



The Narrows

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EROSION BY FLOOD WATERS AT BRYCE

By F. W. Christiansen

The great majority of visitors who see the amphitheatres of Bryce Canyon National Park view the forms during a time when erosion apparently is at a standstill, and unless acquainted with the climatic conditions, as well as the physical geological conditions, the inquisitive minds will probably wonder what has happened in the past to carve such fantastic rock forms as there are in this canyon.

This question can very easily be answered if the canyon is viewed during a torrential storm, common during July and August, or in the spring when the snows are melting. At either of these times the transportation agent can be seen doing its bit in the forming of the canyon as it is today. Every gulley, every depression, every small canyon is filled with water, laden with clay and rock fragments which were previously loosened by frost and chemical action and were waiting to be removed. The bottom of the main canyon is a rushing torrent and the stream carries many tons of solid material from the main canyon called Bryce. From this canyon the flood waters drain east to the Paria Valley which is occupied by the Paria River. The waters then run south to the Colorado River, joining the Colorado at Lee's Ferry.

To understand just how a stream transports the solid material caught in its path, one should have a clear understanding of the physical nature of running water.

If the mass of water forming the current moved forward at a uniform rate, each particle moving forward with the same velocity as every other particle, only the microscopical material, such as fine granules of clay, would remain in suspension; any relatively large solid material dropped into the stream would immediately sink to the bottom. There it would remain at rest unless the stream was flowing fast enough to roll the solid along the bottom. Streams, however, are not of this nature. The central portion of the stream is running more swiftly than the water along the sides and bottom of the stream channel, thus there is a constant interweaving of the swifter current in the central part of the stream with the slower current along the bottom and sides.

The action just described causes an effect similar to stirring water in a container - whirling movements, eddies, and even backward movements are set up. Irregularities in the stream channel, such as curves and falls, also aid in keeping material in suspension, as they also cause eddies and back currents. The loose material in the stream bed is therefore picked up and held in suspension by the various movements of the water. This material held in suspension constitutes part of the load.

In addition to this material carried in suspension, a considerable part of the stream's load is moved by sliding or rolling the material along the bottom, the percent carried by this method depending on the steepness of the grade of the stream. The steeper the grade, the larger the percent carried as bed load, the opposite being true as the stream's grade is decreased.

Another part of the load of a stream is carried by a process called saltation, simply jumping. The particles progress forward by a series of short leaps. Near the bottom of every stream there is a zone filled with grains moving in this fashion.

The particles moved forward by sliding, rolling, and saltation are said to be moved by stream traction. The amount of material carried by this method, as well as material in suspension, depends on the size of the grains and the velocity of the current. The velocity of the stream is dependent on the grade and the volume of water. Two streams with the same grade, but different volumes, will have different velocities. The one with the larger volume will have the greater velocity, and vice versa.

A stream running approximately one-fifth of a mile an hour will transport or carry fine clay; one running one-half mile an hour will transport sand; a mile an hour stream will carry medium sized gravel; one travelling two miles an hour will transport pebbles the size of an egg. Mathematically it may be stated that the maximum size of particles transported by a current varies as the sixth power of the velocity. This means that if the stream's velocity is doubled, it will move particles sixty-four times as large as it moved before. This explains why streams running around five miles an hour will move small boulders.

This law of the sixth power applies to the maximum size of particles and not to the total load of the stream. It is true only under ideal conditions and with perfect spherical and cubical fragments. The average carrying power of streams varies approximately as the fifth power because of the irregular nature of the fragments, as well as other conditions which are not ideal in the natural stream.

In considering the total load of the floods, the chemical load must not be forgotten. Stream waters carry in solution salts of many kinds which have been leached from the soil and rocks over which the water flows. The important substances carried in solution

are calcium and magnesium carbonate; calcium sodium, and potassium sulphates; sodium chloride, and silica.

With an understanding of the foregoing statements, a full appreciation of the transporting agent, water, can be had. This agent, as mentioned before, has everything to do with removal of material from the amphitheatres of Bryce.

Visitors upon seeing the canyon during flood time see the canyon bottoms filled with water transporting tons and tons of material from the canyon. Samples of the flood water taken from Wall Street and the main canyon below during a flood were collected and analyzed for percentage of material in suspension and solution, with the following results:

	<u>In Suspension</u>	<u>In Solution</u>
Wall Street	71.904 gr./100G	.0199 g./100G.
Canyon below Wall Street	31.1758 g./100G	.0218 g./100G.

