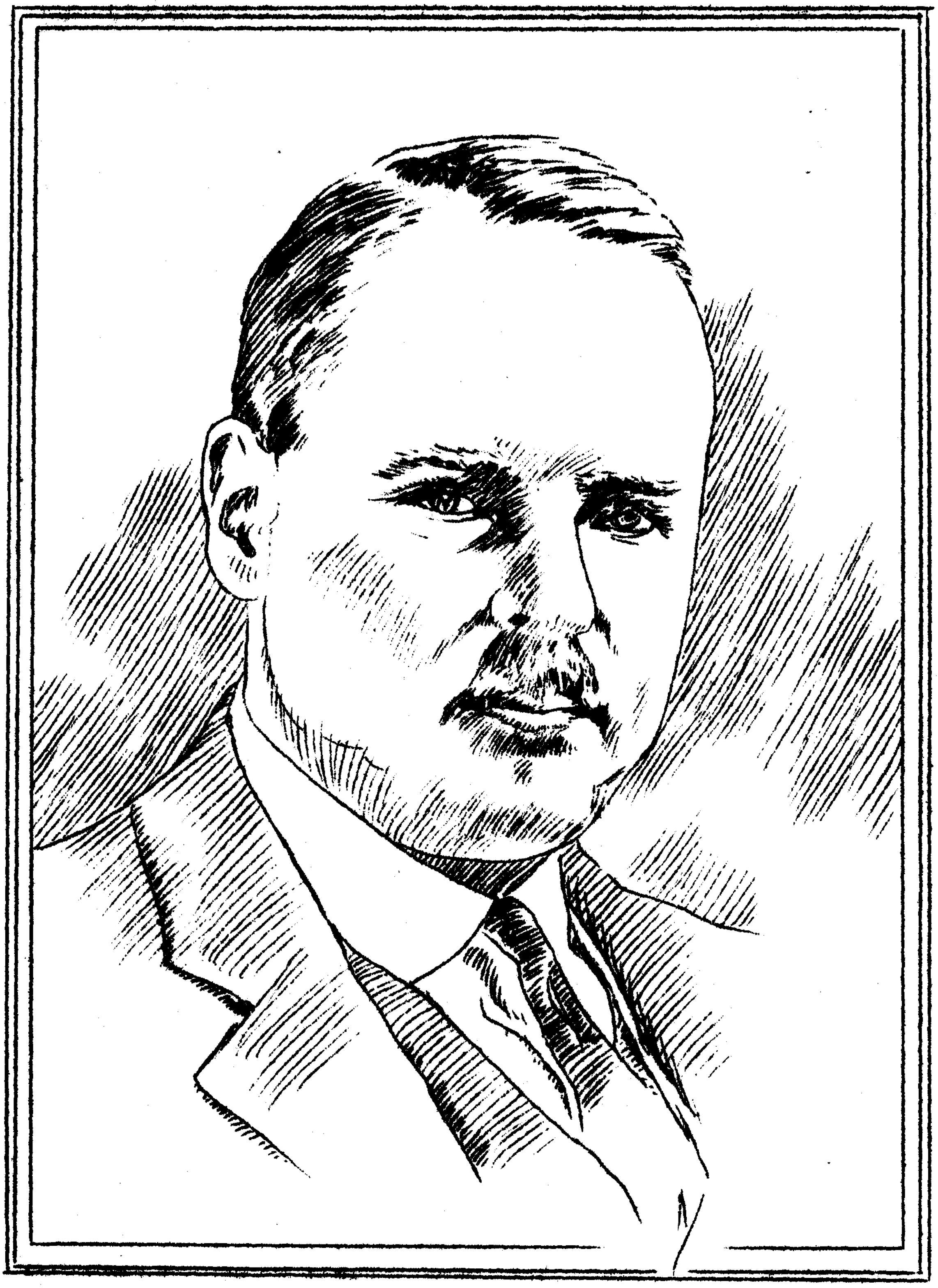
Yellowstone Park, Wyoming. June 1, 1928.

Volume II

RANGER NATURALISTS MANUAL
of
YELLOWSTONE NATIONAL PARK

Third Edition

This edition of the Ranger Naturalists Manual is dedicated to Mr. J. E. Haynes, Acting Director of the Yellowstone Park Museum, in appreciation of his achievements. It was Mr. Haynes who first suggested such a publication and whose active interest, suggestions and generosity have been an inspiration to all who have cooperated in the compiling of this book.



J. E. HAYNES

P R E F A C E

RANGER NATURALISTS MANUAL
o f
YELLOWSTONE NATIONAL PARK

This is a collection of articles pertaining to Yellowstone National Park written by various authorities especially for this Manual. The first edition (1926) was published in typewritten form, of which there were 12 copies. The second edition (1927), which is Volume I, numbered 125 copies, and was prepared at the St. Paul Office of the Haynes Picture Shops, Inc., entirely at their expense. The second edition contained all the material used in the first edition, but in a revised form, and in addition there were many other articles. This is the third edition, Volume II, and there are 125 copies. It was prepared at the Superintendent's Office in Yellowstone National Park. All illustrations are the work of former Park Naturalist Edmund J. Sawyer.

It is hoped that the material found in this volume, in addition to that contained in Volume I, will be of real value to those assigned to lecturing, guiding, information and museum duty, in avoiding conflicting statements and too much repetition; also in getting efficient service under way at the beginning of the season.

This compilation, like Volume I, is the result of a great amount of research and work of many of the staunch friends of the Yellowstone, including present and former members of the staff. Your cooperation is solicited in contributing one or more articles for the amplification of this collection, and in suggesting improvements, which will be greatly appreciated.

Horace M. Albright,
Superintendent.

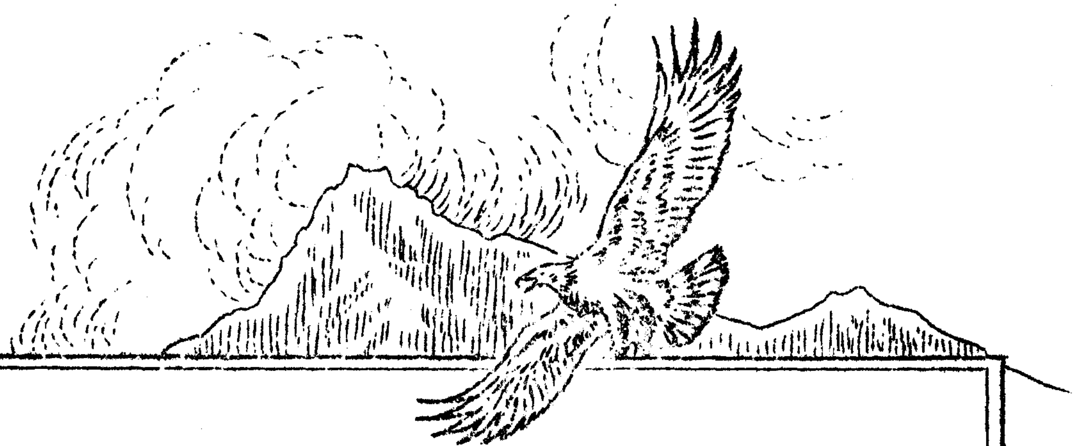


TABLE OF CONTENTS

QUESTIONS AND ANSWERS

"These questions and answers are the contribution of the 1927 Ranger Naturalist division and are intended to help inform rangers regarding answers to common or typical questions." - G. E. Marsh, Head Ranger Naturalist 1927.

They have been prepared by the persons mentioned in each case and then carefully checked by specialists. A great deal of credit is due, especially, to the higher authorities who have freely given of their time and knowledge that these lists might be nearer perfection in their accuracy.

These Questions and Answers are divided into six sections, as follows:

- - - - - - - - - -

SECTION I

History, Administration, Geography

Prepared by:
Gerald E. Marsh, Head Ranger Naturalist (1927)
Marguerite Lindsley, Park Ranger.

Approved by:
Horace M. Albright, Superintendent
J. E. Haynes, Acting Director, Yellowstone Park Museum.

Q. - What is the area of Yellowstone National Park
A. - It has an area of 3,348 square miles (2,142,720 acres).

Q. - What is the length and width?
A. - Approximately 62 miles north and south by 54 miles east and west.

Q. - What is the latitude and longitude?
A. - The latitude is 44.08 to 45.02 North; the longitude is 110 W. to 111. deg. 08 min.

Q. - What evidences are there of Indian life?
A. - Spear-heads and arrow-heads found in the park; mortar and pestle; teepees on Tower Falls road about 3 miles from Mammoth; also some in northwest corner of the Park; Obsidian chips near Obsidian Cliff; the Old Bannock Trail.

Q. - What evidences of prehistoric life?
A. - Fossil leaves; petrified forests; fossil insect galls in fossil leaves; trilobites found in the Gallatin Mountains; lignite in Mount Everts; marine fossils in Mount Everts; elk antler and buffalo skeleton found in travertine at Mammoth.

Q. - When and by whom was the park discovered?
A. - In 1807, by John Colter, an adventurer from the Lewis and Clark Expedition.

Q. - Who was James Bridger?
A. - An early trapper and guide whose stories of the park region were discredited by his listeners. He entered the park first probably about 1830.

Q. - What was the Raynolds expedition?
A. - An expedition led by Captain W. F. Raynolds of the Corps of Topographic Engineers of the U. S. Army, in 1859. They encircled the park but did not enter it.

Q. - What was the Cook-Folsom expedition?
A. - Party led by C. W. Cook and David E. Folsom of Helena, Montana; followed the Yellowstone up to the mouth of the Lamar on a prospecting tour, up the Lamar for a few miles, crossing over to the Yellowstone at the Great Falls; up the Yellowstone to the foot of the Lake and around the east side to the extremity of the west arm; thence crossing over to Shoshone Lake and Lower Geyser Basin on the Madison or Firehole, and finally left the country by following down the Madison River. (Haynes Guide).

Q. - Washburn-Langford-Doane expedition?
A. - A party under the leadership of General Henry D. Washburn, Surveyor General of Montana, which entered the Park in 1870 for the purpose of exploration. The most important expedition and the one which gave the impetus to the national park idea. Entered the park at Gardiner, followed Turkey Pen Trail to Tower Falls, then over Mount Washburn to Canyon; from Canyon to Lake by way of Hayden Valley; around the east side of the Lake following along the south arms to West Thumb; thence across the divide twice to the Upper Geyser Basin; down the Firehole and Madison Rivers; home by way of Virginia City.

Q. - How was the park created?
A. - By Act of Congress in 1872, signed by President U. S. Grant.

Q. - What has been the administrative history of the park?
A. - From 1872 to 1886 there were five civilian superintendents: Langford, Norris, Conger, Carpenter, and Wear, in order; from 1886 to 1916 Army officers were detailed as acting superintendents; from 1916 to 1919 C. A. Lindsley was acting superintendent; since 1919 H. M. Albright has been the superintendent.

Q. - What has been the administrative history of the ranger service?

A. - Scouts were first used in the park in connection with the regular Army service in 1916 but control of the park was not completely relinquished by the Army until the fall of 1918. The complete installation of the ranger service came when Mr. Albright took office on June 28, 1919. James McBrida was the first chief ranger. He was succeeded by Sam T. Woodring in 1922.

Q. - Who was Howard Eaton?

A. - He was a famous Western rancher, horseman and guide. He conducted more than one hundred horseback and camping parties through the park. For him the Howard Eaton Trail, 157 miles long and affording access to many points of scenic and historic interest, was named. He died in 1922. (Haynes Guide).

Q. - What are the principal mountain ranges in and around the park?

A. - The Absaroka Mountains extend the length of the park on the north, northeast, east and southeast. The Gallatin Mountains extend north and south near the western boundary of the park. To the south loom up the majestic Tetons outside of the present boundaries of the park, and inside in the south-central part are the Red Mountains.

Q. - What and where are the highest mountains?

A. - Electric Peak, 11,155 feet, ten miles northwest of Mammoth Hot Springs, is the highest; Humphreys Mountain, 11,000 feet, seven miles east of the southeast arm of Yellowstone Lake, is the second highest; Atkins Peak, 10,900 feet, near Mount Humphreys, is the third highest.

Q. - What is the elevation of the Grand Teton?

A. - 13,691 feet (Chittenden); 13,747 feet (Park Bulletin and U.S.G.S. map).

Q. - What is the meaning of the word "Absaroka"?

A. - The Indian name for the "Crow" tribe.

Q. - What is the lowest point of elevation in the park?

A. - 5313 feet, at the North Entrance.

Q. - What are the elevations of chief points of interest on the roads of the park?

A. -

Mammoth Hot Springs	6238 feet.
Norris Junction	7483 feet.
Madison Junction	6804 feet.
Western Entrance	6688 feet.
Old Faithful Geyser	7365 feet.
West Thumb Junction	7782 feet.
Southern Entrance	6882 feet.
Yellowstone Lake	7734 feet.
Lake Junction	7791 feet.
Eastern Entrance	6950 feet.
Canyon Junction	7733 feet.
Dunraven Pass	8859 feet.
Tower Fall	6597 feet.

Q. - What is the location and elevation of Mount S^h^eridan?
A. - Mount Sheridan, 10,250 feet, is directly west of Heart Lake.

Q. - What is the location and elevation of Mount Washburn?
A. - Mount Washburn, 10,346 feet high, is about midway on the road between Canyon and Tower Falls.

Q. - What is the location of National Park Mountain?
A. - National Park Mountain stands at the junction of the Gibbon and Firehole Rivers.

Q. - What is the location and elevation of Bunsen Peak?
A. - Bunsen Peak, 8600 feet high, named after the German scientist, stands seven miles south of the north entrance and about three miles south of Mammoth Hot Springs on the road to Norris.

Q. - What is the location and elevation of Mt. Everts?
A. - Mt. Everts, 7900 feet high, named after T. C. Everts, who was lost from the Washburn Party for 37 days, is just east of Mammoth.

Q. - What is the location and elevation of Sepulcher Mountain?
A. - Sepulcher Mountain, 9500 feet high, named for the grave-like formation seen from Gardiner, is directly west of Mammoth.

Q. - What is the location and elevation of Obsidian Cliff?
A. - Obsidian Cliff, 7832 feet high, named for the black volcanic glass of which it is composed, is 12 miles south of Mammoth on the road to Norris.

Q. - What and where is the Continental Divide?
A. - The Continental Divide is the dividing line between the water sheds of the Atlantic and Pacific. It is to be found on the western boundary of the park at approximately 44.30 North Latitude and proceeds southeasterly in a zig-zagging manner, going between Shoshone, Lewis, Heart and Yellowstone Lakes, and leaves the park at the south boundary at 110.13 West Longitude.

Q. - What are the four largest lakes in order of size?
A. - Yellowstone, Shoshone, Lewis and Heart. All are located in the south half of the park.

Q. - What is the outlet of each?
A. - The outlet of Yellowstone Lake is the Yellowstone River; of Shoshone Lake, the outlet into Lewis Lake is unnamed; of ~~Leiw~~ Lewis Lake, the Lewis River; of Heart Lake, the Heart River.

Q. - What are the general measurements of Yellowstone Lake?
A. - Elevation, 7734. Its shore line is 100 miles long; its area 139 square miles. Maximum depth is 300 feet.

Q. - What has been the history of the outlet of Yellowstone Lake?
A. - The former outlet of the Lake was through Snake River, the drainage being into the Columbia, thence to the Pacific. The new outlet was formed when Sulphur Creek undermined the north shore of the old lake, causing it to drain via the Yellowstone River into the Missouri, thence to the Atlantic. (See article "Piracy of the Yellowstone".)

Q. - What are the three principal rivers of the park?
A. - The Yellowstone, the Snake, and the Madison.

Q. - Into what does each empty?
A. - The Yellowstone empties into the Missouri near the Montana-North Dakota boundary on the North Dakota side; the Madison, the principal fork of the Missouri, joins the Gallatin and Jefferson at Three Forks, Montana, to form the Missouri; the Snake flows into the Columbia River in southeastern Washington.

Q. - What is the flowing direction and into what do the principal park streams empty?
A. -

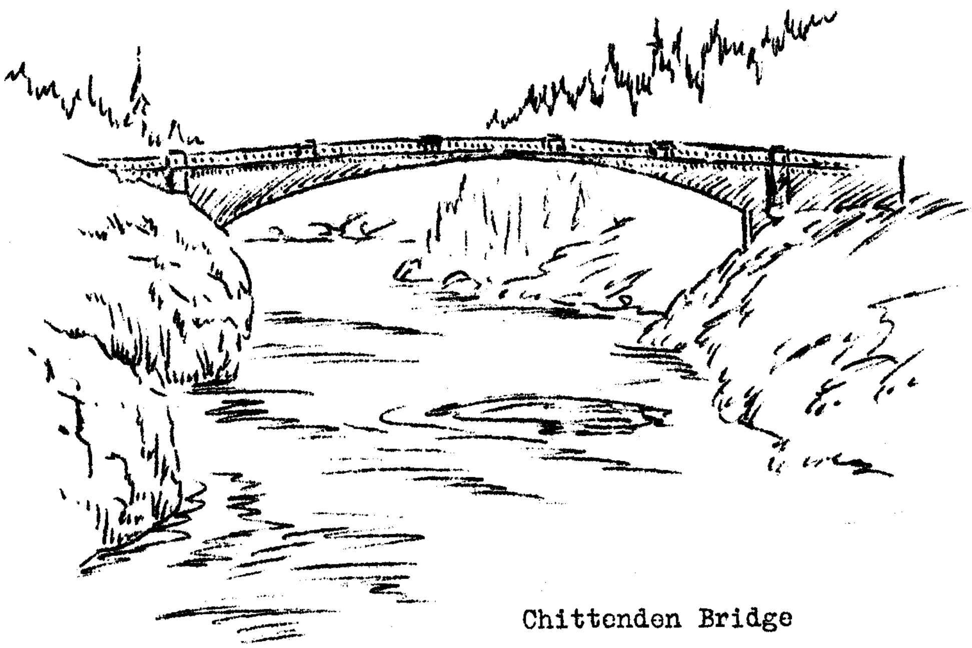
Bechler River	Southwest	into Falls River.
Shoshone River	Northeast	into Big Horn River.
Gibbon River	Southwest	joins Firehole to form Madison.
Firehole River	Northwest	joins Gibbon to form Madison.
Lamar River	Northwest	into Yellowstone River.
Lewis River	South	into Snake River.
Gardiner River	North	into Yellowstone River.
Middle Creek	East	into Shoshone River.
Lava Creek	North	into the Gardiner River.
Soda Butte Creek	Southwest	into Lamar River.
Slough Creek	Southwest	into Lamar River.
Glen Creek	South & northeast	into Gardiner River.
Lupine Creek	North	into Lava Creek.
Trout Creek	Northeast	into Yellowstone River.
Herron Creek	South	into DeLacy Creek.
DeLacy Creek	South	into Shoshone Lake.
Iron Creek	North	into Firehole River.
Little Firehole	Northeast	into Firehole River.
Nez Perce Creek	West	into Firehole River.
Pelican Creek	Southwest	into Yellowstone Lake.
Alum Creek	Northeast	into Yellowstone River.
Tower Creek	Northeast	into Yellowstone River.
Obsidian Creek	North	into Gardiner River.
Blacktail Deer Cr.	North	into Yellowstone River.
Geode Creek	North	into Yellowstone River.
Hellroaring Creek	South	into Yellowstone River.
Grayling Creek	West	into Madison River.
Mist Creek	Northeast	into Lamar River.
Falls River	Southwest	into Henry's Fork of Snake River.

Q. - Where does the Yellowstone River have its source?
A. - In the snowdrifts of Younts Peak, 25 miles southeast of the park.

Q. - What are the names of the principal islands in Yellowstone Lake?
A. - Stevenson, Frank, Dot, Molly, Peale, Carrington, Pelican Roost.

Q. - What is the location of the following features?
A. - Swan Lake Flat.......... $3\frac{1}{2}$ miles south of Mammoth.
Seven Mile Bridge....... 7 miles south of Mammoth.
Kingman Pass............ $3\frac{1}{2}$ miles south of Mammoth.
Willow Park............. $7\frac{1}{2}$ miles south of Mammoth.
Beaver Lake............. 12 miles south of Mammoth.
Twin Lakes.............. 16 miles south of Mammoth.
Solfatara Plateau....... midway on road between Norris and Canyon.
Wolf Lake............... 5 miles northwest of Canyon Junction.
Grebe Lake.............. 4 miles northwest of Canyon Junction.
Cascade Lake............ $2\frac{1}{2}$ miles northwest of Canyon Junction.
Virginia Meadows........ $4\frac{1}{2}$ miles east of Norris.
Virginia Cascades....... 4 miles east of Norris.
Elk Park................ 3 miles south of Norris.
Gibbon Meadows.......... 4 miles south of Norris.
Gibbon Falls............ 9 miles south of Norris.
Monument Geyser Basin... 3/4 mile west of road, 5 miles south of Norris.
Terrace Spring.......... 13 miles south of Norris.
Sentinal Creek.......... flows into Firehole at Fountain Ranger Station.
Twin Buttes............. approximately 3 miles west of old Fountain Hotel.
Goose Lakes............. 1 mile north of Excelsior Geyser.
Firehole Lake........... $1\frac{1}{2}$ miles southeast of Fountain Paint Pot.
Great Fountain Geyser....1 mile south of Firehole Lake.
Midway Geyser Basin..... $4\frac{1}{2}$ miles south of Fountain Ranger Station.
Biscuit Basin........... 8 miles south of Fountain Ranger Station.
Black Sand Basin........ 1 mile west of Upper Geyser Basin.
Mallard Lake............ 4 miles east of Upper Geyser Basin.
Lone Star Geyser........ 4 miles south of Upper Geyser Basin.
Craig Pass.............. $8\frac{1}{2}$ miles east of Upper Geyser Basin.
Norris Pass............. Just south of Craig Pass on road from Old Faithful to West Thumb.
"Corkscrew Hill"........ the road from Craig Pass to DeLacy Creek.
Duck Lake............... 1 mile west of West Thumb.
Fishing Cone............ on Lake shore at West Thumb.
Natural Bridge.......... 6 miles west of Lake Station on old road.
Bridge Bay.............. 4 miles south of Lake Hotel on Lake shore.
Squaw Lake or Indian Pond................... $2\frac{1}{2}$ miles east of Lake Junction.
Turbid Lake............. 7 miles east of Lake Junction.
Lake Eleanor............ $18\frac{1}{2}$ miles east of Lake Junction.
Hayden Valley........... $6\frac{1}{2}$ miles north of Lake Junction.

Northern Pacific Sign..... 8 miles north of Lake Junction in Trout Creek.
Chittenden Bridge......... 1 mile above the Upper Fall.
Canyon Bridge............. bridge across Canyon Creek.
"Yancey's"................ hay ranch 2½ miles northwest of Roosevelt Lodge.
Crescent Hill ("The Gut"). 4 miles northwest of Tower Junction.
Sheepeater Cliffs......... 4 miles southeast of Mammoth Hot Springs.
Wraith Falls.............. 6 miles southeast of Mammoth Hot Springs.
Undine Falls.............. 4½ and 5 miles southeast of Mammoth.
Buffalo Ranch............. 12 miles east of Tower Junction.
Mud Geyser................ 6 miles north of Lake Junction.
Dragons Mouth............. 6 miles north of Lake Junction.
Sulphur Mountain.......... 7 miles south of Canyon Junction.
Mary Lake................. center of the park.
Sportsman Lake............ 1 mile from north boundary - west of Electric Peak.
Gallatin Petrified Forest. on Specimen Creek, 1½ miles northeast of Gallatin.
Specimen Ridge............ 6 miles east of Tower Junction.
Sleeping Giant............ northeast of Yellowstone Lake.
Amethyst Mountain......... south end of Specimen Ridge.



Chittenden Bridge

SECTION II

Geology

Prepared by:
Edward A. Flottman, Ranger Naturalist.

Approved by:
Dr. Wm. C. Alden, U. S. Geological Survey.
Dr. L. M. Prindle, U. S. Geological Survey.
Dr. David White, U. S. Geological Survey.
J. E. Haynes, Acting Director, Yellowstone Park Museum.
Horace M. Albright, Superintendent.

Q. - What is the General Table of Geologic Time Divisions?

A. - Cenozoic	Quaternary	Recent
		Pleistocene or Glacial.
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
Mesozoic	Cretaceous	Upper Cretaceous
		Lower Cretaceous
	Jurassic	
	Triassic	
Paleozoic	Permian	
	Carboniferous	Coal Measures, or Pennsylvanian
		Subcarboniferous, or Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Great Unconformity.	
Proterozioc (Algonkian)	Keweenawan	
	Unconformity	
	Animikean (Upper Huronian of some Authors)	
	Middle Huronian	
	Unconformity	
	Lower Horonian	
	Archean Complex	Great Granitoid Series
		Great Schist Series

Q. - What evidence is there to indicate that the park was formerly covered by a sea?

A. - Fossils of marine life are found in many of the limestones and other sedimentary rocks exposed in and near the park. Near the close of the Cretaceous period the Rocky Mountains were largely blocked out by powerful dynamic movements which uplifted the ranges. Faulting and folding continued well into the middle of the Tertiary period.

Q. - What has been the volcanic activity in the present park area?

A. - "Throughout Tertiary time in the park area, geological history was characterized by great volcanic activity, enormous volumes of fragmental material were thrown out by explosive eruptions and poured out in molten condition in the Eocene and Middle Tertiary, continuing with less vigor through the Pliocene, and extending into Quaternary time.

"Within very recent times there is no evidence of any considerable outburst; indeed the region may be considered long since extinct. These volcanic rocks present a wide range in chemical and mineral composition and physical structure. They may be, however, classed under three great groups - ANDESITES with BASALTS, RHYOLITES, and BASALTS - following each other in the order named. In general the relative age of each group is clearly and sharply defined, the distribution and mode of occurrence of each presenting characteristics and salient features frequently marked by periods of erosion.

"Andesites are the only volcanic rocks which have played an important part in producing the present structural features of the mountains surrounding the park. As already mentioned, they occur in large masses in the Gallatin Range, while most of the culminating peaks in the Absarokas are composed of compact Andesites and Andesitic breccias. On the other hand, the Andesites are not confined to the mountains, but played an active role in filling up the interior basin. That the duration of the Andesitic eruptions was long continued is made evident by the plant remains found in ash and lava beds through 2,000 feet of volcanic material---Arnold Hague," "Geological History of the Yellowstone National Park" P. 6.

Q. - Where were the old volcanic craters located from which molten magmas flowed to give us the great beds of igneous rock?

A. - The so-called Sherman volcano: This volcano burst forth in early Tertiary times not far from the present junction of the Absaroka and Snowy ranges. The average height of the crater rim as represented by surrounding peaks is 9,000 feet above the sea level. Mt. Washburn is of eruptive origin but represents later volcanic activity (later than early Tertiary) which partially destroyed the old crater rim of the Sherman Volcano.

Andesites and basalts were first poured out by the then existing volcanoes. The Andesite period was followed by the Rhyolite period during which time thin sheets of basalt again appeared.

Rhyolite poured out over the great Central Plateau from two main sources namely, the Sherman volcano and what is now Mt. Sheridan. Mt. Washburn came into being during this period of volcanic activity. Rhyolites covered the Andesites to an average depth of 2,000 feet almost completely hiding them. The average elevation of the plateau section was increased from 6000 - 6500 to 8000 - 8500 feet.

Throughout the whole time of volcanic activity there were two or more active craters in the Absaroka range and one in the Gallatin Range, but these affected very little the Central Plateau known to present day visitors.

"A tourist visiting all the prominent geyser basins, hot springs, Yellowstone Lake, and the Grand Canyon and Falls of the Yellowstone, is not likely to come upon any other rock than Rhyolite, excepting of course, deposits from hot springs, unless he ascends Mt. Washburn. A description of the Rhyolite region is essentially one of the Central Plateau. Taking the bottom of the basin at 6500 above sea level, these acidic lavas were piled up until the accumulated mass measured 2,000 feet in thickness. It completely encircled the Gallatin range, burying its lower slopes on both the east and west sides; it banked up all along the west flanks of the Absarokas, and buried the outlying spurs of the Teton and the Wind River Plateaus." ----Arnold Hague. "Geological History of the Yellowstone National Park" P. 7.

Q.- Where does basalt occur (in the park)?
A.- It is found in thin sheets overlying the Rhyolite deposits or in some instances as dikes cutting the more acidic rocks. It can be seen in columnar palisade form along the Yellowstone valley, along the western foothills of the Gallatin Range and Madison Plateau and south of the Falls River Basin. The columnar palisades near Tower Falls in the Yellowstone gorge at and opposite the cliff which overhangs the road and at Osprey Falls in the Gardiner Canyon are of basalt.

Q. - What is the story of the glacial period?
A. - "After the greater part of the basalt had been poured out came the glacial ice, which widened and deepened the pre-existing drainage channels, cut profound gorges through the Rhyolite lavas and modeled the two volcanoes into their present form. ----------.

"Over the Absaroka Range glaciers were forced down into the Lamar and Yellowstone valleys, thence westward over the top of Mount Everts to the Mammoth Hot Springs Basin. On the opposite side of the park the ice from the summit of the Gallatin Range moved eastward across the Swan Lake Valley and passing over the top of Terrace Mountain joined the ice field coming from the east. The united ice sheet plowed its way northward down the valley of the Gardiner to the Lower Yellowstone where the broad valley may be seen strewn with the material transported from both the east and west rims of the park." ----Arnold Hague, P. 10.

Hot Springs and Geysers:

Q. - What are the differences between Hot Springs and Geysers?
A. - (a) - Source of Heat:
In the case of the hot spring the heat may be that generated by the folding and faulting of rocks. In a very few instances it may be due to the smothered combustion of coals, or pyrites (sulphides). Scientific men give no support to the idea that the heat may be due to chemical action. Many tourists get the idea that the heat in the Mammoth Hot Springs comes from the action of water on underlying beds of quicklime. This erroneous idea is acquired naturally when one observes the great beds of calcium carbonate being deposited by the hot waters.

The source of heat for a hot spring may also be that given off by the slowly cooling intrusive lavas or lower layers of extrusive lavas in a region of comparatively recent (geologically) volcanic activity. Observations prove this to be the only source of heat for geysers. Contact with the hot lava itself, or, as is believed to be more generally the case with hot gases arising from the lavas raises the temperature to a fairly high degree. Boiling temperature must be reached before an eruption can take place, and because the water underground is under pressure either from the rock above or the column of water above the temperature at which the water will flash into steam is far above boiling points under atmospheric pressures. Only volcanic areas supply enough heat for the superheated steam essential to geyser action. The heating of the water may take place before it enters the geyser tube, or after, or both before and after. If the water is changed into steam as rapidly as it enters the tube there would be, not a geyser, but only a steam vent. (Example: Dragons Mouth Spring).

(b) - Subterranean Passages.
There are no outstanding essential differences between the ideal cross sections of cold springs and of thermal springs. The former are lacking merely in a source of heat.

To have geyser action convection currents of water in the tube must be impeded. If not impeded there can be only a boiling spring. The tube may be so long or deep that the weight of water above may itself offer resistance to thorough convection. But without a doubt, in most geysers the necessary resistance is offered by the walls of a "bent" or curved tube, and by strictures due to unequal deposition on the tube walls.

Geyser action can endure but an exceedingly short period of years, if at all, where the tube extends upward through layers of highly soluble and poorly resistant rock such as limestone. The force of an eruption itself would tear away the weak rock. But where the waters rise through siliceous rock, the tube may have strong enough walls to withstand the force necessary to throw upward hundreds of tons of water. The tube walls may be of hydrated silica deposited on less resistant rock by rising hot waters.

Q. - What is the Bunsen Theory of Geyser Activity.
A. - "Three things are essential to the existence of a natural geyser; a constant supply of water, a continuous source of heat, and a long narrow or twisted tube extending toward the heat source.

"It is a well known fact that the boiling point of water rises with the pressure and because of the weight of the water above is higher at the bottom of a tube than at the surface. The temperature of water heated in any vessel is generally equalized by connection currents, but in a long narrow or irregular tube this circulation is impeded and while the tube water at the surface boils at the temperature allowed at the existing atmospheric pressure, ebullition in the lower part of the tube is possible only at a much higher temperature, owing to the weight of the water column above it. When the lower levels of water are heated to boiling by gases and vapors arising from the uncooled lavas below, the superincumbent column of water is lifted, causing a slight overflow at the surface, which, because it shortens the column, decreases the pressure thus lowering the boiling point. Logically the superheated water at the base of the column flashes into steam, lifting the water above with great force into the real eruption of a geyser.

"Cool or previously heated water flowing into the tube through many fissures in its sides gradually refills the tube and the process is repeated."----Copy from geyser model.

Q. - Where in the park may an actual cross section of a geyser be found?
A. - In the Firehole Canyon on the east wall of National Park Mountain.

Q. - What is the sequence of events in the life history of a geyser?
A. - There are variations, but the following sequence often takes place:
"(1) The hot vapors rising from unknown depths penetrate the rocks along planes of fracture and shrinkage cracks, decomposing and softening the rock until the pressure of the steam and water is sufficient to force an opening to the surface.-------
"(2) The flowing waters slowly clear out the fissure forming a tube that permits the free escape of hot water and steam, while at the same time the waters change from a thick mud to a more or less clear fluid.
"(3) The spring, at first a simple boiling mudhole, is now an intermittently boiling spring, which soon develops true geyser action.----------------
"(4) The bare rock about the vent or fissure is soon whitened by silica deposited by the hot waters. This sinter may form a mound about the expanded tube or basin, or if the vent shall be small and spray is frequently ejected, it builds up the curious geyser cones so prominent in the Yellowstone.-------"
---Walter Harvey Weed, in "Geysers of the Yellowstone National Park. P. 27.

Q. - What is the difference in the character of the deposits at Mammoth Hot Springs and in the geyser basins?

A. - At Mammoth Hot Springs deposits are 95 to 99 percent calcium carbonate. There is but a trace of silica. "On the plateau, the deposits consist for the most part of siliceous sinter, locally termed geyserite. The reason for the difference is this: At the Mammoth Hot Springs the steam, although ascending from fissures in the igneous rock, comes in contact with the waters found in the Mesozoic strata which here form the surface rocks. The Jurasic and Cretaceous limestones have furnished the lime held in solution and precipitated on the surface as travertine. On the other hand, the mineral constituents of the plateau waters are derived almost exclusively from the highly acidic lavas, which carry but a small amount of lime."------ Arnold Hague. pp. 14 and 15.

Q. - What is the material found inthe Fountain Paint Pot?

A. - Hot clay and other minerals, in a state of ebullition, colored mostly by oxides of iron which impart a variety of colors.---- See Chittenden, p. 192.

Q. - Explain how the hot spring and geyser waters can hold so much mineral matter in solution.

A. - The capacity for dissolving and holding mineral matter in solution is increased:
(1) When water is under increased pressures.
(2) When it contains gases, particularly acid forming gases such as CO_2, in solution.
(3) When its temperatures are increased.
All of these conditions obtain in these waters.

Q. - What factors contribute to the deposition of mineral matter?

A. - When the rising waters reach the surface and the atmosphere their capacity for holding minerals in solution is decreased.
(1) By the consequent lowering of temperature.
(2) By release of pressure and rapid evaporation.
(3) By removal of the CO_2 gas from the water by the algae and by its escape due to heat and release of pressure.
(4) In the winter the freezing of the waters caught in cups and basins or of the slowly flowing water precipitates out great quantities of mineral matter.----Reference: J. E. Haynes, "Thermal Deposition in Yellowstone National Park. 1927 Ranger Naturalists Manual, pp. 57 - 58.

Q. - What other minerals are brought to the surface in solution by thermal waters?

A. - Arsenic sulphide or realgar ($As_2 S_2$) and arsenic sulphite, or orpiment, ($As_2 S_3$) especially in Norris Basin; scorodite or arsenate of iron in Upper Basin; and iron pyrite (disulphide of iron, FeS_2) in all the geyser basins. Oxides of iron and other minerals often give yellow and pink tints to the geyserite. Highly soluble salts such as the carbonates (other than $CaCo_3$) sulphates and chlorides are carried off by the waters. Analyses fail to show traces of copper, silver, tin, or other metals.

From 95 to 99 per cent of the mineral matter in solution at Mammoth Hot Springs is $CaCo_3$. In the geyser basins from one fifth to one third of the mineral matter in solution is silica.

Q. - What is the rate of deposition of travertine or calc-sinter?
A. - The average rate is 1/16 of an inch every three or four days at Mammoth, under favorable conditions. Widely variable.

Q. - Rate of deposition of siliceous sinter or geyserite?
A. - The average rate is less than 1/32 of an inch each year. The most rapid observed rate is about $1\frac{1}{2}$ inches a year. This is also widely variable.

At the rate of one-thirtieth of an inch a year it would take 25,000 years for the deposit around Castle geyser to reach its present development. But geologists believe that deposition has been going on for a much longer period of time.----
Reference:
"Thermal Deposition in Yellowstone National Park", by J. E. Haynes, in the 1927 Ranger Naturalists Manual. p. 57.

Q. - What are evidences of the antiquity of the hot springs and geyser deposits?
A. - (1) Terrace Mountain at Mammoth is made up of travertine deposits, the oldest in the park. "Lying upon the surface of this travertine on the top of the mountain are found glacial boulders brought from the summit of the Gallatin Range, 15 miles away, and transported on the ice sheet across Swan Lake Valley and deposited on the top of the mountain, 700 feet above the intervening valley. It offers the strongest possible evidence that the travertine is older than the glacier which has strewn the country with transported material. How much travertine was eroded by the ice is, of course, impossible to say, but so friable a material would yield readily to glacial movement."----Arnold Hague, p. 13.

Diggings at Mammoth prove that layers of travertine extend under Capitol Hill.

(2) A second method is to determine the rate of deposition of the accumulated sinter and measure its thickness. The following objections can be offered to this method:
(a) No uniform rate of deposition can be found for even a single basin.
(b) The accumulation of sinter may have been either more or less rapid in the past.
(c) Deposits may have been eroded away before the present travertine and geyserite was laid down. Undoubtedly the glaciers would easily erode and carry away the friable and soft travertine at Mammoth.

Q. - How old are the Mammoth Hot Springs?
A. - They may date back to sometime in the Tertiary period. That they were active before the last stage of glaciation is evident since glacial detritus rests upon travertine deposits of Terrace

Mountain and in the Gardiner Valley. If they were active before the first stage of glaciation their origin probably dates back one million years or more.

Q. - How old is Old Faithful?
A. - There is no known way of determining just how long any particular one of the geysers has been active. It is quite possible that geyser action originated as long ago as did Mammoth Hot Springs. It would be very interesting to know what happened to the geysers, if such they were, at times when glacial ice overran the park plateau. It seems possible that the inflow of large quantities of ice water may have materially modified the conditions of geyser eruption, if indeed the ice sheets did not entirely overwhelm the geysers and reduce the outflow to that of hot, or merely warm, springs issuing at the base of the ice.

Q. - What are the ranges of temperature in the hot springs and geysers? Where is the hottest spring located?
A. - See: "Table of Surface Temperatures of Hot Springs and Fumaroles" by Dr. A. L. Day and Dr. E. T. Allen - pp. 68-69 of the <u>1927 Ranger Naturalists Manual</u>.

Q. - What are fumaroles and solfataras?
A. - Fumaroles are holes and vents from which fumes and gases issue. Usually found in all volcanic regions.
Solfataras are vents yielding only sulphur vapors, steam and the like.

Q. - What is the approximate number of paintpots, hot springs and geysers in the park.
A. - Over 3,000. If the fumaroles and solfataras be added the total would approximate 6,000.

Q. - What is the approximate number of geysers and prominent springs?
A. - Between 100 and 200 active geysers or more than in all of the rest of the world together. There are about 690 hot springs and geysers in the Lower Geyser Basin and about 400 in the Upper Basin.
Solfatara Plateau is an extinct geyser basin.

Q. - Where else in the world do geysers occur?
A. - Iceland and New Zealand.

Q. - Where Hot Springs?
A. - On every continent and in a considerable number of countries.

Q. - Has the amount of water from the hot springs and geysers changed considerably during the last fifty years.
A. - No. When one spring dies out, the volume of another is usually increased or a new one is formed. There are increases and decreases from season to season due to variations in precipitation.
"From a geological point of view there is abundant evidence that thermal energy is gradually becoming extinct. Tourists

revisiting the park after an absence of two or three years occasionally allude to the springs and geysers as being less active than formerly and as showing indications of rapidly dying out. It is true that slight changes are constantly taking place, that certain springs become extinct or discharge less water, but this action is fully counterbalanced by increased activity in other localities. Close examination of the source of thermal waters fails to detect any dimunition in the source of supply. Moreover, it stands to reason that if the flow of these waters dated - geologically speaking - far back into the past, the few years embraced within the historical records of the park would be unable to indicate any perceptible change based upon a gradual diminution of heat."----Arnold Hague, pp. 18-19.

Q. - What are algae?
A. - Algae comprise a class of cellular cryptogamic (flowerless) plants, or those never having true stamens and pistils, but propagated by spores or single cell divisions. Plants which include the brown, red and green sea weeds, also fresh water types such e.g. as the common green or blue-green algae of stagnant ponds.

Q. - To what extent is the coloring on the terraces and about the hot springs due to algae?
A. - Where travertine and sinter are being deposited the coloring is almost wholly due to algae, the color shades varying with the temperature.------(See Hague, p. 181). Free sulphur gives some yellowish tints. The black of old terraces is due partly to algae that have been reduced to carbon or to the growth of black lichens, and partly to dried algae and dirt.
Various colors in the geyserite of the Basins and in the Fountain Paint Pot are due to compounds of metals. See questions 11 and 15. Read "Yellowstone Park Algae", by Marguerite Lindsley, p. 96, of 1927 Ranger Naturalists Manual.

Q. - What causes the colors on the walls of the Grand Canyon of the Yellowstone?
A. - When the rhyolite was broken down by the action of steam and hot water as well as by erosion various oxides of metals and other compounds were formed. These impart their colors to the Canyon walls. Ocher and Kaolin are very prominent in the Canyon.

Q. - What is a Moraine?
A. - Debris that has been carried by a glacier and deposited in more or less irregular, hummocky patches, ridges or belts, constitute land forms called moraines. These are generally strewn with boulders and are often pitted by saucer-like basins or kettleholes, some of which may contain ponds of water.
A lateral moraine is formed by the accumulation of debris in a belt or ridge along the side of a glacier.

A terminal moraine is formed by the accumulations at the end of a glacier.
A medial moraine is an accumulation some distance from the margins usually between two close flows or lobes of the glacier. Such a moraine is recognized in the low long narrow ridge on the Ranger Nature Trail near the beaver ponds just below Sepulcher Mountain.
Capitol Hill and other similar knolls about Mammoth Hot Springs make up part of a terminal moraine. Since Mammoth lies at the meeting point of the ice flows from the east and from the west before the united flow started north in all probability these knolls may be members of the two terminal moraines.

Q. - How can one determine the direction in which an ice sheet moved?

A. - The boulders and smaller rocks carried by the glaciers scratch and gouge the rock over which they pass leaving in places marks called striae or striations. The orientation of the scratches on fixed rocks indicate the directions of movement. Generally the stoss edges, i.e., edges of the rock against which the ice advanced, are more smoothly worn off and rounded than the opposite edges. In some cases, as on the ledge exposed beside the road on the slope north of Mt. Washburn, the softer parts of the rock have been worn away, leaving harder lumps or nodules projecting. Tailing out in the lee of each harder projection is a small half-cone or tapering ridge of softer rock pointing in the direction in which the ice moved.

Q. - How can one determine whether or not a valley has been affected by glacial erosion?

A. - A glaciated valley presents a smooth scoured-out appearance. The ice through the aid of tools carried in the form of debris wore off all the outstanding sharp edges and points and carried away much of the loose debris. A glaciated valley may also contain morainal deposits and many pebbles, boulders and bed rock ledges are likely to show glacial striae.
The canyons and broader valleys of the park owe must of their depths to stream erosion. Most of these, excepting the Grand Canyon, were subsequently scoured out, widened, and somewhat deepened by repeated glacial action.

Q. - Was the glacial age final in giving us our present park physiographic features?

A. - That part of the Yellowstone Canyon immediately below the mouth of Tower Creek is due to post-glacial stream erosion and the Grand Canyon is partly, if not mostly, due to post-glacial stream erosion. Whatever modification of the Grand Canyon resulted from glacial action has been obscured by subsequent weathering and erosion. The inner gorges of Gibbon and Firehole rivers have been cut by post-glacial stream erosion. The main valleys of these streams and the canyon of Madison River, within the park, have been glaciated. Much of the smoothly rounded form of the hills is probably also due to glaciation.

Q. - What, in general, are the facts regarding the formation of the Grand Conyon?

A. - It has been cut through rhyolite of the Central Plateau by the river. The rock of the Grand Canyon section was, perhaps, originally no less resistant than that elsewhere, but superheated steam and alkaline waters were much more active in the Canyon section, undermining and decomposing the acidic lavas. The waters of the Yellowstone readily cut into this decomposed lava and carried the loose materials away, leaving the canyon as we know it today. The full history of this part of the Yellowstone is probably rather complicated.

Q. - How did Yellowstone Lake change its outlet from the Pacific to the Atlantic slope?

A. - The Yellowstone Lake was at one time 160 feet deeper than it is at present. The old shore line is in evidence in many places on the surrounding slopes. Geologists are agreed that one old drainage channel was via the South Arm, through Chicken Ridge between Channel and Overlook Mountains and down the Canyon of Outlet Creek to Heart and Snake Rivers. The Continental Divide then extended over Mt. Washburn and around the Lake to the east.

The "piracy" of the Yellowstone is attributed to Sulphur Creek. One can readily see that the Grand Canyon above the junction of the Yellowstone River and Broad Creek is younger than the Canyon on to the north. Throughout this five mile stretch it has the characteristic V-shape of very youthful valleys. Northward from the junction and also throughout Broad Creek the Canyon shows more rounded shoulders and a little broader stream bed, this indicating greater age geologically than the first five miles below the Falls.

Both the Upper and Lower Falls are due to the fact that there extends across the bed of the river at these points walls of firm undecomposed rhyolite. The wall at the Lower Falls is about 100 feet wide and at the Upper Falls it is much wider. The drop in water at the Upper Falls is dependent on the rate of cutting at the Lower Falls. As the Lower Falls decrease in height the Upper Falls increase. The lowering of the level of the rhyolite barrier at the Upper Falls determined the lowering of the Hayden lake level. The present Yellowstone Lake level is awaiting the lowering of a similar barrier in the form of a ridge of firm rhyolite in the bottom of the Thistle Creek narrows.