Converting these figures to the English system, they show that in Wall Street, out of every 100 pounds of flood material (mud and water) that flowed from the steep slope, 71.904 pounds would be solid, and .0199 pounds of material (dominately calcium carbonate and other salts) would be in chemical solution. Farther down the main canyon, below and east of Wall Street, the suspension and chemical loads are of different proportions. Out of every 100 pounds of flood material (mud, fragments of rock and water), 31.125 pounds are solid mud and rock, and .0218 pounds are carried chemically in solution, the suspension load decreased and the solution load increased.

Neglecting the bed load, and taking the figures from the flood stream below Wall Street, every second foot of flood material that passed from the amphitheatre in the stream channel would carry approximately 19.24 pounds of material in suspension and solution. The stream bed near the mouth of the canyon, measured at several places, averaged 15 feet wide and 2 feet deep. During the summer season, according to weather reports, an average of nine storms a season have occurred that would cause such a flood, assuming that .2 of an inch, falling within ten minutes, is ample rainfall to cause a run-off. Assuming that the creek bottom is filled for one hour after a storm, and that the velocity of the stream is four miles an hour (a timed and measured pacing traverse was taken), the stream will carry approximately 6,602 tons of material from the canyon. For nine storms (which is an average over the last 4 years) it would be nine times this much, and for ten days, with approximately twelve hours a day in the spring when the snows are melting, it would be one hundred and twenty times the total load carried in one hour.

These figures indicate that an enormous amount of material is carried out of the canyon each year, (800,000 tons, roughly figured); and when we consider that such water action has been going on for thousands of years, it is easy to see how the entire canyon could have been carved by repetitions of the little cloudbursts which

NARROWS OF THE VIRGIN RIVER

By C. C. Presnall

Ever since 1875 when G. R. Gilbert, a geologist of the Wheeler surveys, described The Narrows as "the most wonderful defile it has been my fortune to behold", it has been a name to arouse the spirit of adventure among both geologists and laymen. Although the name is locally used to designate any one of the three canyons through which flows the Virgin River, yet it is most often applied to the uppermost and narrowest one extending upward from the head of Zion Canyon, at the Temple of Sinawava, to a point several miles beyond the north boundary of Zion National Park. The relation of the various canyons can best be understood by tracing the course of the Virgin River from its source near Navajo Lake to its confluence with the Colorado River at the upper end of Mead Lake.

The stream starts at an elevation of about 9,000 feet from numerous springs issuing from beneath the Pink Cliffs that form the south edge of the Markagunt Plateau, south and west of Navajo Lake; the largest of these springs is supposed to be the underground outlet of Navajo Lake, flowing into Deep Creek. The water from these springs unites to form the two principal tributaries, Deep Creek and the North Fork of the Virgin, as well as Goose Creek, Kolob Creek, Orderville Gulch, and others. These creeks flow through narrow valleys from 5 to 18 miles long, cut into the soft Cretaceous rocks that lie between the Pink Cliffs (limestone) and the White Cliffs (sandstone) of Zion; but upon reaching the latter formation they soon entrench themselves into narrow gorges which in a few miles unite to form The Narrows, extending from the junction of Deep Creek and the North Fork of the Virgin to the Temple of Sinawava, slightly less than nine miles (distances here given in describing the Virgin are measured along the stream, and are obtained by scaling from the most accurate maps at hand). At the Temple of Sinawava the gorge widens markedly and is of sufficiently different character to be designated as a separate canyon from The Narrows, known as Zion Canyon. This canyon averages half a mile in depth and width and is nine and one-half miles long, terminating opposite West Temple, which is one of the westernmost remnants of the Kolob Plateau. Both The Narrows and Zion Canyon have been formed in this plateau, but they differ in that The Narrows are cut through Navajo Sandstone exclusively, whereas Zion Canyon has been further entrenched into the next lower layer, the less resistant Chinle, which through undercutting has favored a widened canyon. Beyond West Temple the river flows through a relatively wide valley eroded from the weak Chinle and Moenkopi formations, past the towns and fields of Springdale, Rockville, Grafton, and Virgin, until it reaches, in about eighteen miles, an exposure of the resistant Kaibab Limestone on the upthrown

side of the Hurricane Fault. There is a small canyon, known as Hurricane Narrows, about five miles long and from one hundred to five hundred feet deep. From thence to the southwest the river flows through broken country for about twelve miles until it emerges upon the broad valley surrounding St. George. Through this valley it follows a widely meandering course for about twenty-two miles to the Utah-Arizona line, where it cuts through the Beaver Dam Mountains, forming a canyon variously known as the Littlefield Narrows, St. George Narrows, Beaver Dam Mountains, or Virgin Narrows. The last name is the one most widely used. This canyon is about twelve miles long, and not over 1500 feet deep. South of the Beaver Dam Mountains the Virgin flows a slow meandering course to the Colorado, eighty-four miles to the channel of the Colorado, and about forty-seven miles to the high water line of Mead Lake, which is about twenty-five miles below the town of Bunkerville, Nevada.