Q. - What are the terraces in Hayden Valley?

A. - These are wave cut terraces such as have been cut or are being carved out along the shore of any existing lake or inland sea. Trace out the contour at 160 feet above the present lake level and one will find that the old lakes are extended southward in the Yellowstone river valley for 16 miles and northward into the Hayden Valley where waters covered all but the Crater Hills. This northern extension reached beyond the present falls of the Yellowstone to what is now Inspiration Point. The whole was really a twin lake being pinched to a narrow width near the present Thistle Creek.

Q. - What are the Hoodoos?
A. - They are made up of large blocks of travertine that broke from the edge of the cap of Terrace Mountain. The travertine may have been undermined by glacial action and by waters to such an extent that it broke into huge blocks and slid down to the present positions.

Fossil Forests:

Q. - Where in the park do fossil forests occur?
A. - Fossil trees are widely scattered over the east slope of Specimen Ridge for the first twenty miles along the junction of the Lamar and Yellowstone Rivers.
The petrified trees most generally seen by tourists are three to four miles northwest of Tower Falls. Others are found in the eastern part of the park along the Lamar River on Cache, Calfee and Miller Creeks, and in the northwestern part of the park along Specimen Creek. (The last mentioned forest is largely outside of the park).
Fossil trees are scattered widely over some 35,000 acres in Park and Gallatin Counties, Montana on the Gallatin Range just outside the park.

Q. - How many different species of trees are represented in the fossil forests?
A. - Ten. While only three of the ten are coniferous and the rest are deciduous, fully 95 per cent of the trunks are of the former. The Sequoia magnifica (Magnificent redwood) is the most common. Among the deciduous leafed trees there are laurels, chestnuts, bays, sycamores, buckthorns and oaks.
In all 150 different species of fossil plants have been found in the park, 80 of which are in the fossil forest beds. Most of the species are unknown among the plants living today.

Q. - How do trees become fossilized?
A. - Genuine fossilization, by which we mean the petrification of trees and other vegetable debris is brought about by processes well illustrated in the Yellowstone National Park. Trees are killed by the waters of hot springs or by lava flows or falls of volcanic ash, and the silica carried in solution by water issuing from or through the lava permeates the plant tissues by the ordinary processes of capillarity. Gradually, sometimes with surprising rapidity, the silica replaces the ligneous matter forming the wood cells particle by particle and is eventually deposited also in the cell cavities and the intercellular spaces, so that petrification is complete. In this way we have often extraordinarily complete preservation of every microscopical detail of the cell structure. Ordinarily, however, a certain amount of decay takes place, so that portions of the tree break down or rot before the replacement is complete. In the latter case, the products of decomposition, embracing so-called "ulmic" or "humic" acids, stain the tissues more or less completely with brownish tints.

The process of silicification may now be seen in some of the hot springs, such as those in the upper basins of the park, in which silica is deposited. However, the most complete petrification by means of silica impregnation takes place when the vegetation is enveloped with volcanic ash and mud, the hot waters or even the cold solutions from which when fresh appear to have great efficiency in permeating and petrifying the plant tissues. Usually the falls of volcanic ash and the flows of volcanic mud are not very thick and the trees killed beneath the smothering cover, rot down to or even somewhat below the surface of the ash deposits when there is little or no heat. When, however, several volcanic explosions cause the laying down of several blankets of ash and mud before the tree has rotted down too far, the petrified stumps may have considerable height. In all these cases, burial by volcanic ashes or muds exercised the further important function of covering the vegetable debris and preventing the access of atmospheric oxygen which is essential to the more complete decay of the organic tissues. Sometimes portions of a tree are carbonized, or even turned to charcoal, and preserved in the carbonized state.

The term "fossil" is applied not only to petrifactions through replacement by silica or lime or iron, but to the molds or impressions left by leaves, seeds, branches, logs, and even flowers in muds or other sediments when conditions have not been favorable for petrifaction and decay has advanced to the point of the actual decomposition of the greater part or all of the vegetable tissues (organic matter), so that only the imprint or mold is left where the leaf or stem was laid down or buried. In most cases, however, where the vegetable debris was rapidly and deeply covered or where the covering was impervious to the air, so that very little oxygen was available, for the use of the bacteria and other agents of decay, more or less of the organic matter escapes decomposition and is preserved in the form of brownish or dark carbonaceous residues, usually shrunken to smaller volume than the original plant. Therefore, we may have carbonized residues of the stems and even the nerves or the epidermis of plants lining the impressions or partly filling the molds. Not infrequently such carbonized portions of stems are shown by means of special treatment to contain vestiges of cell structure visible under the microscope. Such fossils, embracing mere impressions or incompletely carbonized residues of the original plant substance, are obviously very distinct from petrifactions. Many of the fossil leaves, petioles, seeds, and even twigs, found in the ash beds and other sediments of Yellowstone Park belong to the impression or mold type of "fossils".

Q. - What is the story of the fossil forests now exposed on Specimen Ridge?

A. - On the east slope of Specimen Ridge bordering Lamar River Valley are exposed in cross-section at least nine (some think twelve) fossil forests one above the other, the total being

2,000 feet in thickness. The species of trees found in that section, which are the same as those found in the gold-bearing gravels of California, show that the forests grew there during the Miocene epoch of the Tertiary period.

The lowest of forests was entombed by the earliest volcanic eruption to cover that locality. Most of the trees were buried beneath showers of volcanic ash, rock fragments and mud flows and were left standing, comparatively a few of them being prostrated. The weight of ashes, etc., however, stripped the main trunks of limbs and branches. The heat was not intense enough to burn the trees although it killed them and probably reduced them to mere stumps. Following this, the ordinary processes of aqueous solution set in with the water seeping through the newly formed igneous rock to the trees and there replacing the organic matter with silica.

On the surface of the volcanic debris the processes, both physical and chemical, of soil forming took place. A new forest encroached upon the barren area by the slow method trees have of advancing their domain by the cones and seeds being carried only a short distance beyond the frontier each year. A new forest then covered the area and reached comparatively full growth and maturity only to be buried by renewed volcanic eruption and fossilized as was the preceding vegetation. Again a new soil formed and another forest came into being. The cycle of events was repeated until at least nine forests (if not twelve) had become fossilized.

The customary processes of erosion have, since the last Miocene eruption, cut and gouged out deep valleys and canyons, one being the valley of the Lamar River. The enclosing rock, being somewhat less resistant, has been eroded from around many trunks leaving them exposed to view.

Q. - How old are the Fossil Forests?

A. - From a geological standpoint they are relatively young, since the Miocene epoch was very late in geologic time, but one is safe in saying that they are at least three or four million years old.

Q. - How much time is represented in the twelve layers of lava and forests?

A. - "A study of the fossil trees themselves gives at least a rough approximation as to the length of time it may have taken to accumulate the beds in which they are now buried. As already mentioned, there is a succession of forests one above another, through a thickness of 2,000 feet of strata the unit of the measure of the time is the time taken by each forest to grow. Pine trees of the type represented in the fossil trunks require 200 or 300 years to reach maturity and redwoods may require from 500 to 1,000 years. Twelve or more of these forests have been found. By multiplying thisnumber by the minimum age of the trees (200 years) we shall have 2,400 years and by multiplying by the maximum age of the redwood (1,000 years) we shall have 12,000 years as the possible time during which these forests flourished. It is possible that the truth lies somewhere between these extremes".--- F. H. Knowlton in "The Fossil Forests of the Yellowstone National Park, pp. 27-28.

Q. - How can one explain fossilized oaks, laurels, chestnuts, etc. at this altitude?

A. - Undoubtedly there existed a different climate at the times of vegetable growth and volcanic activity than now. This warmer climate may have been due to one or more of a number of factors, but one can best believe that there has been an uplift since the periods of growth and petrification - that is, the altitude was lower when the trees grew.
One may well point out here that there are variations in kinds of plants from forest layer to forest layer showing changes in climatic and soil conditions for the successive periods of growth.

Q. - How is barometric pressure affected by altitude?

A. - Barometric pressure is normally 14.7 lbs. (76 cms. or 30 inches of mercury) at sea level. The total column of air above decreases with elevation and density also decreases with elevation, thus giving lower barometric readings. The normal decrease is one inch for every 900 feet elevation.

Q. - What is the relation of the barometric pressure to the boiling point of water?

A. - Boiling point lowers with decrease in pressure. (Read 1927 Ranger Naturalists Manual, p. 70.

Q. - Why are some people affected by high altitudes?

A. - It is difficult for those of low lung capacity to get a sufficient supply of oxygen in rarified atmospheres.

Q. - (a) What is travertine or calc-sinter?

A. - A soft, cellular limestone deposited by calcareous or lime-bearing waters, chiefly springs. Because it is soft and cellular it is sometimes called calcareous tufa.

Q. - (b) Siliceous sinter, or geyserite?

A. - Hydrated silicon dioxide (SiO_2 nH_2O) deposited by silica-bearing waters. (Hot spring and geyser waters).

Q. - (c) Geyser eggs and needles?

A. - Balls of siliceous sinter formed where geyser water splashes are called eggs. Needles form in geyser spray.

Q. - (d) Stalactites?

A. - Pendant icicle-like forms of calcium carbonate deposited from dripping water (on roof of caverns or under rock ledges).

Q. - (e) Stalagmites?

A. - The complement of stalactites formed by calcareous waters dripping upon the floor of caverns.

Q. - (f) Granite?
A. - A compact igneous rock composed of granular crystalline quartz, mica and feldspar, and sometimes hornblende and augite. The Archean rocks are principally granites. The feldspar is the orthoclase or potash feldspar. When hornblende displaces the mica we have a hornblende granite or syenite.

Q. - (g) Gneiss?
A. - A foliated granite. Has the appearance of being in layers. A metamorphosed granite.

Q. - (h) Quartz (Crystallized silica)?
A. - Rock composed almost wholly of (SiO_2). Impurities such as the oxides of metals give it colors. Pure crystalline quartz is found in hexagonal prisms and pyramids as clear as glass. Forms of quartz: Amethyst, false topaz, chalcedony, agate, onyx, chert, flint.

Q. - (i) Flint?
A. - A compact dark, lithoid form of quartz. It is chalcedonic.

Q. - (j) Andesite?
A. - An aphanitic (the varying constituents so minute as to be undistinguishable to the naked eye) igneous rock consisting essentially of plagioclase feldspars, with hornblende, biotite or pyroxene (usually magnesium-iron-calcium silicate), sometimes cellular, porphyritic, or even glassy; usually rich in feldspar microlites. (Microlites are incipient crystals found in glassy lavas; usually needle shaped or rod like).

Q. - (k) Porphyry?
A. - A rock consisting of distinct crystals embedded in an aphanitic ground mass.

Q. - (l) Basalt?
A. - A dark, compact basic igneous rock consisting of a mass of minute crystals sometimes with more or less glassy base, often containing also visible crystals; composed of plagioclase (a general term for the triclinic feldspar) and pyroxene, with olivine, magnetite, or titaniferous iron as common accessories; a basic lava in which the crystallization has taken place rapidly; usually rich in crystallites or microlites; graduates into dolerite and basic andesite. Most generally the constituent minerals are very minutely crystallized and intimately intermixed.

(m) Pitchstone?
A dark vitreous, acid igneous rock of less perfect glassy texture than obsidian and more resinous and pitch-like.

(n) Pumice?
A glassy form of lava rendered very vesicular through inflation by steam.

Q. - (o) Pyroclastic rocks?
A. - Fragmental or clastic rocks produced through igneous agencies embracing volcanic ashes, tuffs, agglomerates, etc.

Q. - (p) Rhyolite?
A. - An aphanitic or glassy igneous rock showing flowage lines usually applied only to the acidic varieties.

Q. - (q) Peridotite?
A. - A very basic igneous rock composed chiefly of olivine (a silicate of magnesium and iron), with augite (an aluminum calcium-magnesium-iron silicate) or related ferromagnesian minerals, with magnetite and chromite as accessories.

Q. - (r) Obsidian?
A. - A typical form of volcanic glass usually of the acidic class of silicates. It has the close texture, conchoidal fracture, and other qualities of glass. It is usually black, but sometimes red, brown, green, purple, bluish, or gray.

Q. - (s) Dolerites?
A. - The basalts graduate insensibly into the dolerites; the dolerites may be regarded simply as basalts of coarser crystallization. The minerals are evident to the eye.

Q. - (t) Gabbros?
A. - Crystalline rocks composed of the plagioclase feldspar, labradorite (or anorthite), and pyroxene (or a related ferromagnesian mineral), with magnetite or titaniferous iron as a common accessory. They are usually dark heavy rocks.

Q. - (u) Shale?
A. - A more or less laminated rock, consisting of indurated muds, silts, or clays.

Q. - (v) Breccia?
A. - A rock composed of angular fragments, contrasted with pudding-stone or conglomerate in which the fragments are rounded.

Q. - (w) Ocher?
A. - An impure earthy ore of iron or a ferruginous clay, used as a pigment in making paints, etc. Reds and browns in Grand Canyon.

Q. - (x) Kaolin and Kaolinite?
A. - Deposits of Kaolin are composed largely of Kaolinite, a hydrous aluminum silicate; usually in clay-like or earthy form; white or graying white; often tinged with impurities; commonly arises from decomposition of aluminum silicates, especially the feldspars; basic of pottery and china. Very evident in Yellowstone Canyon where it gives Yellowish tints to the walls. Formed when steam and waters decomposed the rhyolites.---- Rock definitions largely from T. C. Chamberlin and R. D. Salisbury, Geology, Vol. I.

SECTION III

Botany

Prepared by:
Dr. Harvey E. Stork, 1927 Ranger Naturalist
W. Forest Whedon, 1927 Ranger Naturalist

Approved by:
Dr. Henry S. Conard, 1926 Head Ranger Naturalist
Horace M. Albright, Superintendent

Q. - How many species of flowering plants are there in the park?
A. - Up to the present time approximately seven hundred and fifty species have been identified.

Q. - How many kinds of trees may be found?
A. - In the park there are both cone bearing and broad-leafed trees. Of the cone bearing there are limber pine, lodgepole pine, white-bark pine, Engelmann spruce, Douglas fir, balsam fir, and the cedar. Of the broad-leafed trees there are three kinds of poplars, an alder, birch, maple, several willows, and approximately one hundred shrubs.

Q. - Which are the most primitive plants?
A. - The bacteria and algae.

Q. - Which are the most recent plants?
A. - The sunflower or composite family.

Q. - What are algae.
A. - An alga is a minute one-celled or a thread-like plant, living in water. Its cell wall is composed of cellulose; it has chlorophyle which enables it to manufacture food for itself out of carbon-dioxide and water.

Q. - What color is an alga?
A. - There are two classes of algae in Yellowstone Park; the green algae, which are various shades of green, and the blue-green algae, which give nearly all the colors seen about the hot springs.

Q. - What are bacteria?
A. - They are similar in structure to algae and microscopic in size. They lack chlorophyle and are usually colorless.

Q. - What effect have the algae on the deposition of travertine?
A. - Water without carbon dioxide gas in it cannot hold travertine in solution. Algae growing in heavy masses catch the water which may be saturated with travertine. This material is deposited on the outside of the plants due to the extraction of carbon dioxide from the water about the plants. This, however, needs further investigation by a competent plant physiologist.

Q. - What varieties of trees can be identified in the petrified forests?

A. - Redwoods, pines, laurels, bay trees, sycamores, buckthorns, oaks, walnuts, hickory nuts, bay berries, poplars, willows, birches, hazel nuts, beech nuts, chestnuts, elms, figs, breadfruits, magnolias, cinnamons, acacias, sumachs, bitter-sweet, maples, soap berries, basswoods, aralias, dogwoods, persimmons, and ash trees are the principal ones.

Q. - How do they differ from the present tree population of the forests of the park?

A. - They resemble the trees of much lower altitudes and warmer climate than do those now found here.

Q. - How are the seeds distributed from the cones of the lodgepole pine?

A. - The seeds are blown about by wind when the cone scales crack apart. The scales open quickly when heated, as by a forest fire. This gives the lodgepole pine an advantage over the other trees, because it gets an early start after a fire. The seeds germinate and the seedlings grow only in full sun-shine. A few cones open every year, however, and some seeds are shed annually, to occupy small openings, or to people new roadways, as on the Norris Cutoff.

Q. - What economic value has the lodgepole pine?

A. - Very little value as lumber. It is used quite extensively as fuel, telegraph poles, and fences. The Indians used the young trees in building their lodges; hence the name.

Q. - In what ways do the trees of the park contribute to the food of the birds and other animals?

A. - The trees supply nuts and other fruits. Larger animals, such as the elk and deer, feed upon foliage and bark. Bark of the aspen serves as food for the beaver. Porcupines feed on the barks of conifers.

Q. - How does the Rocky Mountain cedar (Juniperus scopulorum) differ from the eastern or southern or Tennessee cedar (Juniperus Virginiana)?

A. - There is very little difference between these two. They present almost identical characteristics.

Q. - How does the development of the cone of the cedar differ from that of the pine, spruce, and fir?

A. - The cedar bears a berry-like cone which has fleshy scales fused together. This, however, serves the same purpose as do the cones of the others.

Q. - Which of the park trees can persist with the least moisture?

A. - The limber pine and the cedar.

Q. - Of what economic value is the Douglas fir?
A. - It is a very good lumber tree. About one half of the soft wood in the country is Douglas fir. It is hauled from points in the Northwest to the New England states by way of the Panama Canal.

Q. - Where are the greatest forests of Douglas fir?
A. - In Washington, Oregon, Northern Idaho, and British Columbia.

Q. - How may the different pines of the park be distinguished?
A. - The limber pine and the white-bark pine have needles held in bunches of five, but the white-bark pine has a smooth, grayish white bark and red cones, whereas the bark of the limber pine is rougher and darker, and the cones are green. The lodgepole pine has needles in groups of two.

Q. - At what altitudes are the different pines distributed?
A. - Limber pine from about 4,000 to 7,000 feet; white-bark pine from about 7,000 to 11,000 feet; lodgepole pine from about 5,000 to 9,000 feet, in the park.

Q. - To what extent are the trees of the park utilized as timber?
A. - Their use is authorized only for minor construction purposes within the park limits.

Q. - Why are not the dead trees of the park cleaned away and burned?
A. - A narrow area along the side of part of the Loop Road has been cleared away. As a rule the trees are left, as a part of the policy of the National Park Service to preserve the natural aspect of the park areas. The cost of extensive clearing is prohibitive.

Q. - How does the care of the forests in this park differ from the care of the forests in our national forests?
A. - The forests in the park are not expected to yield commercial returns. The native trees are conserved and no new species are introduced. Both principal and interest are saved, whereas in the national forests the dead wood is cleaned away and there is a regular program of cutting and reforestation.

Q. - Does the National Park Service do any reforestation in the park?
A. - Very little. No effort is made to introduce commercial species of trees.

Q. - By what needle characteristics may the Engelmann spruce, Douglas fir, and balsam fir be distinguished?
A. - The needles of all of them are spirally arranged on the twig. In firs, they tend to turn so as to stand in two rows, making a flat spray. In spruces the leaves bristle out all around the twig; they are square and will roll between the thumb and finger like a match stick; they fall off when old, leaving a little knob or prickle. The fir leaves are flat, and fall off leaving a round scar. The Douglas fir leaf is soft, and sharp-pointed. The balsam fir leaf is blunt or notched at the tip, and rather stiff.

Q. - What are some of the common introduced plants?
A. - Timothy, redtop, quack grass, perennial rye, goat's beard, French weed, and salsify.

Q. - What causes the "knotting" of the pines in the Knotted Pine Forest?
A. - The exact cause of this is unknown. Some believe that it is caused by blight, some by insect bites, some by a chemical in the soil, and others believe it to be caused by mistletoe growing on the trees.

Q. - Where is the hay raised that is used in feeding the animals in the winter?
A. - On the flats at Gardiner, Mammoth Hot Springs, at the Buffalo Ranch, Upper and Lower Slough Creek Ranches and on the Hoppe Ranch north of the park boundary.

Q. - Is the Oregon grape a true grape?
A. - No. Its clusters resemble those of the grape, but it belongs to the barberry family.

Q. - Of what economic value is it?
A. - A tea made from the roots was used by the Indians to subdue fevers and stimulate the kidneys. An extract of the root was also used as a yellow dye. The fruit is used for jellies and the foliage for Christmas decorations.

Q. - Why can it not legally be sent to wheat growing states?
A. - It is susceptible to wheat rust (as the alternate host), and would help spread that plant disease as does the common barberry.

Q. - Is the mountain flax of the park suitable for the preparation of linen?
A. - No. The fibres are tough but not as tough as those of the common, cultivated flax.

Q. - What characteristic desert plants occur in the park?
A. - Sagebrush, cactus, rabbit brush and greasewood.

Q. - What aquatic plants are found here?
A. - Yellow pond lily, marsh marigold, water smart weed, water crowfoot, pond weed, duckweeds, two mosses, and many algae.

Q. - How does the plant life at the highest altitudes differ from that at the elevation of Mammoth?
A. - On the highest elevations the predominating trees are whitebark pine, spruce and fir. In general, the flowering plants are a low growing, due to the shorter season. The flower colors are more brilliant at higher altitudes.

Q. - Will the trees buried in travertine petrify in time?
A. - No, due to the lack of silica.

Q. - What is the park flower?
A. - The fringed gentian.

Q. - What are the characteristics of the following flowers: Clematis (Clematis occidentalis)?
A. - Leaves oppositely arranged, with leaflets shaped like those of the lilac. Petals four, dark blue or purple, spreading like a four-pointed star. Season over by July 10th. Grows on shady hillsides. Seed cluster resembles a large ball of cotton.

Q. - Fringed Gentian (Gentiana)?
A. - Slender stems, sparsely branched, reaching to a height of about one foot. Four petals, dark blue, twisted into a tube with the edges pointing outward. These edges are fringed. Found in moist open places and along roadsides.

Q. - Geranium (Geranium)?
A. - Stem rises from a basal group of leaves, and the stem is somewhat leafy. The flowers average an inch across and have five petals and ten stamens. Two species, the white and the red, are found in the park. They bloom throughout the season and are found in the moist wooded areas, the red one often occurring in the open.

Q. - Lupine (Lupinus)?
A. - Stem stout and erect, growing from one to three feet in height and ending in a flower spike. The leaves are compound with entire-edged leaflets arranged finger fashion. The flower, small, sweet pea shaped, is bright blue, but once in a while they may be entirely white. These bloom from June until September and are found at all levels in open, gravelly, well drained soils and also in shady places.

Q. - Monkey Flower (Mimulus)?
A. - The red monkey flower, Mimulus Lewisii, is slightly hairy and somewhat sticky, growing along cold mountain streams in mid-summer. The commoner yellow one, M. Langsdorffii, called false snapdragon, is abundant about the run-off of hot springs, varying from 2 to 18 inches tall. Two smaller species of Mimulus occur in the park.

Q. - Indian Paintbrush (Castilleja)?
A. - Grows about a foot in height, with a stout, stiff, unbranched stem bearing a large number of narrow, pointed, somewhat hairy leaves, and ending in a close cluster of blossoms. Each flower is tubular, with a deep, sharply pointed lobe at the top. They are interspersed with leaf-like structures which are the color bearers. The colors vary from scarlet or magenta to cream white. They grow in the open, or in half shady moist locations.

Q. - Larkspur (Delphinium)?
A. - The stem is fairly tall, 8 inches to three feet and sometimes more. It is found in open, sunny, rather moist places. In appearance it is thick, smooth, and light green in color. The leaves are cleft and extend like the fingers of a hand. The flower is irregular, the upper part extending backwards into a spur. Three or four species occur in the park. They range from a very pale to a midnight blue in color.

Q. - Meadow Rue (Thalictrum)?
A. - The flowers are small and greenish-white in color. There are no petals. The plant grows about a foot in height and its leaves are similar in shape to those of the columbine.

Q. - Yarrow (Achillea)?
A. - This plant grows from fifteen to eighteen inches in height and is found in dry, gravelly places. Leaves are found at the base of the stem and also on the stem. They are finely divided. The flowers are in heads at the ends of the branches. One of the commonest plants of the world.

Q. - Sunflower (Helianthus)?
A. - The stems are stout and grow about three feet in height. The leaves are opposite. The flowers are yellow with either a yellow or brown disk in the center. They start blooming in July and continue until frost. Three kinds (including Helianthella) in the park.

Q. - Balsam Root (Balsamorrhiza)?
A. - This flower is very similar to the sunflower except that the leaves are large, shaped like an arrow head and borne on separate stems from the flowers. Great clumps or clusters grow a foot or more in height and are found in fairly dry places.

Q. - Fireweed (Epilobium)?
A. - The flowers are rich magenta and grow in loose spikes on the upper parts of the plant, which is generally unbranched. The leaves are lance-shaped with untoothed margins. The flower is exceedingly abundant in the park.

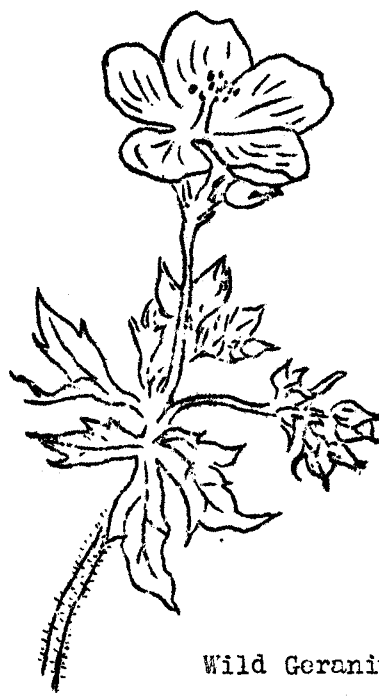
Q. - Dogbane (Apocynum)?
A. - This is a shrubby herb with a tough, fibrous bark and with leaves which have a very sharp, abrupt point. The flowers are small and white or rose-colored. It grows from one to five feet in height.

Q. - Orchid (Calypso)?
A. - There is a single broad oval leaf which grows near the ground and from the base of this leaf a three or four inch stem bearing the flower arises. The flower is slipper-shaped and rose-colored. It is found only in shady, very moist places and is among the rare species.

Q. - Mariposa Lily (Calochortus)?
A. - The stem is slender and shaped like a bulb at the base. It has a single leaf belonging to the stem and bears from one to five white, tinged with greenish yellow or lilac, flowers. Known only from the southeast quarter of the park.

Q. - Rabbit Brush (Chrysothamus)?
A. - The leaves of this low broom-like shrub are numerous and exceedingly narrow and pointed. They are bright green in color. The flowers grow in heads and are yellow. It is in bloom from about the middle of August on through the early fall.

Q. - What are lichens?
A. - Lichens are plants found growing on rocks, tree trunks, etc. They are composed of algae and fungi growing together in a mutually beneficial relationship known as symbiosis. A fine example of lichen growth which lends the color that gives the name may be seen at Golden Gate.



Wild Geranium

SECTION IV

Fishes

Prepared by:
Dr. Harry M. Kelly, Ranger Naturalist
Harry J. Liek, Assistant Chief Ranger
James Dupuis, Park Ranger
Herschel Bowman, 1927 Park Ranger

Approved by:
C. F. Culler, District Supervisor, Bureau of Fisheries
J. H. Brunson, Special Fish Observer, Yellowstone Nat. Park.
Horace M. Albright, Superintendent.

Q. What are the peculiar markings, characteristics, and locations of the following fishes?
Montana Grayling?

A. - The Montana grayling, Thymallus montanus, belongs to a family of fishes most closely related to that of the salmons and trouts. It is described as possessing an elongate, compressed, slender body, with a short head and terminal mouth, a forked tail, an "adipose" second dorsal fin, and with a very long and high proper dorsal fin. It has small scales, and the sides are covered by transversely elongated spots. It inhabits the upper basin of the Missouri, above the Great Falls, and enters Yellowstone Park by way of the Madison River and its tributaries, the Firehole and the Gibbon.

Q. - Rocky Mountain whitefish?

A. - The Rocky Mountain whitefish, Coregonus williamsoni, belongs to the salmon family, and is distinguished from the subfamily of the trout and salmon by its small mouth, not extending back beyond the eye, in contrast to their conspicuously longer jaws. The lower jaw is shorter than the upper, the mouth is very small, the teeth minute or wanting, the head is short and conic, the body elliptical and but little compressed, the color is olivaceous above, but white on the sides.

Q. - Cutthroat trout?

A. - The name "cutthroat" has been used to designate quite a number of closely related trouts of the Rocky Mountain region, but in Yellowstone refers to the Salmo lewisi, to which also the following local names are given: cutthroat, blackspotted or "native" trout. Like the other western trouts and the salmons the mouth is large, extending beyond the eye, with abundant and large teeth, the body is elongated, slightly compressed, though robust, the sides are silvery gray spotted with black, not extending to the belly, with two red streaks under the gills (this is the most characteristic mark) and usually a red cheek and red wash upon the side.

Q. - Rainbow trout?

A. - Several species of closely related western trouts have been dubbed "rainbow", but the usual species distributed by the fish culturist is Salmo shasta, native to the streams of the Sierra Nevada mountains in California. Those in the Yellowstone may be confused with the cutthroat, but may be distinguished by the lack of the red streak under the gills, by a darker bluish back, more abundant black spots upon the sides, often extending upon the belly, by a broad faint pink band on the sides, and by a more rakish, more "wicked" bull dog jaw on the male fish. It is regarded as a livelier fish than the cutthroat and when hooked, gives a harder fight, breaking water more freely.

"Rainbow trout frequently have the red throat the same as the Native. In some instances when both species are prime it is a very difficult matter to distinguish one species from the other and when confronted by such a condition the only infallible mark of distinction is that the Native trout always has yellow fins; on the other hand the fins of the rainbow are of a dark metallic luster."---J. H. Brunson.

Q. - Loch Leven trout?

A. - "Loch Leven trout (Salmo Levenensis) is an European trout introduced from Scotland and is closely related to the brown trout (Salmo fario) and by many considered to be the same fish, the difference in coloring and markings being due to water changes and environment, and has been artificially crossed with that species in the United States, so that it is sometimes difficult to find a pure bred Loch Leven.

"Lew Sarett, in a report on the members of this family in Madison Lake, and they are the descendents of the original plant made in the Firehole River in 1889, reports finding the true Loch Leven, the true brown and a cross of the two. This would indicate their belonging to the same family and the small differences of body shape and markings being due to original environment.

"Body is elongate, depth contained 4½ times total length exclusive of caudal fin. Head short and conical, its length about one-fifth of total length without caudal fin. Dorsal fin higher than long. Caudal when fully extended is square or truncate. Upper parts brown or greenish olive, sometimes with reddish tinge, sides silvery with varying number of X shaped black spots which may be ocellated. Usually has occasional red spots on sides, and adipose fin may have several bright orange spots.

"This species will thrive in waters inhabited by any other member of the trout family and even in streams of higher temperature than will carry other members of the salmonidae and will do equally as well in streams of lower temperature. The Loch Leven will take an artificial fly as readily as the brook or rainbow and its size and strength add to its attraction to the angler."---C. F. Culler.

Q. - Eastern brook trout?

A. - On the whole, Salvelinus fontinalis is a smaller fish than the other trouts in the Yellowstone, with back and sides of a dark olive, marbled or spotted with whitish spots, and with numerous red spots on the sides, with lower fins dusky and edged with black and orange.
"Brook trout fins are usually black, orange and white. The white is always on the anterior border of the fin and gives the fish a very striking appearance."---J. H. Brunson.
Native in the eastern part of our country, it has been widely distributed in the Western and Pacific Coast states. While of the same family as the western trout, it is not closely related, belonging to the Charr. It may be found in Shoshone Lake, Grizzly Lake, the Gibbon, Firehole, Madison and Gardiner Rivers, and in Glen Creek.

Q. - The mackinaw or lake trout?

A. - The lake trout, Cristivomer namaycush, is the largest trout found in the Yellowstone. Its head is very large, the body elongated, dark gray, often greenish on the sides, with well distributed lighter spots, frequently tinged with red. In the Yellowstone, it may be taken in Shoshone, Lewis and Heart Lakes, and in the Lewis and Snake Rivers.

Q. - Yellow perch?

A. - The yellow perch, Perca flavescens, has been introduced only into one place, Goose Lake, in the park. Perch are small fish, dark olive green above, with yellow sides crossed by six to eight broad dark bars, and bright yellow belly, and orange lower fins. The body is narrow or compressed, and the fins sharp or "spiny".

Q. - The chub?

A. - (Edwin Linton his report on Fish Entozoa from Yellowstone National Park, 1893, mentions Leuciscus atrarius as the host of several parasites, giving Heart Lake and the tributary Witch Creek as his localities. Pratt in his Vertebrate Animals of the United States, p. 70, lists Leuciscus lineatus as occurring in "Yellowstone Park, the Snake River basin, common.") I know of no recent or local authorities for the occurrence of this fish, though it probably occurs in several localities besides those mentioned. "Minnows", probably chub, have been caught in the Yellowstone River near Gardiner. Chubs are small or less than medium sized fishes, with soft rayed fins. Colors silvery and often bright, scales frequently edged with black.

Q. - The sucker?

A. - Linton's report, referred to above, states that suckers, Catostomus ardens, were found both by himself and by David Starr Jordan in Witch Creek and Heart Lake in 1889 and 1890. Ranger Herschel Bowman has caught them in the Yellowstone River near Gardiner, and in the Gardiner close to its junction with the Yellowstone, both points close to the park boundary.

Suckers are readily distinguished by their peculiar ventral mouth, with its thick fleshy lips. They are of medium size, elongated, cylindrical or slightly compressed body, soft fins, with a single dorsal fin.

Q. - Where is the fish hatchery?

A. - The main fish hatchery is located on the northern shore of Lake Yellowstone, a third of a mile west of the Lake Hotel. A branch hatchery is maintained on Fish Lake, near Soda Butte Ranger Station.
An earlier hatchery was located on the west shore of the Thumb Bay of the Lake, about three quarters of a mile north of the Thumb Ranger Station, but was abandoned in 1912.

Q. - What is the national park policy in regard to the planting of fish in park waters?

A. - The policy is to keep out exotic fish and carefully protect native species. In barren waters plant native species. Owing to promiscuous planting before the policy was adopted, it cannot be uniformly enforced.

Q. - How are the fish artificially propagated?

A. - In the Yellowstone Park, the cutthroat or native trout is the only fish artificially propagated. At or just before their spawning period, from late May until the middle of July, the fish ascend the streams, from the Lake, going as far as possible towards the shallow reaches near the source. In selected streams dams, and traps are set, to catch such ascending fish. Both sexes are thus secured, and "stripped" of their products, - that is, by gentle pressure the eggs of the female and the milt of the male are squeezed into a pan, where their union, or "fertilization", is secured within a few minutes. The fish are not harmed by this process, nor do they die, as do salmon, following their reproduction, but are returned to the streams, and soon make their way down to deeper water or to the Lake. The eggs are taken to the hatchery, retained on shallow trays of wire cloth in troughs of cool clear water, through the time of their incubation and for a short while thereafter, to allow for the absorption of the excess food or yolk, then placed at once in suitable small, grassy places in the little streams, - localities adapted to the feeding of the small fishes or "fry". If the water of the hatchery were constantly at 50 degrees, the eggs would hatch in about fifty days; if warmer, the process proceeds more rapidly; if cooler, more slowly but with greater safety, depending upon the physical principle that cool water contains in solution more gases - (in this case our interest is in the contained oxygen) - than when warm.

Q. - Which of the park waters were barren when the park was discovered?

A. - All the streams and lakes upon the park plateau, that is above their major falls, contained no fish whatever, except the Yellowstone Lake and River and streams flowing into

Yellowstone Lake. Here the cutthroat trout abounded. Below their falls, all the streams entering the park were supplied with the fishes characteristic of their regions, by the unhindered ascent of these species from lower waters.

Q. - Why?
A. - The falls of the several streams were sufficient barrier to the migration of fishes from the lower streams. The cutthroat trout in the Yellowstone Lake and upper river, may have been transferred with the Lake, when at the close of the Glacial Epoch, its relation to the Columbia drainage was exchanged for that to the Missouri, for the cutthroat is a trout of the western side of the divide; or migration over the divide is not impossible to trout, where, as for instance on Two Ocean Plateau, a lake in a swamp may have outlet streams in both directions.

Q. - What trouts are found in the following lakes and streams: Yellowstone Lake?
A. - Cutthroat or "native" exclusively.

Q. - Shoshone Lake?
A. - Mackinaw, cutthroat, Loch Leven, brook.

Q. - Lewis Lake?
A. - Mackinaw, cutthroat, Loch Leven.

Q. - Heart Lake?
A. - Cutthroat, mackinaw, sucker, chub.

Q. - Grebe Lake?
A. - Rainbow, grayling.

Q. - Wolf Lake?
A. - Rainbow, grayling.

Q. - Duck Lake?
A. - Loch Leven.

Q. - Goose Lake?
A. - The yellow perch.

Q. - Fish Lake?
A. - Cutthroat.

Q. - Grizzly Lake?
A. - Brook.

Q. - Sylvan Lake?
A. - Cutthroat.

Q. - Indian Pond or Squaw Lake?
A. - Cutthroat.

Q. - The Yellowstone River above the falls?
A. - Cutthroat only.

Q. - The Yellowstone River below the falls?
A. - Cutthroat, rainbow, Loch Leven, whitefish, sucker, chub.

Q. - Lewis River?
A. - Mackinaw, Loch Leven, with cutthroat also below Lewis Falls.

Q. - Snake River?
A. - Mackinaw,cutthroat.

Q. - Falls River?
A. - Mackinaw, cutthroat.

Q. - Bechler River?
A. - Cutthroat.

Q. - Gibbon River?
A. - Rainbow, cutthroat, brook, grayling, Loch Leven.

Q. - Firehole River?
A. - Rainbow, cutthroat, brook, Loch Leven, grayling.

Q. - Madison River?
A. - Rainbow, cutthroat, brook, Loch Leven, grayling, whitefish.

Q. - Gardiner River?
A. - Cutthroat, rainbow, brook, Loch Leven, whitefish, sucker, chub.

Q. - Lamar River?
A. - Cutthroat.

Q. - Glen Creek?
A. - Brook.

Q. - Slough Creek?
A. - Cutthroat.

Q. - Nex Perce Creek?
A. - Rainbow, cutthroat, Loch Leven, brook.

Q. - What is the largest trout found in the park?
A. - The mackinaw or lake trout.

Q. - Which is considered the most game?
A. - The rainbow.

Q. - Under what conditions would you use bait?
A. - When the water is cloudy, muddy or high.

Q. - Under what conditions would you use spinners?
A. - Best during the spawning season.

Q. - Under what conditions would you use flies?
A. - In clear water.

Q. - What are the limitations on fishing?
A. - Fish over eight inches in length, not to exceed ten fish per day per person, may be caught and retained.

Q. - Is a license required to fish in Jackson Lake?
A. - Yes, to be secured from Wyoming State authorities.

Q. - What is the distribution of fish in Yellowstone Park?
A. - The distribution of the fish in the park is as follows:

Montana Grayling:
Grebe Lake, Wolf Lake, Gibbon River, Firehole River, Madison River.

Rocky Mountain whitefish:
Yellowstone River below the falls, Gardiner River, Madison River.

Cutthroat trout:
Yellowstone Lake, Shoshone Lake, Lewis Lake, Heart Lake, Fish Lake, Yellowstone River, both above and below the falls, Lewis River, Snake River, Falls River, Bechler River, Gibbon River, Firehole River, Madison River, Gardiner River, Lamar River, Slough Creek, Nez Perce Creek, Sylvan Lake, Mallard Lake, Indian Pond or "Squaw Lake".

Rainbow trout:
Grebe Lake, Wolf Lake, Yellowstone River below the falls, Gardiner River, Gibbon River, Firehole River, Madison River, Nez Perce Creek.

Loch Leven trout:
Shoshone Lake, Lewis Lake, Duck Lake, Yellowstone River below the falls, Firehole River, Madison River, Gardiner River, Nez Perce Creek.

Brook trout:
Shoshone Lake, Grizzly Lake, Gibbon River, Firehole River, Madison River, Gardiner River, Glen Creek, Lava Creek, Blacktail Deer Creek, Lost Lake, Nez Perce Creek.

Mackinaw or lake trout:
Shoshone Lake, Lewis Lake, Heart Lake, Lewis River, Snake River, Falls River.

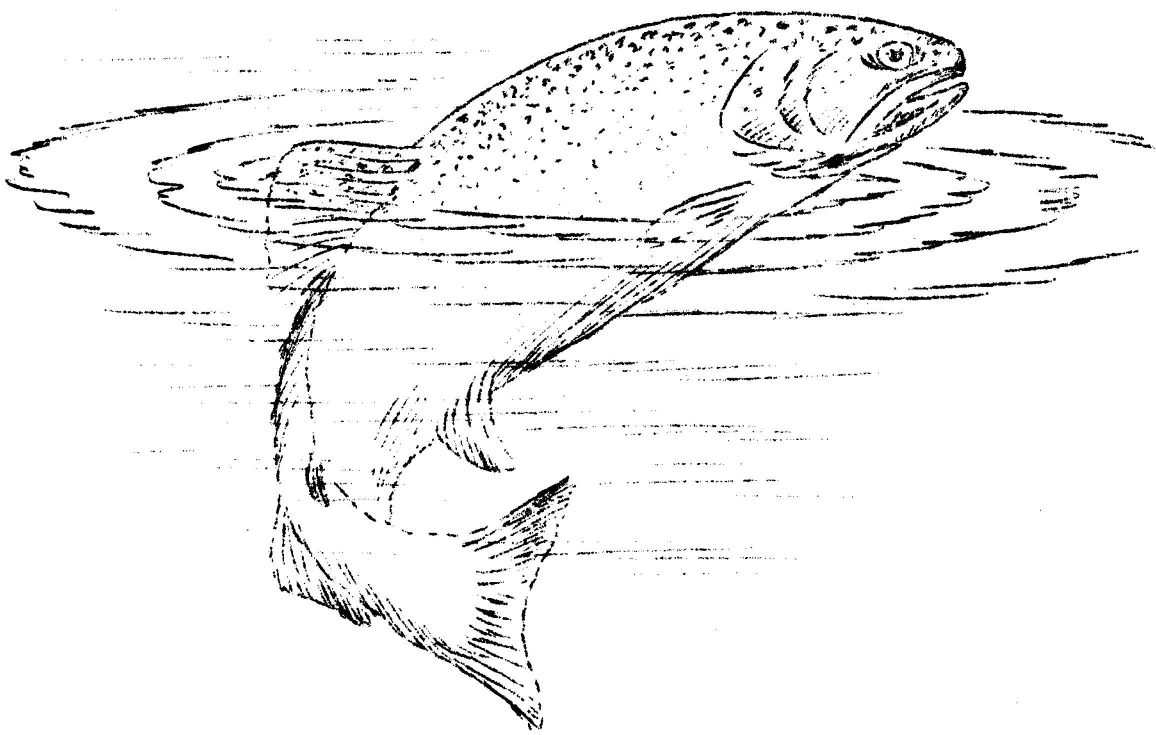
Yellow perch:
Goose Lake.

Chub:
Heart Lake, Gardiner River, Yellowstone River below the falls, Witch Creek.

Sucker:
Heart Lake, Gardiner River, Yellowstone River below the falls, Witch Creek.

Q. - Is there a difference between the Land Locked Salmon, German Brown, English Brown and Loch Leven trout?

A. - "It is my opinion that the Land Locked Salmon, German Brown, English Brown and Loch Leven trout are one and the same fish especially in the waters of the Yellowstone Park since it is rare that a true type speciman of any one of the species is taken, although I have taken specimens which had the black XX marks, i.e., Land Locked Salmon, those with the roundish red spots, i.e., German or English Brown and those with the oblong black spots which are the true Loch Levens. Some state that they have crossed since being introduced into the waters of this country, but it is my opinion that they simply revert back to the true type of their parents, in any case, the amateur can readily distinguish any of this species from any of the other trouts excepting the brook, dolly varden and mackinaw, because of the jaws and tongue being filled with rows of murderous teeth."---J. H. Brunson.



SECTION V

Birds

Prepared by:
E. J. Sawyer, Former Park Naturalist.

Approved by:
Horace M. Albright, Superintendent
Dr. Harry M. Kelly, Ranger Naturalist

Q. - What are the diagnostic features and marks of the following Yellowstone birds?
Golden eagle?

A. - Great size and massive build. General dark (nearly black) coloration. This, with soaring habit. Can seldom be certainly distinguished in the field from the immature Bald eagle (owing to dark head of latter). Positive characteristic at all ages - feathered tarsus (feathers extending down to the toes themselves).

Q. - Osprey?

A. - Great size, with narrow wings; white underparts. Nests on pinnacles in Canyon, and on Eagle Nest Rock.

Q. - Water ousel?

A. - Stocky, blackish, short upturned tail; size of small robin, "tipping" habit; found beside or in swift streams.

Q. - Western or Louisiana Tanager?

A. - Between bluebird and robin in size, with scarlet head, yellow body except back, wings and tail (which are mainly black).

Q. - Raven?

A. - Like crow, but larger, croaking calls (never a real "caw), wings longer and more slender than in crow, often soars in flight.

Q. - Pelican?

A. - Great white water bird with prominent bill and bill-pouch.

Q. - Canada goose?

A. - The only common goose in the park. Large size, with long neck, general dark coloration. Details: black head, neck and tail; whitish throat patch.

Q. - Barrow goldeneye?

A. - Male: black and white; head glossy black with white crescent at base of bill. Female: grayish; not easily distinguishable by description from various other female ducks; but usually seen in company with males of the species.

Q. - California gull?

A. - The gull most commonly seen on Yellowstone Lake. Blue-gray above, white below; wings black-and-white-tipped.

Q. - Swan?
A. - Great size (at least as large as goose) and general white color, with very long neck.

Q. - Great blue heron?
A. - Great size (stands about three and one half feet tall), slender build, long legs, wings and bill; general blue-gray color; legs carried straight behind and neck doubled back on breast in flight.

Q. - Rocky Mountain jay?
A. - Called "Camp robber". Grayish bird larger than robin; blackish crown; short, rounded wings, graceful, gliding flight; very bold.

Q. - Killdeer plover?
A. - Size of robin, long legs, runs very fast, two black bands across white breast; very noisy; in open grassy, bare or wet places.

Q. - Red-tailed hawk (Western form)?
A. - Larger than crow, broad wings, soars, may be either light or dark; reddish tail as seen from above. As usually seen, not easily distinguishable from Swainson hawk.

Q. - Black-headed jay?
A. - Larger than robin; appears nearly uniform very dark blue, but has black head; very long crest. Harsh notes.

Q. - Western horned owl?
A. - Very large, brownish, conspicuous "ears".

Q. - Mallard?
A. - Common wild duck, green head, white neck ring, brown breast, generally grayish body, black about tail region - Male. Female is generally buffy, mottled. Larger than other species.

Q. - Mountain bluebird?
A. - Between sparrow and robin (or somewhat larger than sparrow) in size; male, deep blue except lower belly and under tail; female, grayish; with pale blue wings, tail.

Q. - Migratort, etc.?
A. - See Sawyer, in 1927 Ranger Naturalists Manual.

Q. - Clarke nutcracker?
A. - One of the most typical birds of the region. The bird is commonly called the Clarke crow; it is rather closely related to the crow family. The bird is rather larger than a robin, general color pale gray, wings black with a white patch on the tips of the secondary feathers; middle tail feathers black, outer ones white.

SECTION VI

Animals

Prepared by:
J. M. Hitchings, 1927 Ranger Naturalist.
Gerald E. Marsh, Head Ranger Naturalist.

Approved by:
Dr. Wm. T. Hornaday, former Director, N. Y. Zoological Park.
Dr. Joseph Grinnell, University of California.
Horace M. Albright, Superintendent.
Sam T. Woodring, Chief Ranger.
E. J. Sawyer, former Park Naturalist.
Ansel F. Hall, Chief Park Naturalist.

Q. - How many of each of the following are there in the park: Buffalo, elk, mule deer, antelope, black bear, grizzly bear, moose, mountain sheep:

A. -

Buffalo, Lamar Valley Herd - count	894
Buffalo, Pelican Flats-Cold Creek Herd, estimated	125
Total	1,019
Mountain sheep - estimated	650
Antelope - (Count-1927)	641
Moose - estimated	600
Mule deer - estimated	1,875
Elk - (Count February 1927)	17,347
Black bear - estimated	275
Grizzly bear - estimated	100

(In the Jackson Hole herd of elk there are about 19,000 animals).

Q. - What is the attitude of the National Park Service toward predatory animals?

A. - Predatory animals are designated by the Service as consisting of wolves, mountain lions and coyotes. It is not the policy of the Service to exterminate these animals. Wolves and lions are comparatively rare and for this reason are not regarded as a serious menace to the other wild life of the parks. The coyote requires vigorous measures in some of the parks, particularly Yellowstone and Glacier, and, although more than 200 are killed annually in the Yellowstone, there is no apparent decrease in their number.

Q. - How many park elk die or are killed yearly?

A. - Average killed outside 785 (actual average of reported kills for the past five (5) years. Average deaths 200 to 300, occasionally 500 to 600.

Q. - Where may the animals listed in the first question be found at the different seasons of the year?

A. - The principal summer range of the buffalo is along the headwaters of the Lamar River, including the Cache, Miller and Cold Creek districts. The captive herd drifts down the Lamar about mid-October. Its principal winter range is on the ridges and meadows along this stream, extending from the drift fence on Mt. Norris to the junction of the Yellowstone and Lamar Rivers. Winter feeding begins early in January and is concluded about April 1st. The Cold Creek-Pelican Creek herd, otherwise known as the wild herd, summers on the headwaters of the Lamar River and winters principally on the Pelican Creek meadows.

Mountain sheep summer on Cutoff Mountain, Abiathar Peak, Thunderer, Mt. Norris, Amethyst Mountain, Specimen Ridge, Mt. Washburn, the Trident and in the vicinity of Big Horn Pass. Their principal winter range is along the slopes of Mt. Norris, Specimen Ridge, vicinity of Junction Butte, along the east bank of the Yellowstone River from the Lamar River junction to Cottonwood Creek, along the west bank of the Yellowstone River near the mouth of Bear Creek and along the canyon of the Gardiner River between Mammoth Hot Springs and Gardiner.

The summer range of the antelope extends along the Yellowstone and Lamar Rivers from Blacktail Deer Creek to the foot hills of Mt. Norris. Their winter range comprises a small area along the north boundary of the park within a radius of about five miles from the Gardiner entrance.

The winter elk range extends along the Lamar and Yellowstone Rivers from Cache Creek to the north boundary and approximately 20 miles beyond, including such well known districts as Crevice, Bear Creek, Palmer Creek, Reese Creek, Molhern Creek, Cedar Creek, Cinnibar Mountain and Yankee Jim Ridge outside the park, and the Blacktail, Hellroaring, Tower Falls, Slough Creek and the Lamar River districts within the park. The Gallatin herd winters on the Game Preserve bordering the northwest corner of the park and the Madison herd winters in the national forest in the Grayling Creek district. A few small bands winter along the warm basins in the central area of the park. The spring drift to the summer range on the high elevations of the park usually occurs late in May but weather conditions govern their movements and they vary somewhat in point of time from year to year. The fall drift to the lower elevations usually occurs early in October.

Considerable numbers of the southern or Jackson Hole herd, which is estimated at approximately 19,000, summer on the high plateau regions of the district south of the park.

Bears are found throughout the entire park area during the period normally beginning on or about April 1st and ending on or about November 15th. Their hibernation period normally dates from November 15th to April 1st. The degree of their variances from normal is determined by weather conditions and food supply. Hibernation may or may not occur near their summer feed ground. The real extent of their wandering after the close of the tourist season is not definitely known.

Q. - What is the difference between horns and antlers?
A. - Antlers are outgrowths of the skeleton and are of the same composition as bone. True horns are epidermal outgrowths and may be compared with finger nails, hair or hoofs. The horny sheath covers a bony core. Antlers are sometimes called horns but horns are not correctly called antlers. Antlers are borne by male members of the deer family - in the case of the caribou by the females also - and are shed annually. True horns are borne by cattle, sheep, goats and buffalo. Antelope have the only true horns which are shed. In general antlers are branched or forked; horns, not. The case of the antelope is an exception; hence the name "Prong-horn".

Q. - When are horns and antlers shed?
A. - Elk....................................February and March
Moose..................................December and January
Deer...................................January and February
Antelope...............................December.

Q. - When do the horns and antlers attain full growth?
A. - Elk....................................September
Moose..................................July
Deer...................................August and September
Antelope...............................The growth is slight each year, the animal not shedding the entire horn but just the horny sheath, the new horn being well developed under the old shell.

Q. - What is meant by carnivorous, herbivorous, and omnivorous?
A. - Carnivorous.................... eating or feeding on flesh.
Herbivorous.................... eating plants.
Omnivorous..................... eating everything indiscriminately.

Q. - What animals in the park are carnivorous?
A. - The carnivorous animals found in the park are mountain lion, Canada lynx, bobcat, timber wolf, coyote or prairie wolf, badger, fisher, otter, fox, mink, skunk, weasel, wolverine and pine marten.

Q. - When do the various animals that hibernate go into and come out of hibernation?
A. - Black and grizzly bears usually go into hibernation about October 10th to 20th but the time of hibernation varies with the season. They usually come out of hibernation about the middle of April. These dates may, under favorable conditions, be extended to November 15th to April 1st.
Woodchucks or marmots go into hibernation about August 10th to 31st and come out for the summer about the last of April or the first of May. They appear much earlier in a temporary way.
Kennicott ground squirrels or "picket pins" go into their holes about August 15th to 20th and come out sometime in April.

Q. - What is the difference between the black and grizzly bears?
A. - The grizzly bears may be recognized by their high shoulders, powerful proportions, grizzly-gray hair and long, slightly-curved claws on the front paws. The standard color is brown next to the skin, the extremities of the hairs being a silvery-gray, from which comes the name "silver-tip". The black bear differs from the grizzly in form, being highest in the middle of the back, low at the shoulders and light brown to black in color and also by the fact that in walking he usually carries his head low. He is a smaller animal. His claws are short, strongly curved and well adapted to tree climbing. The typical black bear is a glossy black with brown muzzle and white "star" on his breast.

Q. - Of what does the food of the bear consist?
A. - In regard to food habits, bears are omnivorous and devour about anything they can chew. All bears eat succulent roots, berries, insect larvae, honey, frogs, reptiles, grass, fish and any other kind of flesh they can obtain.

Q. - What use does the beaver make of his tail?
A. - The large flat tail of the beaver has attracted much interest. The tail is used as a rudder when the animal wishes to turn quickly, as a prop or stool when a tree is being cut, and to slap the water, perhaps as a danger signal. I feel that it is not a danger signal in all cases as the other beaver are sometimes not disturbed by the noise. The beaver does not use his tail as a trowel, carry mud on it, plaster the mud down, cut trees down with it, nor scull with it when swimming as does the muskrat.

Q. - What is the food of the beaver?
A. - The favorite food of the beaver in Yellowstone Park is the bark of the aspen tree, although willows and alders are sometimes used. The bark of pine trees is occasionally used. In the summer other plants are taken as food, such as rose bushes, cow parsnip, choke cherry, thistles and various others. Its favorite winter food is the bark of the aspen tree.

Q. - How and why does the beaver build dams?
A. - Beavers build dams in order to create ponds in which to build their lodges and in which they are protected from their enemies, and also to back up the water as close as possible to the place where they are "lumbering" or cutting trees. More than this, the pond serves as a refrigerator in which the animals store their winter supply of food.
The dams are made of mud, sticks and grass. Sticks are placed across the stream, usually butt end upstream, although some are laid across the current. These are covered with gravel and mud from the upstream side, more twigs are then laid on and covered, and thus the dam is built. The

top is plastered with mud. The dam usually has a curve down stream, due to the fact that the beaver works on the ends of the dam as the water starts to flow around. A dam is never finished as the beavers keep adding sticks from which they have chewed the bark.

Q. - How does the beaver build his home?
A. - The lodges are usually built out in the water and started on a small island or elevation. The lodge begins as a burrow under a pile of sticks and mud, placed in a similar manner to those in the dam. The interior is kept hollowed out as the work goes on. The house is loosely built in one place above the chamber to permit ventilation. The floor is a few inches above the level of the water and usually about 5 feet long - 3 to 4 feet wide and 2 or more feet high. The floor is bedded with slough grass and wood fiber.

Q. - What is the food of the porcupine?
A. - The favorite food of the yellow-haired porcupine in Yellowstone Park is the bark of the lodgepole pine.

Q. - How far will a beaver carry food to store it for the winter?
A. - The average distance that a beaver will drag logs to store them for winter is from 100 to 200 feet. They have been known to drag them for more than 250 yards.

Q. - Which of the animals is the swiftest runner?
A. - The antelope is the swiftest of all North American mammals.

Q. - Are there any poisonous snakes in the park?
A. - It is generally considered that there are no poisonous snakes in the park; however, rattlesnakes have been found on the Lower Yellowstone River within the park, and on Crevice Mountain.

Q. - How often does a snake shed its skin?
A. - The outer skin may be completely renewed about three times a year.

Q. - What are the habits and markings on the bull snake?
A. - The western bull snake is harmless, and very beneficial, destroying large numbers of ground squirrels or "gophers", rats, and mice. It is found mostly on the Gardiner flat and along the Gardiner River to Mammoth, reaching up to Silver Gate, but not found on the park plateau. In regard to the color and markings, it is light yellow with many black cross blotches and spots. The body is stout, and the snake may be as much as 7 feet in length.

Q. - Why is it forbidden to carry antlers from the park?
A. - Tourists are not permitted to carry antlers from the park for it would encourage specimen hunting and everything in this region should remain in its natural state and location.

Another reason that might be given is that to permit a search for them would increase the fire hazard. A few tourists are careless about fires that they build, as well as with the cigars and cigarettes they smoke, when permitted to leave the beaten path.

Q. - Can you tell the age of an elk by the points on the antlers?
A. - It is not possible to tell the age of an elk by the points on the antlers after about the fifth year. Usually an extra tine or "point" is gained each year until the fifth to seventh year; the antler has then attained its full growth and no tines are added in succeeding years of the elk's life.

Q. - When and how was the present Lamar Valley herd of American bison in Yellowstone Park started?
A. - The present herd of over eight hundred animals was started in 1902. 18 cows were purchased from the Allard herd of the Flathead Agency in Montana and 3 bulls were purchased from the Goodnight herd of Texas. Two male calves were captured from the park's wild herd in the fall of 1903 and a female calf was captured in the fall of 1904.

Q. - What is the one menace which has threatened the herd since that time and how is it guarded against at the present time?
A. - A disease called hemorrhagic septicemia which is a sort of blood poisoning resembling blackleg. At the present time a fresh supply of serum is kept at all times at the Buffalo Ranch with the necessary instruments to vaccinate the entire herd at the first sign of its breaking out.

Q. - What disposition is authorized for the herd surplus?
A. - Live buffalo may be shipped for stocking of public parks, zoos or private estates upon the receipt of the amount necessary to cover the expenses of catching, crating and transporting of the animals to the railroad. The slaughter of steers for market purposes was authorized in the fall of 1925 and 38 have been slaughtered since that since.

Q. - To whom should application for the shipment of bison or other park animals be made, and at what time of the year?
A. - To the "Director, National Park Service, Department of the Interior, Washington, D, C.", who has authority to permit shipments. Requests should be made sometime in September or early October.

Q. - What is the color, weight, mating season, time of birth of young and number of young born of the various animals of interest to the tourist?
A. - See table on following page.

Name of Animal	General Color	Weight# Pounds	Mating Season	Time of Birth of Young	No. of Young
Buffalo	Dark brown	1800##	Aug. and Sept.	April through June	1, seldom twins
Moose	Black to rusty brown, light colored legs	900	September	May and June	1, occasionally twins
Elk	Reddish-brown in summer Winter, cows brownish & bulls pale gray-brown	700	Sept. and Oct.	May and June	1, occasionally twins
Mountain sheep	Gray-brown	300	December	May and June	1, occasionally twins
Mule deer	Brown	200	Nov. and Dec.	May and June	1, occasionally twins
Antelope	Reddish-tan and white and black markings	100	Sept. and Oct.	May and June	1 to 2
Grizzly Bear ###	Deep brown with grizzled or frosted appearance	600	July	January	1 to 2 occasionally (3-4)
Black Bear ####	Chiefly brown to black	250	June	January	2 occasionally (1-3-4)
Mountain Lion	Pale rufous brown	200	?	?	3 to 4
Canada Lynx	Summer, Grayish-brown Winter, paler & grayer	35	March	May or June	3 or 4
Coyote	Yellowish-gray	25 or 30	February	April	3 to 10
Timber Wolf	Brownish-gray	90	January & March	March and April	3 to 13
Beaver	Silvery-brown	35	February	May	2 to 5

\# Average - adult male.
\## One has been reported by the American Bison Society as being 2800 pounds in weight.
\### Young at time of birth, 16 ounces to 1-1/2 pounds.
\#### Young at time of birth, 9 to 12 ounces.

FLORA OF YELLOWSTONE NATIONAL PARK (TABULATION)

By Dr. Henry S. Conard,
Ex-Chief Ranger Naturalist.

(LIST REVISED JANUARY 1, 1928)

FLOWERING PLANTS

Abies lasiocarpa
Abronia ammophila
Acer glabrum
Achillea millefolium
Aconitum columbianum
Actaea arguta
Adiantum pedatum
Adoxa moschatellina
Agoseris glauca
    dasycephala
    pumila
  parviflora
  purpurea
  villosa
Agropyron caninum
  pseudorepens
  scribneri
  smithii
  spicatum
  tenerum
Agrostis hiemalis
  humilis
  palustris
Allium Brandegeei
  brevistylum
  cernuum
  Nuttallii
  rubrum
  sibiricum
Allocarya scopulorum
Alnus tenuifolia
Alopecurus aequalis
  alpinus
Amelanchier alnifolia
  elliptica
Anaphalis margaritacea
Androsace filiformis
  septentrionalis
Anemone globosa
Angelica pinnata
Anogra Nuttallii
Antennaria arida
  corymbosa
  lanata
  media
  oblanceolata
  parvifolia
  pulcherrima
  racemosa
  reflexa
  rosea
  umbrinella ✓
Apocynum androsaemifolium
  cannabinum
Aquilegia flavescens
    minima
Arabis Drummondii
  exilis
  furcatus ?
  glabra
  Lemmonii
  lignipes
  microphylla
  Nuttallii
  perelegans
Aragallus albiflora
  lagopus
  Purshii
Arceuthobium americanum
Arctostaphylus uva-ursi
Arenaria congesta
  sajanensis
Argentina anserina
  argentea
Arnica cordifolia
  foliosa
  fulgens
  gracilis
  longifolia
  mollis
  Parryi
  Rydbergii
  ventorum

FLORA OF YELLOWSTONE NATIONAL PARK (TABULATION) Conard

Artemisia biennis
cana
drancunculus
frigida
gnaphalodes
scopulorum
tridentata
trifida
vulgaris discolor
Asplenium
Aster adscendens
angustus
apricus
caerulescens
campestris
Canbyi
conspicuus
elegans
Engelmannii
Fremontii
integrifolius
laetevirens
longifolius
Mearnsii
meritus
proximus
Astragalus aboriginorum
aculeatus
alpinus
carolinianus
Drummondii
elegans
goniatus (A. hypoglottis)
hylophilus
mortoni
vexilliflorus
Balsamorrhiza sagittata
Barbarea americana
Batrachium confervoides
flaccidum
Grayanum
Beckmannia erucaeformis
Berberis
repens
Betula glandulosa
fontinalis
Blitum capitatum
Botrychium Coulteri
Brassica campestris
Bromus brizaeformis
marginatus
Porteri
tectorum
Calamagrostis inexpansa
canadensis
hyperborea americana
Callitriche palustris
Caltha rotundifolia
Calypso bulbosa
Camassia esculenta
Camelina microcarpa
Campanula rotundifolia
uniflora
Capsella bursa-pastoris
Cardamine Breweri
unijuga
cordifolia
Carex athrostachya
aurea
diandra
canescens
disperma
festivella
Hoodii
lanuginosa
petasata
Piperi
Preslii
Raynoldsii
rostrata
siccata
vallicola
vesicaria
viridula
xerantica
Carum gairdneri
Castilliea confusa
gracillima
lauta
longispica
lutea
miniata
pallescens
pulchella
Ceanothus velutinus
Cerastium arvense (C. oreophilum)
vulgatum
Ceratophyllum demersum
Chaenactis Douglasii
achillaaefolia
Chamaenerion augustifolium
Chenopodium album
aridum
Conardii
Fremontii

Chenopodium hians
murale
salinum (C. glaucum)
Chimaphila umbellata
Chrysanthemum leucanthemum
Chrysopsis depressa
hispida
villosa
Chrysothamnus
nauseosus consimilis
speciosus
pumilus
varus
viscidiflorus elegans
Cirsium foliosum
undulatum
Cicuta occidentalis
Claytonia lanceolata
Clematis Douglasii
ligusticifolia
occidentalis
Cleome pungens
Cogswellia platycarpa
Collinsia parviflora
Collomia linearis
Comandra pallida
Corallorhiza innata
multiflora
striata
Cornus instolonea (C. stolonifera)
Corydalis aurea
Crepis acuminata
elegans
glauca
gracilis
occidentalis
subacaulis
Cryptogramma acrostichoides
Cryptanthe Watsoni
flexuosa
Cymopteris Fendleri
Cystopteris fragilis
Danthonia cusickii
intermedia
unispicata
Dasiophora fruticosa
Disporum trachycarpum
Delphinium cucullatum
Nelsonii
Delphinium Nuttallianum
Deschampsia alpicola
caespitosa

Distichlis spicata
Dodecatheon pauciflorum
Draba andina
incerta
laevicapsula
Nelsonii
nitida
oligosperma
prealta (D. lapilutea)
streptocarpa
Dracocephalum parviflorum
Drymocallis convallaria
pseudorupestris
Eleocharis acicularis
palustris
Elymus condensatus
glaucus
Elaeagnus argentea
Elyna Bellardii
Epilobium adenocaulon
alpinum
anagallidifolium
Hornemanii
paniculatum
perplexum
suffruticosum
Equisetum affine (E. hyemale)
arvense
laevigatum
Erigeron acris
asper
caespitosus
compositus
discoideus
multifidus
corymbosus
lapiluteus
lonchophyllus
luteus
macranthus
microlonchus
radicatus
ramosus
salsuginosus
superbus
uniflorus
ursinus
ursinus gracilis
Eriocoma cuspidata
Eriogonum andinum
heracleiodes
ochroleucus ?

Eriogonum ovalifolium
Piperi
subalpinum
umbellatum
Eriophorum
Eriophyllum integrifolium
Erodium cicutarium
Erysimum asperimum
cheiranthoides
inconspicuum
Erythronium grandiflorum
Euphorbia serpyllifolia
Festuca brachyphylla
idahoensis
Fragaria americana
ovalis
platypetala
Frasera speciosa
Fritillaria atropurpurea
pudica (Ochrocodon)
Gaillardia aristata
Galium boreale
trifidum
triflorum
Gaultheria humifusa
Gaura parviflora
Gayophytum Nuttallii
Gentiana affinis
elegans
plebeja
Geranium Richardsoni
viscosissimum
Geum strictum
Gilia Harknessii
pungens
borealis
Glyceria nervata
nervata elata
pauciflora
Gnaphalium thermale
Grayia Lanata
Grindelia subalpina
Habenaria dilatata
hyperborea
Halerpestes cymbalaria
Hedysrum cinerascens
sulphurescens
Helianthella quinquenervis
Helianthus annuus
Nuttallii
Heracleum lanatum
Heuchera ovalifolia
parvifolia
Williamsii
Hieracium albiflorum
cynoglossoides
gracile
Scouleri
Hippuris vulgaris
Hordeum jubatum
nodosum
Horkelia gordoni
Hutchinsia procumbens
Hydrophyllum capitatum
Ionactis alpina
Iris missouriensis
Isoetes paupercula
Iva axillaris
Juncus balticus
brunnescens
confusus
ensifolius
longistylis
nevadensis
Parryi
Regelii ?
Tweedyi
Juniperus scopulorum
sibirica
Kalmia polifolia
Koeleria cristata
Lactuca pulchella
Lappula caerulescens
erecta
florabunda
occidentalis
subdecumbens
Ledum glandulosum
Lemna cyclostasa
minor
trisulca
Lepidium apetalum
Leptotaenia multifida
Lewisia pygmaea
rediviva
Linnaea americana
Linum Lewisii
Listera nephrophylla
Lithospermum lanceolatum
pilosum ?
Lolium perenne
Lomatium orientale ?

FLORA OF YELLOWSTONE NATIONAL PARK (TABULATION) Conard.

Lonicera caerulea
ciliata
involucrata
utahensis
Lupinus caespitosus
candicans
leucophyllus
Macounii
parviflorus
Luzula intermedia
parviflora
spicata
Lychnis vespertina
Lycopodium annotinum
Lysiella obtusata
Machaeranthera pulverulenta
Macronema grindelioides
Madia glomerata
Matricaria suaveolens
Melica spectabilis
Melilotus officinalis
Mentha canadensis
Mentzelia dispersa
decapetala
laevicaulis
Tweedyi
Mertensia Bakeri subglabra
ciliata
coronata
Tweedyi
Mimulus Langsforfii (M. guttatus)
Lewisii
moschatus
Mitella pentandra
Moehringia lateriflora
Moneses uniflora
Monolepis Nuttalliana
Monotropa hypopitys hirsuta
Montia chamissonis
Muhlenbergia andina
squarrosa
Myosotis alpestris
Myosurus apetalus (M. aristatus)
Myriophyllum spicatum
Nemophila breviflora
Nuphar polysepalum
Oenothera strigosa
Opuntia polyacantha
Oreastrum alpigineum
Oreostemma Hydeni
Orthocarpus luteus
Oryzopsis hymenoides
Osmorrhiza nuda ?
Osmorrhiza obtusa
Oxyria digyna
Pachylophus caespitosus
Pachystima myrsinites
Panicum occidentale
thermale
Parnassia fimbriata
kotzebuei
palustris
Pedicularis bracteosa
cystopteridifolia
contorta
groenlandica (P. surrecta)
racemosa
Penstemon cyaneus
deustus
procerus
pulvereus
pseudoprocerus
radicosus
Phacelia Franklinii
leucophylla
linearis
sericea
Phalaris arundinacea
Phleum alpinum
pratense
Phlox Hoodii
Kelseyi
longifolia
multiflora
Phyllodoce empetriformis
Physaria didymocarpa
Physocarpus malvaceus
Picea Engelmanii (P.pungens only a var. according to Jones)
Pinus albicaulis
flexilis
murrayana latifolia
Plantago major
Poa alpina
ampla
Canbyi
crocata
Fendleriana
epilis
olneyae
paddensis
palustris

Poa pratensis
Sandbergii
Wheeleri
Polemonium viscosum (confertum)
Grayanum
Haydeni
occidentale
parvifolium
pulcherrimum
Polygonum amphibium
bistortoides
buxiforme
Douglasii
erectum
Hartwrightii
polygaloides
Populus
augustifolia
balsamifera
tremuloides (aurea)
Potamogenton filiformis
lonchitis
natans
pectinatus
praelongus
Potentilla biennis
glaucophylla
gracilis
hippiana
Macounii
millegrana
monidensis
Nuttallii
pennsylvanica strigosa
viridescens
Wyomingensis
Prunella vulgaris
Prunus melanocarpa
Pseudotsuga taxifolia
Pteridium aquilinum
Pterospora andromedea
Ptilocalais tenuifolia (nutans)
Pulsatilla hirsutissima
Pyrola asarifolia
incarnata
chlorantha
minor
picta
secunda
Pyrrocoma lanceolata
uniflora

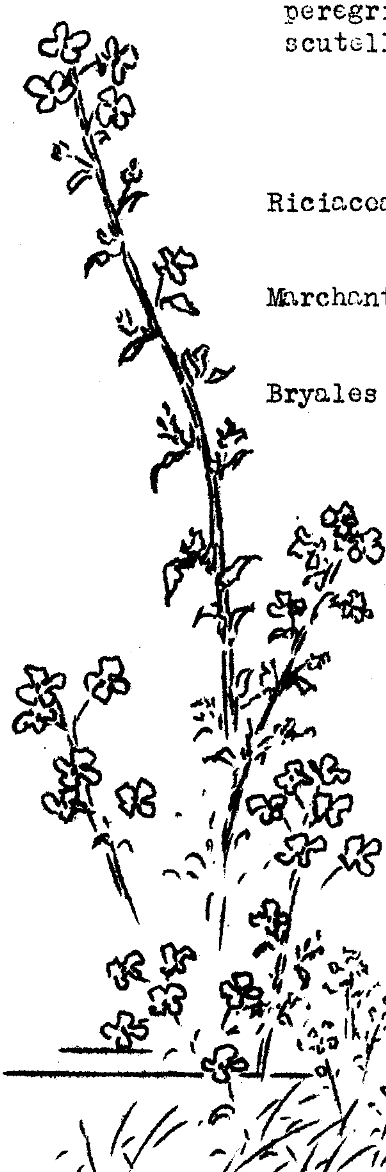
Ranunculus alismellus
alpeophilus
Douglasii
eremogenes
inamoenus
intertextus (natans)
Macounii
Purshii
reptans
Rhus trilobata
Ribes cereum
Hudsonianum
parvulum
setosum (saximontanum)
viscosisimum
Roripa hispida
Rosa acicularis
Bourgeauiana ?
Fendleri
Macounii
Rudbeckia occidentalis
Rubus parviflorus
strigosus
Rumex acetosella
britannica ? (crispus ?)
mexicanus
occidentalis
paucifolius
persicarioides
Sagina saginoides
Sagittaria arifolia
Salix anglorum
bebbiana perrostrata
cordata
exigua (fluviatilis)
geyeriana
glauca glabrescens

planifolia
pseudomonticola
pseudomyrsinites
equalis
scouloriana
tenera
wolfii idahoensis
Salsola pestifer
Sambucus melanocarpa
Sanicula bipinnatifida
Sarcobatus vermiculatus
Saxifraga arguta
caespitosa
rhomboides
saximontana
subapetala

Scirpus americanus
occidentalis
Scutellaria galericulata
Sedum integrifolium
stenopetalum
rhodanthum
Selaginella densa
Senecio altus
balsamitae
canus
Purshianus
crassulus
Cymbalarioides
Fremontii
glaucescens
hydrophilus
lapathifolus
longipetiolatus
mediocris (Sp. inedit.)
mutabilis
perplexus
serra
subnudus
triangularis
Shepherdia canadensis
Sibbaldia procumbens
Sieversia ciliata
turbinatus
Silene acaulis
anthirhina
multicaulis
Sisyrinchium augustifolium
occidentale
Sitanion hystrix
Sium cicutaefolium
Smelowskia calycina
Smilacina amplexicaulis
Smilacina sessilifolia
stellata
Solanum triflorum
Solidago canadensis procera
concinna
dilata
elongata
missouriensis
nana
rubra
scopulorum
serotina
Sophia incisa
Sorbus scopulina
Sparganium augustifolium
Spartina gracilis
Spergularia sparsiflora
Sphaeralcea rivularis
Spiraea lucida
Spraguea milticeps
Spiranthes stricta
Sporobolus asperifolius
brevifolius
Stellaria borealis
crassifolia
Edwardsii
longifolia
longipes
laeta
obtusa

umbellata
Stenotus caespitosus
Stipa columbiana
comata intermedia
richardsoni
williamsii
Streptopus amplexifolius
Symphoricarpus occidentalis
rotundifolius vaccinioides
Synthyris Wyomingensis
Taraxacum ceratophorum
erythrospermum
officinale
Taraxia brevifolia
subacaulis
Tellima bulbifera
parviflora
Tetradymia canescens
Thalesia fasciculata
lutea
Thalictrum dioicum
occidentale
sparsiflorum
Thelypodium sagittatum
Thermopsis montana
Thlaspi arvense
parviflorum
Tofieldia intermedia
Townsendia Parryi
Tragopogon pratensis
porrifolius
Trifolium hybridum
pratense
repens
Rydbergii

Triglochin maritima
palustris
Trisetum subspicatum
Trollius albiflorus
Typha latifolia
Urtica gracilis
Utricularia vulgaris
Vaccinium membranaceum
scoparium
Valeriana ceratophylla
septentrionalis
wyomingensis
Verbena bracteosa
Veronica americana
peregrina (xalapensis)
scutellata
Veronica serpyllifolia
(humifusa)
wormskjoldii (alpina)
Vicia linearis caespitosa
Viola adunca
blanda
linguaefolia
nephrophylla
palustris ?
subvestita
Woodsia oregana
scopulina
Wyethia helianthoides
Zygadenus elegans
venenosus



MOSSES

Riciaceae
Riccia fluitans
Beyrichiana
Marchantiaceae
Marchantia polymorpha
Reboulia hemisphaerica
Bryales
Aulacomnium palustre
Brachythecium collinum
Bryum turbinatum (det. Andrews)
Buxbaumia aphylla
Ceratodon purpurens
Climacium dendroideum
Dicranoweisia crispula
Dicranum strictum
Fontinalis hypnoides
Grimmia ovalis montana
Hypnum aduncum gracilescens (Weed)
Leptobryum pyriforme
Orthotrichum rupestre speciosum
Pogonatum alpestre
Pohlia nutans
Polytrichum juniperinum piliferum
Thuidium abietinum

ADDITIONS AND CORRECTIONS FOR LIST OF

FLOWERING PLANTS OF YELLOWSTONE PARK

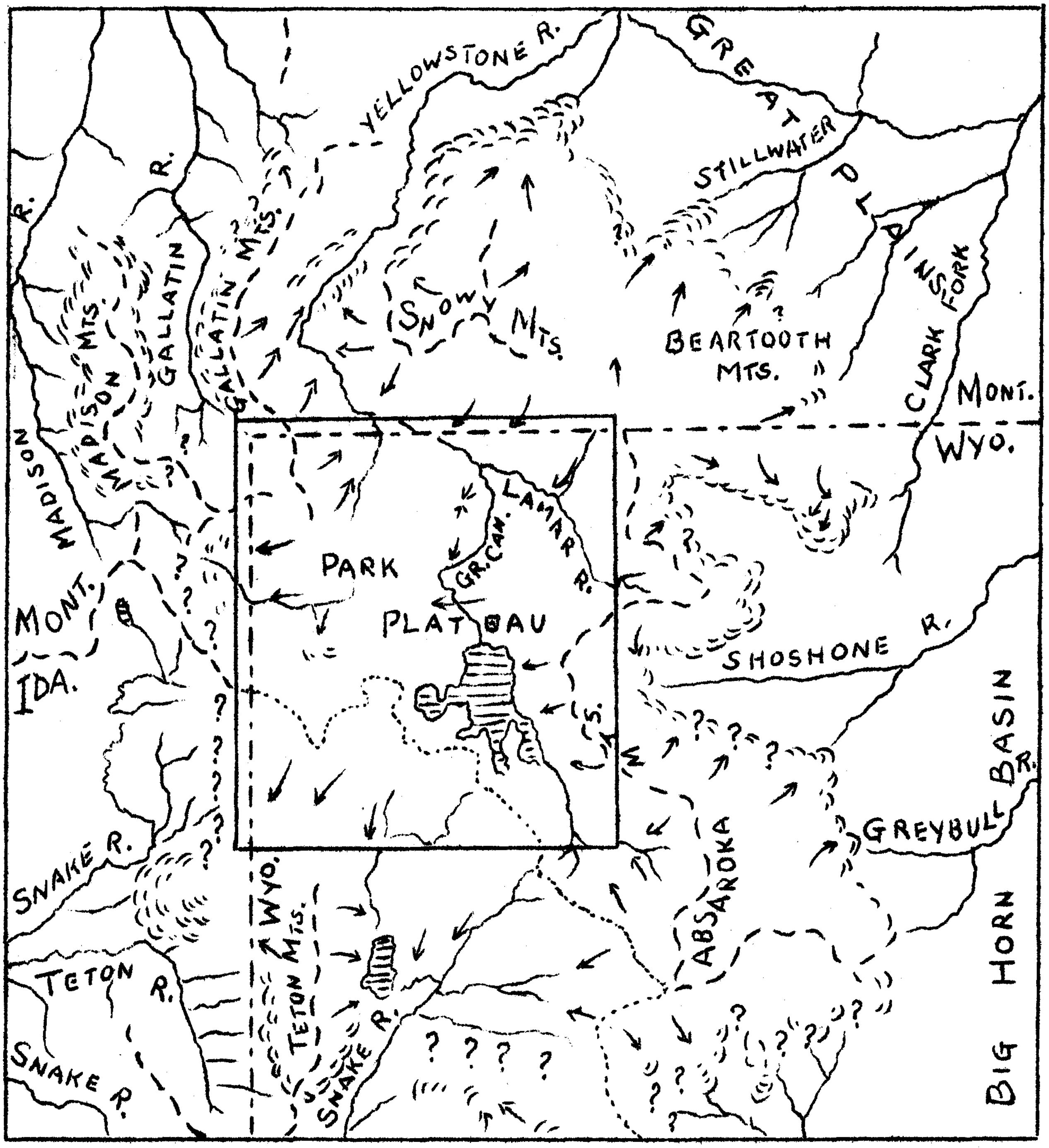
By Dr. H. S. Conard - March 10, 1928

Note:- Since cutting the stencils for the complete list of flowering plants of Yellowstone Park, the following corrections and additions have been received from Dr. Conard and are to be included as a part of the foregoing list.

Add Allocarya Nelsonii ?
    Aster multiflorus
    Astragalus flexuosus
        tenellus (vexilliflorus)
    Castilleia exilis
    Erigeron speciosus
    Dodecatheon radicatum
    Floerkea proserpinacoides

Read Eurotia lanata NOT Grayia

Add Ligusticum filicinum
    Lupinus Burkei ?
    Mentzelia compacta
        nuda instead of laevicaulis
    Mertensia foliosa instead of coronata
    Monarda menthaefolia
    Penstemon collinus
        cyananthus
        cyaneus (glaber)
        Rydbergii
    Pyrrocoma integrifolia
    Salix scouleriana NOT scouloriana


YELLOWSTONE R.
GREAT PLAINS
STILLWATER
R.
R.
MADISON MTS.
GALLATIN
GALLATIN MTS.
SNOWY MTS.
BEARTOOTH MTS.
CLARK FORK
MONT.
WYO.
MADISON
PARK
PLATEAU
GR. CAN.
LAMAR R.
MONT.
IDA.
SHOSHONE R.
BIG HORN BASIN
B. R.
GREYBULL
ABSAROKA
SNAKE R.
WYO.
TETON MTS.
TETON R.
SNAKE R.
SNAKE R.

GLACIATION OF YELLOWSTONE NATIONAL PARK AND ITS ENVIRONS

By Wm. C. Alden, Ph.D., Geologist
U. S. Geological Survey

Approved and published by permission of the Director, U. S. Geological Survey.

Two or more times during the Great Ice Age, or glacial epoch, ice from the Keewatin center of glaciation west of Hudson Bay invaded the northern part of Montana, but at no time did it approach within less than 165 miles of Yellowstone National Park. General climatic conditions, however, were such that very extensive glaciers developed in the Rocky Mountains, and this was notably true in northwestern Wyoming and adjacent parts of Montana where areas covered by ice were very extensive.

The alternation of conditions favorable and unfavorable to glaciation - that is, colder and warmer periods, led to four or five distinct advances of the continental ice sheet alternating with interglacial stages during which the ice cap was largely, if not wholly, melted away. While it is probable that these alternating glaciations and deglaciations characterized the Rocky Mountains as well as the Northern Plains, no definite evidence of all these stages has yet been found in or adjacent to Yellowstone Park.

From regional studies this far made it appears probable that Yellowstone Park was glaciated at least three different times - that is, during the early, middle, and later parts of the Pleistocene, or the glacial epoch, but even the evidence of three stages can not be very definitely recognized within the Park itself. I shall attempt in this description to give but the barest outline of what was probably a complex history of the Park during the Ice Age and indicate where some of the glacial phenomena may be seen and studied to advantage. Of course, it should be understood that credit is due to many different geologists for what is known of this glacial history.

Generally speaking, the mountain glaciers originated in the higher parts of the mountain ranges, and the great streams of ice advanced thence slowly and majestically over lower tracts and down the valleys, in some cases even reaching to the adjacent plains before the rate of melting of the ice so far overtook the rate of forward movement as to cause the glacial fronts to halt and there dump the drift composing the terminal moraines. The principal high mountain tracts are now, and have for a long time been, the Snowy Range north of the Park, the Granite or Beartooth Mountains to the northeast, and the Absaroka Range in and adjacent to the eastern part of the Park.

From these more or less distinct high tracts great glaciers at each stage of glaciation extended north and northeast and east, far down toward the border of the plains. To the southwest and west of these mountains lies the great plateau composing most of the Park. Either the Park plateau was itself a place of ice accumulation or the ice from the adjacent mountains was confluent at its maximum stages and extended southwestward covering the great plateau and spilling over its outer margins into lower tracts to the south and west.

Near the head of the Grand Canyon of the Yellowstone, at the top of the south cliff and below the edge of the flat on which stands the Canyon Camp east of Upper Falls, there is (overlying the volcanic rock (rhyolite) and underlying a thin bed of sandstone and cemented gravel) about 100 feet of loose, stony material which is probably old glacial drift.

There is also bouldery drift exposed in the road cuts on both sides of the Canyon, so that it is certain that that part of the plateau in which is the canyon has at some time been overridden by a glacier. Careful consideration of such data as are now in hand leads to the inference that, although there was not prior to the first glaciation such a deep canyon as now, there was a valley in the place of the upper part of the Canyon and in this the drift was deposited. Ice probably moved southward from the south slope of the Washburn Range as far as the head of the Canyon. At the rapids three miles below the outlet of Yellowstone Lake there is about 150 feet of unsorted glacial drift, or till, exposed in the bluff at the east bank of the river, but this probably came from the east. There is also some evidence that ice spread westward across the central plateau to join a main current going west down the Madison valley. A great marginal lobe of the ice appears to have extended across the broad basin in which lies the Hebgen Reservoir, north and northwest of West Yellowstone, and to have laid its terminal moraine near Horse Butte and about the foot of the hills adjacent to the reservoir. Here are found many granitic boulders which were probably brought by ice moving southwestward from the Gallatin Range to join this lobe.

Another great lobe moved southwestward across the Pitchstone Plateau into and down Falls River basin, and spread over about 200 square miles of the lava fields of adjacent parts of eastern Idaho. On melting it left there a great deposit of glacial drift. To this drift contribution was also made by glaciers heading in the northern part of Teton Mountains. Not far from the Ranger Station, which is near the southwestern corner of the Park, glacial scratches upon smoothed basalt ledges show that this, or later, ice was there, moving in the direction S. 60° W.

A third lobe, about 25 miles south of the southern entrance to the Park, though perhaps not at the earliest stage of glaciation, moved southward down Snake River valley into Jackson Hole and laid its terminal moraine across the floor of the basin south of Jackson Lake. Here the lobe was joined by a great glacier which came down the Buffalo Fork valley from the northeast.

Whatever of earlier glacier ice moved eastward from the Absaroka Mountains down the valley traversed by the Cody road must have been so long ago that the inner gorge, which is marked by rock pinnacles, towers, and castellated forms, has been cut by the river since. Farther north ice from the eastern flank of the Absarokas and the southern part of the Beartooth Mountains joined and moved eastward down the Clark Fork of the Yellowstone. Here, as also along the Cody road and east of Jackson Hole, and on Stillwater River northeast of the Park in Montana, the relations make it probable that canyons 1000 feet deep have been cut since the earliest glaciation, but before the time of the last glaciation.

A vast flow of ice from the northern half of the Absarokas and the granite ranges to the north converged from the southeast, east, northeast, and north, and (together with some from the north flank of the Washburn Range) advanced down the Yellowstone valley from the vicinity of Junction Butte and extended northwestward into Montana, overrunning the site of Gardiner. The limit of this advance was near Chickory Station, about 35 miles below Gardiner. This glacier was joined by ice moving northeastward in the park from the east flank of the Gallatin Range. To this latter flow are probably to be referred the glacial boulders found high up on Bunsen Peak and on the travertine cap of Terrace Mountain. To the ice from the east may be referred glacial boulders on top of Mt. Everts.

It was probably not until much later that the jumble of great blocks of travertine "Hoodoos" slid down from Terrace Mountain. In the early part of the glacial epoch, Gardiner River valley was probably something like 1,000 feet less deep than now. It appears fairly certain that Gardiner River valley had not been deepened sufficiently for the main travertine terraces, on which are the headquarters buildings at Mammoth Hot Springs, to be formed prior to the first stage of glaciation. Possibly it was not that deep before the second stage of glaciation. The pre-glacial bed of Gardiner River may then have been but a few hundred feet below the level of the bottom of the lava capping Mt. Everts instead of 1,400 to 1,600 feet below that level as now. It was probably not until after the second glaciation that Yellowstone River cut down to the level of the terrace north of Gardiner, which is now about 650 feet above the stream. Unfortunately the evidence on which some of these conclusions are based comes from localities outside the park.

It is possible also that Yellowstone River had only partly cut the great notch or portal (by which it now flows through the wall of upturned limestone south of Livingston) before the valley above was invaded by glacier ice. The river channel between Gardiner and Livingston had, however, been cut down to levels not more and, in places, considerably less than 700 feet above the present river bed by the time the second (middle Pleistocene) glaciation occurred.

The earliest known glaciation of the Northern Rocky Mountains was followed by a very long period of milder climate during which the glaciers were very much reduced in size, if not wholly melted away, and streams resumed the work of deepening their valleys in the mountains and on the park plateau. So much did they accomplish that by the time the climate was again so changed as to induce glaciation, the streams had cut down in some places nearly to the level at which they are now flowing.

Terminal moraines marking what appear to be limits of glaciers of the second stage (middle Pleistocene) are in places outside the Park quite well preserved. The outer moraine of the ice descending Snake River valley lies on a broad terrace south of Jackson Lake, through which moraine and terrace the river has since cut a trench 300 to 400 feet in depth. It is possible that the drift which is spread on the plain traversed by Falls River southwest of the Park, in Eastern Idaho, and also that in the broad basin of Madison River west of the Park was deposited at the second, rather than the earlier, stage of glaciation.

The outer terminal moraine of the Yellowstone glacier lies on the broad upper terrace north of Chickory Station, on both sides of the river and high above the railway near Pray Station. There is a similar middle Pleistocene moraine of Pine Creek glacier a few miles farther north.

Glacial scratches, or striae, on a ledge of sandstone exposed in the slope below the tourist camp at Mammoth Springs show that before the last advance of the glaciers, Gardiner River had cut its valley down to within 100 feet of its present depth at that place. At Gardiner also glacial deposits lie on the lower terrace not more than 100 feet above Yellowstone River. The last of the Yellowstone glaciers extended down the valley about 30 miles below Gardiner and its terminal moraine lies south of Chickory Station where it extends down off the upper terrace. The last glaciation thus appears to have reached its maximum after the river had cut its valley down to the lower terrace level.

With the final oncoming of milder climatic conditions the ice fronts were melted back. There appear to have been several times when the melting so nearly balanced the rate of advance of ice that the glacier fronts ceased for a time to retreat and oscillated back and forth so that drift was piled in irregular terminal moraines. A well marked terminal moraine, pitted with numerous hollows, in several of which are ponds, and with knolls sprinkled with large granite boulders, is crossed by the Cooke City road in the lower valley of Lamar River near Junction Butte. How far the ice of the Lamar glacier crowded southward around the east flank of Mt. Washburn and up Yellowstone River is not certainly known. The great granite boulder beside the road to Inspiration Point on the north rim of the Grand Canyon evidently came from granite ledges along or north of Lamar River, 30 miles or more to the northward. This great boulder measures about 16x16x21 feet in diameter and probably weighs 100 tons or more. Evidently it could not have been carried 30 miles up the Yellowstone by water alone. Glacial scratches on the bedrock beside the road south of Dunraven Peak and about 3½ miles north of Canyon Hotel show that there ice was probably moving southward down the slope and the presence of unsorted glacial drift or till in road cuts in the vicinity of the head of the Grand Canyon, as stated above, also shows that glacier ice crossed that area.

Besides the big boulder near Inspiration Point there are scattered smaller boulders and pebbles of pink and gray granite along the road for about 2 miles north of the Hotel, and also on the surface at the camp south of the Canyon, but the writer has not found granitic pebbles or boulders included in the glacial till at any of the cuts. The presence of the granitic boulders in this vicinity suggests that at some stage of glaciation ice from Lamar valley advanced southward past the east flank of Mt. Washburn as far as the head of the Canyon. There is, however, no indication that ice traversed the Grand Canyon. The character of the Canyon walls, set as they are with projecting buttresses and towers, does not accord with that of a gorge which has been scoured by a glacier. Either (1) the Grand Canyon is of later origin than the glaciation, or (2) its walls have subsequently been modified by weathering and erosion, or (3) the granite boulders were not carried up the valley to their present position by a glacier from Lamar valley.