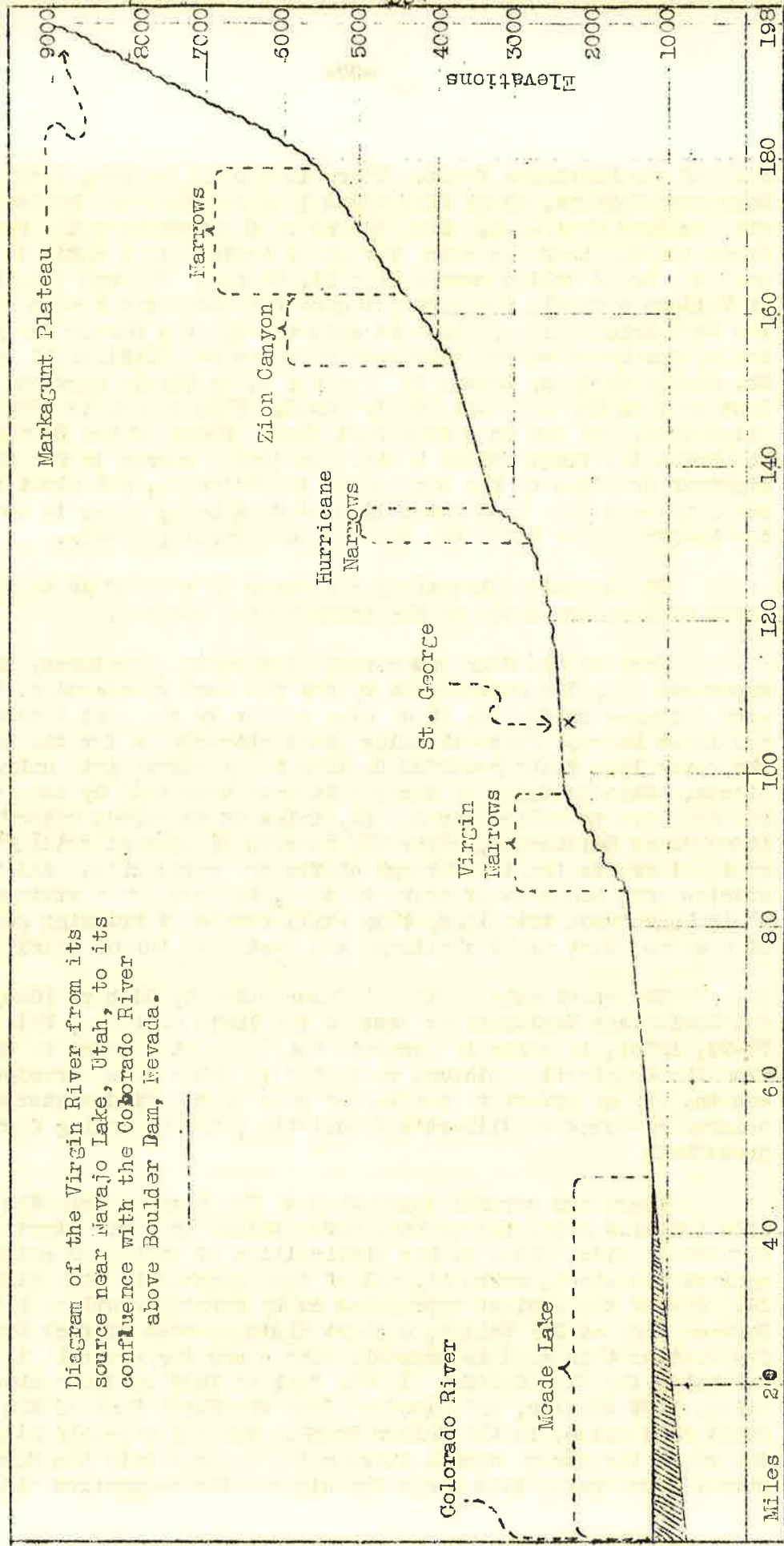
The relative elevations and sizes of these four canyons and three valleys are shown on the accompanying diagram.

Each of the four has certain interesting features, but the uppermost one, The Narrows, is by far the most spectacular, and the very features which make it so also render it the most inaccessible and least known. Hence it holds great attractions for the many people who never lose their youthful desires to penetrate into unknown places. Strange tales concerning it have been told by some of the few who have travelled through it, tales of dangerous waterfalls, treacherous quicksands, cavernous reaches of eternal twilight, or raging torrents foaming through clefts two yards wide. All these stories have elements of truth in them, but even when stripped of their Münchhausen trappings, they still furnish intriguing glimpses of a canyon that might challenge the most adventurous spirit.

The previously mentioned description by Gilbert (Geographical and Geological Explorations West of the 100th Meridian, Vol. III, pp. 78-79, 1875), is entirely accurate but does not detract in the least from the fascinating picture presented in other less veracious accounts. In an effort to counteract some of the wilder stories, and enlarge somewhat on Gilbert's description, the following facts are presented.

There are several approaches to The Narrows from the upstream side (parties going through the gorge seldom or never start from the downstream side, owing to the difficulties of wading or swimming against the strong current), all of them reached by Utah Highway No. 14. One of the easiest approaches is by turning south on a Forest Service road at Dry Valley, a short distance west of Duck Creek. In dry weather this road is passable with a car for several miles through and below the Pink Cliffs. In the fall of 1936 we drove about eight miles, left the car, and hiked on down the North Fork of the Virgin eight more miles, to the Walker Ranch. Two and one-half miles below the ranch the stream starts intruding a gorge into the Navajo Sandstone. Traversing this gorge for six and three-quarters miles brings

Diagram of the Virgin River from its source near Navajo Lake, Utah, to its confluence with the Colorado River above Boulder Dam, Nevada.



one to the confluence with Deep Creek, and the beginning of the Narrows proper, which in about nine miles opens out into the Zion Canyon, making a total hike of twenty-six and one-quarter miles for this route. For some reason this has to date been the least used route; we could learn definitely of but three men who had used it previously to October 10, 1936, when four of us, Don Jolley, Howard Firm, Russell Mahan, and myself, came through in one and one-quarter days. Doubtless there have been others of whom we do not know.

Probably the most strenuous route is by way of Three Creeks and Deep Creek, leaving the highway just west of the summit (Midway) or driving to Navajo Lake and on south a few miles. Howard Firm tells me that this route is at least thirty-five miles long. He spent two very hard days in travelling it in June, 1936.

Another route, and the one most often used, is by way of Crystal Creek. By turning south at Webster Flat, a car can be driven several miles toward the Crystal Springs region. From thence to the Temple of Sinawava is approximately thirty miles. At least two parties travelled this route during 1936, and it has probably been traversed at least once a year for ten years or more.

There are, of course, several variations to each of these three routes, depending on which tributary brook is selected for the start. There is also a fourth route, short and relatively easy, consisting of an auto trip to the lower Kolob Plateau, and a hike down Oak Creek, Kolob Creek, or Goose Creek. This is the only route that can readily be made in one day.

The reader may infer from the foregoing paragraphs that there are no dangerous obstacles or dangerous places in The Narrows. There are none, provided that the trip is made at extremely low water, in late September or October. Difficulties are usually not very great in late May and June before the summer rains, or in early September after the rains have ceased. Neither are there many difficulties from high water during the winter, but the few that have made this trip in freezing weather have no desire to repeat the performance. All the stories of dangerous waterfalls and long stretches of treacherous quicksands are absolutely unfounded. The only dangers in these gorges, aside from the ever-present likelihood of a sprained ankle or broken leg, are those arising from high water, which is practically continuous from March to May, and occurs frequently and irregularly between late June and early September. High water in The Narrows is a terrifying thing. Safe beaches or ledges are practically nonexistent, and certain death would be the fate of a swimmer in the narrow, tortuous channel, where the stream rushes roaring down a grade nine times as steep as that of the Colorado River.

The river usually looks harmless enough to the thousands of visitors that travel the Narrows Trail every summer; and so it is, even in high water, so long as they remain on the trail. It is even possible to penetrate into the Narrows a mile or two beyond the trail

with comparative safety, provided it is done in the forenoon, on a clear day, and when the first ford is not over knee deep. Knee depth at that ford usually means waist depth before reaching the mouth of the Orderville Gulch (two miles above the trail), and swimming depth a short distance above the gulch; and that means you turn around and go back - swimming upstream in the Virgin Narrows is like walking on the ceiling, it isn't done. During July and August it is very unwise to be in the Narrows beyond the trail after noon, since cloudbursts and floods usually occur in the afternoon. However, some very dangerous ones have been known to come in the morning, so the only rule for absolute safety is to stay on the trail during the rainy season.