Granite boulders from ledges near and north of Lamar and Yellowstone rivers are scattered over slopes and hilltops to the south, high above the latter stream, showing that the ice from Lamar valley was about 2,000 feet or more thick, and crowded far up the slopes above the valley bottoms. Along the road between Tower Creek and Mt. Washburn such boulders are plentiful up to 7,800 feet above sea level, or about 1,900 feet above the river to the north. Above this height no such boulders were noted by the writer. About a mile farther south and 500 feet higher, between T.J. 8 and T.J. 9 mile posts, ledges have been exposed in grading the road which show clearly the effect of glacial abrasion. Protruding from the softer matrix of the volcanic breccia of these ledges are pieces of harder rock and tapering away from the north, or lee, side of each such projection is a half cone of the softer rock, showing rather definitely that there the ice was moving northward down the slope from the Washburn Range.

These relations lead to the following suggestions:

Glacier ice from the lower Lamar valley may not at any stage have passed Mt. Washburn and reached the head of the Canyon, but the ice was very thick in the vicinity of Junction Butte and it may not have melted there until after the plateau south of Mt. Washburn was cleared of ice. If the Yellowstone valley from the south end of the lake to Mt. Washburn was cleared before the valley was cleared to the north, water must have been ponded in the valley to a height determined by the lowest elevation of outlet. There are several passes south of the lake with elevations of about 7,900 to 8,000 feet above sea level, and through one or more of these the ponded waters may have escaped southward to Snake River. Great bergs breaking from the front of the ice north of Mt. Washburn might thus float southward and carry granite boulders to what is now the head of the Canyon. As the ice front melted back, down the north slope of the Washburn Range, it would finally open an outlet for the water to the northwestward and reverse the direction of flow about the east end of the range.

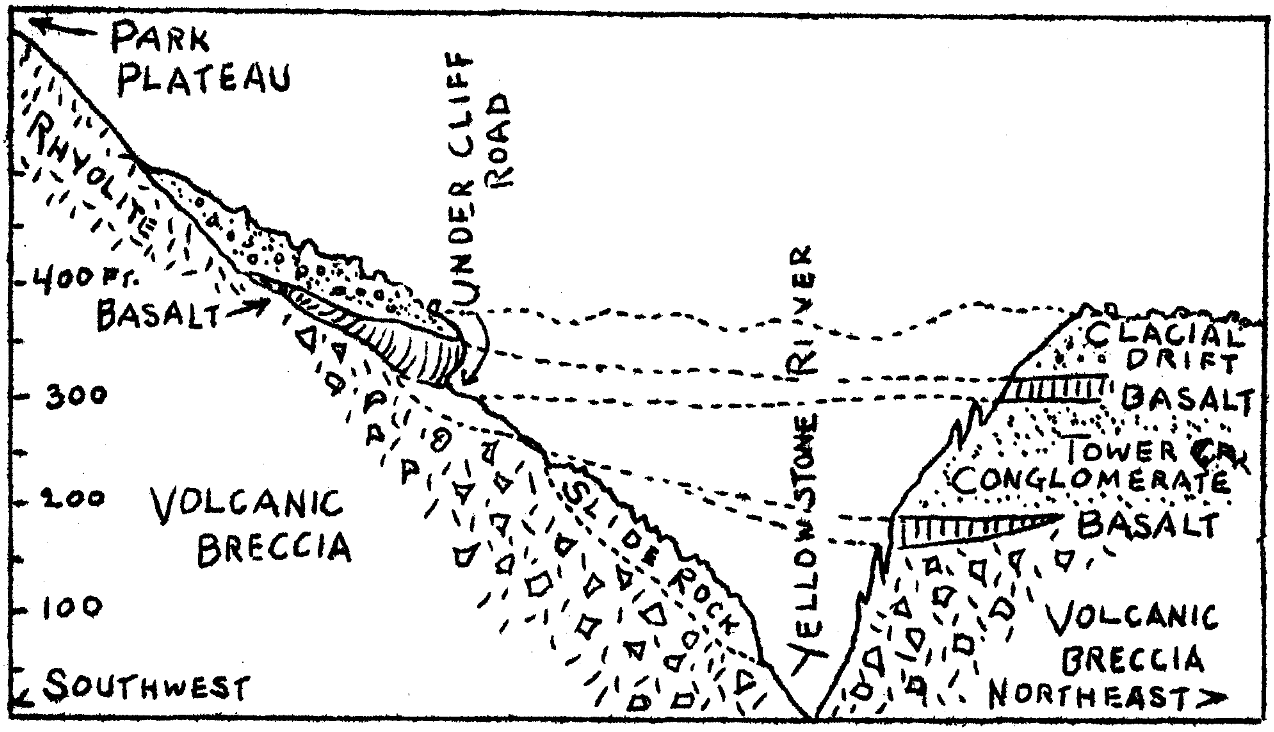


Fig. 1. Cross-section of post-glacial gorge of Yellowstone River below mouth of Tower Creek.

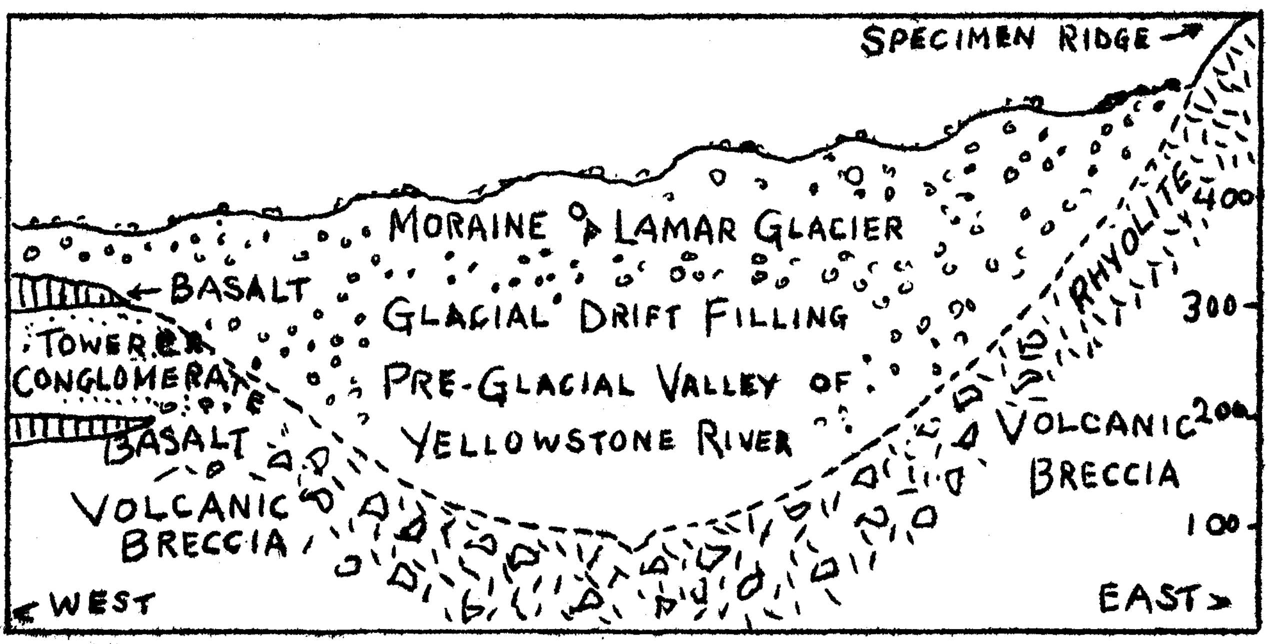


Fig. 2. Diagram of north bluff of Yellowstone River east of mouth of Tower Creek.

YELLOWSTONE NATIONAL PARK AND ITS ENVIRONS DURING THE GREAT ICE AGE

By Wm. C. Alden, Ph.D., Geologist
U. S. Geological Survey

Crests of mountain ranges

Continental Divide

Lakes

Approximate outer limits of glaciers of the Great Ice Age, including terminal moraines

Directions of ice movement

As -	Ashton	Lo -	Logan
Bo -	Bozeman	Me -	Meeteetse
B.T.-	Big Timber	Mo -	Moran
Ch -	Chicory	M.S.-	Mammoth Springs
Ck -	Cooke	M.W.-	Mt. Washburn
Co -	Columbus	No -	Norris
Cy -	Cody	O.F.-	Old Faithful
Du -	Dubois	Pr -	Pray
Ga -	Gardiner	Ro -	Roscoe
G.G.-	Gallatin Gateway	R.L.-	Red Lodge
J.B.-	Junction Butte	T.F.-	Tower Falls
Ky -	Kelly	Vr -	Victor
La -	Laurel	W.Y.-	West Yellowstone
Li -	Livingston		

GLACIAL BOULDER

Probably the most interesting phenomena associated with the glaciation of the Park (some of which appear to have been overlooked by some earlier writers) are to be seen between the mouth of Tower Creek and thejunction of Yellowstone and Lamar rivers. A wonderful succession of deposits is exposed in the northeastern wall of the canyon, which is 400 to 500 feet deep at this place, and much of this is in plain view from the Undercliff automobile road. The lower part of the great canyon wall (fig. 1) consists of volcanic breccia (A), or debris thrown out by explosive eruptions far back in the Tertiary period (Miocene). Above this, and exposed in places, is the lower palisade of basaltic columns (B), the edge of a lava flow which occupied an ancient post-Miocene channel. Upon this basalt is 100 feet or more of partly cemented stream gravel (C-Tower Creek conglomerate). In this gravel were found remains of an extinct species of horse ([illegible] Pliocene or late Tertiary). Recent study shows that this gravel lies in an ancient river channel, which was eroded after the eruption of the great sheets of rhyolitic lava which underlie the major part of the Park plateau. This gravel is also exposed along the automobile road on the southwest side of the canyon below the overhanging cliff, and also farther north where the road is back from the cliff. Above the conglomerate is the upper palisade of basalt columns, the edge of a later basalt flow (D). This is part of the same sheet of basalt as forms the overhanging cliff above the automobile road. This basalt flowed down over the southwest side of the ancient valley, which was cut into the rhyolite of the Park plateau, and spread out over the Pliocene river gravel in that valley, apparently shoving the river over against thwwest slope of Specimen Ridge. Just when this basalt flow occurred is not known, but it was evidently after the Pliocene horse had left its bones in the ancient river gravels. The river then cut a new valley directly north of the bend of the present canyon, which is east of the mouth of Tower Creek. Through this newer valley the stream flowed to join Lamar River either east or west of Junction Butte.

Onelooking north to northeast from the hills east of Tower Creek Camp can see that the basalt palisades do not extend eastward to the slope of Specimen Ridge (fig. 2). In this gap is the ancient valley now filled with glacial drift. Glacial drift (E) also overlies the upper sheet of basalt on both sides of the present canyon below Tower Creek. From this relation it is evident that Yellowstone River [illegible], below the mouth of Tower Creek is now flowing in the last of a series of stream channels, and that the present gorge there has been eroded since the glaciation of the Park began. Indeed, it may be that the river was there shifted to its present course by the last of the great glaciers which entered the Yellowstone valley from Lamar valley. Whatever may be the details of history of Yellowstone River above the vicinity of Tower Creek, it is evident that in this part of its course the stream has had a remarkably checkered career.

It may be that the terminal moraine in the vicinity of Junction Butte was formed at a readvance of the ice following a recession.

At any rate the ice front evidently stood there for some time and it then completed the filling of the old river gorge with drift and supplied conditions for shifting the river to its present course below Tower Falls. The river then started cutting the gorge (which is now 400 feet to 500 feet in depth at this place) through the drift, the two basalt flows, the Tower Creek conglomerate, and deep into the underlying volcanic breccia.

Relations indicate that an enormous glacier moved westward down Madison Canyon. At Gibbon Falls glacial till is exposed in the road and one surface (possibly of a rock ledge, but probably of a boulder) shows very well the effect of glacial abrasion. Much ice also moved southwestward across the central plateau to join that in the Madison valley. The presence of some granitic pebbles along and near the road north of Norris basin indicates that either ice, or water from melting ice, went southward through the pass from the head of Obsidian Cliff. The granitic ledges nearest there are at the east base of the south part of the East Gallatin Range near Indian and Winter creeks. Most of the ice heading in the cirque-scalloped crest of the East Gallatin Mountains went northeast to Gardiner River valley, overriding Terrace Mountain and leaving boulders high up on Bunsen Peak. Bouldery morainal deposits between Mammoth Hot Springs and the Gardiner River bridge probably mark one of the last positions of halt of the ice front when it was being melted back to its source.

One great glacier heading on the west flank of East Gallatin Mountains advanced down Fan Creek valley to the Gallatin valley and deposited a low bouldery moraine between the Montana State line and Bacon Rind Creek. Here Gallatin River has been diverted to the north side and cut a small gorge through a ridge of limestone north of the road. Another glacier in Upper Gallatin valley barely reached the Montana line and laid one moraine at the north side of its bilobate end and another at the south side of a pond in a pass which leads southward to Grayling Creek.

A third glacier, either at the earlier or later stage, turned southward near the Montana boundary and may have contributed to the great piedmont lobe which covered more than 100 square miles of the bottom of the great basin in which is West Yellowstone Station and Hebgen Reservoir. Boulders of granitic rock, such as is exposed on the headwaters of Grayling, Campanula, and Gneiss creeks, are among those lying on a morainal deposit beside the road north of Hebgen Reservoir. Boulders of rhyolite, basalt, and gneiss perched on gneissic ledges on top of Horse Butte may also have been carried there by ice moving westward from the highlands in the Park, but this may have been at an earlier glacial stage.

At the mouth of Beaver Creek, west of the bend in the middle canyon of the Madison below Hebgen Reservoir, the automobile road skirts the foot of a great terminal moraine. Here a great glacier heading in the Madison Range to the north moved southward and built its moraine, nearly or quite blocking the Canyon for a time. Possibly a lake was formed in the valley above and while the glacial dam held at this point the fine obsidian sand and gravel which underlie the broad terraces north and west of West Yellowstone were deposited in the lake.

Other glaciers occupied mountain gorges of the Madison Range and a whole series of great moraines encircled the mouths of canyons which gashed the west flank of these mountains and some of those on the east flank. There were also smaller glaciers in the West Gallatin Range. Morainal deposits above and below Ringling Ranch on Taylor Creek, 4 or 5 miles northwest of the northwest corner of the Park, indicate quite definitely two distinct stages of glaciation. It does not appear, however, that the valley of Gallatin River was occupied by glacier ice below the point where it enters Montana near the mouth of Fan Creek.

The limit of the last advance of the ice from the Park southward into Jackson Hole is marked by the great terminal moraine at the south end of the basin of Jackson Lake. Wonderful moraines of the Teton Mountain glaciers also inclose the basins of Jenny Lake and the other beautiful glacial lakes farther south. Ice in Falls River basin at this stage extended no farther southwest from the Park than the vicinity of Indian Lake near the Idaho-Wyoming State line. Probably the glaciation of the basalt ledges near the road south of Bechler River Ranger Station, cited above, occurred at this time.

In the southwestern corner of Lower Geyser basin is a peculiar curved ridge rising about 500 feet above the surrounding flat. This is known as Twin Buttes. These buttes are composed of volcanic debris and they are so connected that the abrupt southeast faces compose the wall of a crater-like amphitheatre nearly half a mile in diameter. Indeed, it may be that this actually is a volcanic crater with one side blown out. Steam issues from crevices near the top of the buttes, and at the south base is a small spray geyser and a bubbling "paint pot" of hot mud. In the amphitheatre are four small lily ponds lying among the bouldery knolls and ridges of what appears to be a glacial terminal moraine. Two or three miles farther east, the auto road on the east side of Firehole River crosses a pitted gravelly deposit like a small moraine. These suggest that in the latter part of the glacial epoch a lobe of the Madison valley ice may have lain for a time in Lower Geyser basin with its front against Twin Buttes. Farther south the travertine subsequently accumulated about Prismatic Lake and Excelsior Geyser, filled the valley from side to side, and covered any morainal deposits which may have been there.

The outer limit of the ice on the east side of the crest of the Absaroka Range is crossed by the Cody road in Shoshone valley near the mouth of Eagle Creek, about 6½ miles outside of the eastern gate of the park. The absence of glacial drift and the presence of the picturesque towers, pinnacles and castellated forms developed by weathering and erosion of the volcanic breccia farther down the valley indicate that the last Shoshone glacier did not extend beyond the limit indicated.

The maximum extent of the ice in and adjacent to Yellowstone Park during the Great Ice Age was probably about 9,500 square miles. The maximum thickness was probably at least 2,000 feet. When present climatic conditions were initiated some 8,000 or 10,000 years ago the ice on the Park plateau and in the mountain gorges nearly or quite melted away. Are there no remnants of these great glaciers? There are a few small glaciers in the mountains east and northeast of the Park, each less than one square mile in extent. It is an interesting speculation as to whether these small glaciers are the last remnants of former great glaciers or the beginnings of a new ice age.

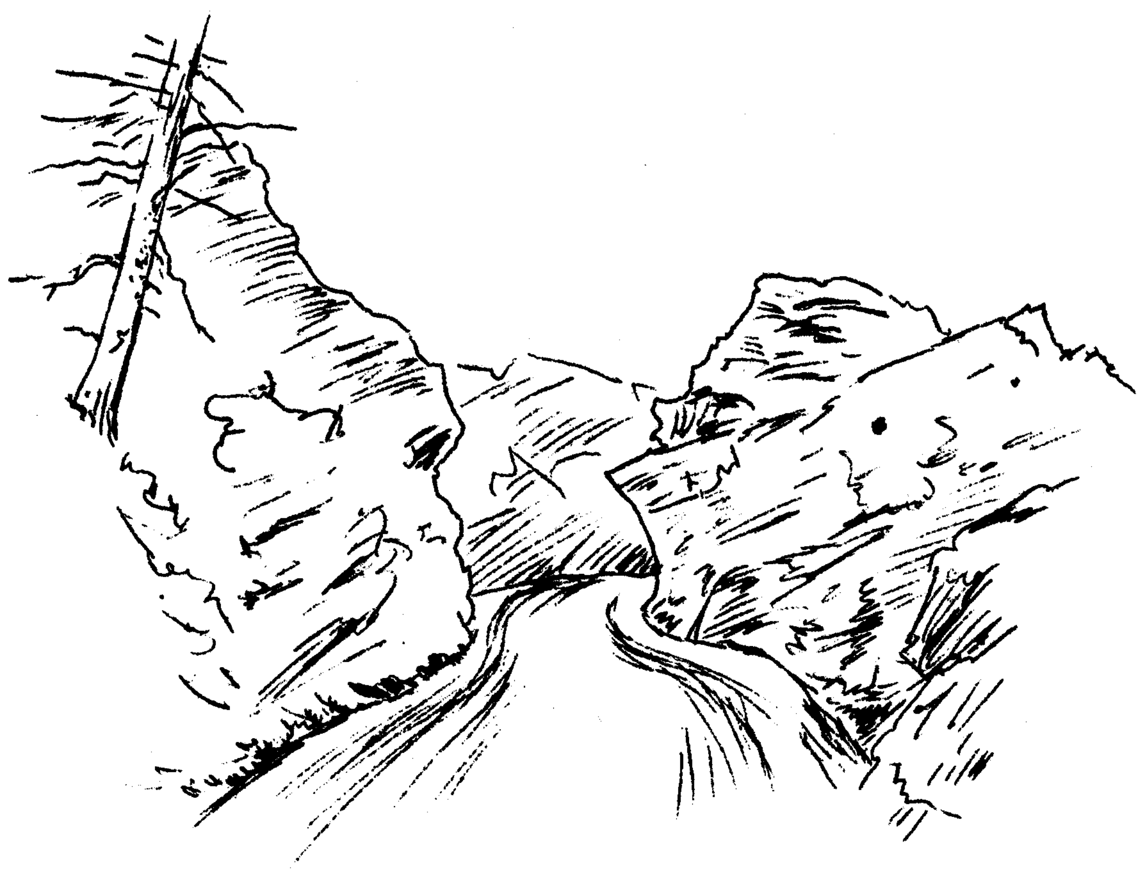
There is a small glacier on Sunlight Peak in the Absaroka Mountains about 15 miles, as the crow flies, northeast of the east Park entrance on the Cody road, and there are several small glaciers on the granitic peaks 12 to 15 miles northeast of Cooke, Montana. One of these, Grasshopper glacier, is particularly interesting on account of the remarkable structure of the stratified ice, and on account of the presence of included remains of grasshoppers. Facilities are provided at Cooke for reaching this glacier by horseback. These small glaciers all lie about 10,000 feet above sea level. The outer limits of the glaciers of the Great Ice Age in the region of Yellowstone Park range in elevations above sea level as follows: 4,500 feet on Clark Fork to the northeast, 5,000 feet in Yellowstone valley on the north, 6,600 feet in Madison valley on the west, 6,800 feet in Jackson Hole on the south, 7,000 feet in Gallatin valley to the northwast.

After Yellowstone River cut the newer part of its gorge (that below the mouth of Tower Creek) it renewed cutting along the canyon farther south. The down-cutting of the stream and the weathering and crumbling of the volcanic rock composing the sides of the gorge has brought this magnificent canyon to its present condition. It is not at present clear to the writer just how much of the erosion of this canyon was accomplished since the disappearance of the last ice cap from the Park Plateau and how much is to be referred to earlier stages.

One of the striking features of Yellowstone Park is the jumble of great blocks of rock known as the "Hoodoos", crossed by the road between Mammoth Hot Springs and the Golden Gate. These rocks are composed of travertine such as caps Terrace Mountain to the southwest. Apparently the travertine was in part underlain by soft clay shale, and the cliff may have been undermined by the glacier ice which came over it from the southwest. At some time after the last ice melted away, enormous masses of the travertine broke away from the cliff and slid down to their present position.

Certain irregular hummocky deposits resembling terminal moraines appear to be the products of landslides. Such deposits occur at many places in the Rocky Mountains. They are mostly of post-glacial origin and are particularly apt to occur where beds of clay shale such as those of cretaceous age were upturned when the mountains were uplifted. The force of gravity is continually trying to pull down the mountains. Not for a moment does it cease its pull. Such upturned clay beds become saturated with water and, especially where not buttressed by more rigid rocks, are liable to cause the overlying beds to slide down onto the adjacent lowlands. The flood which swept the village of Kelly in Jackson Hole in May, 1927, was the result of a break in a great dam which had been formed by a landslide in June 1925. This slide had blocked the Gros Ventre valley and formed a lake about 5 miles in length, with a maximum depth of about 225 feet. As the result of the breaching of the dam in May 1927, the lake level was lowered about 60 feet but there is yet (in December 1927) a considerable body of water there impounded.

It should be noted that the glacial history of the Park and its environs as here presented differs in some respects from that indicated by earlier writers. These interpretations are more or less tentative, awaiting more detailed study of the phenomena.



SILVER GATE

THE AMERICAN BISON IN YELLOWSTONE PARK

By Marguerite Lindsley, Park Ranger

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Ansel F. Hall, Chief Naturalist, National Park Service

In 1894 Emerson Hough, who made the trip through Yellowstone Park on skis that winter, estimated that the park buffalo probably numbered around 150, the remnant of the native animals of this section. Subsequent to his poachers further reduced the herd until in 1902 it was reported that only 22 remained in the park herd. At that time there were four in captivity on Stevenson Island in Yellowstone Lake, owned by the boat line concessioner, Mr. E. C. Waters. In July 1902 the world's total of pure blood bison was 1,676 animals. At the close of 1922, twenty years later, the American Bison Society census showed 12,521 bison in the world, and the 1926 census gives the total number of pure blood bison throughout the world as 16,517, of which 16,437 are in North America.

Canada's big captive herd is the largest herd in the world but it is the product of the Pablo-Allard herd of Montana, purchased by the Dominion Government in 1907.

In 1902 $15,000. was appropriated for the establishment of a new Yellowstone Park herd. Colonel C. J. Jones ("Buffalo Jones"), famous scout and buffalo hunter, was employed as Game Warden. Eighteen cows were acquired from the Allard herd near the Flathead Agency, Montana, and delivered by Howard Eaton, famous Wyoming guide. Three bulls were purchased from the Goodnight herd in Texas and brought back by Buffalo Jones.

In 1908 the new herd had increased to 74 animals. This year (1908) hay was cut for the first time at the Buffalo Ranch, one hundred tons being cut and stacked during the summer. That year 35 wild buffalo were seen, an increase of 13 in six years, while the new herd had increased by 53.

In December, 1911, there were 147 animals in the new herd and it then suffered its first set-back. Hemorrhagic septicemia, a blood poisoning resembling black-leg, attacked some of the younger animals and 22 died. A serum to protect the herd was developed and in June, 1912, the animals were vaccinated. Again, in 1919 there was an attack of this disease and 13% of the herd, from the younger animals, was lost. Vaccinations were made in 1919, 1920, and 1921. In 1922 the third outbreak of septicemia claimed 16% of the herd total of 506.

"Having suffered such a heavy loss in 1922, and knowing that the disease is capable of exterminating a herd of buffalo in a short time, we no longer take any chances on its getting a good start while we 'call a doctor'". (Superintendent Albright) Fresh serum is kept on hand at all times at the Buffalo Ranch, together with instruments with which to vaccinate the herd at the first sign of another outbreak.

At present there are three designations for the buffalo in the park; the Show Herd at Mammoth, the Mountain Herd which roams the high country of the east side of the park, and the Lamar Valley Herd. The Lamar Valley Herd total at this time (January 16, 1928) is 886, consisting of 221 bulls, 151 steers, 393 cows and heifers, and 121 calves. This herd grazes well back in the hills at the headwaters of the Lamar and its tributaries in the summer, but they come down with the early storms to the Buffalo Ranch. In midwinter when they cannot forage through the deep snows they must be fed. In the summer a great fence of logs, seven feet in height, holds the herd in the upper valleys away from the hay fields which produce their winter feed.

One hundred and one buffalo have been shipped to public parks, zoos, and private estates for exhibition purposes, and 70 have been shipped as a nucleus for new herds at other points. One hundred and ten have died from hemorrhagic septicemia, which occurred during the years of 1912, 1919, and 1922.

The first castrations of surplus male calves occurred during the winter of 1918 when 44 calves of the 1916 and 1917 calf crops were castrated.

The slaughter of steers for market purposes was authorized in the fall of 1925 and 38 have been slaughtered since then.

A total of 40 infirm, decrepit, and injured animals have been killed, and other losses resulting from accidents, calving, fighting among themselves, and the severities of the winter seasons, amount to a total of 65.

There has been a depletion of 288 in the herd total during the past eight years, or an average of 36 annually. Our facilities are ample for handling a herd of 1,000 head and we expect to reach this figure with the calf crop of 1928. The problem will then be to keep the herd total somewhere near this figure or increase our hay lands and other facilities.

The desired method of controlling the increase is to find a market for the steers and cull out aged, infirm, and crippled animals from year to year.

We normally ship about two dozen for exhibition and stocking purposes each year. Our total shipments this year consisted of 26 live animals and 23 slaughtered steers.

DESTRUCTIVE INSECTS OF YELLOWSTONE NATIONAL PARK

By Dr. H. E. Burke, Entomologist,
Bureau of Entomology, U.S.D.A.

Approved by:
Superintendent Horace M. Albright

Forest insects kill trees in three ways: by destroying the foliage, by destroying the inner bark of the main trunk, or by destroying the small rootlets. At the present time the important pests of the forests of the Yellowstone fall into the first two classes -- defoliators and bark destroyers or girdlers.

The defoliators are again divided into those which destroy the foliage by biting and chewing it, and those that suck the sap until the needles die, turn brown and finally fall from the tree.

To fight the biting defoliators it is necessary to apply a stomach poison to the foliage, which they will take into the alimentary canal when they are eating the needles. To fight the sucking defoliators it is necessary to place in contact with them a smothering or burning substance while they are on the foliage. Either of these materials may be applied to the foliage in the form of a liquid spray or of a dust. Arsenate of lead is the stomach poison usually used, and sulphur, nicotine or petroleum oil the contact poison.

Both stomach and contact sprays have to be applied by the use of special machinery, such as sprayers, dusters, airplanes etc., which makes these methods of control expensive and applicable only to areas of special value, such as roadsides, camp sites etc.

The bark destroyers are fought by felling the infested trees and destroying the insects developing in the inner bark. Sometimes the tree is barked so that the broods die from exposure, sometimes the tree is burned, and sometimes it is placed where it will be exposed to the direct rays of the sun for from three to seven days and then turned. An air temperature of 80° will give a bark temperature of 110° to 120°, which will kill some of the more important girdlers in three hours' exposure.

The most important forest insects of the Yellowstone are three biting defoliators and five bark beetles. The defoliators are the spruce budworm, Cacoecia fumiferana (Clemens), which has killed numerous Douglas firs near Roosevelt Lodge, and the lodgepole sawfly, Neodiprion sp., and the lodgepole needletyer, Eulia sp., killers of many lodgepole pines near West Yellowstone. The five bark beetles are the Douglas fir beetle (Dendroctonus pseudotsugae Hopk.), responsible for many of the budworm-defoliated Douglas firs near Roosevelt Lodge as well as the death of healthy Douglas firs at Roosevelt Lodge and Tower Falls; the mountain pine beetle (Dendroctonus monticolae Hopk.), killer of lodgepole pine in the Sylvan Pass area, at Cub Creek and at Dunraven Pass; the Engelmann spruce beetle (Dendroctonus engelmanni Hopk.), killer of many Engelmann spruce east of Yellowstone Lake; the fir beetle (Dryocoetes confusus Sw.), killer of Alpine Fir in the Sylvan Pass area, and the Oregon engraver beetle (Ips oregoni Eich.), which has caused the death of many lodgepole pines in the camp sites at Old Faithful, Thumb, Lake, Fishing Bridge, and on some of the geyser formations, such as the Roaring Mountain and Mud Volcano areas.

One sucking defoliator, the spruce gall aphid (Chermes cooleyi Gill.), caused considerable alarm in the spring of 1927. The foliage of many of the Douglas firs along the Madison and Gallatin Rivers turned brown and fell from the trees. So far as could be determined the aphid was the cause of the trouble. The new foliage, however, came out in good condition, and it is not believed that any serious permanent damage resulted.

THE SPRUCE BUDWORM

The full-grown spruce budworm is a dark brown or reddish brown caterpillar, about an inch long, with a black head and marked with a number of light yellow tubercles. It lives in a nest of chewed needles, loosely chewed, and webbed together in the opening buds of fir, Douglas fir, spruce and other coniferous trees. Very often it is seen hanging down from the tree on a long web.

About the tenth of July most of the caterpillars transform in the nests to reddish-brown mummy-like chrysalids three-fifths of an inch long. Seven to twelve days later each healthy chrysalis produces a grey or brown moth, mottled with darker brown patches, streaks and spots, and with a wing spread of about one inch.

Upon emerging the moths fly about on the foliage and from tree to tree. Mating soon takes place, and the female lays masses of eggs on the foliage. The eggs are pale green, oval and flattened. They are laid in overlapping rows, usually on the under sides of the needles. The eggs hatch in from ten to twelve days and each young caterpillar crawls to some protected place, such as under a scale of bark or an old cone, where it spins a small white hibernating cocoon and spends the winter in retirement.

In the spring about the time that the new growth starts and the buds begin to open, the young caterpillars leave their hibernation cocoons and mine into the opening buds. Most of the needles in a bud are eaten off and the young twig is blighted. A single caterpillar may blight more than one bud. During an epidemic infestation when they are in great numbers, all the new growth may be killed by the young caterpillars and all the older foliage destroyed by the feeding of the older caterpillars.

One year's complete defoliation will kill some trees, and three or four years' defoliation will kill most of them.

The application to the foliage of a poison spray or dust about the time the new buds are opening is the only method of control thought feasible for this pest.

THE LODGEPOLE SAWFLY

The adult female lodgepole sawfly is a small brownish wasp-like insect about 5/16 inch long, with a wing spread of three quarters of an inch. The male is smaller and black, with many-branched antennae.

The sawflies emerge from the ground about the first of June and fly to the foliage of the trees when they mate. The female then lays her eggs in shoe-shaped pockets on the edge of a needle, two to eleven eggs to a needle. In about a month the eggs hatch out and the young caterpillars mass together around a needle and start feeding on it.

In feeding the caterpillars eat irregular patches of pulp from the outer surface. Sometimes they strip off the pulp completely leaving only the midrib. As they grow older they scatter somewhat and eat the entire needles down to the sheath. Most of the feeding is done on the older needles, but sawfly caterpillars will eat the new growth.

The full-grown caterpillar is smooth and of a greenish or greyish-green color marked by lighter stripes along the sides and the back. It is about an inch long and has a dark brown head with conspicuous black eyes. There are three pairs of true legs and eight pairs of fleshy false ones.

About the middle of September the caterpillars are full-grown and drop to the ground. As soon as each finds a suitable place under the top layer of old needles that cover the ground, it spins a tough brownish parchment-like cocoon around itself and shortens up into a dark-green, quiescent grub-like stage. In this stage it passes the winter, or even the second or third winter, before it transforms to a chrysalis-like pupa and then to a sawfly which emerges and flies to the foliage to make and start a new generation.

During the period 1921-1925 the sawfly and the needletyer, working together, killed about 12,000 acres of lodgepole pine forest near West Yellowstone. The Park Service protected the trees along the highway between West Yellowstone and the Madison River Bridge by using an arsenical spray on the foliage during 1924, 1925, 1926 and 1927. The formula used was 25 pounds of powdered arsenate of lead and one gallon of fish oil to each 400 gallons of water, applied with a large power sprayer.

THE LODGEPOLE NEEDLETYER

The adult lodgepole needletyer is a small brownish-grey moth with a wing spread of three-eighths of an inch. Sometime between the fifteenth of May and the first of July it emerges from a small brown mummy-like chrysalis which has overwintered under the top layer of old needles on the ground in the forest. Soon after emergence the moth flies to the foliage of a lodgepole pine, mates, and the female lays a mass of from one to twenty-five flat oval slightly corrugated light-green eggs on the concave side of the needle. Usually the eggs are laid overlapping one another in two alternating rows near the middle of the needle.

About nine days after they are laid the eggs hatch out and the young caterpillars crawl around over the foliage until they find a suitable needle. When a suitable needle -- usually one of the new growth -- is found, a hole is gnawed through the surface near the tip, and the interior is mined out for food and to form a protective tube for the inmate.

In about two weeks the young caterpillar has eaten most of the needle's interior and has become too large for its home. It therefore sheds its skin, emerges from the needle, and drawing several surrounding needles to it webs them together to form a large tube. Within this web-lined tube it lives until full-grown, feeding on the surfaces of the needles, and enlarging its home as needed by drawing together more needles.

As soon as a caterpillar attains maturity, which is about the first of September, it drops to the ground by a long silken thread, crawls under the top layer of needles, finds a suitable place, webs together a few old needles or old cone scales and changes to the brown mummy-like chrysalis, in which stage it spends the winter.

When the caterpillars occur in epidemic numbers the leaf surface of many of the trees is almost completely destroyed by the end of August. Several years of this kind of defoliation will kill some trees.

Working in cooperation with the sawfly, the needletyer killed about 12,000 acres of lodgepole pine near West Yellowstone during the period 1921-1925.

The arsenate of lead spray is a good control for this species.

THE DOUGLAS FIR BEETLE

The Douglas fir beetle is the most important barkbeetle enemy of forest trees in Yellowstone Park. Hundreds of Douglas fir trees have been killed in the areas near Crescent Hill, Garnet Hill, Hellroaring Mountain and along the Yellowstone River between Little Buffalo Creek and Blacktail Deer Creek. Small groups of trees have been killed at Roosevelt Lodge and at Tower Falls.

The adult insect is a stout reddish to blackish brown cylindrical beetle about one-fifth of an inch long. The pupa (chrysalis) is about the same size as the beetle, white, and has the wings and legs folded on the chest. The top of the head is flattened. The larva (grub) is about three-tenths of an inch when grown, and is white with a brown head.

Usually the winter is passed in the young-beetle stage under the bark of a dying tree. Sometimes a single beetle is found in a cel by itself, but more often the inner bark will be so completely mined out that a number of beetles are found together in a common chamber.

The young beetles emerge from their winter quarters during the period April to July and attack new trees. In budworm areas they attack the trees that are weakened by budworm defoliation; in other areas they attack trees weakened by fire or other injury, or even trees that appear in perfect health.

In attacking a tree the beetles start in a crevice in the bark of the main trunk and gnaw a mine through the outer bark and nearly straight up through the inner bark for from eight to fourteen inches. The female beetle, as she gnaws her way along, deposits from 60 to 160 eggs in alternate groups along the sides of the mine.

The eggs hatch in about two weeks after they are laid and the young grubs start lateral mines of their own in the inner bark. Each grub (larva) makes its own mine, feeding and growing as it goes. The larval mine is narrow when it starts from the parent mine, but is broadened by the grub as it grows and mines along. Fully developed larval mines are from three to six inches long.

By the first of August many of the grubs are full-grown and ready to start transforming into the pupal (chrysalis) and beetle stages. An enlargement of the end of the mine is made from the inner bark, and in this so-called pupal cell the transformation to beetle takes place.

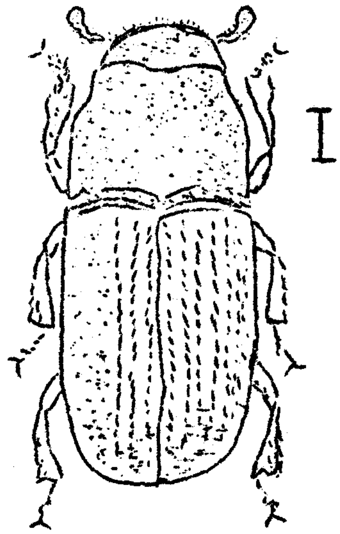
The young beetles mine through the inner bark until most of it is destroyed. Some may emerge from the tree in the fall, but most of them remain under the bark until the next spring.

Trees infested with the Douglas fir beetle are indicated by the reddish boring dust lodged in the crevices of the bark and on the ground at the base, and by the yellowing or reddening of the foliage.

Control consists of felling and barking or felling and burning the infested trees before April first of the year following an attack.

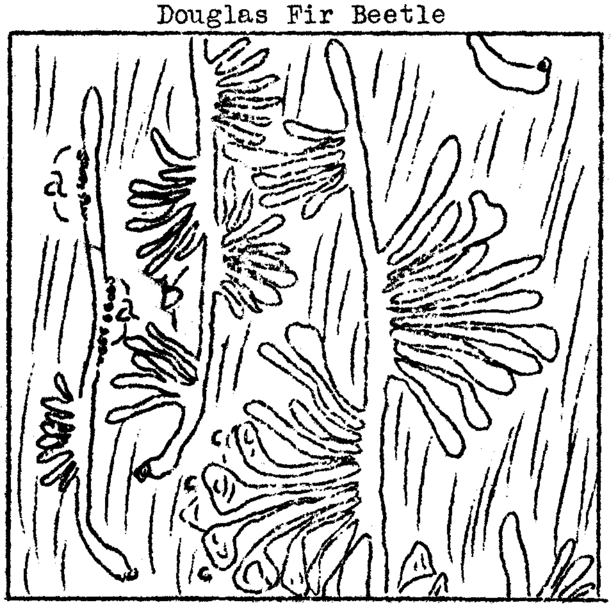
Mountain Pine Beetle

a-eggs. b-larval mines. c-pupal cells
(Reduced)

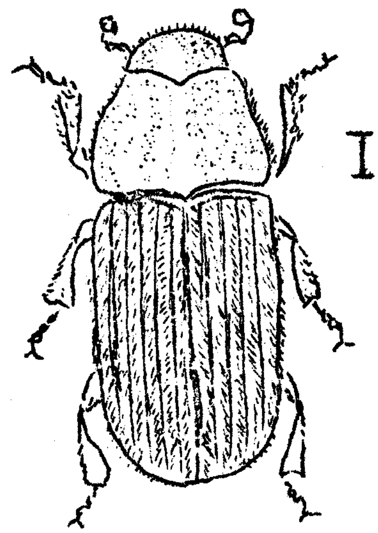


Adult Mountain Pine
Beetle (Greatly Enlarged)

Douglas Fir Beetle



a-eggs. b-larval mines. c-pupal cells
(Reduced)



Adult Douglas Fir
Beetle (Greatly Enlarged)

THE MOUNTAIN PINE BEETLE

The mountain pine beetle attacks and kills all species of pines that occur in the Yellowstone. It is a destructive enemy of the lodgepole throughout most of our range, and has killed nearly all the mature trees in large areas in the Yosemite and the Crater Lake Parks. During the last few years it has killed numerous lodgepole and white-bark pines at Cub Creek, and whitebark pines at Dunraven Pass.

The adult insect is a black cylindrical barkbeetle about one-fifth of an inch long. The pupa (chrysalis) is about the same size as the beetle, but is white and has the legs and wings folded on the chest. The top of the head is deeply grooved and there are two prominent forward-curved spines in front. The larva (grub) is about three-tenths of an inch when grown, and is white with a brownish head. The front is marked by a prominent transverse rugose elevation.

The winter is passed as parent beetles, larvae or young beetles in the inner bark of dying trees. In July the young beetles start to leave the dying trees and attack new ones. The emergence and attack continues into September or October, though most of the attacks are probably made in August. Fire-scorched and otherwise injured trees are attacked in many cases, but often thousands of perfectly healthy trees are killed.

Usually the attack starts in a crevice of the bark of the main trunk. A tunnel from twelve to thirty-six inches long is gnawed nearly straight up through the inner bark by the parent beetle. The eggs are laid in small niches in the sides of the tunnel. The entrances to most of the tunnels are marked on the outer bark by masses of resin mixed with boring dust, the "pitch tubes".

The eggs hatch in from ten to fourteen days after they are laid and the young grubs start lateral mines in the inner bark. A few grubs become full-grown in from sixty to ninety days, and transform to pupae and then to beetles; but most of the brood does not mature until June of the following year. The larval mines are from two to three inches long and each terminates in an enlargement, the pupal cell, within which the transformation to pupae and beetles takes place.

The combined boring of the parent beetles and the larvae completely kills the inner bark of the tree attacked, and by fall they start dying. Some turn red, but many remain green until the following July.

Trees infested with the mountain pine beetle are indicated by the reddish boring dust lodged in the crevices of the bark and on the ground at the base, by the "pitch tubes" on the bark, and by the yellowing or reddening of the foliage.

Control consists of felling and burning the infested trees, or felling and placing them in the sun for several days and then turning them. An air temperature of 80° F. for three hours will give a killing temperature in the bark of from 110° to 115°.

THE ENGELMANN SPRUCE BEETLE

The Engelmann spruce beetle looks and lives very much like the Douglas fir beetle. The beetle is usually broader and dark, and the larva bears a pair of plates on the back of the last two segments. The tunnels under the bark are usually shorter.

Both Engelman spruce and blue spruce are attacked and killed. Numerous mature Engelmann spruce have been killed during the last few years on Frank Island and in the forests east of Yellowstone Lake. A few infested trees were found in 1926 at Grayling Creek snowshoe cabin, near the northwestern boundary of the park.

The species overwinters as larvae and young beetles in the inner bark of the trees attacked during the preceding summer. Development is completed and the young beetles emerge and attack new trees during June or July.

The first evidence of an attack by this species is the reddish boring dust in the crevices of the bark and on the ground. Often woodpecker work shows on the bark. Later the needles fade slightly and fall to the ground.

Control consists of felling the trees infested and barking them before May first of the year following the attack.

THE FIR BEETLE

The fir beetle is about three-sixteenths of an inch long, cylindrical, slender, dark brown or blackish in color, and clothed with reddish hairs when viewed under the microscope. It attacks and kills the Alpine fir in various sections of the park. In 1926 a number of trees were killed in the Sylvan Pass section.

The species overwinters in the inner bark in the larval and young beetle stage. Emergence and attack on new trees takes place in the spring. The tunnels made by the parent beetles curve considerably and often extend horizontally instead of straight up the trunk like the Douglas fir beetle, mountain pine beetle and the Engelmann spruce beetle. The eggs are laid in niches along the sides of the tunnel, and the larval mines wind irregularly through the inner bark.

An infestation is indicated by the boring dust on the bark and the yellowing or reddening of the foliage in September and later.

Control consists of felling the infested trees in the spring and burning or barking them.

THE OREGON ENGRAVER BEETLE

One of the most important forest insect problems in the Yellowstone is the protection of the trees in the various camp areas. Such trees are growing under more or less unnatural conditions caused by the various activities of many more or less irresponsible human beings. The soil over the roots becomes packed, causing a lack of proper aeration, and the bark of the main trunk is injured by the scorching of many camp fires, by nail holes, ax cuts, scraping of automobiles and in various other ways.

The creation of unnatural conditions in any forested area usually leads to a concentration in the area of the insects that normally live in the broken tops, branches and wind-fallen trees which are scattered throughout the surrounding forest.

The hot water overflows and other activities around the geyser formations also create unnatural conditions and a similar concentration of injurious forest insects.

Probably the most important insect enemy of the trees in the camp and geyser-formation areas of the Yellowstone is the Oregon engraver beetle.

The beetle is about three-sixteenths of an inch long, blackish or reddish brown in color, cylindrical, with the rear end excavated and marked by four teeth on each side of the excavation. The larvae are small white grubs with brown heads. The pupae are shiny, white, and about the same size as the beetles. All stages are found in the inner bark of the main trunk of dying trees.

In the Yellowstone there are two generations of the Oregon engraver beetle each year. Beetles from the overwintering generation emerge from the dying trees during the last of June, attack new trees and lay eggs which develop into the second generation. Beetles from the second generation emerge the last of August from the trees they have killed, attack new trees and lay eggs which develop into the overwintering generation of the following year.

The Oregon engraver beetle in attacking a tree usually starts in a crevice of the bark and gnaws through the outer bark down into the inner bark, where it hollows out a small chamber. From this from three to five female beetles gnaw separate tunnels, which radiate out in all directions from three to six inches through the inner bark. The eggs are laid along the sides of these tunnels in separate niches. Each grub forms a separate mine through the inner bark. This mine is from one to three inches long and generally becomes wider as the grub grows. The mine terminates in a small cell or enlarged portion in which the grub transforms into the pupal and beetle stages.

Infested trees are indicated by the red boring dust in the crevices of the bark and on the ground at the base of the tree, and by the yellowing or reddening of the foliage.

Control consists of felling and burning the infested trees during the late fall or early spring.

THE SPRUCE GALL APHID

The spruce gall aphid is a small, dark, scale-like sucking insect which spends the winter resting upon the upper surface of a Douglas fir needle. In the spring, as soon as the weather becomes warm, it starts to grow, sheds its skin and throws out a protective covering of long curled threads of a white secretion that resembles wool. About the first of May, twenty-five to forty light-yellow eggs are laid under the woolly covering. These hatch when the new growth of the tree starts and the young crawlers move out on the needles, insert their beaks into the tender growth and commence to feed and grow. It is the sucking of the sap in feeding that injures the needle, and if the insects are sufficiently numerous causes it to turn brown, die and finally fall from the tree.

As soon as the aphids are full grown, they lay eggs as their parents did. These eggs soon hatch, and the young insert their beaks into the needles, take on a dark color, secrete a little "wool" about themselves, and so remain until the following spring before growing and becoming adult.

Certain individuals of the spring generation develop wings and fly away to the Engelmann spruce, where they lay their eggs on the needles. The young hatching from these crawl to the developing buds of the spruce and settle at the bases of the young needles and feed. The irritation of this feeding causes an abnormal growth of the bud, which forms a cone-like gall in which a new generation of insects develop. The gall thus formed gives the insect the name of the spruce gall aphid.

Control consists of spraying the foliage of the infested trees in the early spring with a solution of ten gallons of miscible oil and two quarts of forty per cent nicotine sulphate to four hundred gallons of water.

While this insect caused considerable harm and alarm in the spring of 1927 because of the browning of the foliage of many Douglas firs along the Madison and Gallatin Rivers, it is usually not considered an important forest insect. Often, however, Engelmann spruce trees are covered with the cone-like galls and look rather ragged.

FISH HATCHING IN THE PARK

By Dr. Harry M. Kelly, Ranger Naturalist

Approved by:
C. F. Culler, Supervisor, Bureau of Fisheries

While most of the species of trout which customarily are artificially propagated, are found somewhere in the various streams and lakes of the Park, the native homes of the Rainbow, the Mackinaw, the Brown, the Eastern Brook Trout are elsewhere, and only the "Native" or "Cut-Throat" or "Black Spotted" or "Rocky Mountain" trout, as it is variously called, is hatched by man's agency within the Park limits. There is reason for this; the Cut-throat is a Spring breeding species, while most other trout lay their eggs in the Fall or early Winter, and the conditions of human habitation in the Park necessarily limit hatching operations to the Summer season.

Two federal fish hatcheries are maintained in the Yellowstone; the principal one, with its present capacity of about thirty millions of eggs annually, is situated on the northern shore of Lake Yellowstone near the Lake Hotel. It was originally established on this same lake, near West Thumb. A smaller or branch unit, under the same management, is located in the northeastern part of the Park, along the Cooke City road, on Soda Butte Creek. Its annual capacity is about three millions.

Open season for the hatchery staff begins as promptly as access may be had to these parts of the Park, with the partial melting of the winter's snow. As the ice leaves the lake, already the trout of both sexes are feeling the urge to reproduction, and by their instincts are led to move in large numbers towards the mouths of the streams tributary to the lake, and later to ascend the several streams themselves. Temperature seems to be the controlling factor both in the maturation of their sexual products, and also in regulating the rapidity of their ascent of the stream.

Barring unsuperable difficulties, in nature the trout will continue to ascend the stream until either they are limited by the size of the headwater stream, or they are overtaken by the coming of their own sexual maturity. Then upon convenient clean gravel bars, the eggs are poured out among the small stones, and partially covered by the restless movements of the female. Meanwhile nearby males likewise exude their product into the water, called "milt" which on coming in contact with the several eggs, perform the necessary impregnation to start the new creature upon its life journey. There is no intimate mating between the sexes similar to that with which we are accustomed in higher animals.

Hatching of such naturally laid eggs occurs in approximately a month's time, though wide differences exist, as the rapidity of development in any particular case is governed by the temperature of the local water, - things proceeding slowly with less, and more rapidly with greater heat. And for several weeks more, after the embryo is freed from the egg shell - again the precise time is determined by the temperature - the tiny fish is burdened by the great weight of its "yolk sac" hanging to its belly, until all this great mass of food originally provided by the mother fish is absorbed, and then the little "fry", as it is now called, less than an inch in length, slim, active, and hungry, soon sets forth upon its quest for food, first along the shallow, protected margin of its birth stream, and gradually further and further down stream into the deeper waters. Should the multifarious enemies of its young life be circumvented, in the course of its fourth year this trout will have become mature, and then and henceforth each year of its life, it will instinctively return in the late Spring time to its home stream for the exercise of its reproductive duties.

Each Spring, usually in middle or late May, as soon as the hatchery operatives are able to enter the streams, still swollen with the rapidly melting snow, they build across the mouths of certain chosen creeks, dams or traps, so constructed as to prevent adult fish from ascending these streams further, and concentrate them into a box or pocket, similarly to the action of a wire rat trap or the common fyke net. These traps are visited by the hatchery force daily, and the fish found here are "stripped" of their products. In practice the skilled operator will distinguish, both by form and coloration, the separate sexes, and also the immature and spent individuals. Taking the fish from the trap one by one, and holding them securely but carefully with one hand, the operator slips the other hand with some pressure along the under side, from gills to vent, and under such well controlled manipulation, causes the fish to release, without harm to either itself or its products, the eggs or sperm, as the case may be. Into a convenient pan that has been rinsed in water two or three females are stripped, then a male is caused to squirt therein its milk white milt; the process is repeated for a number of cases a small quantity of water added to bring the two sexual products together in the pan for about two to three minutes. By that time, union of the two elements has occurred, the "fertilization" necessary to start an independent life. Then the excess milt is rinsed off, and these fertilized eggs are ready to be transported in a considerable quantity of fresh cool water for the further care of the hatchery.

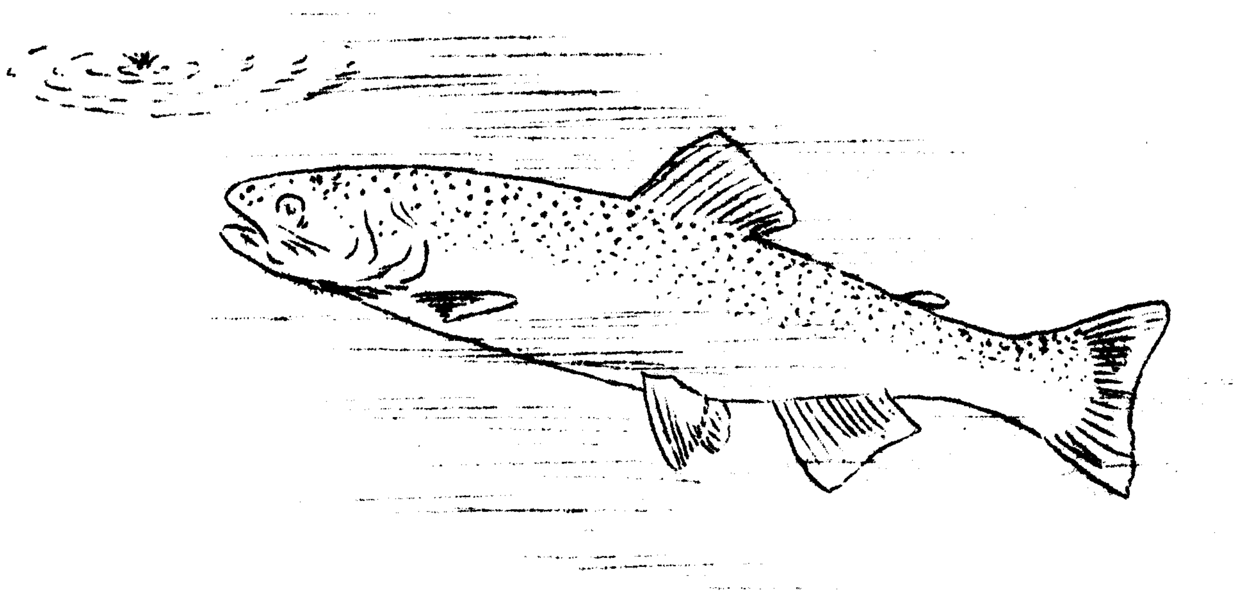
In common practice, from about one thousand to fifteen hundred eggs may be expected from each female. The table spoon full of milt, or more, from the male contains countless millions of tiny sperm cells, enough to inseminate the eggs of many females. Each season in any given locality trout eggs run remarkably true to size, regardless of the size or age of the parent fish, and it is therefore easy to calculate the numbers of eggs handled by the use of perforated measuring cups of standard content.

The stripped eggs are brought to the hatchery as quickly as possible with a minimum of disturbance or exposure to high temperatures. They are spread out, about six thousand to each container, into shallow wire mesh trays, and stacked from six to eight trays deep, are submerged in the cool clear running water of the hatchery trough. The eggs are carefully inspected within the first day of their hatchery residence, so that any not properly developing may be removed. Such spoiled eggs are detected by their white, opaque color, as contrasted with the translucent pink of the good eggs. Ordinarily less than five per cent of the eggs taken fail to develop, and this is due largely to failure in fertilization. Some later death may be due to parasitic fungi, but this is not expected in well conducted hatcheries.

The eggs lie undisturbed upon the hatchery trays, except for occasional examination to see that all is going well, until about the eighteenth day, when, if the product of the hatchery is to be shipped to a distant point, these "eyed eggs", - so-called from the distinct appearance of the two black eyes at this stage of development, are taken off the trays, given a "concussion bath" to kill off the unfertile eggs, they are then immersed in a strong salt solution and the unfertile eggs with those that have become fungused are removed by a skimming process. They are then placed on trays and handpicked. After this operation is completed they are either placed on trays in proper compartments for hatching or packed for shipment in insulated refrigerator boxes, in which, packed in wet moss, upon cheese cloth trays, surrounded by ice, they may continue in further development, though slowly at this low temperature, while they journey safely even to points of great distance, timed that their hatching shall not occur before delivery at their destination. Eggs thus shipped may either be transferred to hatchery troughs to complete their development, or "planted" in a manner similar to the mother fish's disposition of her eggs in the stream, and left to further care by nature.

Should, however, it be planned to distribute these fish at near by points, - within a short haul by boat or truck, - then the hatchery retains its young fish until fully hatched, about a month on the average, and then they are further kept until the mass of food yolk attached to their under sides is wholly absorbed, and the hungry "fry" or "advanced fry" as they are technically known are ready to seize the tiny edible morsels, and further able to "swim up" against the current, and to take care of itself.

Not all fishes successfully withstand the artificial removel of their eggs and sperm, or flourish under the subsequent hatchery culture. Fortunately trout bear both these operations very well, with little harm or danger to either the parent fish or their products. In such cases, the results of scientific fish culture are much more satisfactory than those of unaided nature. There are three principal factors which contribute to the success of fish culture. First, as against the less than 10 to 15 per cent, which receive successfully the fertilizing sperm, artificial insemination succeeds in from ninety to ninety five per cent. Second, with the mother's deposition of her eggs in the stream bed, they are subjected to the depredations of all sorts of aquatic enemies, amongst which the adult trout themselves count largely, as they are always voracious cannibals. Especially high mortality occurs in the stages following the fry's release from the egg membrane, when, weighted down by the heavy yolk sac, it is unable to move rapidly, and yet is always attracting notice, both by its attempts at movement and by its color, highly in contrast with the somber background of the stream bed. As against these serious dangers, is the protection of the hatchery during the incubation period. Third, the "planting" of hatchery raised fry is believed to secure more favorable surroundings for the young fish than those hit upon in the hap hazard distribution of stream raised trout. It must be said, however, that in the late summer, when the active existence of the fry begins, their greatest enemy, their own adult kind, has largely retreated to the deeper waters of lower stream and lake. As a result of these factors, it has been shown that hatcheries such as those in Yellowstone Park have been able to deliver as living, free fry, approximately ninety per cent of the fertilized eggs, while in unaided nature estimates which are regarded as liberal rarely rise above three per cent.



SOME PRINCIPLES OF LECTURING

By Gerald E. Marsh, Head Ranger Naturalist, 1927

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum

It has been my experience that most men, realizing their limitations, are eager to secure sound principles that will aid them in their lecturing, and once they have been given those principles, do all within their power to apply them. At the same time there are authorities and authorities, amateur and otherwise, on the art of lecturing, who are more than willing to tell the poor lecturer just how it should be done. The interesting feature of this is, that if most of them were given an opportunity to demonstrate their wares before an audience, they would make a consummate mess of the whole business. It has always struck me as a bit queer that men who would never think of criticizing a musical number because they lacked training in technique, often become voluble in their remarks concerning the refined and delicate vocal mechanism in its effect upon one of the most delicate of nature's creations, the human mind!

I suppose that the customary procedure in the preparation of the average lecture is about as follows: The prospective lecturer sits down, runs his hand through his hair several times, bites the end of his pencil rather viciously, and mulls the situation over as well as he can. A speech must be given and it must be a certain length. The subject assigned him was the Geology of the Park. A popular lecture always has some funny stories but who in the world could tell any funny stories about geology? Well, it wouldn't do any harm to work in two or three of the Bridger yarns. Anyway, people want to laugh and be entertained on their vacations and the last thing in the world that they want is to be bored by a lot of heavy geological history! And so poor old Bridger is brought in for the umptieth time to pinch hit for the Geologist as he has pinch hit many times before for the Botanist or the Historian.

I have a great deal of sympathy for this so-called average lecturer, With no guide posts his is a doubly hard job. It must be admitted that he labors hard to make the best use of his materials and give the people what he thinks they want. I am inclined to feel, however, that he errs in assuming that a lecture, in order to be popular, must contain funny stories, and in assuming that geology cannot be made interesting to audiences. In other words, it is not always safe to measure the success of a lecture by the amount of laughter it provokes.

There are some speakers who look on the occasion for a lecture as an opportunity for an exhibition of "good speaking". They are consumed with a desire to display something - knowledge, witticism, an unusual vocabulary, an exceptional voice, or any one of a dozen other speaking assets which they may possess. Do not understand me to say that these things are not valuable! They are tremendously so, but they are not the end which the lecturer should have in mind. They are only means by which the speaker may more effectively achieve his real purpose or end. What the real purpose or end is I shall leave for consideration for a moment. A second type of lecturer which is common is one in decided contrast to the "exhibitionist". These are the lecturers who never give a thought to the delivery side of the lecture. They are usually scientific, or specialists on some subject, and feel that a subject which is so intensely interesting to them must be just as interesting to everybody else. The audience of the "exhibitionist" is likely to go away from the lecture commenting upon the qualities of the speaker and forgetting what he said; the audience of the "specialist" is likely to become lost in the maze of technical terminology and dull academic rehearsal of cold, scientific facts, and leave before the lecture is over, glad to be rid of both the man and the subject. Both of these types are subjective. I mean by that that both of them think of their lectures in terms of themselves. A good lecturer thinks in objective terms, or in terms of his audience.

The real end or purpose of a lecture ought to be to achieve a certain definite response from the audience. Naturally, then, the first question that a lecturer ought to ask himself before beginning the preparation of his speech is, "What response do I seek from my listeners"? Somewhere I read once an analogy to the effect that a speaker who didn't formulate his purpose in terms of a definite response from the audience was like a man boarding a train without knowing his destination. I thought it was pretty apt. What this response is that is sought will depend upon the occasion and the audience. It might be any one of the following suggestive responses:

"Have a better understanding of the administration of our national parks".

"Understand more clearly the nature of the national park system".

"Understand the geological history of this section of the park."

"Visit the Tower Falls region and Mount Washburn while in the park."

The above responses could be added to indefinitely. They are not in any case told to the audience but are bull's-eyes for the speaker that will aid him in directing his material with more telling effect. If one can find a sentence which states accurately what he wants to achieve with his audience he has found something of inestimable value to which he can tie all the material he uses, thereby insuring unity and coherence in his lecture. If lecturers would hold religiously to this one elementary principle the bad habit of useless wandering would be avoided and irrelevant material would be reduced to a minimum.

Having determined the response sought from the listeners the next step in preparing the speech is the organization of available material. It would be useless here to go into abstract principles of speech construction for the structure of each lecture must vary, oftentimes greatly, and must depend upon the particular factors surrounding that lecture. Two principles, however, do seem to me to be worth stressing at this point: simplicity of organization and climactic arrangement. In regard to the first of these, I believe that the best speaker is the one who can accomplish his purpose with his audience with the greatest economy of energy to them and to himself. Most people are not trained to listen to lectures and doing so fatigues them. Naturally, the more complicated the organization of the speech becomes, or the more technical it becomes, the more mental strain follows on the part of the audience. A speech, simply organized and developed with clear logical sequence has a great advantage over one not so organized in conserving the mental energies of the listener. The second principle is that of climax which demands that the lecture be built up to a strong conclusion; that the best, strongest, most colorful, vivid, and exciting material be saved until the last. It is necessary that a speaker make a strong beginning but it is just as necessary that he make a strong ending. It is a quite well known psychological truth that the first and last impressions are longest remembered. Many good lecturers have been ruined by being permitted to fade out at the conclusion.

Knowing what he wants to accomplish; having collected accurate data and organized it, simply,logically, and climactically, the lecturer goes before his audience ready to speak to them. From now on his principal job is to catch and hold the attention of his audience. In a way that sounds simple enough but judging from the many speakers who have permitted their listeners to walk out on them mentally or physically, or both, it isn't as easy as it sounds. But if the speaker cannot hold the attention of the audience it would be just as well for them and better for him if he would take his hat and coat and go home.

There are hundreds of devices used by professional speakers for holding attention, and most of the best lecturers spend an infinite amount of time and energy mastering them. Of course, once in a while a speaker will hold attention because of his position, or because of his brilliance or the originality of his thought, or because of a fascinating vocabulary or voice, or because he is intensely dynamic physically. But such men, who can hold attention by the superb development of a single factor, are very unusual. Most of us are not so gifted and consequently must depend upon a reasonably good development of several factors.

Attention may be held by material or delivery or both. Probably the one principle which should be regarded above all others and which applies equally well to both material and delivery is the following: Avoid monotony! Nothing is so deadly as to sit and try to listen to a dry cataloging of dull facts by a listless and colorless speaker who goes through the entire speech without a bit of variation.

Let us consider for a moment the "material" side of holding attention. By "material" I mean the data or thought element of the speech. Audiences do not care to sit and listen to the hackneyed repetition of stale facts with which they are already well acquainted, given in the same old way. Neither can they listen to material that is totally foreign to them. Anything absolutely unknown is absolutely uninteresting! Rather it is a combination of old and new in a novel way that intrigues them. It is only by contrasting or comparing new material with what they have already in their experiences that the new material becomes recognizable or interesting. Another principle that ought to be assimilated is this: There should be variation in the forms of discourse used. Exposition, or the explaining of formations or processes, becomes heavy and fatiguing after a few minutes, and continued for very long without throwing in some Narration or Description as lighter material for relief will soon so tire the audience that they will stop paying attention. The third principle is this: Use human interest material as much as possible. Anything which will awaken sympathy on the part of the audience will help to hold attention. The last principle is one mentioned before: Arrange the material in order of climax and try to arouse as much curiosity as you can regarding what is to come. These people are motivated to an exceptionally high degree of "curiosity". That is what impelled them to visit the park in the first place so an appeal which drives at "curiosity" will have great force.

We now consider a few simple methods of delivery for holding attention. One prominent writer says that a speaker should have "a full realization of the content of each word as he utters it - and - a lively sense of communication." If a person ponders over that for a few minutes it begins to mean a great deal. "A full realization of the content of each word" implies to me that the one using it has explored it and picked it to pieces and digested it intellecturally, but more than that, he is also capable of appreciating the word emotionally. That doesn't mean that he needs to sob or quaver over his words - not at all - but it does mean that he must feel them - feel them sympathetically - and show to his audience that he does feel them.

I don't believe anyone would disagree when I say that people are much more likely to pay attention to a speaker who has a strong, positive, vigorous speech manner than to one who hesitates and is negative in bearing, attitude and speech. I think this is especially true where the lecturing is to be done out-of-doors or in hotel and lodge lobbies where there are countless counter attractions. There it is a matter of the survival of the fittest and the weak and the meek cant stand the pace.

For holding attention variation in rate, pitch, and force, seems to me to be absolutely necessary. Mono-rate, mono-pitch, or mono-force will tend to lull an audience to sleep. Discrimination as to the relative importance of words ought to help produce variety in the three factors.

Another factor that is quite important is the matter of the kind of language used. Here we return to the same principle that was stated some time ago. Listeners are easily fatigued and if long, technical, or strange words are employed they will soon get discouraged, confused and quit paying attention. It is interesting to note in this connection that our greatest speakers have always been men who specialized in simple one-syllable Anglo-Saxon words - words that smelled of the earth! Of course in the explanation of a hot spring some unfamiliar words must be used but even these should always be defined in terms that are perfectly clear to everyone listening. And concerning this last point lecturers ought always to be objective - that is, they ought to think always in terms of the audience. A process perfectly simple to the lecturer may be an intricately complicated mechanism to the listeners. How often this is forgotten!

I think I shall stop here. I have not, as you will readily see, touched one thousandth of the principles of lecturing, but I have tried to stress the most fundamental ones. In the rush of preparing for summer lectures I don't believe that many more could be digested and more would therefore be useless. My only hope is that you will find them of some help in going forward with that truly great work - the educational service of the National Park Rangers. I believe in these principles implicitly. May I say in conclusion that I believe the greatest virtues that a speaker can possess are: Directness, Simplicity, Earnestness, Enthusiasm, Sincerity, Tact and Intelligence. Lincoln once said that he assumed that in many respects his audience was wiser than he was and consequently he tried very humbly to give them the best he had. A pretty good bit of advice! If a lecturer thinks about that for a bit I doubt whether he would ever be guilty of the unforgivable sin of "talking down" to his audience!

FOUR ACES AND A QUEEN

By Gerald E. Marsh, Head Ranger Naturalist, 1927

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Ansel F. Hall, Chief Naturalist, National Park Service
Dr. H. S. Conard, Ex-Head Ranger Naturalist

Note: This is a general lecture to be used as a substitute at any point in the park. This lecture is written in a style adapted for actual delivery rather than for reading. The whole lecture has been somewhat condensed. Particular portions would be enlarged depending upon place of delivery. For instance, if delivered at Lake that portion would be greatly enlarged. (Gerald E. Marsh)

Yellowstone National Park is one of a chain of nineteen national play-grounds of the American people. One of these, Lafayette Park, lies east of the Mississippi River, off the coast of Maine: a small area of rugged granite rock formations. Two of them lie outside the boundaries of what we consider the United States: Mount McKinley National Park in Alaska containing the highest mountain in America, and the Hawaiian National Park in the middle of the Pacific Ocean. The other sixteen lie west of the Mississippi River and most of them constitute a sort of a loop in the Rocky Mountain and Coastal region. As an introduction to our subject let us briefly trace our way around this loop.

To the north of us, on the boundary between the United States and Canada, in the north-western part of the state of Montana, Glacier National Park, an area a little less than half that of Yellowstone, preserves for the American people snow-clad mountains of Alpine grandeur, beautiful glacial lakes, and a primitive wilderness. Then, further to the west, in the south-west part of the state of Washington massive Mount Rainier rears its majestic head up in the clouds over fourteen thousand feet, giving us Rainier National Park as the next link in our chain. South, then, into Oregon. In the south-western part Crater Lake, with it varying and fascinating colorings of turquoise blue or jade green, fills the crater of an old extinct volcano. On, then, to California. First we come to Mount Lassen National Park, setting aside the only active volcano in the United States. Then we come to that fairy-land of the state of California, with its beautiful valleys, and waterfalls, and Giant Sequoias, Yosemite National Park. Further to the south are Sequoia National Park and

General Grant National Park, both of them, like Yosemite, setting aside the great Sequoias, some of them twenty five feet or more in diameter and stretching into the air over two hundred feet. From California, seemingly blessed with more than its share of parks, we journey to the south-western part of the state of Utah where we come to a relatively new park, Zion, whose canyon is almost as deep as Yosemite's and whose colors are more vivid than those of the Grand Canyon of the Colorado. And we cross the border to the south into Arizona, the north-western part, where we come to that yawning chasm which you all know as the Grand Canyon of the Colorado: a mile deep; one thousand and nine square miles in area; hewn out through the ages by the Colorado River as it swept down through Arizona on its way to the gulf and the Pacific Ocean. East, then, to Mesa Verde Park, setting aside those remarkable cliff-dwellings of the ancient inhabitants of America. Then up north-west of Denver, Rocky Mountain National Park -- three hundred and ninety seven square miles of great mountains; an area of truly great scenic beauty. And then we come home to the last of this great chain -- to the park of all parks: Yellowstone.

Yellowstone Park, 3,348 square miles in area, a little over two million acres, most of which lies in the north-west corner of the state of Wyoming! A land area larger than the states of Delaware and Rhode Island combined! It seems as though those who originally conceived the idea of a park must have taken a pencil and ruler and drawn what seemed to them to be a square which would include all of the great wonders of this region. And they did almost make it a square for the park is 62 miles long and 54 miles wide, but whether by so doing they included all of the major attractions is another question.

A word now in regard to the topography and geography of Yellowstone. Notice on the map that the Continental Divide passes through the park in a south-easterly direction, coming in near West Yellowstone and passing out near the south-eastern corner of the park. As you pass from Old Faithful to West Thumb you will cross this divide twice and will pass by Isa Lake which has outlets into both the Atlantic and Pacific Oceans. Approximately one-fourth of the park, the south-western corner, lies on the western side of the water shed and has its drainage into the Pacific; the rest drains through the Missouri into the Atlantic. Three of the largest lakes next to Lake Yellowstone, Shoshone, Lewis and Heart Lakes drain to thw west; Yellowstone Lake drains to the east. And the rivers? Yellowstone River has its source in the snow drifts of Younts Peak 25 miles from the south-east corner of the park; flows north through the Lake and the Grand Canyon; goes out of the park at Gardiner and then north-east until it joins with the Missouri in North Dakota. As you travel south to Old Faithful you follow for awhile the Gibbon River. 34 miles south of here, at Madison Junction, the Gibbon unites with the Firehole, which comes north from the geyser basins, and the two form the Madison which then goes out at West Yellowstone and up to Three Forks, Montana, where it joins with the Jefferson and Gallatin to form the Missouri. And lastly the Snake River flows south, bends westward and joins the Columbia in the south-eastern part of the state of Washington. Bechler River drains the south-western corner of the park and flows into the Henrys Fork of the Snake in Idaho.

Of the mountains, the Gallatin Range rises along the western boundary and we see it extending from Mount Holmes on the south to Electric Peak, the highest in the park, on the north, as we travel between Norris and Mammoth. The Absarokas, from the Indian meaning "crow", extend in the form of a half-moon along the northern boundary, all through the eastern part of the park, and curving around on the south-eastern part of Lake Yellowstone. Then to the south, outside of the park but standing like gray sentinels guarding it, loom up the majestic Tetons. The Tetons, with Jackson, Jenny, and Leigh Lakes at their feet, present a picture of incomparable grandeur and beauty, not even excepting that marvelous gem of the Canadian Rockies, beautiful Lake Louise.

There is little evidence of much habitation of this region by Indians; arrow and spear heads found near Obsidian Cliff and made of that black volcanic glass which seemed so well adapted for that purpose; teepees at Sheep-eater Cliffs three miles south of here on the road to Tower Fall; the Old Bannock Trail which sweeps up from West Yellowstone through the passes to Mammoth, then to Tower Fall and out of the park at the north-eastern corner, -- a difficult trail used by the Bannocks on hunting trips to escape their stronger enemies outside of the park. The only tribe known to have inhabited this region was a degenerate branch of the Shoshones, the Sheep-eaters. After all, this park didn't lend itself to Indian occupation. The winters were intensely cold; the snow was deep, sometimes as much as fifteen feet; game animals for these reasons were very scarce. Then, too, imagine the Indian's reaction to steaming pools and spouting geysers! Always awed by spirits! A region of the devil! And so adverse climate, limitation of food supply, and superstition combined to keep the red man out of the Yellowstone.

The first white man in here was John Colter, an adventurer from the Lewis and Clark Expedition, who came in here in 1807. The second white man who entered the park was probably James Bridger, famous guide, trapper, and adventurer. But it wasn't until 1870 that the expedition responsible for the creation of a national park started into the Yellowstone country. Led by Surveyor-General Washburn of the state of Montana, the party came in at Gardiner, followed the Yellowstone River past Tower Fall; saw the Grand Canyon; passed around Lake Yellowstone; came north by the geyser basin and camped on September 19, 1870 at the junction of the Firehole and Gibbon Rivers. Here, at Madison Junction, around that historic campfire, the National Park idea was born. It was there that Cornelius Hedges, a philanthropist if there ever was one, suggested that this marvelous region be set aside for the enjoyment of all the American people rather than for exploitation for private gain. It was with remarkable rapidity, considering the slowness of communication at that time, that Congress acted upon the appeal of the Washburn party and on March 1, 1872, President Ulysses S. Grant signed the act that created Yellowstone National Park.

So far, in brief, we have taken a bird's-eye view of the topography, geography, and early history of Yellowstone. Now, what are the attractions that makes this place unique? There are five major ones and I like to think of them as four aces and a queen. We encounter them all as we trace our way around what is known as the grand loop. Tonight, let us take a rapid journey and touch them all.

At the present moment we are at Mammoth Hot Springs, five miles south of Gardiner, Montana, and approximately two miles south of the Montana state line. If you will look out of the window to the east tomorrow morning you will see Mount Everts, named after a man who was lost in the park for 37 days. You will see about 1500 feet of its face exposed to view and in that 1500 feet you will see strata of limestone. Those strata tell an interesting story of the time before this part of the country was heaved up into a great mountain system; of the time when this whole area was submerged beneath a great sea. They tell of the decomposing of organic material; of the building of these layers from the bones and skeletons of marine inhabitants. Then came upheavels and in one of the earth's convulsions the face of that cliff was exposed. It was significant for a discussion of the hot springs for it shows us the kind of materials through which the hot waters come.

There is very little difference between a cold spring and a hot spring except that in the latter the water comes in contact with subterranean heat. How far down? I cannot say. Geologists differ. Some say five hundred feet; some, two thousand. At any rate we can say that at this point the source of heat is comparatively close to the surface of the earth. The waters from snows and rains seep down through cracks and fissures of the earth; come in contact with gases and steams from below; take up carbon dioxide; seek their own levels and come bubbling out as we see them on the terraces. As the water comes up bearing carbon dioxide it takes a great deal of this limestone material, such as we see on the face of Everts, into solution. And when it gets to the top what happens? The water cools; it evaporates; microscopic plants absorb carbon dioxide as their food. All these factors contribute to the depositing of this limestone, or calcium carbonate, or Travertine,--that white, fragile, soft, chalky substance that you see above us. How fast is it deposited? Probably four to six inches each year.

The coloring in these springs is caused by microscopic plants called Algae. One of our most interesting plants and probably the most primitive one. It is a close relative of the plant that causes the scum in the waters back east during "dog" days; and of the plant that causes the red in the Red Sea; and the sea kelp off the coast of California. Growing in these waters as a hot water plant; in the hot springs at temperatures of 140 to 165 fahrenheit; in the geyser basins in water as hot as 192 fahrenheit. Only a few degrees below the boiling point which is about 198 or 199! And yet a close relative grows in the arctic and antarctic regions in water one degree below the freezing point where it is possible for it to grow only four weeks out of the year.

How old are the hot springs? I don't know. Possibly a hundred thousand years. The highest point of activity is shown in that flat-topped mountain above us to the south-west; the lowest point, a few hundred feet below us at Boiling River. Building up at the rate of from four to six inches each year where there is activity, you can estimate the length of time the hot springs have been in action. That green hill to the south of us, laid down as a terminal moraine by one of the gigantic glaciers that swept down, has beneath it a stratum of travertine material indicative of the fact that there was activity before the glacial period. Not long ago, beneath that stratum of travertine, thousands of years old, an elk antler was unearthed! It would be interesting to speculate on the tremendous age of that antler!

So much for the first ace of the Yellowstone: the Hot Springs at Mammoth! The second lies fifty miles to the south of us and is known as the Upper Geyser Basin. I wish only to mention it here as one of the greatest attractions that nature has to offer anywhere for my colleague at Old Faithful will tell you adequately about geysers and geyser action. It will be sufficient to say here that there are geysers in only two other places in the world--

New Zealand and Iceland. But in no place in the world can geyser activity compare with the steaming infernos of this park.

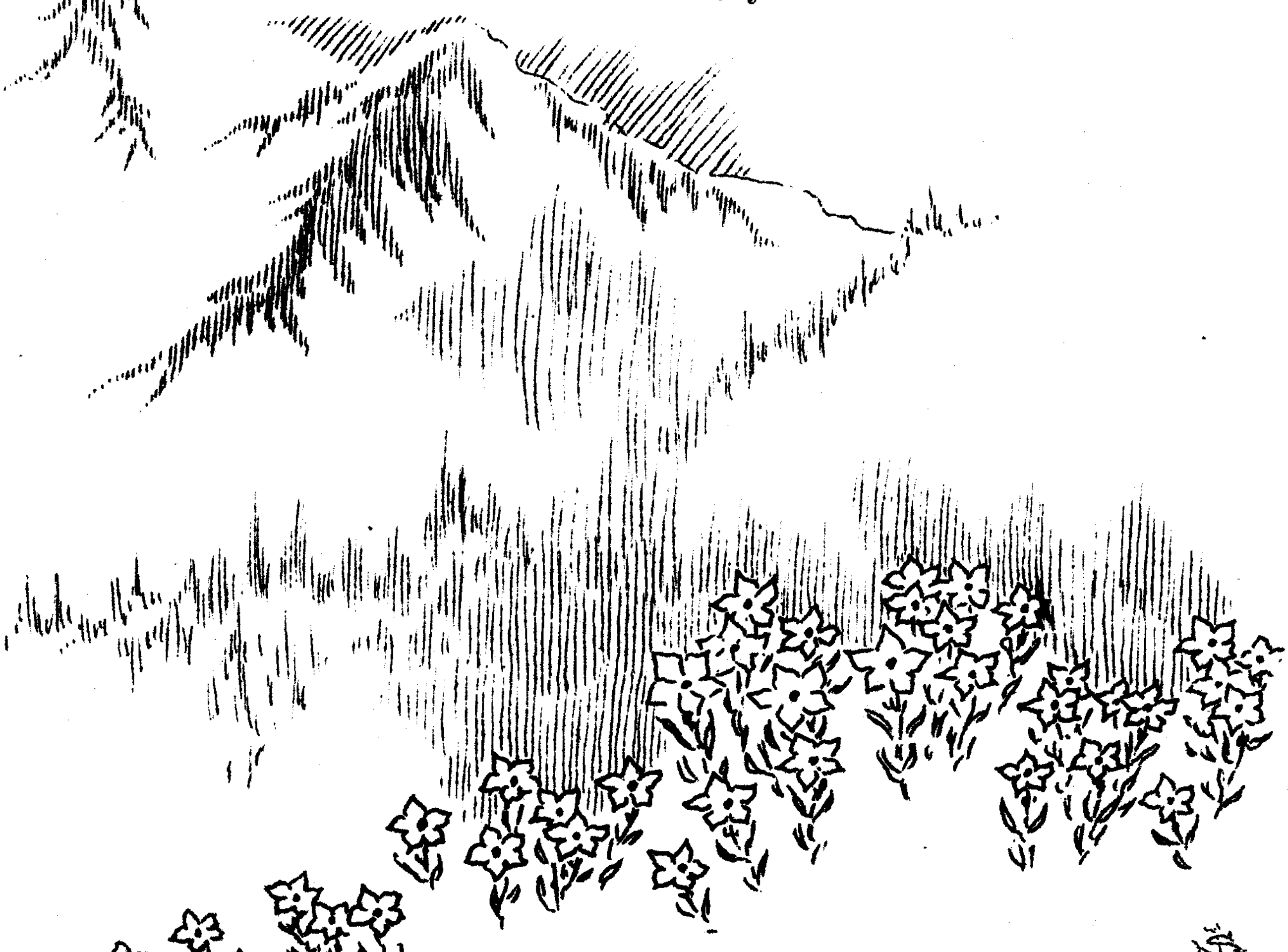
Forty miles east of the Upper Geyser Basin, by road, and you come to the third ace of Yellowstone Park - Lake Yellowstone, rivaling in beauty any of America's mountain lakes. With a shoreline of 100 miles; 139 square miles in area -- over 88,000 acres. Large enough, if it were land, to house comfortably the population of any of our major cities except Chicago or New York. The second largest lake at its altitude, 7734 feet, in the western hemisphere, the largest being Lake Titicaca in the Andes of South America. A lake which formerly had its outlet into the Pacific Ocean through the Snake River until a great glacier closed its outlet and forced it to find a new one into the Atlantic through the Yellowstone. The only body of water stocked with fish when the white man came here, and that the native, or cutthroat trout, a fish of Pacific waters! Containing only that kind of fish in its waters today! A lake which formerly had a much higher water level as indicated by terraces rising many feet above it. An unusual and fascinating lake, meriting, certainly, to be classed as one of the four aces of the Yellowstone!

Fifteen miles north of Lake Yellowstone we reach the fourth ace, -- the climax probably of your visit here, the Grand Canyon of the Yellowstone. Most of you no doubt have visited the Grand Canyon of the Colorado. When you saw it you probably used some such adjective as "tremendous", "immense", or "gigantic", but I doubt whether you used the word "beautiful". However, I do think that the word "beautiful" might be used in connection with the Grand Canyon of the Yellowstone. Twelve to fourteen hundred or more feet deep; two thousand feet across; twenty miles long; three miles of the most brilliant coloration ever lavished by nature. Blues, greens, browns, yellows, scarlets, brick-reds, mingled and intermingled in "bewildering, intoxicating magnificence". Containing two water-falls, the Upper and Lower Falls, the latter with a fall of 308 feet, -- nearly twice the fall of Niagara.

And the "Queen" of the Yellowstone? The Tower Fall region!. Don't miss it! I don't know why but I always think of flowers, and trees, and animals when I think of Tower Fall. Eighty-five percent of this park is covered with forest. Eighty percent of this eighty-five is covered with lodgepole pine. In addition there are Douglas firs, spruces, western cedars, and limber pines. Of the Trees that shed their leaves the most prominent are the quaking aspens.

And animals! Lots of them at Tower Fall! I only wish to mention a few: Antelope, five or six hundred of them, timid,

graceful, beautiful, fleet! Depending for their safety on speed! The swiftest animal in America! Elk, about seventeen thousand. Mule deer, between sixteen and nineteen hundred. No Virginia deer. There were a few but none have been seen for some time. Possibly they could not protect themselves from the attack of predatory animals as could their swifter cousins, the antelope. Moose, ranging alone, not often seen since they avoid civilization, and yet one of the most dangerous animals in the park. And finally the buffalo! About one thousand in two herds: one, the Lamar Valley herd in that valley, and the wild herd, never cared for, rarely seen except by the ranger who rides fire-patrol, up in the eastern recesses of the park, as wild as any animal that roams the earth today! Visualize, if you can a sight that was seen early last spring: An old buffalo bull, separated from his companions, gaunt, majestic; forlornly rumped against the winter storm -- the last ghostly reminder of the days when the plains of America were buffalo land and the red man roamed from Mexico to Hudson Bay!



MOUNTAIN PHLOX

THE NATURAL HISTORY OF YELLOWSTONE NATIONAL PARK
(Evening Lecture at Mammoth Hotel and Lodge)

By H. E. Stork, Ph.D. - 1927 Ranger Naturalist

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Gerald E. Marsh, 1927 Head Ranger Naturalist.

I have been delegated, ladies and gentlemen, to speak to you briefly on the natural history of Yellowstone Park. This is the oldest of our nineteen national parks, having been established in 1872 at a time when there was relatively little known about the natural features of this area. The boundary lines were at that time apparently drawn with pencil and ruler, and the natural boundaries that nature had established were disregarded. The founders almost succeeded in making a perfect square; but the length is somewhat greater than the breadth, being sixty-two miles and fifty-four miles respectively. If you multiply these two figures you get three thousand three hundred and forty-eight square miles as the area. This is the largest area of any of our national parks.

The Yellowstone valley became known relatively late in our western history. In fact, at the time when it first really became known, the surrounding territories had been well settled and a railroad had been pushed to within five hundred miles of the present park. There are several reasons why this great mountain plateau became known at so late a time. In the first place it rises approximately one and one-half miles above sea level, is fenced in round about by the Absarokas on the east, the Gallatins and the Madison Plateau on the northwest and west, and by the Tetons, which should form the logical park boundary, on the south. Thus it is a great catch-basin for the snows of winter, and being snowbound for so many months of the year, the region was not a good hunting ground for the Indians; and they were never here in large numbers. The only tribe that is known to have made this their habitation is the Tukuarikas or Sheep-eaters. The Sheep-eaters were a degenerate group not war-like and not well able to hold their own against the Blackfeet, Crows, Bannocks, and other surrounding tribes. Although some of the other tribes made excursions through the park area at various times either as a short-cut or to secure the black obsidian, which they prized as material for shaping spear points and arrow heads, the wonders of the Yellowstone never became a part of Indian lore and legend, and consequently the white man learned very little from the Indian about this remarkable region.

The first white man who entered the park was John Colter, who had been with the Lewis and Clark expedition and on returning in 1806 had left that party at Mandan, engaged in fur-trapping, and walking southward during that winter came to the Jackson Hole territory the following spring of 1807. He entered the park from the south and in the course of the next five years learned a great deal not only about the park itself but about surrounding regions as well. They were five years of hardships. He was alternately friend and enemy of the different Indian tribes, was forced to run the gauntlet, suffered exposure and privation to such an extent that he met an early death as a result of his hardships soon after he went home to the East. His report was incorporated with that of Lewis and Clark, but never seems to have received general publication and did not become widely known. Because of the hardships he endured and probably also because of the nature of the region, folks in the East spoke of this country as "Colter's Hell." Fortunately that name did not persist. It would be less elegant as a name for the largest and oldest of our national parks than is the present name of Yellowstone - a name which the Indians attached to the lower river in Montana and which later came to be applied to the canyon and lake and the surrounding region. Between the time of the Lewis and Clark expedition and the Civil War days there were over one hundred exploring expeditions sent to the great West; in fact about the best thing Congress did in those days was to send out western exploring expeditions. With one or two exceptions none of these expeditions reached the Yellowstone country. This was not a place to explore for good agricultural land. Nature seems to have contrived to put as little of commercial value into this park area as possible. The timber is largely lodgepole pine, which does not interest the lumber manufacturers. The prospector looking for mineral wealth here never seemed to have received much encouragement, and as for agriculture, you yourselves know that it would be very hard to pick out a one hundred and sixty acre farm on which you could make even a scant living. And this is fortunate, because it has served to retain this area for us to use as a great national playground.

During the years before the Civil War there were sparodic explorations on the part of trappers, prospectors, and adventurers. None of these made any effective report concerning the natural features of this region. One of these scouts and adventurers was James Bridger. The story of Bridger reads like a romance. Born in Virginia in 1804, he must have come West at an early age, for he is already heard of in the West in 1824. During the thirties, forties, and into the fifties he figured extensively in the history of this entire western region. He was an excellent scout and therefore much in demand for various minor expeditions. It is said that he had a sort of sixth sense of direction and elevation and that he could take a buffalo hide and with a piece of charcoal sketch out lines and contours almost as accurately as does a topographer. Bridger tried to tell his story of the wonders of the Yellowstone in St. Louis. As a historian he unfortunately was a good romancer, and folks never believed his reports. He had a reputation for telling tall tales, and folks said the truth was not in him. Forced into the role of romancer, he played the part well. He knew how to embellish a story, and his stories improved with the telling. For example, he related quite accurately to his friends in the East that among other marvelous wonders there was here a mountain of glass. This much is true. As you drive from here on the road toward Norris you drive over a part of this mountain known as Obsidian Cliff. It is a great volcanic plug of black glass and looks much like anthracite coal, but you may be sure that it has no carbon in it. It is silica.

Although Bridger's story concerning a mountain of glass was not believed, he continued telling it, and in the telling of it the black, opaque glass became transparent. And then Bridger had his story of how he was hunting one day when he came upon a deer, apparently within gun-shot. He levels his trusty rifle and fired, and nothing happened. A second shot, a third, and still the deer grazed calmly on. Good marksman that he was, he was naturally chagrined at this, clubbed his rifle and rushed up to strike the animal between the antlers. Instead he bumped his own nose into the transparent glass mountain that stood between him and the deer. That improved the story, but he did not rest there. Gradually in the telling the sides of the glass mountain became somewhat convex, and when he went around to find his deer, he saw him calmly grazing a mile down the meadow, having been magnified by the telescopic powers of the glass mountain.

Another characteristic of Bridger which made people question his veracity was his remarkable ability to explain things. We are all of us likely to mistrust the champion explainer. To illustrate: he told of taking a drink of water from a cold mountain stream. After he had continued his journey down the mountain, he was again thirsty and drank again at the foot of the mountain from what he thought was the same stream. He reported that the water was quite warm. So much no doubt was actual fact. The unfortunate thing was his explanation. The mountain was so steep and the water had to run so fast that the friction had warmed it when it got to the bottom. I have dwelt at some little length on James Bridger because he knew this Yellowstone region thoroughly at an early date; in fact, better than you will know it after spending a week here. He was able to report the nature of this region in the East and had he done so successfully and had he been believed, it would no doubt have been exploited by private interests, and we would not have our great national playground today.

The expedition which finally explored the park, recognized the value of its natural resources, got its report through to Congress, and secured action on the part of Congress was the Washburn expedition of 1870. This expedition was privately organized and financed by citizens of the territory of Montana and had official status only because a contingent of five soldiers under Captain Doane were assigned as a guard to the expedition. This group of nineteen men explored the park in August and September of 1870 and saw practically all the features of interest with the exception of the Mammoth Hot Springs; and when they were encamped on the night of September 19th on the meadow by National Park Mountain thirty-four miles south of here at what is now known as Madison Junction, they deliberated on what disposition they should make of the natural wonders that they had learned about. Naturally they were human, and human nature never changes much, and they considered staking out private claims. This area was all public domain at that time. Our country had purchased the greater part of it from Napoleon in 1803 in the Louisiana purchase. Your grandfathers might have come here before 1870 and made private claim of part of the geyser region or of the brink of the Grand Canyon or of these hot springs, and you might be quite opulent today, deriving great revenues from the sale of these wonders of nature to the sight-seers. That would be fortunate for you but unfortunate for the rest of the two hundred thousand or more people who come here annually to enjoy the wonders of the Yellowstone. Actually, not an acre of this great area was ever privately owned before 1870, and at that time around the campfire at National Park Mountain there was one Cornelius Hedges who is responsible for the first suggestion that instead of making private claims the area be recommended to Congress to be set aside as a natural park. Hedges' suggestion was accepted by the other members of the party, the recommendation was made to Congress, and Congress acted with remarkable speed. President Ulysses S. Grant signed the dedicatory act on March 1, 1872, dedicating this great mountain plateau "for the benefit and enjoyment of the people", to quote the actual phrase of the act, a phrase which is also written above the arch at Gardiner.

Since that time eighteen other national parks have been created. Most of these are west of the Mississippi because it is that section of the country which still had sufficient public domain after 1870 out of which national parks could be created. There is one national park east of the Mississippi, Lafayette National Park off the coast of Maine. Several pbojects are under way in the East for the creation of national parks. However, once land has come into private possession, it is very difficult for the state to secure it again in order to give it to Congress to be created a national park.

To understand and appreciate the large number of natural curiosities which Nature has crowded into so small an area in this park, it is necessary that we know something of the geological history of this region. The earliest chapter of geology which we must consult is that which deals with the early times when this entire area was still sea-bound. At that time various forms of minute animal life formed calcareous shells generation after generation, age upon age, until the accumulations of the dead shells falling to the sea-bottom had formed great layers of calcareous ooze. When eventually through the folding and buckling of the earth's crust the first rugged islands were lifted from the water and erosion carried down sand, silt, and sediment and made layers of land deposit upon the calcareous ooze, the latter was compressed into limestone. If tomorrow morning you will look across the Gardiner Valley to the bare, exposed side of Mount Everts, you will see these layers of grayish limestone. That face of Mount Everts represents a normal fall, Mount Everts having risen and the Mammoth region having fallen until there is a difference of some seventeen hundred feet elevation. Thus you can see the same strata of limestone exposed which you know underlie this region. How these layers of limestone figured in the later hot spring history of this region we shall see presently.

Omitting many chapters of geological history, we come to the time when this Rocky Mountain region was lifted from the sea waters by the folding and buckling of the earth's crust. I would have you bear in mind particularly the fact that the various natural curiosities of this park are practically all dependent upon one fundamental phenomenon, and that is the presence here of molten and semi-molten rock unusually near the surface. It is this molten rock which was thrust up along lines brought on by the intense folding and faulting of the earth's crust which made possible the outpourings of lava that give us so many curious rock formations in the park. A great proportion of the park's area is overlaid with lava rocks of various types. Those of you who have driven the Tower Fall road will have seen the basaltic columns that form the peculiar "log fences". The molten basalt upon cooling shrinks and splits into five-sided columns, thus giving the strange palisade effect. Obsidian Cliff, of which we have spoken previously, is a great mass of quartz that was melted in these furnaces of the earth, thrust out, quickly cooled so as to form the viscous glass instead of crystallizing into the usual characteristic quartz crystals. Bunsen Peak is a great mass of rhyolite, and as you look at the strata of Mount Everts tomorrow, let me also remind you to observe the cap of lava rock that has overflowed the strata on the south half, which has a depth of somewhat over two hundred and fifty feet.

When the first intense volcanic activities subsided and lava flows ceased, there was a long period of time during which the gases from the cooling lava rock accumulated and periodically burst forth as volcanic eruptions. If these volcanic eruptions had quartz in them and if they partially buried the forest trees of that time, the conditions were suitable for petrification of those trees; and it is to that period that we trace our petrified forests. The water would dissolve the silica from the volcanic ash which would ooze into the substances of the wood replacing atom for atom the cellulose and lignin of the wood, and the result would be an exact replica of the original stump done in flinty stone. So nicely has this replacement been executed that a microscopic cross section of a petrified redwood tree presents a picture very similar to the cross section of a piece of present-day redwood. Because of the fidelity with which these materials have been replaced with stone, it has been possible to identify a great number of woody plants of these early forests even though no live plants have been left. There were in those early forests redwoods, pines, oaks, magnolias, laurels, basswoods, in fact such species of trees as you find in semi-tropical climates of the present day. There has even been identified one species of fig tree and one species of bread fruit. Naturally not all the forests of that time were preserved. It is only in spots here and there and occasionally in somewhat larger areas that the conditions were right for this petrification to take place. One of the best places to see these petrified forests is on Specimen Ridge some six or eight miles horseback ride from Tower Fall. If you cannot take this trip, let me suggest that you study the specimens of fossil trees in our museum here. In front of the museum you will see a piece of giant redwood which tells an interesting story millions of years old. You can trace year by year the rate of growth of that tree by its yearly growth rings.

Sometimes there will be several years that are scant. These lean years may be due to the dry climate of that day or to over-shading by neighboring trees; perhaps insects ate the leaves off of the tree. You can figure out your own story as to what happened with a fair degree of certainty that no one will contradict you. In places it is even possible to see where the falling of neighboring trees knocked away the bark so that the tree had to heal over the wound. These petrified forests of the Yellowstone are unique in two respects. In the first place, they are standing forests, having been petrified exactly in the position in which they grew. In the second place, they are unique in that there is not just a single forest, but succeeding forests sprang up and were petrified one after the other. It seems that after one volcanic outburst and eruption, there was a long lull, petrification took place, soil was formed on the debris, and a new forest sprang up. Then some fine day the sky was overcast with the clouds of steam and volcanic ash from another eruption, and thus the process was repeated not once but some eleven or twelve different times.

Another feature of the park curiously interesting is the hot-spring area here at Mammoth. Concerning the hot springs we must remember in the first place that they are fundamentally like cold springs. Water from rain and melting snow seeps into the ground in higher elevations, percolates through fissures and crevices, is confined in subterranean reservoirs, and eventually comes out in some lower level in the form of a spring. In this region, however, the molten rock is not so far beneath the surface, and as it cools it gives off hot gases and superheated steam which rise through fissures in the earth in the form of fumaroles or solfataras; but more likely they encounter the subterranean waters and heat them so that they come out as a hot spring. But these hot waters pass through beds of limestone that we mentioned in our first chapter of geological history; and hot water with carbon dioxide in solution is capable of dissolving a great load of limestone or calcium carbonate. It is carried in solution as the bicarbonate of lime. When it comes to the surface, the cooling and evaporation of the water and the loss of carbon dioxide allow the calcium carbonate to be thrown out of solution and it is deposited in those beautiful terraces that you see here below Terrace Mountain. This substance we know as travertine. The word travertine is derived from an ancient name for the city of Tivoli in Italy. In this region the river Tiber in its youth laid down secondary deposits of lime from cold water. Travertine deposited from cold water is quite solid and is quarried in those regions as a highly desirable building material. But the travertine laid down by hot water is loose, porous, and friable as you see in the chalky mass that forms our beautiful terraces. If we walk on these terraces, they soon crumble to formless heaps of slacked lime. It is for that reason that we are bidden not to walk on or to break the formations of the terraces.

One other striking feature of the hot springs is the brilliant colors that you observe. These colors are not of mineral nature as is often surmised. Rather they are organic colors due to the presence in hot waters of myriads of minute plants. These plants represent the most primitive form of life that we know; and it is interesting to speculate that they may be left over from that early period of the world's history when life originated in the waters and when the waters of the earth were still a good deal hotter than they are today. There are a number of species, differing in their pigments and in the temperature of the water in which they can grow.

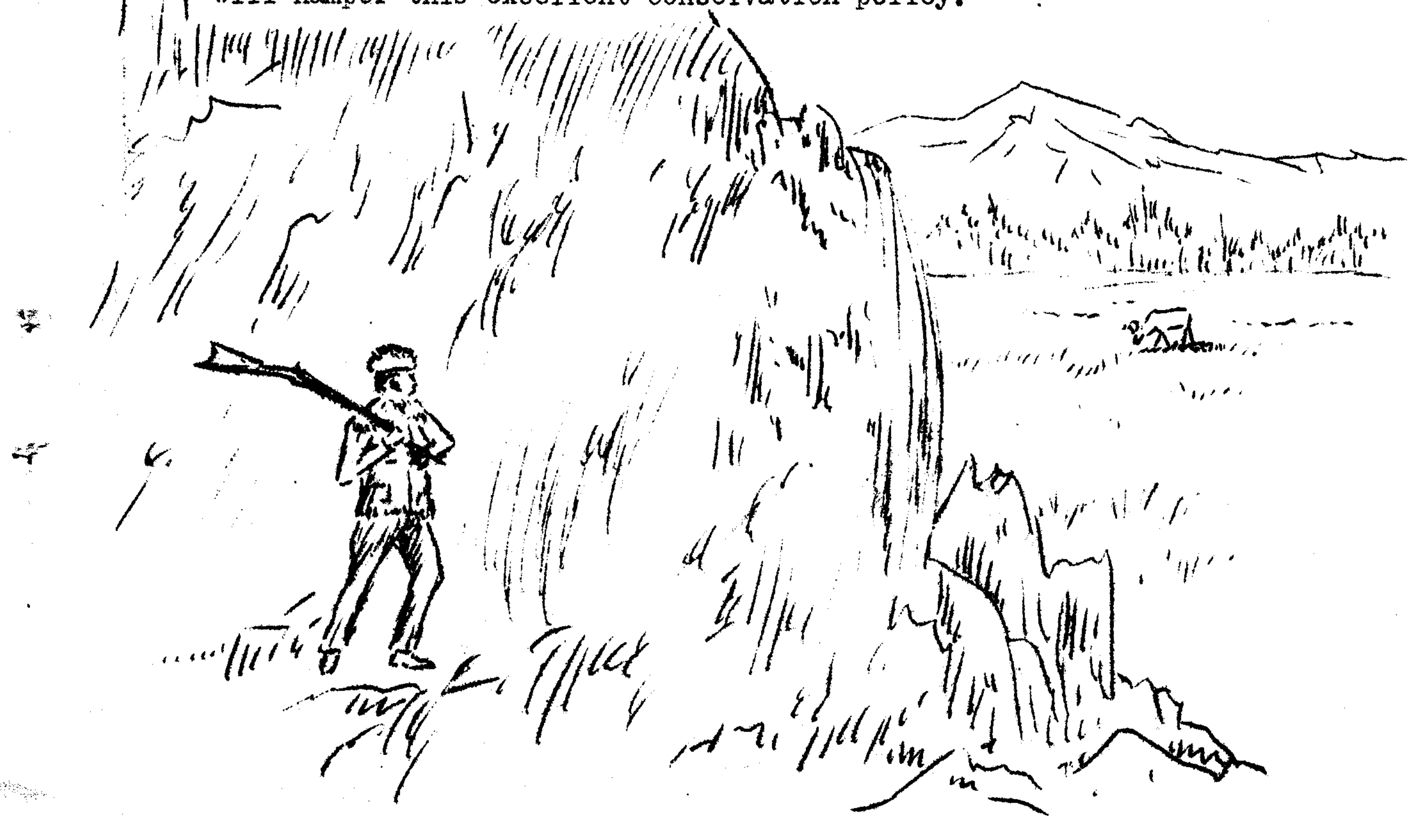
The geysers are fundamentally similar to the hot springs. The difference lies principally in the fact that the waters of the geysers pass over acidic lava rock, dissolve silica instead of lime, and deposit that silica slowly but very firmly to form an extremely strong and resistant tube. This tube, usually irregular and sinuous, is capable of resisting a great deal of pressure and consequently makes possible the periodic steam explosions of superheated water which you know as eruptions. Such explosions would not be possible in the loose, friable tubes that are built by the disposition of lime in this hot spring region.

Thus we see that lava flows, fossil forests, hot springs, geysers, - all are dependent upon subterranean heat coming near the surface; and even the Grand Canyon of the Yellowstone, which many regard as the climax of all that is beautiful in the park, was largely dependent for its formation upon this fundamental phenomenon. The Yellowstone River could never have cut this canyon through this mass of ryolite rock so rapidly had it not been assisted by heat from beneath. In fact, even today steam vents are seen at the bottom of the canyon. Not only did this process of what we might call a baking or cooking with subterranean heat assist the crumbling of the rock, but it made possible the formation of unusually brilliant colored forms of manganese, iron, etc., which give the beautiful rainbow hues we so much admire from our Artist and Inspiration Points.

In relatively recent times as the geologist thinks there came the great winter of geological time, the Ice Age. Enormous ice sheets moved down slowly from the great Absarokas on the east, from the Gallatins on the northwest, and from the Madison Plateau on the west, wiping out the semi-tropical forests that had existed here. They changed the contours of the land and diverted the channels of streams. With the return of the warmer climates they melted and left behind the great masses of sand, gravel boulders, and rubble that form the terminal moraines which you see particularly in this region between here and Gardiner. Capitol Hill, which you see just across the lawn from the hotel, is an example of such a terminal moraine. It is interesting to note in passing that beneath Capitol Hill you find layer upon layer of travertine laid down by hot springs even before the glacier age. That gives us some little clue as to the great antiquity of these hot springs. If they have been active before the glacier age and have continued through the glacier age and ever since, it is not reasonable to fear that they will become extinct by next year or even in five years from now when you return. The pictures that the springs present may be different. The same volume of water passes over the terraces; sometimes it is spread out widely in thin sheets, sometimes it is concentrated in small areas. Year in, year out and even week for week it presents a different picture.

You will have an opportunity to make a closer study of these springs tomorrow morning at nine o'clock at which time a ranger guide will conduct you over the Terrace Trail, a distance of two and one-half miles, for the purpose of explaining the hot springs and the terrace formations.

After the glacier period there came to this region a plant life very different from the early semi-tropical life. The forests are restricted in the number of species. They are practically all a sub-Alpine type. While not of interest to the lumberman, they are nevertheless adequate for protecting the wild life that is native here. The National Park Service is making an effort to protect absolutely this forest. There is no effort made to introduce new species, but those that are native here are to be protected for all time. Likewise the seven hundred odd species of flowering plants on our forest floor, on our dry hillsides, and in our swamps are to be protected. The same is true of the more than two hundred species of birds in the park and likewise of the fifty-two species of mammals. Nature has established a nice balance between these forms of life. Disturb one or two or three of these species and you disturb the balance all along the line. It is the effort of the Park Service to maintain the original balance of nature by protecting all these forms of life so that future generations may be able to come to this area to get a breath of fresh mountain air and to see what original wild life was like even before the days of the American Indian. We hope that you will do nothing that will hamper this excellent conservation policy.



FLOWERS OF YELLOWSTONE NATIONAL PARK
(Lecture at Old Faithful)

By Herma G. Albertson - 1927 Ranger Naturalist

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Dr. H. S. Conard, Ex-Chief Ranger Naturalist.

(The first part of the lecture is devoted to a discussion of the trees found in Yellowstone Park. A complete report of the lecture given on trees is to be found in the Ranger Naturalist Manual for 1926. About a dozen different flowers are used at the lecture each evening. As these vary with the seasons, I have written the talk used for several of the more common flowers found around Old Faithful).

The flower that attracts the most attention in Yellowstone Park is the Rocky Mountain Fringed Gentian. Since it was made the Park flower in 1926 we admire and cherish it even more than we did before. Because it is an annual and difficult to pollinate, a rigid protection must be given it or it will be depleted from Yellowstone as its relatives have been from the East and middle West. At present there are fields of these beautiful anilin-blue flowers to be seen throughout the season. The gentian is not a fall flower in the Park but blooms from June to September. In June when the first tourists visit the Geyser Basin they find the gentian growing near the warm water from the geysers. Later they are found in most of the moist meadows of the Park. The gentian derives its name from King Gentianus of Illyria who was the first one to discover its medicinal properties.

A flower that could very well have been the Park flower is the Bluebell of Scotland or Harebell. It grows abundantly throughout the Park and is especially beautiful on the drier, open slopes and hillsides. It is the true Bluebell of Scotland although the flower itself is larger in America. It has a wide distribution, being found throughout the northern hemisphere as far north as the Arctic Circle.

The forepart of the season the swamps are filled with tall purple and white spikes. The purple spikes are known as Little Elephant from the close resemblance to a tiny elephant's head. You will notice that the upper petal forms the forehead, the two side ones the floppy ears, the lower petals the neck and a protuberance from the center, the trunk. The white spikes are Wild Orchids. Each flower is a miniature lady's slipper. This is one of the few very fragrant flowers of the Park. There are not many fragrant wild flowers. Fragrance seems to be something plant wizards bring about more often than does Nature.

The low shrub with holly-like leaves which grows abundantly in the open woods is known in the West as Oregon Grape. It is sometimes called Holly-leaved Barberry. In the spring the plants have clusters of bright yellow, fragrant blossoms which are replaced by green grape-like berries that turn a purplish-blue in the fall. As soon as the berries ripen they are eaten by the animals and birds. They make delicious jam and jelly. The yellow juice of the stems and roots was used by the Indians as a dye.

Only one kind of Columbine is found in abundance in the Park and that is the beautiful light yellow one. It is considered by many folks the loveliest of all the Park flowers, because of its delicate hue and graceful nodding heads. Occasionally one sees one of these flowers with yellow petals and pink sepals, but that is more often due to the age of the flower than a different species. It is an interesting fact that honey bees and little wild bees get the pollen only from these flowers as their tongues are not long enough to reach the nectaries hidden in the tips of the spurs. Butterflies cannot obtain nectar either, since their weak legs cannot stand the strain of an inverted position from a pendant flower.

Meadow-rue, another member of the same family, is found early in the season. Since it is a wind pollinated flower it blossoms before the neighboring plants are very tall. As a result it towers above the other flowers, cutting down the chances of not being pollinated. The male or staminate flowers are born on one plant while the female or pistillate flowers are born on another plant. The fringy effect of the blossoms is due to the stamens of the staminate flowers.

The Shooting Star, also known as Wild Cyclamen and sometimes called American Cowslip, grows in the more moist portions of the Park. They are among the first flowers to venture into a region as the snow disappears.

During the early part of the season the entire geyser basin is carpeted with small white flowers called Chickweed. As the flowers go to seed one can usually see some member of the Sparrow family getting a meal from the tiny seeds which are excellent bird seed.

No flower is more interesting than the Monkey Flower or False Snapdragon. The first ones to appear around Old Faithful are about an inch and a half tall, bearing deep reddish-purple flowers. They carpet the slopes below the Inn. Later a yellow one blooms in the hot run-off streams from the geysers and hot springs, growing in water many degrees warmer than you would care to keep your hand in. Then a larger yellow Monkey flower forms yellow beds about all of the warm springs of the region and one can almost trace the course of the lukewarm streams by the yellow blossoms. Later a deep red Monkey Flower, whose flowers are about an inch and a half long, blooms along the cold streams of the Park. The Red Snapdragon and Red Geranium bloom profusely along the road from Old Faithful to West Thumb and on part of the slopes of Mt. Washburn. If you have a vivid enough imagination you will probably see the grinning face of an ape in the face of the flower and it is from this peculiarity that it gets its name, Mimulus.

Several kinds of Delphinium or Larkspur are found around Old Faithful. The early blooming one is a very low plant with beautiful deep blue flowers. Later the Tall Larkspur, perhaps the most poisonous of all, blooms along the roadsides and in the meadows of the higher regions of the Park. Most of the Larkspurs are poisonous but the Tall Larkspur with leaves so closely resembling the Monkshood is responsible for most of the death among stock. After the blossoming period the leaves lose their poisonous properties. The seeds are very poisonous. The Tall Larkspur is very common in the region between Yellowstone Lake and the Grand Canyon.

In some localities of the Park the swampy areas will be blue with Monkshood or Aconite. The resemblance of the flower to the cowl of a monk gives it the name, Monkshood, while the town Aconite in Asia Minor where it was first discovered is responsible for the scientific name. The drug, aconite, which is used as a heart depressant and also to contract the pupil of the eye, is extracted from a European Aconitum. It is a curious fact that countries like New Zealand, Australia, Arabia and South Africa which have no native bumblebees, also lack native Monkshood.

The Indian Paint-brush grows abundantly throughout the Park in shades varying from cream-white through the deep crimsons and magentas. The more adverse the conditions under which it grows the deeper the color. This plant is often accused of being a thief but since it has both leaves and green color it cannot be a thief altogether, but is guilty only of petty larceny. Occasionally it breaks in and steals from the roots of its neighbors such juices as the plant must work over into vegetable tissue. The Indian Paint-brush is the state flower of Wyoming and hence should be abundant in the Park.

Yarrow is one of the plants which is found throughout the entire world. It was introduced into America where it has found growing conditions so excellent that it has "run wild" and become a real pest in some localities. It is also native to North America from the Rocky Mountains to the Pacific. In parts of Yellowstone it attains a very fine development. Under the high steel bridge between Old Faithful and West Thumb, it forms a lacy blanket of white. It appears not only along the waysides of the world, but in mythology, folk-lore and medicine. Chiron, the centuar, who taught its virtues to Achilles that he might make an ointment to heal his Myrmidons wounded in the siege of Troy, named the plant for Achilles, who was his favorite pupil. It is mentioned in old books as a love charm; as a herb brewed by crones to cure divers ailments, from loss of hair to ague; as an inducement to nosebleed for the relief of congested headaches, and as an ingredient of an especially intoxicating beer made by the Swedes.

Several kinds of Wild Buckwheat grow in the semi-arid regions. It is a flower of the sagebrush area where it often carpets the ground with yellow or white clumps of flowers. The large, feathery umbrella-like heads are the cause of the name Umbrella Plant which is incorrect as each ball of flowers is, in fact, a tiny snowball in itself. When fall comes the flowers as well as the leaves turn pink, rose, or red. The yellow species is called Sulphur Plant and is the more common of the two out on the Geyser Basin. The seeds furnish food for many of the birds.

Another flower of the same area is the Lupine, Bluebonnet or Wild Pea. Many of the lupines are poisonous and cause heavy losses to sheep men. The mature fruit of the non-poisonous variety is used by the Indians for food. The lupines form a group of mis-named plants. They derived their name from the latin word, lupus, meaning a wolf because people thought it was stealing the fertility from the soil and storing it away in the nodules on the roots where it would be kept. In time they believed the soil would become unfit for crops. However, we now know that the very opposite takes place; that the plants return to the soil foods that other plants must have.

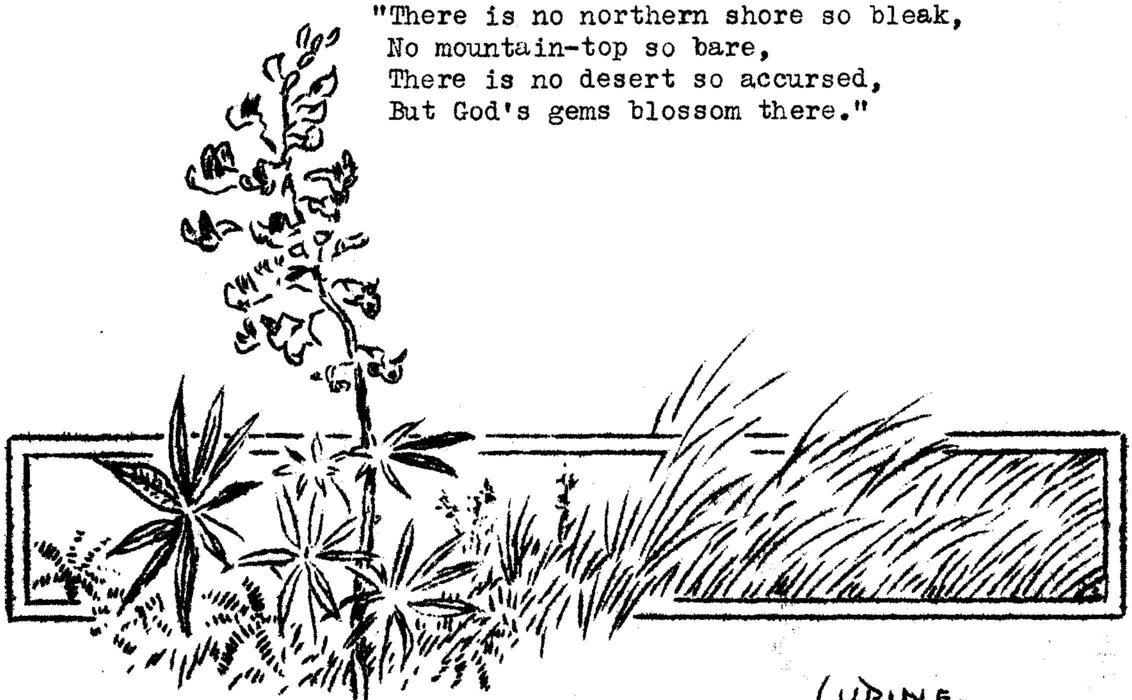
In mid-summer the slopes of Dunraven Pass and Mt. Washburn as well as the roadsides are converted into a real alpine garden by the tall purplish-pink spikes of the Fireweed. Since it is one of the first plants to come in on a region that has been swept by fire or logged over, it was given the name, Fireweed. It is also known as Willow-herb because of the similarity between its leaves and those of the willows.

In June the drier slopes of the desert regions of the West are covered with clumps of golden yellow flowers resembling dwarf sunflowers. They are the Balsam-root, so called from the odor of balsam occurring in the roots of the plant.

Pentstemons or Beard-tongues of several kinds grow on the south slopes of the more exposed hills. The tall anilin-blue one is probably the most attractive of all. When cultivated this plant becomes about three times its present size. This is one of the few species that can be cultivated with success.

Whether you climb to the highest peak or walk through the deep woods or the desert areas of the Park or over the hot spring and geyser basins, you will find some plant growing which explains what the poet had in mind when he wrote:

"There is no northern shore so bleak,
No mountain-top so bare,
There is no desert so accursed,
But God's gems blossom there."



LUPINE

BEAVER OF YELLOWSTONE NATIONAL PARK
(Lecture at Roosevelt Lodge)

By J. M. Hitchings, 1927 Ranger Naturalist

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Dr. E. R. Warren, Roosevelt Field Naturalist
E. J. Sawyer, Park Naturalist, Yellowstone Nat. Park
Ansel F. Hall, Chief Naturalist, N. P. S.
Dr. H. S. Conard, Ex-Chief Ranger Naturalist, Y. N. P.
Gerald E. Marsh, 1927 Head Ranger Naturalist, Y. N. P.

We usually think of the larger animals here in Yellowstone Park as being the most intelligent, but when a study of some of the smaller species is carried on we find that their habits, and what I call intelligent acts, seem to challenge the intelligence of man. There is a very thick layer of veneer separating the highest and the lowest of the human race, but only a thin layer of varnish between man and the so-called "lower animals". If you were to make a study of some of the most intelligent animals I feel that you would think that they are not so "low" after all.

I really think that man gives himself credit for doing more thinking than he actually does and, after all, do we not learn much by "trial and error"?

After making a study of the beaver and learning of his wonderful mechanical and engineering skill, also his habits of industry, I feel that man has much to learn from the lower animals and still more to practice before he can say that he is in every respect above the lower forms of life.

This little animal, the beaver, undoubtedly leads many of the animals of the world in mechanical and engineering skill and also in habits of industry. He is chiefly nocturnal in his habits, sleeping during the day and working after night fall. The beaver is not often seen during the day, but may be seen in the hour before sunset.

The beaver is the largest gnawing animal in North America. He is about 28 to 30 inches long plus a 12 to 15 inch tail which is four to five inches wide, flat, hairless and covered with scales. The color of the animal is brown, weight 40 to 50 pounds, and the webbed hind feet are well adapted for swimming.

The beaver builds four kinds of structures - dams, canals, lodges and burrows - although they do not build all in every case.

The dams are built chiefly of sticks and mud. First, sticks are laid across the stream, butt ends up stream. They then dig up some mud and gravel from the upstream side and cover the sticks.

Some sticks are soon laid across the current so as to underpin the first layer, each layer being covered with mud; then the dam is built until it is above the level of the water. A ridge of mud is always built up right along the water's edge of the dam. The dams usually have a curve upstream due to the fact that the beaver keeps building at the ends of the dam as the water begins to flow around. The dam is never finished. They keep adding to it all the time, usually logs from which they have eaten the bark.

A path is maintained over the dam right where the water runs through, so the animals will be in water when they cross. They often build a series of dams, the newer ones farthest from home, always moving toward the place where lumbering.

Why do they build the dams? In order to make a pond sufficiently deep for their lodges and in which they can hide from their enemies (mountain lion, lynx, wolf, coyote and bear) and to back the water as close as possible to the place where they are lumbering. The water back of the dam may be about four to five feet at the deepest point.

The beavers also build canals, and these are probably higher engineering achievements than the dams. To plan deliberately and dig a canal in which to float logs to a pond, and not only that, but to build dams in the channels to hold the water to a certain level are intelligent acts. The canals vary in size from one to four feet in width and from eight inches to twelve feet in depth. Up here by Yancey's where we go to see beaver, they have dug a canal around a hill to the place where they are lumbering. At this place they cut the aspen trees, divide the logs into pieces about three feet long, drag the pieces about four rods to the canal, float them in the canal down to the pond, and then bury the logs in the mud outside of the lodge.

The lodges are built chiefly of mud, sticks and grass, and in somewhat the same manner as the dams. The lodge is usually started on the highest point in the pond as a small island. The lodge begins with a burrow covered with mud and sticks and as the work goes on the interior is then hollowed out and built more loosely at the top for ventilation. A floor is build a few inches above the level of the water. It is fairly well bedded with grass and wood fiber. The lodges are about four to ten feet in diameter, four to five feet high, and often larger. There are some extremely large lodges on Tower Creek and also on the creek in the vicinity of The Petrified Tree. Within the lodge the room may be five feet long, three feet wide and two feet high, large enough to accommodate a man. Such a house may accommodate twenty or more beavers at one time. It is on the floor of this room that they serve their meals in the winter and here that the several mothers rear their three or four babies in the spring. There are usually at least two entrances to the lodge, each being below the level of the water.

Besides a lodge the beaver colony always has one or more burrows in the banks of the pond. The burrows are often marked by a pile of mud, logs, and sticks close to the water's edge, under which one can find the entrance to the burrow. When driven from the lodge by enemies the animals take refuge in the burrows.

The bark of the quaking aspen tree is the favorite food of the beavers in Yellowstone Park. They usually fell the young trees. Preferably, they cut trees not over ten inches in diameter, although I have seen some aspen cut that were twelve inches to fourteen inches in diameter. Cottonwoods three and one-half feet in diameter have been felled by beaver. The trees are cut with the teeth, which are very long and well adapted to such work. The enamel on the incisors, which are the gnawing teeth, two above and two below, is only a thin shell on the outside, the softer dentine wears off faster than the enamel, always keeping the teeth with a chisel edge. (Show skull and teeth). Here I have a skull of a beaver which will give you an idea of the size of the teeth. (Pull out a lower tooth). The teeth are very long, the lower being curved and about four inches in total length. The gnawing teeth continue growing throughout the life of the animal, about one inch of the upper and one and one-quarter inches of the lower teeth remain beyond the bony socket.

With such teeth the beaver can cut down a four inch aspen in about an hour, and he does it in this manner. He takes his position on the side of the tree where it is most convenient for him to cut. (Use specimen showing position of beaver and height cut above the ground). The beaver usually cuts the tree about six inches to twenty inches above the ground. The bark is usually removed all the way around the tree, and the cutting the same, if the tree is on the level. If the trees are on a hill the cutting is from the up hill side, the trees falling down hill as they lean that way. (Use a chip, showing how they remove the chips). The chips are removed in this way. The beaver cuts in three or four times at this point and then about the same number usually about three inches above. He then takes a hold with his teeth between the two gnawed points and pulls out the chip. The average chips will be about two and one-half to three inches long and one inch wide. I have seen chips six to seven inches long.

Popular articles often state that a beaver can fell a tree in any desired direction, but I believe that this is not true, for in places where they have been lumbering one finds trees down in every direction. I think that the beaver cuts the tree where most convenient to himself and lets it fall as it may.

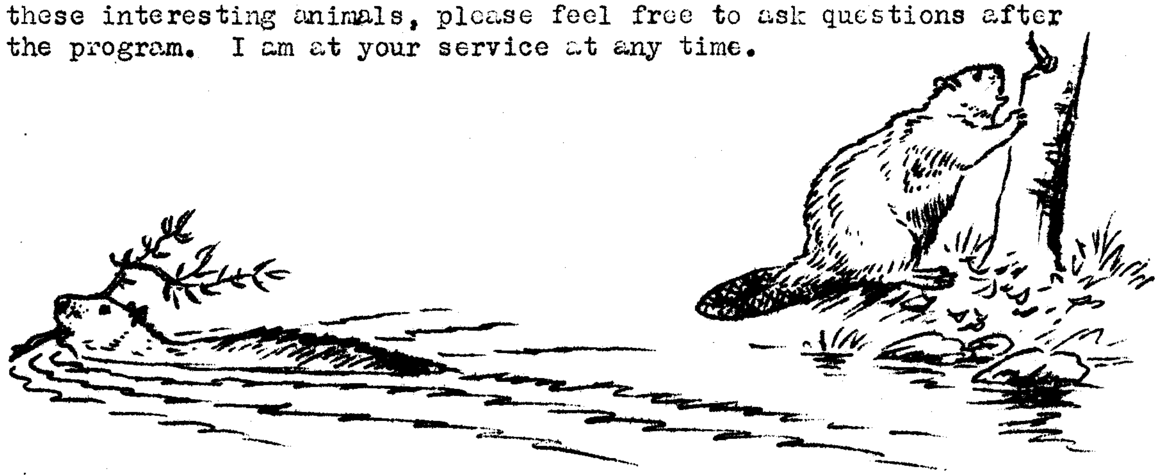
At the approach of cold weather the beavers begin to store their winter supply of food. As I said before their favorite winter food is the bark of the quaking aspen, although during the summer they may eat thistles, rose bushes, willows, and alders.

From the felled trees the beaver first remove the branches and drag them to the lodge, stripping off the bark if hungry or forcing them into the mud at bottom if storing for winter food. After the branches have been removed the main trunk of the tree is cut into pieces from three to seven feet long, depending upon the diameter. By using his teeth the beaver drags logs to the water and then floats them to the desired location near the lodge. If not too large, they are forced into the mud the same as the smaller branches. During the winter months the beaver can dive out under the ice, drag a piece of aspen onto the platform within the house and have lunch.

Of course you are all interested to know about this large flat tail of the beaver. (Show a dried beaver tail). The scaly part of the tail is about nine inches long and five inches wide. The beaver does not cut the trees down with the tail, never uses it as a trowel, does not even carry mud nor plaster it down with the tail. The tail is used as a prop or stool when cutting a tree, as a rudder when he wishes to turn quickly in the water, and he also slaps the water as a danger signal, but does not skull with it as does the muskrat when swimming.

The value of the beaver is rather difficult to put in words, but the creature is of real interest to the close observer. The beaver may build a dam, flood an area, thereby killing some trees by shutting off the oxygen supply from the roots, and then proceed to cut many more. You may think this is real destruction; but the region will be deserted after the food supply is gone, the water will drain out, and then the area will soon form a fine meadow furnishing grass for the larger grazing animals. Many a fine meadow here in the park was once a beaver pond. Surely it is worth while to know these facts first hand. The habits of the beaver may be seen by taking the beaver dam trip from this camp. If you have not seen these animals and their wonderful engineering work, come with me tomorrow night to the beaver dam.

If I haven't answered all the questions you had in mind about these interesting animals, please feel free to ask questions after the program. I am at your service at any time.



WATER SHEDS OF YELLOWSTONE NATIONAL PARK & VICINITY

By: - Marguerite Lindsley,
Park Ranger.

Approved by:
Superintendent Horace M. Albright
J. E. Haynes, Acting Director, Yellowstone Park Museum
Ansel F. Hall, Chief Naturalist, National Park Service
G. E. Marsh, Head Ranger Naturalist (1927)

Yellowstone National Park, saddling the backbone of the continent as it does, gives rise to streams which eventually flow into both oceans. The Continental Divide cuts the park into the Atlantic and Pacific water sheds. Heart, Lewis and Shoshone Lakes are all on the Pacific slope. Just south of the southeast corner of the park is Two Ocean Pass where the waters of Pacific and Atlantic Creeks mingle before they start on their journeys to the respective oceans. Pacific Creek flows into Snake River after the latter has left Jackson Lake. Atlantic Creek flows into the Upper Yellowstone River before it flows into Yellowstone Lake.

Snake River rises outside of the park but flows north into it, then west to the Snake River or southern entrance where it turns and flows south into Jackson Lake. From there it flows east, south, west through the Grand Canyon of the Snake, north to where it is joined by the North or Henrys Fork and then south and west thru Idaho. It finally flows north again and joins the Columbia at Pasco, Washington. This river certainly earns its name of Snake.

Bechler River drains the southwest corner of the park and eventually flows into the North Fork of the Snake in Idaho. Madison Lake is the name given first to Shoshone Lake when it was thought to be on the Atlantic slope and to drain into the Madison through the Firehole. This name now applies to a small lake at the head of Firehole River.

Green River rises at a distance of about 45 miles south of the park and flows south into the Colorado and eventually into the Gulf of California.

The Yellowstone River itself rises south and east of the park at the foot of Younts Peak, a mountain named for the first "game-keeper" of the park. After flowing through Yellowstone Lake it passes through the Grand Canyon of the Yellowstone and out of the park, north until it reaches the big bend at Livingston, Montana, where it turns east and joins the Missouri near a little town in North Dakota, Buford. This marks the site of one of the earliest trading posts in the West, old Fort Union. In those days the Yellowstone was called Elk River.

Two of the well-known park rivers, the Gibbon and the Firehole, join at Madison Junction to form the Madison which, together with the Jefferson and the Gallatin, forms the Missouri. When Lewis and Clark explored the area of the Louisiana Purchase in 1805, they followed the Missouri to a point in Montana where these three great rivers came together. This point they called Three Forks and the three rivers were also named by members of this party, - the Jefferson in honor of President Jefferson, the Madison for Secretary of State, James Madison, and the Gallatin for the Secretary of the Treasury, Albert Gallatin. The Gallatin River also has its headwaters inside of the park.

The headwaters of the Gallatin and the Gardiner are very close in the northwest corner of the park, but these waters do not meet until the Yellowstone and the Missouri converge in North Dakota. The junction of the Gardiner and the Yellowstone marks the northern boundary of Yellowstone National Park.

Clark Fork of the Yellowstone rises just across the divide from Soda Butte Creek, one of the tributaries of the Lamar or east fork of the Yellowstone inside of the park. It, Clark Fork, flows south, east and then north to join the Yellowstone at Laurel, Montana.

Wind River of Wyoming has its headwaters very close to those of the Yellowstone and the Buffalo Fork of the Snake. It flows south and east until it meets the Popo Agie and then turns almost directly north, through the famous Wind River Canyon north of Shoshoni to Thermopolis where it is joined by Owl Creek and immediately changes its name to the Big Horn. Somewhat farther north it is joined by the Shoshone River. The north or main fork of the Shoshone River rises in the mountains east of the park and many of its tributaries, such as Middle Creek, come from the park itself. The south fork joins the main Shoshone in the great reservoir formed by the dam west of Cody. This fork rises near the headwaters of the Yellowstone. Shoshone River used to be known as the Stinking Water because of some great sulphur springs on its banks.

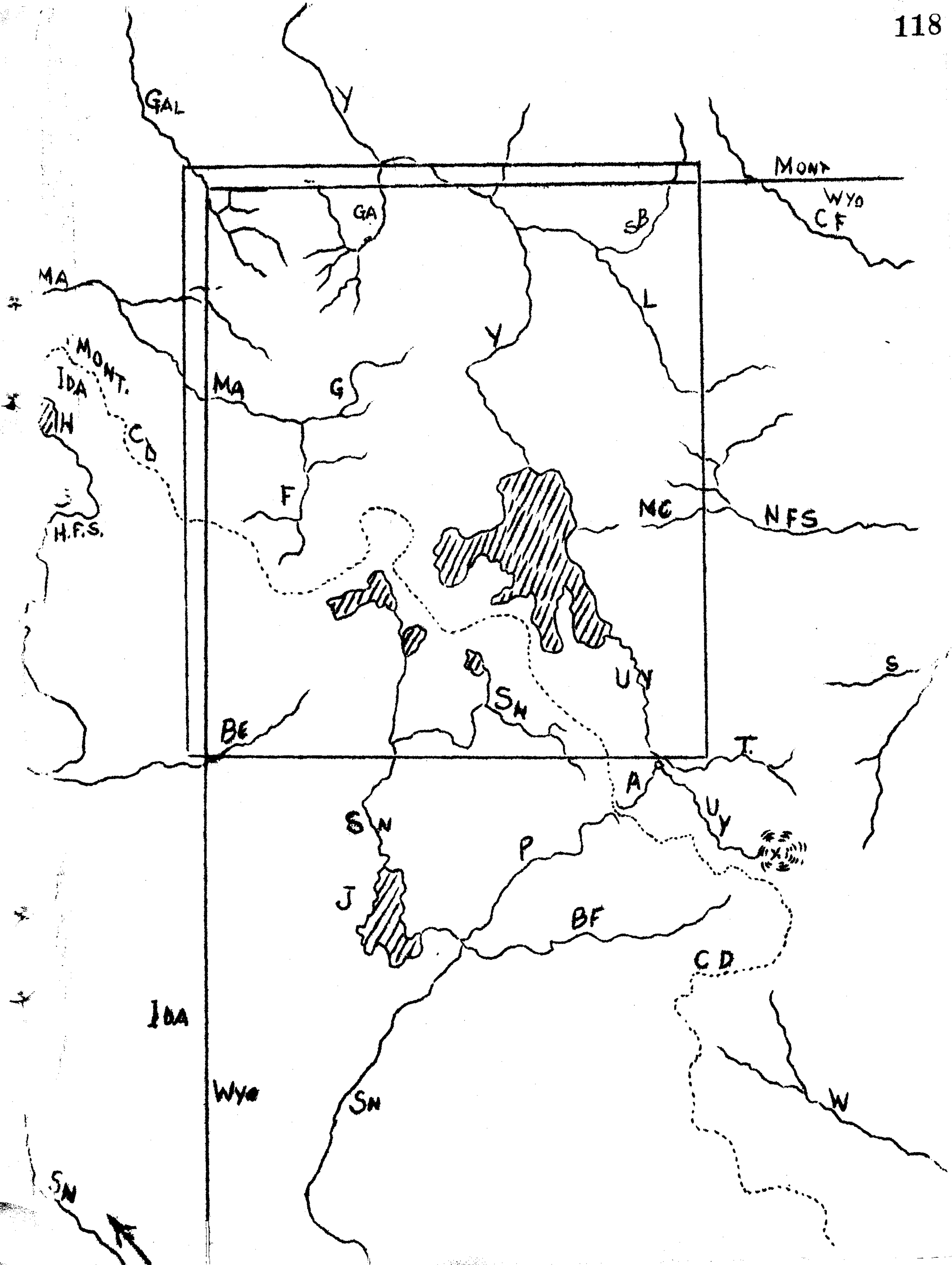
The North Fork of the Platte River has its source in the southern part of Wyoming and empties eventually into the Missouri in Nebraska. One of the most famous rivers of Wyoming and Montana is Powder River which rises near the town of Powder River, Wyoming. It is known as the river that is "a mile wide, an inch deep, and it flows up hill". This river eventually flows into the Yellowstone in the eastern part of Montana.

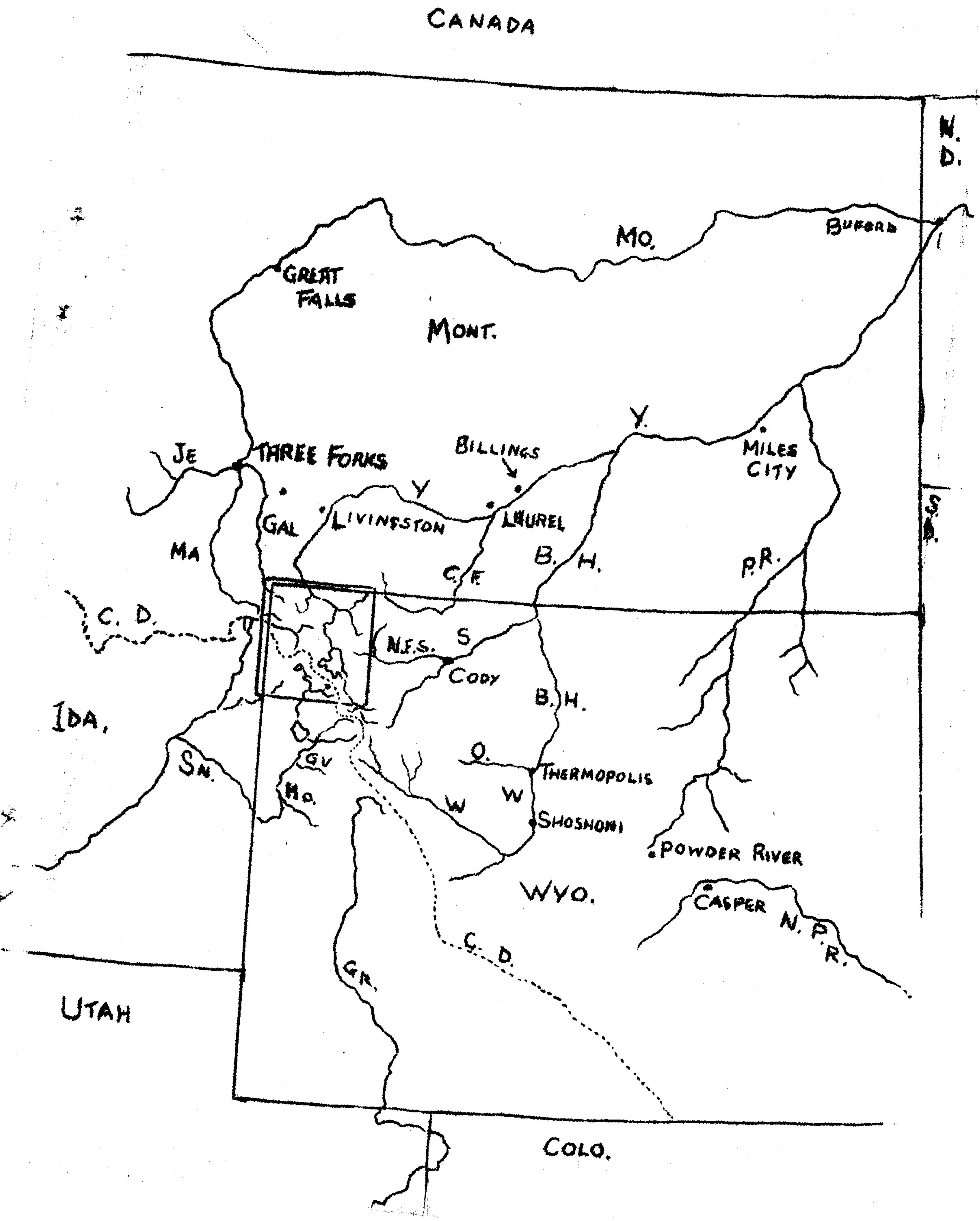
Key to Maps

A - Atlantic Creek
BF - Buffalo Fork - Snake River
BH - Big Horn River

L - Lamar River
Ma - Madison River
MC - Middle Creek

BL - Bridger Lake
CD - Continental Divide
CF - Clark Fork - Yellowstone River
F - Firehole River
G - Gibbon River
Ga - Gardiner River
Gal- Gallatin River
Gr - Green River
GV - Gros Ventre River
H - Henrys Lake
HF - Henrys Fork or North Fork - Snake River
Ho - Hoback River
J - Jackson Lake
Je - Jefferson River
Mo - Missouri River
NFS - North Fork Shoshone River
NPR - North Platte River
O - Owl Creek
P - Pacific Creek
PA - Popo Agie River
PR - Powder River
S - Shoshone River
SB - Soda Butte Creek
Sn - Snake River
UY - Upper Yellowstone River
W - Wind River
X - Younts Peak
Y - Yellowstone River


GAL
Y
MONT
WYO
CF
GA
SB
MA
L
Y
MONT.
IDA
MA
G
IH
CD
F
MC
NFS
H.F.S.
UN
S
SN
BE
T.
A
SN
UY
P
X
J
BF
CD
IDA
WYO
W
SN
SN



CANADA
N. D.
MO.
BUFORD
GREAT FALLS
MONT.
Y.
MILES CITY
JE
THREE FORKS
BILLINGS
Y
GAL
LIVINGSTON
LAUREL
MA
B. H.
C. F.
P. R.
C. D.
N.F.S.
S
CODY
S. D.
IDA.
B. H.
O.
THERMOPOLIS
SN.
GV
Ho.
W
W
SHOSHONI
POWDER RIVER
WYO.
CASPER
N. P. R.
C. D.
GR.
UTAH
COLO.

ACOUSTIC PHENOMENA OVER YELLOWSTONE LAKE

By Marguerite Lindsley, Park Ranger

Approved by:
Superintendent Horace M. Albright
J. H. Renshawe, U. S. Geological Survey
J. E. Haynes, Acting Director, Yellowstone Park Museum
Ansel F. Hall, Chief Naturalist

From time to time the so-called "musical sounds" over Yellowstone Lake have been reported or written up by the persons who have heard them. Mr. J. E. Haynes, Acting Director of the Yellowstone Park Museum and for forty years a resident of Yellowstone Park has heard these sounds and states that his impression is that they are more like a "roar" or a "whir", "more like the noise made by a large number of birds flying through the air" than like "music".

No systematic study has ever been made of this phenomenon but various theories have been propounded from time to time and herewith is given a resume of these as complete as the data on hand allows it to be.

There follows a letter from Mr. J. H. Renshawe, who was with early surveys in this region. This letter is dated November 14, 1926. It is quoted in full, as the reference to the bolt of lightning from a clear sky is thought by some to be closely allied in cause to the acoustic phenomenon.

> "Referring to your note of October 26th I am sorry that I have not yet had time to look up the reference to "mysterious noises" in the Army reports, but in the field season of 1885 I had a supply camp on the west shore of the Lake about half way between the present location of the Lake Hotel and the Lake outlet, and frequently heard what has been called the music - something more like a moan. The sound seemed to come from a hot spring on the bank of the Lake on the opposite shore, and was dependent on the state of the atmosphere and the direction of the wind. I have been at or near the spring several times, but have heard only the hissing sound of the escaping steam.
>
> "M. D. Scott, who was killed by lightning on Yellowstone Lake, was employed by me in the field season of 1885 and had charge of the supply camp referred to above. He was one of those wandering spirits we used to meet in the old west, chiefly employed in prospecting or such other congenial opportunities as might furnish occupation between times. Scott was an unusually high class man, and while, as was natural in such a wandering life, he carried all his wordly goods in his pack, I

found, upon settling up his affairs, that he had on deposit in various Montana banks quite a sum of money--something over $15,000.00, which, of itself, shows that he was above the usual class of wanderers.

"On the Sunday morning of September 5, 1885 I started across the Lake to storm point to make a "station" using a small home-made boat with a square sail and oars. In the party, besides myself, was Scott and two other men. We started out using the sail, but when about half way across the wind gathered too much force for the rude sail so we resorted to the oars. I sat at the bow holding a corner of the sail which I had wrapped around the mast--Scott sat on the seat in front of me, which also served as a base for the mast. The other two men sat one on the next seat and the other at the stern.

"As Scott pulled at the oar his back and head would bump against the mast, and evidently the lightning bolt after striking the mast switched to his head at the moment of contact, down the left side of his body and out through the bottom of the boat. All of us were left unconscious. I was the first to wake up as from a sound sleep and found Scott lying across by lap, having fallen backwards from the seat in front of me, and apparently having died instantly--the other two men were lying in the bottom of the boat which was then half full of water--but after a time both revived, and applying the oars soon pulled in to the shore. Fortunately for all of us the boat had been made of new lumber, and as the bolt passed through the bottom the broken fibres fell back and to a great extent stopped the inflow of water.

"The bolt of lightning that wrecked us apparently came from a clear sky and when I waked up the sun was shining and the air was quite still.

"On account of lack of facilities (we having only a packtrain) we were unable to carry Scott's body out, so gave him rude but safe and respectful burial on the terrace near camp. From letters found in his pack I learned the home address of a sister, and after communicating with his family in Illinois his father and two brothers came out and carried him back to their home.

"Later I may find the reference to the "mysterious noises" and will give you the report that contains it, but I am sure now that I have never seen it."

In the September 18, 1926 issue of the Literary Digest there appears an article by Stephen Forbes of the State Natural History Survey at Urbana, Illinois, who reports having heard the sounds in 1890 when with Professor Edward Linton, then of the Washington Jefferson College, Pennsylvania, he was making a biological survey of the waters of the park under the auspices of the U. S. Fish Commission.

"Linton and I heard these sounds with wonder and delight in different places and under different conditions--once I remember when we were riding on horseback through the woods, but never when they could be explained as due to anything in our immediate neighborhood.

"I was so interested in this perplexing phenomenon that I made the following footnote reference to it in my report of our operations, made to the commissioner, Col. Marshal McDonald, and published in the Bulletin of the U. S. Fish Commission for 1891. Referring to Shoshone Lake, I wrote:

"'Here we first heard, while out on the lake in the bright still morning, the mysterious aerial sound for which this region is noted. It put me in mind of the vibrating clang of a harp lightly and rapidly touched high up above the tree-tops, or the sound of many telegraph wires swinging regularly and rapidly in the wind, or, more rarely, of faintly heard voices answering each other overhead. It begins softly in the remote distance, draws rapidly near with louder and louder throbs of sound, and dies away in the opposite distance; or it may seem to wander irregularly about, the whole passage lasting from a few seconds to half a minute or more. We heard it repeatedly and very distinctly here and at Yellowstone Lake, most frequently at the latter place. It is usually noticed on still, bright mornings not long after sunrise, and it is always louder at this time of day; but I heard it clearly, tho faintly, once at noon when a stiff breeze was blowing. No scientific explanation of this really bewitching phenomenon has ever been published, altho it has been several times referred to by travelers, who have ventured various crude guesses at its cause, varying from that commonest catch-all of the ignorant, 'electricity," to the whistling of the wings of ducks and the noise of the 'steamboat geyser'. It seems to me to belong to the class of aerial echoes, but even on that supposition I cannot account for the origin of the sound.'

"I am surprised that it has not been studied and understood before now, and I hope that some of the many scientific men who doubtless visit the park every year may find in it an attractive problem for vacation study."

In the magazine "Science" for June 11, 1926 there appears an article by Mr. Hugh M. Smith containing observations made by him in 1919 when he was Commissioner of Fisheries. In this article he quotes "The Yellowstone National Park" by Chittenden, 1915 edition, which gives an account of the phenomenon. The article is as follows:

"It is highly gratifying that the American people are making yearly increasing use of the Yellowstone National Park and that each season many thousands become for the first time acquainted with its beauties and wonders. Among future visitors there will be some who will experience the strange and bewildering musical sounds that for many years have been noted in certain parts of the park. As a partial contribution to the solution of the mystery, a personal observation on one manifestation of the weird phenomena may be of interest.

"This subject has received scant mention in various published reports and articles, and by some people has been relegated to the catagory of yarns and myths which helped to make Jim Bridger famous. The best account seems to be that contained in the best work on the park, that of General Chittenden, from which the following quotation is taken. (Pages 288-289):

> 'A most singular and interesting acoustic phenomenon of this region, although rarely noticed by tourists, is the occurrence of strange and indefinable overhead sounds. They have long been noted by explorers, but only in the vicinity of Shoshone and Yellowstone Lakes. They seem to occur in the morning and to last only for a moment. They have an apparent motion through the air, the general direction noted by writers being from north to south. They resemble the ringing of telegraph wires or the humming of a swarm of bees, beginning softly in the distance, growing rapidly plainer until directly overhead, and then fading as rapidly in the opposite direction. Although this phenomenon has been made the subject of scientific study, no rational explanation of it has ever been advanced. Its weird character is in keeping with its strange surroundings. In other lands and times it would have been an object of superstitious reverence or dread and would have found a permanent place in the traditions of the people.''

"In the summer of 1919 during a visit to the park in connection with governmental fish-cultural and fish-planting work therein, the present writer, in company with Mr. A. H. Dinsmore, of St. Johnsbury, Vermont (a former superintendent of fish hatcheries in the park), made a camping trip to Lewis and Shoshone Lakes, employing pack horses, with helper, and having as a part of the equipment an Oldtown canoe transported by motor truck from Yellowstone Lake to Lewis Lake.

"About eight o'clock on the morning of July 30, after having camped for two days and two nights on the shore of Shoshone Lake at its outlet at the southern end, we entered the canoe and pushed off from the shingly beach, headed for the northern end of the lake. The surface of the lake was glassy, the air was still, a faint haze overhung the water, the sky was cloudless, and the lake for a considerable distance out was in the shadow of heavily timbered hills. The canoe had barely gotten under way and was not more than twenty meters from the shore when there suddenly arose a musical sound of rare sweetness, rich timbre, and full volume, whose effect was increased by the noiseless surroundings. The sound appeared to come from directly overhead, and both of us at the same moment instinctively glanced upward; each afterward asserted that so great was his astonishment that he was almost prepared to see a pipe organ suspended in midair. The sound, by the most perfect gradation, increased in volume and pitch, reaching its climax a few seconds after the paddling of the canoe was involuntarily suspended; and then, rapidly growing fainter and diminishing in pitch, it seemed to pass away toward the south. The sound lasted ten to fifteen seconds and was subsequently adjudged to range in pitch approximately from a little below center C to a little above tenor C of the pianoforte, the tones blending in the most perfect chromatic scale.

"It was at once realized that this was probably a manifestation of the strange phenomena referred to by General Chittenden, whose book had been read in camp, and that an opportunity was presented to investigate and perhaps elucidate the mystery. So favorable was the opportunity that in a short time we were reproducing the sound at will.

"Following the dying away of the music and the short period in which we were held spellbound, paddling was resumed and, as the canoe gained sufficient headway, the music recurred in practically the same form as at first, and, as the paddling ceased and the momentum of the canoe fell off, the sound died away. It was thus perceived that the sound was coincident with the motion of the canoe; when a certain speed was reached and maintained, the sound was produced and maintained; before that speed was attained there was no sound, and after that speed was lost the sound ceased.

"A search for the cause of the sound disclosed the following situation: A jointed bamboo salmon rod with its butt-end touching the side of the canoe was projecting backward about half a meter beyond the gunwale; the waxed silk line was reeled in, but about a meter of line with the lure at the end was wrapped several times around the terminal joint; a lead sinker weighing one hundred grams, that had been attached in order to carry the lure into deep water frequented by the large trout with which the lake had been stocked, was dangling from the end of the rod about five centimeters below the surface of the water. As the canoe moved through the water, the short length of free line, held taut by the sinker, rapidly vibrated in conformity with the speed of the boat; the vibrations were transmitted through the bamboo rod to the canoe, whose thin, curved, rigid sides and bottom acted as a sounding board and gave out an augmented volume of sound that seemed to be concentrated or focused overhead. The combination of essential factors present in this case seems to have been a smooth water surface, a vibrating cord, a resonant body to which the vibrations were transferred, and still air, with perhaps other favorable atmospheric conditions. Later, in other parts of the lake, where the surface was disturbed by ripples or waves and there was slight to moderate movement of the air, attempts to reproduce the sound were futile, although the other factors were as in the original manifestation.

"It is not to be inferred that the conditions and explanation herein given are held to account for all the mysterious musical sounds that have been heard in the park. On the contrary, owing to the rarity of the occasions when canoes had been used in park waters, it seems likely that the exact combination of factors noted must have been exceptional. All that is claimed for this manifestation is that it fulfilled the requirements of the mystery as described by the best observers and that its cause was ascertained. An account of the occurrence was promptly given the superintendent of the park.

"That acoustic conditions on Shoshone Lake that morning may have been peculiar is suggested by another observation as the canoe was skirting the eastern shore of the lake and the Shoshone Geyser Basin came within visual range. During several of the eruptions of the principal geyser, the splashing of the geyser water on the hard siliceous platform was distinctly heard. The distance in an air line, according to the official Geological Survey map, was approximately nine kilometers."

In 1924 Park Naturalist Edmund J. Sawyer made a shore line trip around Yellowstone Lake with Mr. Haynes. There follows his description of the grounds:

"It was in the summer of 1924, while making our shoreline trip around Yellowstone Lake, that Jack Haynes and I heard the sounds in question. My impression now is that we heard them at various points of our trip, but I recall them with particular distinctness as occurring while we were on and about Steamboat Point. As to a "full description" of the experience - unfortunately, it happens that the sounds might very aptly be characterized as especially difficult if not impossible of "full description". Indeed the impressive and outstanding feature of the sounds is their very weirdness, their (apparently) fortuitous origin. It was a mid-morning of a fine day, without a breath of wind when this "sound of going", like a strong wind (but a wind which could not be felt and which did not stir a leaf or cause a ripple on the water about us), reached us or passed overhead. It was something like a noise of a 'stooping' falcon or the swish of a swooping flock of mallards or teal. It went as it came - mysterious in its nature, its origin and direction, and gave no clue to its identity. ---"The wind bloweth wheresoe'er it listeth, and thou hearest the sound thereof, but thou cans't not tell whence it cometh nor whither it goeth". But I would not say that the sounds are "musical". Or if musical, that quality is certainly secondary in effect--a mere incidental and lost in the sheer uncanniness of the phenomenon.

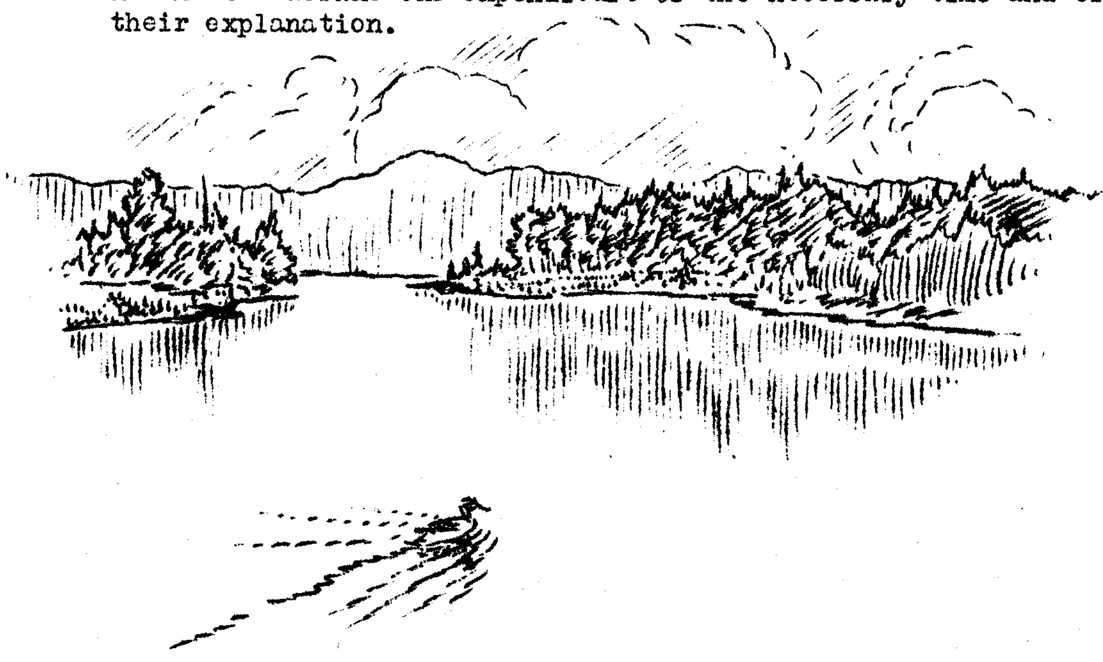
We stayed about Steamboat Point for perhaps half an hour, hearing the sound repeated at intervals of a few minutes. With each repetition the mystery was deepened rather than explained.

"As to a possible explanation; this would be little or nothing more than a guess on my part. I can only fancy that there may be such a 'lay of the land'--as a certain favorable arrangement of canyons or mountain peaks,--somewhere about the lake and, that these conditions project the wind across the lake at a height above the water of some hundreds of feet. Be the explanation what it may, I can certainly testify that the sound is real--as real as it is baffling."

Mr. Haynes adds to this as follows:

"I have read with interest Sawyer's account of the mysterious, overhead noises of Yellowstone Lake and can add nothing further to it. There is no question about the reality of these noises. I want to suggest the consideration of this phenomenon from the standpoint of static electricity and only the other day was contemplating writing to the Department at Washington to see if it is possible to have investigations made there with galvanometers or other similar instruments. You remember that in the early days a boat was struck by lightning on Yellowstone Lake although the day was practically clear. It is possible, therefore, that the noise is a by-product of the discharge of electricity of a very high voltage."

From time to time there have been reports in the newspapers regarding these noises but all of them are based on the articles and letters here quoted. As yet very little is known regarding them and they present a very nice scientific problem for a summer's research. It is to be hoped that in time enough interest will be manifested in these phenomena to warrant the expenditure of the necessary time and effort in their explanation.



THE PIRACY OF THE YELLOWSTONE

Extracts from an article by J. Paul Goode written for the Bulletin of the American Bureau of Geography, Vol. II, No. 2, June, 1901 - copyrighted.

Approved by:
Horace M. Albright, Superintendent

Ever since the Grand Canyon of the Yellowstone was introduced to the general public it has enjoyed a well-deserved fame for its grandeur and for the unrivaled beauty of its coloring. To the physiographer it has stood as a type pre-eminent of a very young river valley in the trench stage of development. All who have seen it have been profoundly impressed by it. It is now possible to introduce this already famous canyon in a new light, as the scene of one of the greatest piracies on record.

The Yellowstone Lake (7741 ft. elev.) lies in a depression in the southeastern part of the great rhyolite plateau of Yellowstone National Park. On the east the land rises rapidly to the high crests of the Absaroka range. On the north and west and for the most part on the south, the land rises to the general level of the plateau, eight hundred to a thousand feet above the lake. North and south of the lake and fringing the west shore, are considerable areas of flat land, not far above the present lake level and plainly lacustrine (the deposits which have accumulated in fresh water areas) in origin.

The valley of the Upper Yellowstone extends from over thirty miles to the southeast, past the limits of the park and from up in the heart of the Absarokas. The flat bottom of this valley averages over a mile in width for twenty miles above the lake, and it is manifestly very old. It has been shown that this and the Lamar valley to the northeast were old and well developed before the rhyolites were poured out to form the park plateau in Pliocene time.

It is believed that this whole region has been covered with ice moving west from the Absarokas and north from the Tetons, and it may easily be supposed that in the unequal recession of the ice margin, obstructed drainage would give rise to overflow to the west, establishing channels that would be abandoned on further recession of the ice. But there is one such channel that gives evidence of very long use even after the ice had left the plateau. This is a "windgap" between Overlook and Channel Mountains. Here a canyon with walls several hundred feet high cuts the present divide, down almost to the 7900 ft. contour. Yet this surprising notch is poorly drained, puny streams starting from the marshy col and flowing to the opposite oceans. This notch has been recognized as a former outlet of the Lake, and the fact is well known that the present lake is about 160 feet lower than its old level. Lacustrine deposits are recorded on the United States

Geological Survey maps practically up to the 7900 ft. contour all around the lake, and at its foot to a point four miles below the present lake outlet at Thistle Creek canyon or the rapids of the Yellowstone River. At this level also are found terraces, old sea cliffs and beaches, and while other shore phenomena are found at lower levels, yet in many respects the most strongly marked records are at this higher level.

Through the Thistle Creek narrows to the north the country flattens down into Hayden Valley - a triangular depression in the plateau, ten miles east and west by seven or eight miles north and south. The surface of this depression is covered with moraine deposits of glacial drift, and all around this valley the hills show a significant profile, undoubtedly terrace and sea cliff.

At Grand Canyon the strongest impression one gets is that the canyon is extremely young, that the river is still actively corrading at the bottom, and the walls all along are actively sloughing. Yet this impression of youth has its greatest emphasis only when seen from the east flank of Mt. Washburn. Here, at an elevation of about two thousand feet above the canyon's rim the whole eighteen miles of canyon is in view, from the falls to Junction Butte. With this view it is easy to see that the canyon is not all the same age. The north half is distinctly older than the southern or upper half. In the north half the shoulders are markedly rounded, the walls less steep and the stream at the bottom has long ago found an axial equilibrium with the material it has to handle and is not deepening or widening its bed in any striking way. It is a surprise to note too, that Broad Creek, which empties into the Yellowstone just at the east foot of Mt. Washburn, has a canyon every whit as wide, as deep, and with shoulders as rounded as the main canyon at this point.

One cannot help wondering why the Yellowstone Canyon is so young only above this point, why the deep stratified clays in Hayden Valley, why the cliffs at the high level in Hayden Valley. Why did the Yellowstone Lake abandon a good outlet at Overlook Mountain and flow off to the north?

On the recession of the ice from the region of the upper Yellowstone Canyon, the plateau of rhyolite stretched untouched by the river action, from the south base of Mt. Washburn southeast across the site of the present canyon, at the general plateau level of about eight thousand feet. There was no canyon, and no Yellowstone River there. The two depressions in the plateau, Hayden Valley and the present lake basin, if they existed in the preglacial time, outflowed by some other route, at present unknown. On the recession of the ice from the region, these basins overflowed to the west over available cols. There are a number of these but the one which established itself for greatest permanence was the one described at Overlook Mountain.

Taking the topographic map and supplying a shore line for a lake outflowing at this channel, the surprising fact is shown that such a lake not only pushes itself into the great valley over sixteen miles to the southeast, but it goes on through the narrows at Thistle Creek on the very level of the terrace and sea cliff noted. It covers all of Hayden Valley with the exception of the very peak of the Crater Hills and extends on past the falls and the Canyon Hotel to Inspiration Point on the north to Hawk's Rest far down in the Absarokas on the southeast.

After once seeing the deep, old valley of the Lamar River the impression is inevitable that the Yellowstone Canyon is a very late comer. In short, the Yellowstone Canyon, from Junction Butte to the east flank of Mt. Washburn is not the work of the Yellowstone River at all, but was made by Broad Creek, then a small tributary of the Lamar, of no more consequence than Tower Creek which joined it from the west. Its canyon may have begun in preglacial time, but long after the general ice-sheet had left the region it remained an obscure stream, slowly pushing its growing gorge back into the rhyolite plateau.

The col between the Sulphur Creek gorge and the greater lake lay about two miles north of Inspiration Point in the old Continental Divide. Yet the Sulphur Creek pirate was a long time eating through this two miles or so of barrier. And all of this while - a good fraction of post-glacial time - the great lake was giving its water through the Overlook Mountain channel to Snake River, and the beaches, terraces and sea cliffs were building at the 7900 ft. contour - about 160 ft. above the present lake level. In the Hayden Valley part of the lake similar beach records were making and the stratified clays were being deposited off-shore.

The rate of advance through the col by the Sulphur Creek pirate would depend upon three factors, the volume and gradient of the stream and the nature of the rhyolite. The volume of water was not large, being only the drainage from the south flank of Mt. Washburn and the east flank of Dunraven peak. The gradient was high, about 1500 ft. in the Sulphur Creek branch alone, while the rhyolite in the path of the canyon was in admirable condition for easy working.

The rhyolite, on first cooling from its flow, was hard and firm of texture, obsidian or volcanic glass being one phase of it usually found at the surface. In deeper levels it might have been as hard and crystalline as basalt but the hot vapors from below have attacked the rock and in many places totally changed its character, making the felspars over into kaolin and leaving the once firm lava a crumbling mass, almost like slaked lime. Yet this solfataric action has not been universal. It has worked very effectively in certain areas, while in other places the solid rhyolite has wholly escaped the decomposing action. Were this not so the canyon would, long ago, have advanced clear to the present lake.

The trend of the physiographical history of the region was suddenly changed when the col was cut through by the advancing canyon. The water of the lake began to flow out to the north, the increased volume very greatly hastening the deepening and widening of the trench. The lake level was rapidly lowered, the Overlook Mountain outlet was suddenly abandoned, and with this change the Continental Divide was transferred to its present position south of the lake. The lowering of the lake level was extremely rapid for a hundred feet, while the outlet was merely cutting into the decomposed rhyolite. In the hundred feet of rapid lowering but slight traces of shore action on the lake could be expected. But this rapid lowering was checked when the river reached the 7800 ft. contour for it came upon a firm wall of undecomposed rhyolite standing squarely across its path - the site of the present Great Falls - and the river settled down to the task of sawing this barrier in two. It is still at the task with nearly a quarter of its work yet to do. This barrier is only about 100 ft. thick and is very plainly marked in the brow of the canyon wall, forming a narrow gateway through which the water rushes. The inner walls of this gateway are very precipitous, as may be seen in the familiar view of the Great Falls. Immediately above and below this gateway, the canyon walls fall into a wide V-shape in section. Figure 1 shows the relation of the barrier to this fall, and how the canyon is narrowed to the precipitous gateway in the barrier. As seen from the downstream side, this barrier is evidently cut down a little over half of its height and one may easily conjecture that this fall which is now 308 ft. in height, must have been much higher, perhaps even 700 ft. The present brow of the falls is near the upstream face of the barrier, and, standing at the brow one may see that the firm rock of the barrier projects at the bottom on the east side of the stream, as a shelving ledge upon which the water is ceaselessly pounding - shown in longitudinal section in Figure 2. So this fall may be said to be showing signs of old age - that is, the rapids phase of development has already begun.

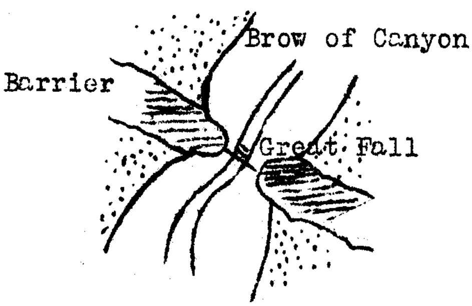


Figure 1.

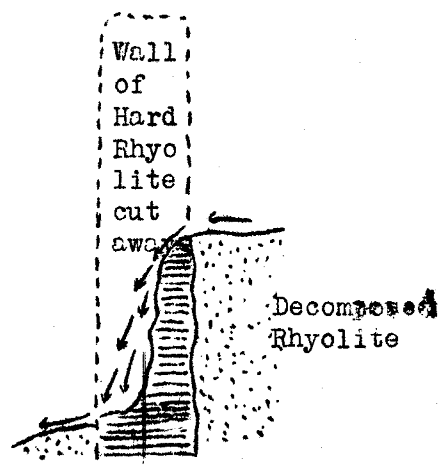


Figure 2.

When the lake outlet approached the barrier at the contour of 7800 ft. a current was formed at the Thistle Creek narrows, and two separate lakes resulted, with a short river between. The lower lake covering

Hayden Valley we may provisionally call Hayden Lake. The river at the narrows had glacial drift only to work on and was competent to cut this out widely as Hayden Lake level followed the lowering brow of the falls.

The problem was made more complex when the river found another wall of firm rhyolite at the site of the Upper Fall. This wall is much thicker than the lower one, and the process is proportionally slower. It was the lowering of this barrier that determined the lowering of the Hayden Lake level. When the wall was cut below the 7700 ft. contour Hayden Lake was drained, and this has only very recently been accomplished as is shown by the flat and sinuous course of Trout Creek.

The wearing down of the barrier at the Upper Fall has always lagged behind that of the Lower. It could not be touched at all until the lower barrier was reduced below its level, and the height of the Upper Fall has increased in height almost uniformly with the decrease in height of the Lower Fall as it has been limited at its lower level by the brow of the Lower Fall. It is plain to see that when the Lower Fall has finally sawed through its barrier the river will gradually carry the canyon gradient back to the Upper Fall which will then be perhaps 400 ft. high.

With the lowering of these two barriers other barriers were uncovered in the path of the stream above. The most important of these is a ridge of firm rhyolite in the bottom of the Thistle Creek narrows. This became a large factor in the history of the Yellowstone Lake, when in the cutting of the canyon at this point this firm rhyolite was reached at a level of about sixty feet above the present lake. The lake level since then has waited on the lowering of this one barrier. It is the only barrier which now determines the lake level, although it seems plausible that in earlier stages a barrier at Mud Geyser, and perhaps even the Upper Fall barrier were agents also in maintaining the lake at the sixty-foot terrace, the action on each barrier much deferred by the lack of gradient due to the former higher elevation of these lower barriers.

This is the postglacial history of Yellowstone Lake and the Canyon as it may be read from the data on hand. The whole great lake, with its drainage basin of about fifteen hundred square miles, was captured by the little Sulphur Creek canyon, taken bodily from the Snake River and the Pacific slope, and added to the Lamar River and the Atlantic slope. And the volume of water in the captive stream was so great as to dominate the lower valley of the Lamar and to reduce that older stream to the rank of a minor tributary.

OBSIDIAN CLIFF

By Dr. Arthur L. Day, Director,
Geophysical Laboratory of the Carnegie Institution

It is common tradition in the Ranger Service, handed down apparently from one year to the next and reappearing annually in the daily lectures on the Park formations, that Obsidian Cliff is a lava flow which somehow, perhaps through contact with water, was so quickly cooled that it became instead of crystalline, rhyolite like its neighbors of similar chemical composition. There is not sufficient evidence available yet to enter upon a full discussion of the origin of Obsidian Cliff but there are observations ready to hand which indicate that this particular explanation may not serve.

The obsidian mass exposed above ground is found to extend from Obsidian Lake southward beyond the Lake of the Woods (some five miles) and from the Loop Road eastward for about two and one half miles. It appears to be from two to five hundred feet thick above the level of the road and, if it emerged from the depths substantially where it now lies, may be much thicker. Within these dimensions it seems to be practically a continuous undifferentiated mass. To explain the quick cooling of such a mass is something of a problem! Much smaller flows of rhyolite of like composition and wholly crystalline are numerous in Yellowstone Park. How shall the much larger mass cool more rapidly than the smaller ones when exposed at the surface.

Small lava streams no more than fifteen or twenty feet thick (Aetna, Vesuvius, Hawaii) are said to require a year to cool. The great flow from Sakurajiuna (Japan) in 1912 took its way for a considerable distance beneath the sea. From the surface its appearance under water differed little from its appearance before entering, and the amount of heat carried away from it by the water served to raise the water temperature at the surface directly over the flow no more than 2° C. (Perret). Nor did the structure or texture of the portion of the flow which cooled beneath the sea differ appreciably from that cooled in air, except possibly for a few inches at the surface. Neither is there any obvious physical reason why water should be able to draw out the heat from a mass of lava much faster than air; for an inch or two, yes, for the heat capacity of water is much greater than that of air; but after that the controlling factor in heat flow is the conductivity of the lava itself which is the same for like temperatures whether in water or in air and is small, particularly if the outer layer is pumiceous as at Obsidian Cliff. There is certainly no obvious way of cooling a great mass of lava quickly either in water or otherwise. A drop or thread or bubble of liquid rhyolite or even a few pounds of it could be cooled quickly and when so cooled might form glass, whereas if more slowly cooled it might crystallize but there the experimental analogy ends. Obsidian Cliff is simply too great a mass to be cooled at such a rate.

It has been of some interest to try to trace the source of this idea of quick cooling as the explanation of the glassy structure of Obsidian Cliff. Iddings in the Seventh Annual Report of the U. S. Geological Survey (1885-6) says in his opening paragraph on the Obsidian Cliff, Yellowstone National Park, (p.255): Obsidian Cliff "is formed of nearly vertical columns of black obsidian, or volcanic glass, which has resulted from the rapid cooling of a perfectly fused, igneous rock." Later on (p. 260) in offering an explanation of the vertical columnar structure of the Cliff he appears to find this manner of cooling not quite suited to account for the vertical columns, for he says here: "The very rapid surface cooling of a molten rock tends to produce cracks parallel to the surface and cracks normal to the surface appear only in that portion of the mass which cools more slowly."

Although Iddings did not fail to observe and to record accurately the fact that only the deep-seated portion of Obsidian Cliff is uncrystallized, while near the surface of the flow more of the mass is crystalline than vitreous, nevertheless he appears to overlook the bearing of this observation upon "quick cooling". If this mass has remained vitreous because of"quick cooling", however the word quick may be defined, the surface layers certainly will have cooled quickest and should therefore remain completely vitreous while farther into the mass crystals might have time to form and in the deep interior a good deal of it might perhaps be expected to crystallize, if the rate of cooling is the dominating factor.

The very considerable amount of crystallization in the upper strata and its almost complete absence in depth is diametrically opposed to the quick cooling idea.

It would appear that Iddings himself was later somewhat less confident of the dominating influence of quick cooling for in his closing paragraph speaking of the lithophysae he says (p. 295) they "are of primary crystallization out of a molten glass which was gradually cooling and consolidating - - -". Also in his later work (Chap. X of Hague's Monograph on the Geology of Yellowstone Park, U. S. Geological Survey 1899) his only allusion to this vital matter in the discussion of obsidian formation is confined to the following observation (p. 403) "Glasses absolutely free from microlitic crystallization are seldom met with - - - The colorless glasses free from microlites are in almost every instance highly pumiceous - - - It must therefore have been the sudden expansion of the inclosed vapors and the consequent chilling of the magma that prevented the microlitic minerals from crystallizing before the magma solidified." The reference here is obviously confined to the surface layer which, when the pressure is removed on emergence of the lava at the surface, loses its dissolved glass which thereupon inflates the surface layer to a pumice which cools almost at once. Such pumice is still found here and there on the surface of the Obsidian Cliff mass although most of it has been carried away by subsequent glacial action. This detail, however, has little or no bearing upon the quick cooling hypothesis as an explanation of the vitreous character of the great mass of obsidian below.

A good deal of information isstill needed before the manner of solidification of Obsidian Cliff is entirely cleared up but enough has perhaps been said to show that the simple explanation by quick cooling needs to be more carefully considered.

LIST OF DISTANCES FROM YELLOWSTONE PARK POINTS

By Marguerite Lindsley, Park Ranger

Many inquiries are made regarding automobile road distances from Yellowstone Park Points. The following have been worked out with the aid of the 1927 Automobile Blue Book, Vol., 4, the 1927 Yellowstone Rules and Regulations pamphlet, and a Rocky Mountain Motorists 1927 Official Road Map of Wyoming. These are given as approximate distances as road grading, paving and construction work will cause changes from time to time.

From MAMMOTH HOT SPRINGS:-

	Miles
Banff	743.7
Banff to Spokane	382.6
Butte	203.4
Billings	195.4
Calgary (via Glacier Park)	657.4
Cheyenne (via Cody)	616.5
Cheyenne (via Lander)	584.5
Chicago (via north entrance, Billings, to A.Y.P.)	1638.2
Chicago (via south entrance and A.Y.P.)	1722.1
Chicago (via east entrance and Big Horns to A.Y.P.)	1608.7
Chicago (via Yellowstone Trail from north entrance)	1662.7
Denver (via Cheyenne)	724.6
Denver (via Salt Lake City, Vernal, and Steamboat Springs)	982.3
Glacier National Park (via Great Falls)	409.0
Glacier National Park (via Helena and Choteau)	413.0
Glacier National Park (via Missoula to west entrance)	514.2
Jackson, Wyoming	150.9
Kansas City (via Denver, Limon, and Manhattan)	1491.6
Lake Louise	784.6
Los Angeles (via Arrowhead Trail)	1166.8
Minneapolis (via Yellowstone Trail)	1177.7
Missoula (via Yellowstone Trail)	344.4
Moran, Wyoming	118.9
New York City (via north entrance, A.Y.P., Lincoln Highway)	2551.5
New York City (via south entrance, A.Y.P., Lincoln Highway)	2635.4
New York City (via east entrance, Big Horns, A.Y.P., Lincoln Highway)	2522.0
New York City (via east entrance, Big Horns, A.Y.P., Albany)	2614.7
Portland (via Old Oregon Trail)	996.8
Portland (via Yellowstone Trail)	1016.4
Rapid City (via Billings)	631.9
Sacramento (via Elko, Reno)	1143.0

	Miles
Salt Lake City (via west entrance)..................	427.8
Salt Lake City (via south entrance).................	501.0
San Francisco (via Elko, Reno, and Sacramento)......	1242.8
San Francisco (via Ely, Austin, and Reno)...........	1276.8
Seattle (via Yellowstone Trail).....................	974.4
Seattle (via Old Oregon Trail and Walla Walla)......	1114.0
Seattle (via Old Oregon Trail and Portland).........	1204.8
Spokane (via Yellowstone Trail).....................	569.4
Spokane (via Old Oregon Trail)......................	965.8
Vancouver (via Yellowstone Trail and Seattle).......	1141.0

Other National Parks

Bryce Canyon (via Nephi)............................	710.5
Zion Park (via Kanab)...............................	834.2
North Rim of the Grand Canyon (via Nephi)...........	842.2
South Rim of Grand Canyon (via Las Vagas and Needles).	1320.8
Rocky Mountain (via Denver and Boulder).............	799.0
Yosemite (via Ely, Tonopah, and Mono Lake)..........	1107.8
Crater Lake (via O.O.T. and Portland, Roseburg and Medford)..................................	1392.8
Mt. Rainier (via Yellowstone Trail to Seattle)......	1293.0
Glacier Park (via Great Falls)......................	409.0

From CODY:-

Mammoth Hot Springs (east entrance to park 55.4 miles from Cody).................................	126.9
Thermopolis...	135.6
Cheyenne..	487.8
Denver..	595.9

From GARDINER:-

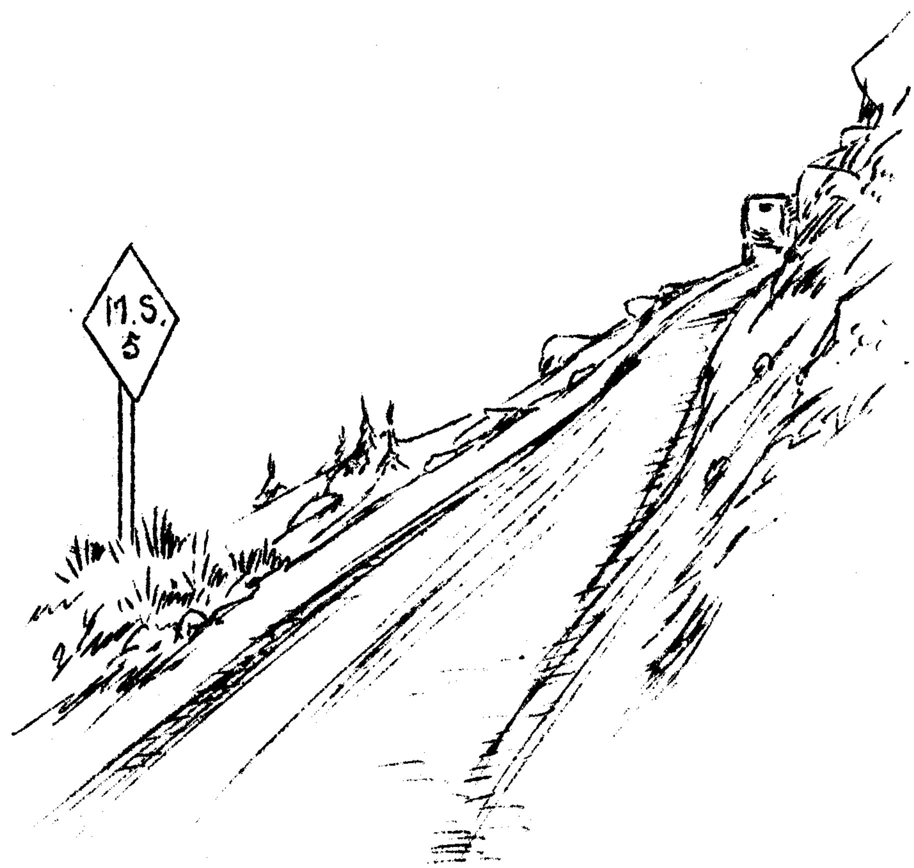
Mammoth Hot Springs.................................	5.0
Livingston..	59.4
Glacier Park (via Great Falls)......................	404.0
Seattle	969.4

From SNAKE RIVER:-

Mammoth Hot Springs.................................	88.9
Lander..	184.0
Rock Springs..	244.0
Cheyenne (via Riverton and Casper)..................	510.0
Denver (via Riverton and Casper)....................	618.0
Salt Lake City......................................	408.0

From WEST YELLOWSTONE:-

	Miles
Mammoth Hot Springs..................................	47.8
Pocatello..	176.3
Boise..	448.3
Portland...	949.0
Seattle (via Old Oregon Trail and Walla Walla).....	1066.2
San Francisco (via Ely, Austin and Reno)...........	1229.0



PLACE NAMES OF YELLOWSTONE NATIONAL PARK
(Including the Principal Duplications and Errors Determined in 1927)

By:- Horace M. Albright, Superintendent
J. E. Haynes, Act. Director, Yellowstone Park Museum
Marguerite Lindsley, Park Ranger

F O R W A R D

For several years, students of the history of Yellowstone National Park and of the natural phenomena, have noticed in the literature of the park, and the maps (particularly those in the very valuable Atlas belonging to Monograph XXXII), that there is a certain lack of definiteness in nomenclature.

In the summer of 1927 Dr. A. L. Day, Director of the Geophysical Laboratory, Washington, D. C. and Mr. J. E. Haynes, Acting Director of our Yellowstone Museum, conferred with me about the place name problem, and we decided that one of the important problems of Yellowstone Park was to study the place names and decide all of the important questions of nomenclature on which we could get data from the old books and maps.

Accordingly, we constituted ourselves an informal committee, and with Park Ranger Marguerite Lindsley as research aid and secretary, we made a careful analysis of the place names of Yellowstone Park, with the result that a great many interesting questions were settled. The following lists, prepared by Miss Lindsley, and carefully checked by Dr. Day, Mr. Haynes and myself, will make permanent the results of our study.

We realize that our work is not complete, but, a splendid beginning has been made, and as soon as time permits a further study will be given to the problems of Yellowstone nomenclature with special emphasis on the naming of park features now unnamed.

There are a number of Yellowstone pioneers who have not been honored by having their names placed on natural features of the park. Fortunately there are a number of unnamed features to which the names of distinguished pioneers and benefactors of the park can be given. Of course, the giving of names to features heretofore unnamed must receive the approval of the United States Geographical Board.

Horace M. Albright
Superintendent

NOTE:- All decisions are based on the best information from a thorough study of the original names, the present condition of the features affected, and their relationship to similarly named features. In all cases where now applicable the original names are approved.

Togwotee Pass, not Two-Gwo-Tee, not Togotee, not Twogwotee.
White Elephant Back Terrace, not White Elephant, not Elephant's Back.
Old Bath Lake, not Bath Lake. (It went dry in 1926)
Orange Spring Mound, not Orange Geyser.
Cheops Mound, not Cheops Spring,
Soda Spring, not Dedolph Spring. (Dedolph appears on the analysis)
Stygian Caves, not Stygian Cave and Stalactite Cave.
Cinder Pool, not Verma Spring. (They are separate springs. The one with the black globules floating in whitish water is Cinder Pool).
Growler-Spring, (Near site of former Norris Lunch Station). It is sometimes a "growler" similar to the Black Growler Steam Vent, and at other times a violently boiling sulphur spring.
Ledge Geyser, near Valentine Geyser, erroneously called "Mud Geyser" in the past.
Emerald Spring, (Norris). (See also Emerald Pool at Old Faithful)
Green Dragon Springs, (Name suggested by Ranger Phillips in 1926)
Phillips Cauldron, near Gray Lakes at Norris.
Leather Pool, near Fountain Paint Pot, erroneously called White Sulphur Spring.
Fountain Paint Pot, (Not Mammoth Paint Pots)
Steady Geyser, not Black Warrior Geyser.
Black Warrior Springs, near crater of Steady Geyser.
Surprise Pool, near Great Fountain Geyser. (Not near Gentian Pool).
Grand Prismatic Spring, not Prismatic Lake.
Midway Geyser Basin, not Excelsior Geyser Basin or Hell's Half Acre.
Solitary Geyser, not Solitaire Geyser.
White Pyramid Geyser Cone, not White Pyramid.
Crested Pool, not Castle Well.
Indian Pond, not Squaw Lake.

Buffalo Herds (American Bison) will be known as:
Show Herd (near Mammoth)
Lamar Valley Herd - not Tame Herd.
Mountain Herd - not Wild Herd.

Gardiner to Mammoth

Gardiner River
Eagle Nest Rock - nest of osprey or fish hawk
Boiling River
Mt. Everts

Mammoth Hot Springs

Capitol Hill - glacial terminal moraine
Devils Thumb - not Devil's Thumb
Hymen Terrace
Liberty Cap
Minerva Terrace
Mound Terrace

Mammoth Hot Springs (Continued)

Cleopatra Terrace
Old Palette Spring - not Palette Spring
Main Terrace
Blue Springs
Canary Spring
Jupiter Springs
Jupiter Terrace
Pulpit Terrace
Cheops Mound - not Cheops Spring
The Buttress
Highland Terrace
New Highland Terrace
Lookout Point
Devils Kitchen
Old Bath Lake - not Bath Lake
Orange Spring Mound - not Orange Geyser
Soda Spring - not Dedolph Spring
Stygian Caves - not Stygian Cave and Stalactite Cave
Squirrel Springs Ridge
White Elephant Back Terrace - not White Elephant or Elephant's Back
Glen Spring
Old Angel Terrace
Angel Terrace
Clematis Creek
Clematis Gulch - not Chinamans Gulch
Primrose Creek
Snow Pass
Sentinel Butte
Elk Plaza
McCartney Cave
The Esplanade
The Grottoes
Narrow Gauge Terrace
Pinyon Terrace

Mammoth to Norris

The Hoodoos
Silver Gate
Bunsen Peak
Terrace Mountain
Golden Gate
Cathedral Rock
Rustic Falls
Glen Creek
Swan Lake Flat
Electric Peak - elevation 11,155
Gallatin Mountains
Swan Lake
Quadrant Mountain

Mammoth to Norris (Continued)

Bannock Peak
Antler Peak
The Dome
Mt. Holmes
Trilobite Point
Gardiner River
Obsidian Creek
Willow Park
Apollinaris Spring
Crystal Spring
Obsidian Cliff
Beaver Lake
Ancient Beaver Dam - note length
Lemonade Creek - the old Green Creek
Semi-Centennial Geyser
Roaring Mountain
Twin Lakes
Bijah Spring
Frying Pan Spring

Norris Geyser Basin

Porcelain Basin
Growler-Spring
Onyx Spring
Opal Springs
Porcelain Terrace
Blue Geyser
Apple Green Geyser
Primrose Springs
Iris Spring
Arsenic Geyser - not Arsenic Spring
Constant Geyser
Whirligig Geyser
Hurricane Vent - not Hurricane or Hurricane Geyser
Congress Pool
Locomotive Spring
Nuphar Lake
Ledge Geyser - not Mud Geyser
Valentine Geyser
Black Growler Steam Vent
Crown Crater - not Crown Geyser or Crown
Ebony Geyser
Harding Geyser - not Tippecanoe Geyser
Steamvalve Spring
Bathtub Spring - not Schlammkessel
Emerald Spring - not Emerald Pool
New Crater Geyser - not Fissure
Minute Man Geyser - not Minute
Monarch Geyser Crater - not Monarch or Monarch Geyser
Vermilion Spring

Norris Geyser Basin (Continued)

Echinus Geyser
Fearless Geyser
Palpitator Spring - not Palpitator
Corporal Geyser
Veteran Geyser
Vixen Geyser
Double Bulger
Pebble Geyser Cone
Cradle Mud Spring
Coral Geyser
Pearl Geyser
Phillips Cauldron
Green Dragon Springs
Little Alcove Spring
Big Alcove Spring
Gray Lakes
Medusa Spring
Hydrophane Springs
Recess Spring - within Norris Geyser Basin, not at the head of Elk Park
Orpiment Springs
Perpetual Spouter
Ragged Hills
Crystal Spring
South Fork Tantalus Creek
East Fork Tantalus Creek
Tantalus Creek
The Reservoir
Verma Spring
Cinder Pool - separate from Verma Spring
Horseshoe Spring
Realgar Springs
Frying Pan Springs
Realgar Creek
Receptacle Spring
Rock Spring
One Hundred Spring Plain
Sieve Lake

Norris to Canyon

Gibbon River
Virginia Cascades
Virginia Meadows
Solfatara Plateau

Norris to Madison Junction

Norris Geyser Basin
Elk Park
Gibbon River

Norris to Madison Junction (Continued)

Duck Rock
Chocolate Pots
Gibbon Meadows
Paint Pot Hill
Artist Paint Pots
Monument Geyser Basin
Beryl Spring
Iron Spring
Gibbon Falls - 80 feet.
Terrace Spring
Madison Junction
Gibbon River
Firehole River
Madison River

Madison Junction to West Yellowstone

National Park Mountain
Purple Mountain
Madison River
Mt. Haynes

Madison Junction to Old Faithful

Firehole River
Ancient Geyser Cross Section
The Narrows
Firehole Cascades
Nez Perce Creek
Porcupine Hill

Lower Geyser Basin

Kidney
Oakleaf
Round
Jug
Cliff
Gourd
Stirrup
Fungoid
Lone Spring
Thud Springs
Kaleidoscope Geyser - not Kaleidoscope
Pithole Springs
Sprinklers
Gentian Pool - not Gentian
Clepsydra Geyser - not Clepsydra
Leather Pool - not White Sulphur Spring
Fountain Geyser - not The Fountain
Jet Geyser - not Jet

Lower Geyser Basin (Continued)

Fountain Paint Pot - not Mammoth Paint Pots
Silex Spring - not Silex
Celestine Pool - not Celestine
Bellefontaine Geyser - not Bellefontaine
Jelly Spring - not Jelly
Spasm Geyser
Tangled Creek
Underhill Spring
Narcissus Geyser - not Narcissus
Bead Geyser - not Bead
Pink Cone Geyser
Hot Lake - separate from Firehole Lake
Black Warrior Springs - not Black Warrior (meaning Steady Geyser)
Steady Geyser - not Black Warrior Geyser
Firehole Lake
Young Hopeful Geyser
Tank Spring
White Dome Geyser
Surprise Pool - not Surprise (deleted from near Gentian Pool)
Firehole Spring
Broken Egg Spring
White Creek
The Five Sisters Springs
The Diamond Spring
Black Spring
Buffalo Pool - (see also Buffalo Spring or Skeleton Pool)
Ojo Caliente Spring
Skeleton Pool - (Buffalo Spring? See also Buffalo Pool)
Goose Lake

Midway Geyser Basin
(Not Hell's Half Acre or Excelsior Geyser Basin)

Excelsior Geyser Crater - not Excelsior Geyser
Flood Geyser - not Flood
Indigo Spring
Iris Pools
Opal Pool
Grand Prismatic Spring - not Prismatic Lake
Tromp Spring - not Tromp
Turquoise Pool - not Turquoise Spring

Upper Geyser Basin

Mustard Springs
Avoca Spring - not Avoca
Silver Globe Spring - not Silver Globe
Shell Geyser - not Shell
Jewel Geyser - not Jewel
Sapphire Pool
Biscuit Basin

Upper Geyser Basin (Continued)

Cauliflower Geyser - not Biscuit Basin
Mirror Pool - not Mirror
Calthos Spring - not Calthos
Sprite Pool - not The Sprite
Gem Pool - not Gem
Restless Geyser - not Restless
Bench Spring - not Tomato Soup Spring
Iron Springs
Artemisia Geyser - not Artemisia
Sentinel Geysers - not Sentinel Geyser
Morning Glory Pool - not Morningglory
Cyclop Spring - not Cyclops
Fan Geyser - not The Fan
Mortar Geyser - not Mortar
Chain Lake - not Chain Lakes
Riverside Geyser
Spa Geyser - not Spa
Rocket Geyser - not The Rocket
Grotto Geyser - not The grotto
Splendid Geyser Crater - not Splendid Geyser
Brilliant Pool - not Brilliant
Bonita Pool - not Bonita
Daisy Geyser - not Daisy
Comet Geyser - not Comet
White Pyramid Geyser Cone - not White Pyramid
Punch Bowl Spring - not Punchbowl or The Punchbowl
Black Sand Pool
Iron Creek
Sunset Lake - not Sunshine Lake
Rainbow Pool
Handkerchief Pool
Whistle Geyser - not Whistle
Green Spring
Emerald Pool
Niobe Creek
Cliff Geyser - not Cliff Spring
Spouter Geyser - not Spouter
Pine Springs
Three Sisters Springs - not Three Sisters
Myriad Group
White Geyser
The Ruin
Bijou Geyser - not Bijou
Mastiff Geyser - not The Mastiff
Catfish Geyser - not The Catfish
Giant Geyser
Purple Pool - not Purple Spring
Round Springs
Oblong Geyser
Inkwell Spring - not The Devil's Inkwell
Motorboat Vent - not The Motorboat
Orange Pool

Upper Geyser Basin (Continued)

Spanker Spring - not The Spanker
Terra Cotta Spring - not Terra Cotta
Tortoise Shell Spring - not Tortoise Shell
Crested Pool - not Castle Well
Castle Geyser
Chinaman Spring - not The Chinaman
Old Faithful Geyser
Chromatic Pool
Beauty Pool
Wave Spring
Economic Geyser Crater - not Economic Geyser
Calida Pool - not Calida
Limekiln Springs - not The Seashell
Witches Cauldron
Turban Geyser - not Burning Pool
Grand Geyser
Triplet Vents - not The Triplets
Solitary Geyser - not Solitaire Geyser
Bulger Spring - not The Bulger
The Churn
Spasmodic Geyser - not Spasmodic
Sawmill Geyser - not The Sawmill
Tardy Geyser
Scalloped Spring - not The Teakettle
Chimney Cone - not Chimney
Liberty Pool
Sprinkler
Lion Geyser
Lioness Geyser
Big Cub Geyser
Little Cub Geyser
Beach Spring
Doublet Pool - not The Doublet
Sponge Geyser - not The Sponge
Teakettle Spring - not The Teakettle
Model Geyser
Giantess Geyser - not The Giantess
Vault Spring - not The Vault
Infant Geyser
Butterfly Spring - not The Butterfly
Anemone Geyser
Midget Geyser
Beehive Geyser
Topaz Spring
Ear Spring
Goggles Spring
Cascade Geyser - not Cascade
Sputterer Spring - not The Sputterer
Mottled Pool
Dragon Geyser
Lone Star Geyser - not Lone Star

Upper Geyser Basin to West Thumb

Kepler Cascades
Spring Creek
Turtle Rock
Norris Pass (with arrow)
Craig Pass
Isa Lake (Atlantic Slope)
Continental Divide - 8,262 feet
Isa Lake (Pacific Slope)
Corkscrew Hill
Herron Creek
De Lacy Creek
Shoshone Point
  Shoshone Lake
  Teton Mountains
Dry Creek
Continental Divide - 8,365 feet
Yellowstone Lake
Duck Lake

West Thumb

Thumb Paint Pots
Lakeshore Geyser
Fishing Cone

West Thumb to South Entrance

Continental Divide - 7,981 feet
Dogs Head Creek
Lewis Lake
Aster Creek
Lewis Falls
Lewis River
Moose Falls
Crawfish Creek

West Thumb to Lake Junction

Bluff Point
Arnica Creek
Pumice Point
Spruce Point
Mt. Sheridan (with arrow)
Dot Island
Stevenson Island
Absaroka Mountains
  Sleeping Giant
Weasel Creek
Bridge Bay
  (Side Road)
  Natural Bridge
  Bridge Creek

Lake Junction to East Entrance

Pelican Creek
Indian Pond or Squaw Lake
Turbid Lake
Bear Creek
Lake Butte
Cub Creek
Sylvan Lake
Top Notch Peak
Lake Eleanor
Sylvan Pass - 8,559 feet
Middle Creek

Lake Junction to Canyon Junction

Mud Geyser
Mud Volcano
Dragons Mouth Spring - not Green Gable Spring
Hayden Valley
Elk Antler Creek
Trout Creek
Crater Hills
Sulphur Mountain
Alum Creek
Otter Creek

Grand Canyon

Artist Point
Inspiration Point
Point Sublime
Point Lookout
Grand View
Red Rock
Cascade Creek
Crystal Falls
Castle Ruins
Glacial Boulder
Upper Fall - 109 feet
Lower Fall - 308 feet

Canyon Junction to Tower Fall Junction

Hedges Peak
Dunraven Peak
Mt. Washburn (from summit) - elevation 10,346 feet
  Yellowstone Lake and Teton Mountains
  Yellowstone Canyon and Absaroka Mountains
  Gallatin Mountains
  --Dunraven Peak and the Geyser Basins
Carnelian Creek
Tower Creek
Antelope Creek

Canyon Junction to Tower Fall Junction (Continued)

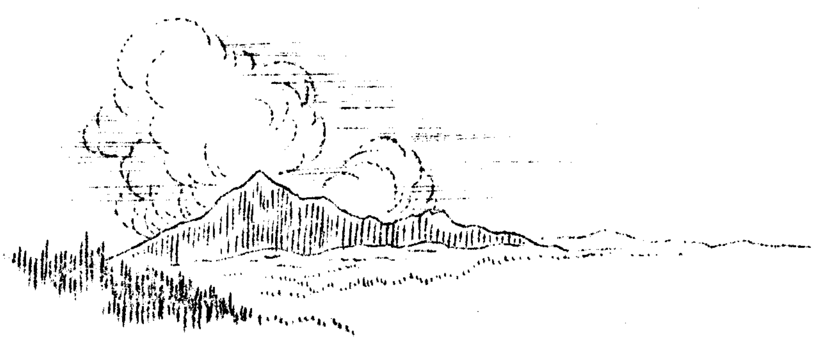
Specimen Ridge
Tower Fall (with arrow)
Overhanging Cliff
Palisades
The Needle - not Cleopatra's Needle

Tower Junction to Cooke City Station

New Baronett Bridge
Specimen Ridge
  Fossil Trees $2\frac{1}{2}$ miles (with arrow)
Lamar River
Lamar River Canyon
Soda Butte Creek
Soda Butte
Druid Peak
Mt. Norris
The Thunderer
Soda Butte Canyon
Pebble Creek
Devils Well (with arrow)
Amphitheater Creek
Baronett Peak
Abiathar Peak

Tower Junction to Mammoth Hot Springs

Petrified Tree
Elk Creek
Crescent Hill - not The Gut
Geode Creek
Oxbow Creek
Blacktail Deer Creek - not Blacktail Creek
Wraith Falls
Lupine Creek
Lava Creek - not East Gardiner River
Undine Falls
Sheepeater Cliffs
Indian Teepees
Gardiner River - not Middle Gardiner River



CLIMATIC FEATURES OF YELLOWSTONE NATIONAL PARK

By Edgar H. Fletcher, Meteorologist
U. S. Weather Bureau - Yellowstone Park, Wyoming

The nature of the many inquiries on the part of the ever-increasing throngs of tourists that annually visit Yellowstone National Park would indicate that the weather and climate of this unique region is not well understood. The object of this article is to set forth some of the salient climatic and allied physical features peculiar to this vast wonderland that has been set apart "for the benefit and enjoyment of the people."

The Weather Bureau Observatory, erected in 1903, is situated on a built-up section of extinct hot springs formation on a northeast mountain slope at Mammoth Hot Springs within the park, five miles south of the northern entrance at Gardiner, Montana. At this place are located the local and field headquarters of the National Park Service; also the Yellowstone Park, Wyoming post office. The elevation here is 6,241 feet above sea level; latitude 44° 58' N., longitude 110° 42' W. The general character of the vicinity is mountainous, with elevations reaching to 8,000 and 9,000 feet within a comparatively short distance.

From the northern entrance near the mouth of the Gardiner River canyon, past Mammoth Hot Springs through Golden Gate canyon to the main plateau-level of the park, the elevation rises from 5,300 feet to 7,500 feet in a distance of less than ten miles. This may be seen from Figure 1, which is a north-south profile of the whole park region, including the Teton Mountains and Jackson Hole section.

Yellowstone National Park at present comprises an area of 3,348 square miles or about the combined size of Delaware and Rhode Island, and contains more spectacular hot-water phenomena, in the form of active geysers and hot springs, than all the rest of the world combined, besides being one of the world's greatest wild animal preserve. Its great central plateau has an average elevation of approximately 8,000 feet, surrounded by mountains whose peaks rise to from 10,000 to 11,000 feet, embracing a section of the main ranges of the Rocky Mountains. The whole region is built up of material once ejected from far beneath the surface by volcanic activity.

Within the central valleys are located several lakes, the largest of which is Lake Yellowstone, with an area of 139 square miles, the second largest body of water at its elevation in the western hemisphere. The Yellowstone River is the outlet of this lake, and its placid waters a few miles north plunge over gigantic waterfalls into a canyon of indescribable grandeur and magnitude.

However, this is characteristic of all streams flowing out of this elevated region several thousand feet higher than the surrounding country. A series of cascades or cataracts is formed where the water flows over the edges of the igneous rocks. Some of the larger rivers, as the Yellowstone and Gardiner, have cut deep chasms or canyons far back into the lava beds within the park, thus producing high waterfalls and steep cascades almost within the heart of this region.

CLIMATIC FEATURES OF YELLOWSTONE NATIONAL PARK   Fletcher.

The Continental Divide, traversing the southwestern section, sheds the waters of the park to both the Atlantic and Pacific Oceans. Three large rivers, the Snake flowing westward to the Columbia, and the Madison and the Yellowstone flowing northward to the Missouri, have their head waters in this region, which has aptly been termed the "top of the world."

Authentic weather records date back to 1887, the early record of temperature and precipitation having been made under the direction of the army surgeon stationed at what was then known as Fort Yellowstone. Subsequent to 1903, a fully equipped meteorological station has been in operation, and continuous autographic records are made of temperature, rainfall, wind direction, wind movement, sunshine and barometric pressure. The anemometer, wind vane and electric sunshine recorder are located on the roof of the two-story Weather Bureau building, which is surrounded by an open lawn of one acre. The thermometer shelter, tipping-bucket rain-gage and Marvin shielded rain-and-snow-gage are located over sod ground on rear of the reservation.

In cooperation with the National Park Service, records of temperature and precipitation have been made at twelve ranger stations at different points in the park.

The chief characteristics of the climate are the short, cool summers, the long, rigorous winters with a tendency to linger late in the spring, and the usually pleasant, open falls. The severity of the winters is not due so much to prolonged periods of extremely low temperatures, but rather to the persistence of comparatively low temperatures and much cloudy, unsettled weather with frequent light snows.

The occasional severe cold waves that occur do not continue for more than two or three days without some moderation in temperature. An exception to this rule was in the unprecedented cold wave of December 1924, when the minimum temperature at the Weather Bureau station did not rise above 26° below zero for five consecutive days, and above 12° below zero for ten days.

Frost or freezing temperature occurs frequently at the higher levels, even in the summer months. A lack of knowledge of this fact is sometimes surprising, if not a little unpleasant, to the unprepared tourist coming from the hot weather prevailing at lower altitudes.

Except for slightly greater extremes, the temperature conditions over the main park plateau for the midsummer season compare closely with those of the mid-winter months at Yuma, Arizona, and approximately with the early May temperatures at lower-altitude stations in the same general latitude.

The highest temperature ever recorded in the park was 97°. The record for the past 25 years shows that the temperature at the Weather Bureau station reaches 90° only once in about each ten years, but less frequently at places of higher altitudes.

The lowest temperature ever recorded was 59° below zero at Riverside ranger station near the western entrance, December 19, 1924. The 40-year absolute minimum temperature at the Weather Bureau station is 41° below zero, which occurred January 14, 1888. On an average, the minimum reaches 30° below zero only once in about each decade at the latter station, while occurrences of from 15° below to 20° below zero are to be expected almost every winter, and the average number of days annually with temperature of zero or below is 24.

But it must be remembered that much of the main region of the park lies above the 7,500-foot level, where a marked increase in the degree of severity of the winter climate prevails, as compared with the record at Mammoth Hot Springs. However, it may be stated that the effect of subzero weather seems to be somewhat ameliorated in this dry atmosphere.

The daily range in temperature in summer is quite marked, the temperature often ranging from 35° or 40° during the night to 75° or 80° in the afternoon. The summer and early fall seasons are especially delightful and invigorating, having an ample supply of sunshine under favorable temperature conditions. There being less scattering and absorption of the solar rays at this altitude by reason of the purity and dryness of the air, the sunshine is very intense and exhilarating. This accounts for the remarkable growth of native grasses and wild flowers during the extremely short growing season.

No agricultural pursuits are carried on within the park except that necessary to provide hay for the winter sustenance of the large buffalo herd, and to a limited extent that of the elk and other animals when natural forage is inadequate or buried beneath unusually deep or crusted snow.

A wide variety of animal and plant life peculiar to the different temperature zones formed by the variation in altitude is found within the park, representing in latitude the region from the temperate to the frigid floral and faunal realms; but in the park the distribution depends upon altitude instead of latitude. This range of animal and plant forms may be illustrated by the bird-life. Such extreme forms as grebes, pelicans and thrushes show the wide range in classification; while the presence of humming-birds, the lazuli bunting, rosy finches and the Barrow goldeneye duck indicate the vast geographical range represented.

The normal annual precipitation increases from slightly less than 15 inches near the northern boundary to about 31 inches at Snake River on the southern border. The region is semiarid; and while precipitation is well distributed throughout the year, the winter and spring months receive slightly heavier amounts. Cloudy days with continuous rain are of rare occurrence at any season, but summer thunderstorms occur frequently, though usually mild in character and often accompanied by light hail.

The total annual snowfall at the Weather Bureau station is about 100 inches for the average season. Wide variations from this normal occur, however, ranging during the past 40 years from a maximum of 210 inches in 1890 to a minimum of 20 inches in 1915. On account of the low absolute moisture content of the air the average daily snowfall, except for an occasional storm at infrequent intervals, is extremely light, but it is of frequent and almost daily occurrence during much of the cold season.

The greatness of the total annual depth is chiefly accounted for by reason of the fact that very little melting occurs until spring. There is nevertheless considerable settling of the snow caused by days of comparatively mild temperatures, by an occasional, but not well marked "chinook" condition, or by evaporation into the thin air prevailing at this altitude.

Snow in material depths does not normally accumulate at Mammoth Hot Springs until midwinter or past, and the highway from there to the northern entrance at Gardiner, Montana is open for travel during the entire year. The average depth of snow on the ground at the end of February for a period of 23 years at the Weather Bureau station is 12.6 inches, while the greatest depth ever recorded is 35.6 inches in March, 1917.

In general the region of greatest snowfall is in the southern third of the park, where the average annual accumulation is slightly more than 200 inches, and depths of upward of 100 inches on the ground are measured in the early spring. In years of abnormal snowfall, depths in excess of 15 feet accumulated on portions of the higher divides. This method of nature in storing moisture high up on the watersheds to be melted in the late spring or early summer, is of great economic value to the park as well as to regions at lower levels that depend upon its waters.

A season of unusually light snowfall has quite an adverse effect upon the park, as the proper display of many of the natural wonders crowded into this region depends upon soil moisture and stream-flow. The geysers and hot springs are more active with a plentiful supply of water. Snow in quantities that insure late melting not only contributes to the growth of an adequate supply of natural forage for the large herds of wild animals, but it materially minimizes the park's greatest menace - the fire hazard in summer.

Contrary to a popular belief, the weather at this place in winter, with its disagreeable features of cold, snow, wind and storm, is not without its economic importance; on the contrary, the country thrives because of it. Even the "ill wind" serves a useful purpose in drifting and piling the snow into deep depressions and canyons, and thus retarding its melting until late in the season. These large bodies of compact snow in sheltered places act as natural reservoirs to conserve the water supply, and to diminish destructive floods, which are sure to occur with the rapid melting of blanket snow.

While the wind movement is fairly active, velocities beyond forty miles per hour do not often occur, except over the more elevated and open stretches. Situated to the southward of the main Alberta and North Pacific storm tracks, and at an elevation to be least affected by the deflecting influences of the surrounding topography, the prevailing winds are from the south and southwest for every month of the year. Northerly or westerly winds occur only for brief periods at rather infrequent intervals, and usually are accompaniments of cold waves in winter. No damaging storms have been recorded.

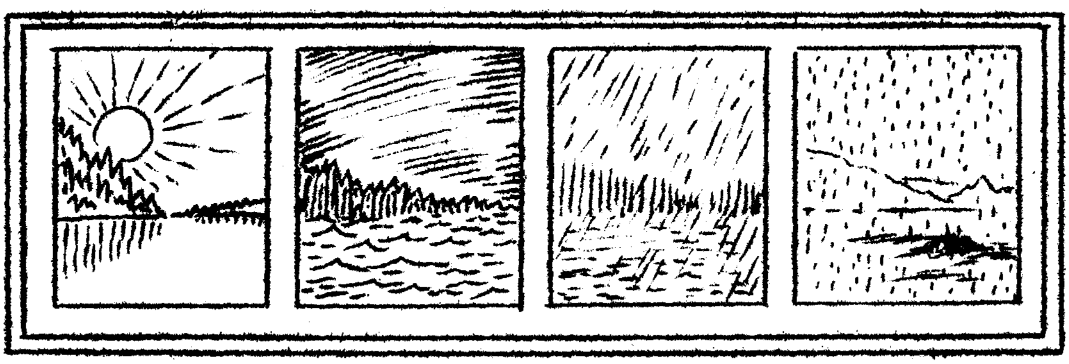
Fogs rarely occur, except in the vicinity of the larger lakes and in the geyser basins during the colder season of the year.

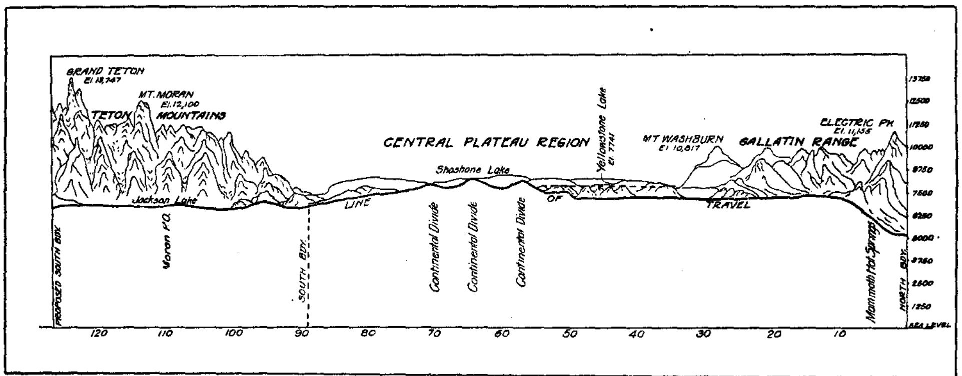
The hot springs and geysers do not affect the weather at any appreciable distance from their location. However, local condensation in fog-like form is quite marked in the main thermal regions in winter.

In a few remarkable instances the general severity of winter conditions fails to have its usual effect upon the fauna. This is due to the offsetting influence of thermal springs and warm, open streams. Thus it happens that one may have the weird experience of flushing Wilson snipe amid the snow and in the extreme cold of January, for the snipe remain all winter along the steaming overflow streams that carry off the water from Mammoth Hot Springs. Several other species of birds, which are ordinarily only summer residents in similar latitudes, remain along the open streams all winter.

Figures 3, 6, 9 and 10 show graphically the monthly values of temperature, precipitation, humidity, sunshine and wind as recorded at the Weather Bureau station, Mammoth Hot Springs, while Figures 2, 4, 5, 7 and 8 show annual averages and extremes for the entire park, as determined from the records of the 13 stations where weather observations have been made.

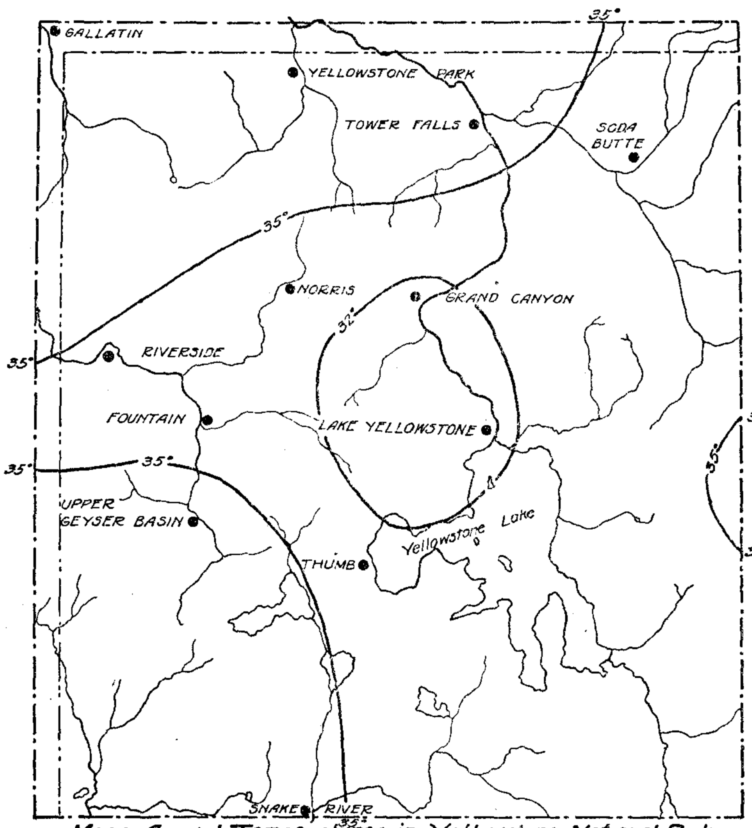
Owing to sharp differences in elevation within short limits, the climate varies considerably with location. Therefore, it should be remembered that wide deviations from the charted values may exist in the more elevated regions where no records have been kept.





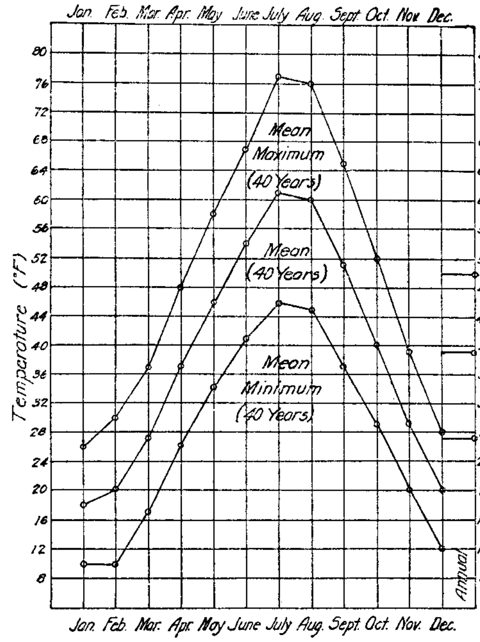
Profile through line of travel North and South in Yellowstone National Park and region South of Park including Teton Mountains and Jackson Lake.

FIG. 1



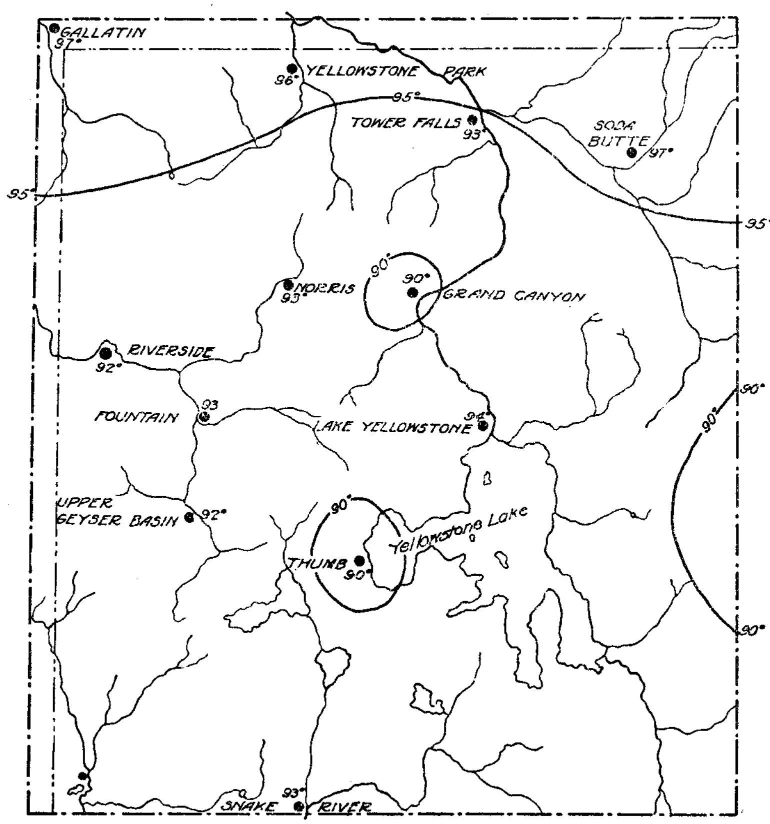
Mean Annual Temperatures in Yellowstone National Park

FIG. 2



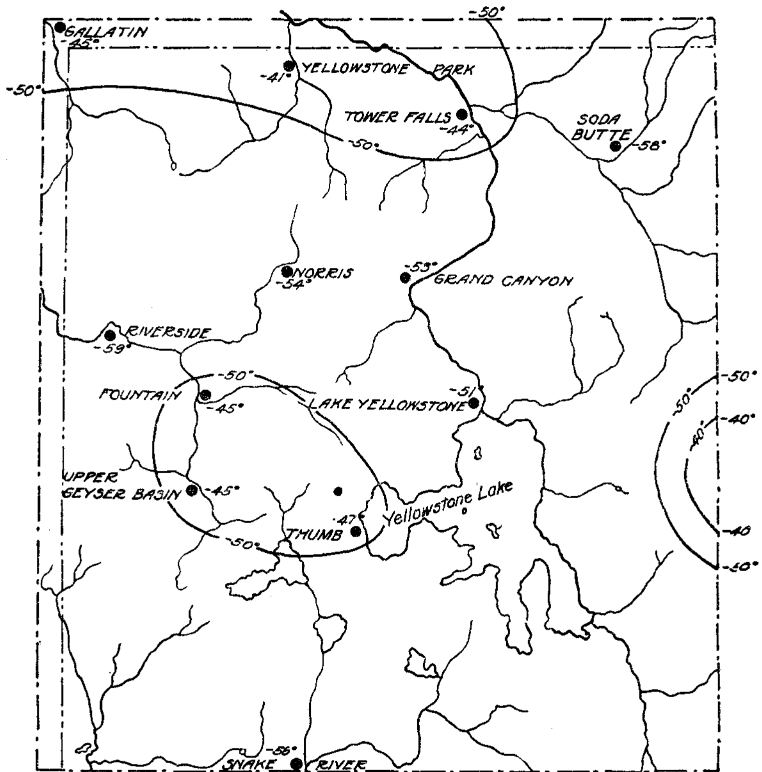
The march of monthly averages of temperature at Mammoth Hot Springs, Yellowstone Park, Wyo

FIG. 3



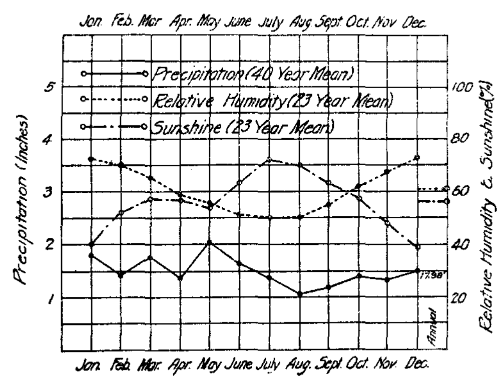
Highest Temperatures Ever Observed in Yellowstone National Park

FIG. 4



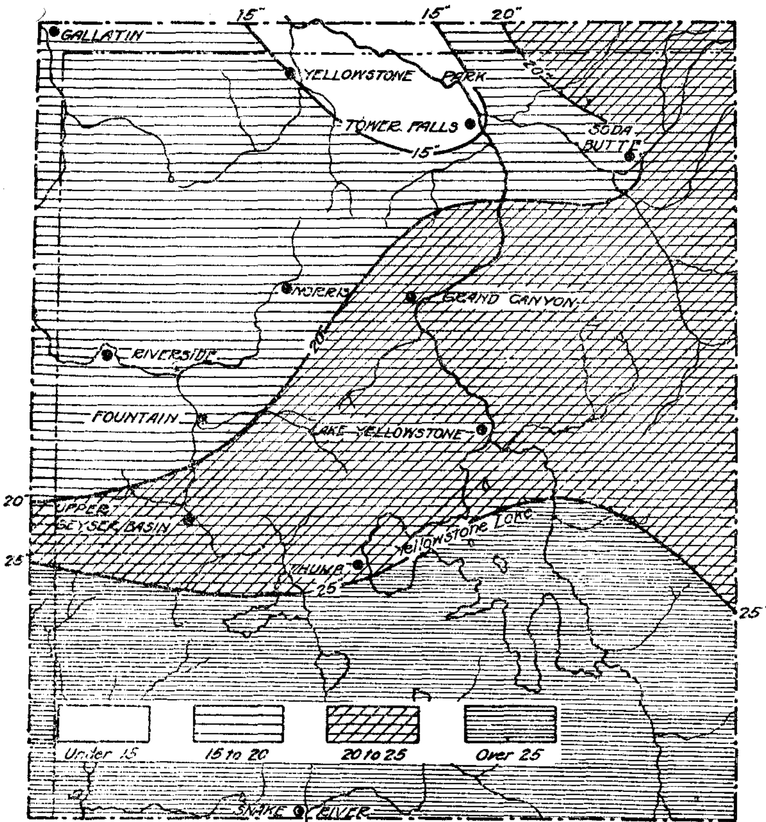
Lowest Temperatures Ever Observed in Yellowstone National Park

FIG. 5



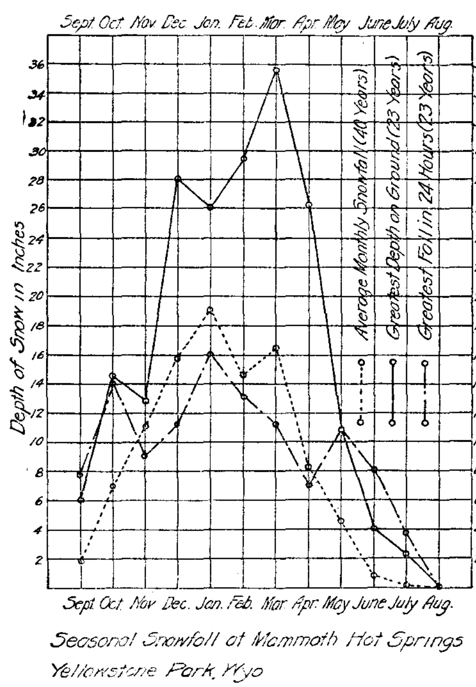
Monthly and annual averages of precipitation, relative humidity, and sunshine at Mammoth Hot Springs, Yellowstone Park, Wyo.

FIG. 6



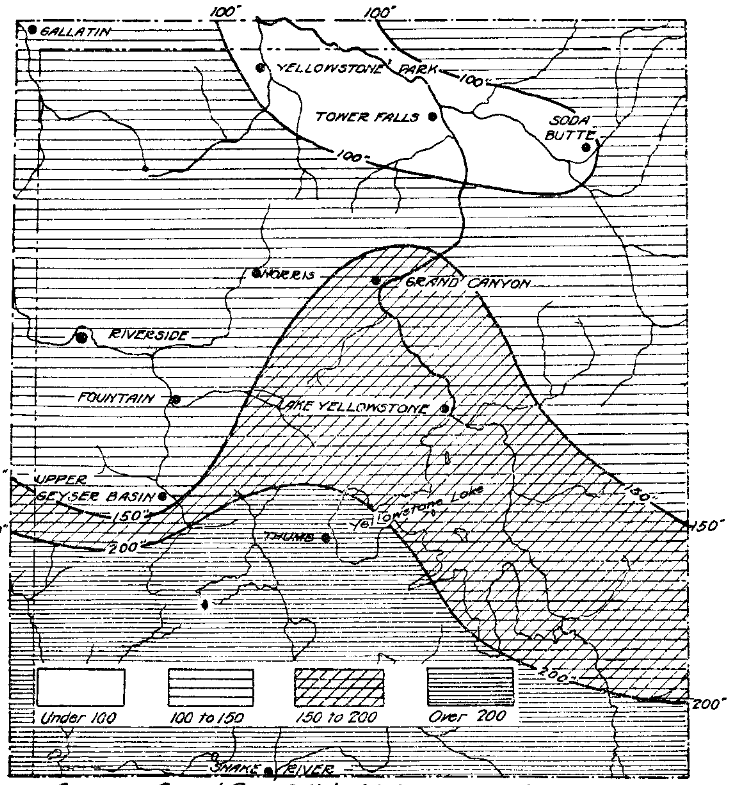
Average Annual Precipitation in Yellowstone National Park

FIG. 7



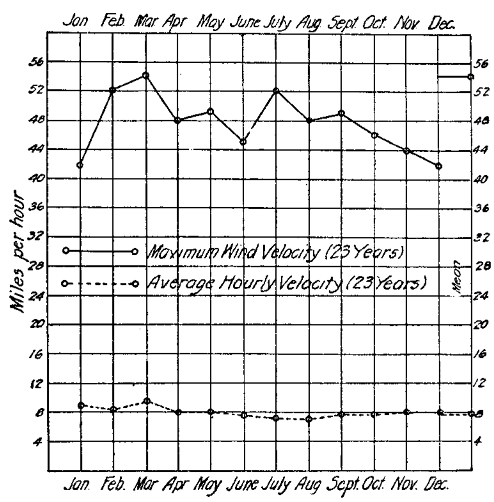
Seasonal Snowfall at Mammoth Hot Springs
Yellowstone Park, Wyo.

FIG. 9



Average Annual Snowfall in Yellowstone National Park

FIG. 8



Maximum and average hourly wind velocity at Mammoth Hot Springs, Yellowstone Park, Wyo.

FIG. 10

ON BEING A RANGER NATURALIST

By Ansel F. Hall, Chief Naturalist, N. P. S.

Let's sit down and chat a few minutes about this business of being a Ranger Naturalist. Those of you who have been chosen for this interesting work already know more or less about the duties which are expected of you by your Government - you know that you may be expected to dispense information, to deliver lectures, to lead trips afield, and to conduct or direct other such educational activities. In this Ranger Naturalist Manual and in your daily contacts with other educational officers, you will continually have before you references and advice about your official work.

It is not this official work which I wish to discuss at the present time, but rather something which probably touches you personally more closely than any other phase of your summer's work. I wonder if you have analyzed your personal reasons for joining the Park Service educational staff and what you, yourself, are planning to gain from your summer's experience? Surely, there is something besides a "job" that has brought you to the park. Is it the possibility of carrying on technical field work in your own branch of science in this great natural reserve? Is it the possibility of broadening your scientific horizons? Is it the possibility for public service? I wish that I might talk with each one of you personally about your plans before you start your Government duty because - well, simply because, I could probably save you from some disappointments and could possibly point out a number of opportunities that will be of great value to you personally.

You are not obligated to take advantage of these opportunities. The Park Service educational staff functions primarily to help the hundreds of thousands of visitors to a greater enjoyment of the parks through enthusiastic understanding of their scientific features. What you, yourself, get out of it is entirely "up to you". This may sound like a sermon, but I have seen so many Ranger Naturalists who were disappointed at finding it impossible to conduct research problems which they had planned and who awoke too late in the season to the other possibilities which lay before them, that I am going to attempt, even at the risk of appearing pedantic, to lay before you some advice based upon the experience of Ranger Naturalists of past years.

In the first place, do not come to the park expecting to carry on important scientific research in your particular branch of natural history. Your "job" should require at least eight hours of your time each day, and you must expect this time, and perhaps more, to be devoted to serving the public or to the preparation for the details of this service. We hope that a portion of the time of staff members will ultimately be set aside for research problems, but under present conditions any research must supplement an already exceedingly heavy official program. You will find if you do undertake such a problem "on your own" that your available time will be exceedingly limited and you will be in an atmosphere of activity which practically precludes deep and consecutive thought on a single important problem.

Ranger Naturalists have found it possible, however, to collect scientific field data and specimens at various odd times and while conducting field trips. These data when afterwards worked up at leisure, have oftentimes proved to be exceedingly valuable.

There are several splendid opportunities for research which few Ranger Naturalists realize at the beginning of their service. These opportunities lie in the development of teaching methods and in the working out of the most effective means of reaching the people with whom you come in contact. It is only in the past few years that the importance and the possibilities of adult education have been nationally recognized. We in the Park Service have been conducting adult educational activities in the field for almost a decade, and out of our experience has evolved a general knowledge of the most effective methods of reaching our public. We have been so beset, however, with the great demand for service that it has only been possible to work out the simplest principles of adult education, and these merely by empirical methods of trial by error. There remains before us a vast field of research for those interested in developing the science and art of teaching; and in formulating its principles. Where else in the world but in the National Parks could be found a single organization which serves two and a half million people per year in such outdoor laboratories as these? Where else could we find people as receptive as these visitors who have come, some of them, thousands of miles to see the very things which we are here to explain. Delivering a lecture or leading a field trip is not merely a job! It is an opportunity - an opportunity, first, to broaden your experience and improve your technique in educational methods, and secondly an opportunity to carry on real research problems in adult education. Great will be the reward to the man who succeeds in formulating the principles of adult education in our many lines of service! Think of the opportunity of applying these principles to help our two and a half million annual visitors, and think also of the possibilities in applying these educational principles to similar work throughout our country!

Whether or not you attempt individual research in the methods of adult education, there are other opportunities which you can scarcely escape. You may expect to benefit greatly by the personal contacts which you make during your service in the park. From the standpoint of public service, personal contacts are vitally necessary to carry the message. The facts which you deliver in a lecture may be exceedingly important, and you may also stir up much enthusiasm in your audience, but your best "missionary" work will be accomplished when you meet, singly or in twos or threes, those who are most interested. Whether it is your nature or not, you must be a social (or perhaps I should say sociable) individual during your service in the park. Always mix with your audiences after your lecture and then, as well as at all other times, try to encourage the interest which these people display. Not only is this an important part of your work, but you will find it a most agreeable part if you approach it with the idea of making friends, both for yourself and the park.

How will you benefit most scientifically from your experience in the park? I would say by broadening your scientific horizon. Regardless of what your training has been, you are expected to interpret the out of doors not in terms of botany or geology or zoology alone, but in terms of natural communities. You may be a geologist assigned to conduct trips over the geyser formations at Old Faithful, but dispensing geological information will not suffice. Your visitors are interested in the park as a whole and its many phases of wild life; they will ask you questions about the birds and flowers on the trailside. At first it will keep you "on your toes" to supply all this varied information, and you may wonder if information of this kind is important in a region so interesting because of its thermal phenomena. You will soon realize, however, the value of these other phases of natural history; were it not for such occasional variety you could not maintain vital interest in the big and important scientific features.

The very fact that you must accumulate this mass of general field information in a number of sciences will prevent your deep study of any one subject during your period of service. You will find at the end of the season, however, that you will look upon your own branch of science with an entirely new perspective. The importance of this perspective in science cannot be overestimated; it is worth far more than a summer of generalization. Several Ranger Naturalists have told me that as they returned to teaching or research in their own field, they were astonished at the unsuspected depth and breadth of many of their own problems when looked at with a new and broader perspective.

These suggestions, fellow naturalists, are offered to you merely to indicate a few of your opportunities. No one will urge you to follow them. The value, to yourself, of your summer in Yellowstone will be exactly what you choose to make it.