Low water stage, later in September and October, is the ideal time for a Narrows hike, there are then no more hazards than on a slippery, rocky scramble through the mountains, yet the trip is strenuous enough to test the strongest hiker. It offers some of the most unusual and spectacular scenery in the western United States; very difficult to photograph, however. For those who contemplate the trip, the following notes may be useful.

Since about half the trip is wading (or even sometimes swimming), it is best to wear old light-weight clothes, and very heavy soled shoes to prevent bruised feet. A change of heavy wool socks, a blanket, food for three to five meals, a camera, and adhesive tape complete the necessities. Each party should carry one rope in case it is necessary to "trolley" the packs across a deep ford. These are the minimum requirements, assuming that members of the party are willing to take turns at stoking a fire all night.

The narrowest gorges will be found above The Narrows proper; nine or ten feet is the minimum width on any of the routes previously given. There are no waterfalls on any but the North Fork route, where there is a twelve foot fall that can be easily walked around; just follow the deer tracks. However, there may be several artificial falls caused by log jams which are usually not difficult to scramble over. These jams change in character and location with every large flood; in fact the entire bottom of the gorges changes markedly each year, due to the shifting sand and gravel bars. Small patches of quicksand may be encountered in a few places; the traveler will soon learn to detect them at a distance.

The deepest part of the gorge is in the Narrows proper at a point about four miles upstream from the end of the Narrows Trail. There the canyon is 2300 feet deep, 2300 feet wide at the top, and about twenty-five feet wide at the bottom, but as viewed from the bottom it appears to be 800 or 1000 feet deep and not over 100 feet wide at the top. This is because nearly vertical walls of that height shut off the view of the steeply sloping walls leading to the actual brink above.

Most of those making the trip will be looking for "the place where you see stars in the daytime", and "where you can't see the sky". The Narrows do not have monopoly on either of these so-called phenomena; they are commonplace, for the stars can be seen during daylight almost anywhere that the atmosphere is free of haze, provided you know where and when to look for the brightest stars, and in any mountains you can find nooks or recesses from which the sky cannot be seen. It is the same in The Narrows. If some bright stars happen to be within the limited angle of visibility, they will be seen, perhaps a little more plainly than from the open viewpoint because the canyon walls shut out the sunlight; and all sight of the sky can be shut out in many hundreds of places simply by retreating into one of the recesses that line both sides of The Narrows. During our October trip we saw no stars, and could find no place where the sky could not be seen from the center of the stream. There were several places where the sky was not visible directly overhead, however.

Debunking these two half-truths does not detract at all from the chasmic grandeur of the gorge. The steep, forbidding walls with grotesque carvings partially revealed by the dim light; the constant menacing roar of the river; the crazy patterns made by shattered trees in the log jams; and the overwhelming immensity of it all gives one a feeling that he is descending into the unknown depths of the earth, or that he is exploring another planet, or that he has perhaps become a part of Coleridge's fantastic dream -

"Where Alf, the sacred river ran
Through caverns measureless to man,
Down to a sunless sea."

Softening this awesome spectacle there are several openings, where the walls recede, forming resplendent spots of color in the fall. There are occasional glimpses upward to the pine covered plateaus above the canyon. Along the stream are numerous springs, one very large one being located on the west wall about two and one-half miles below Goose Creek and four and one-fourth miles above the terminus of the Narrows Trail. This spring issues from the vertical wall about twenty feet above the river and cascades in several streams down over a large dome-shaped deposit of travertine that has become heavily covered with green moss and ferns. It is one of the most beautiful springs I have ever seen.

At frequent intervals throughout the gorge water ouzels will be seen and heard. Their wild warbling songs exactly fit the mood of the gorge, and they add just the right accent of life to the somber chasm.

All these features are part of what may be termed without exaggeration "the trip of a lifetime".

ALONG NATURE'S HIGHWAY

A new bird record for Bryce was made on October 24, 1936, when a Long-tailed Chickadee (Parus atricapillus septentrionalis) was seen feeding in the conifers below Yovimpa Point, at an elevation of approximately 8000 feet. Several Mountain Chickadees (P. g. gambeli) were seen nearby, and other long-tailed chickadees may have been in the flock, which was moving too rapidly for close study. This bird has been seen in Zion, and is to be expected in this region as a migrant or uncommon winter visitant.

C.C.P.

One August day the usual afternoon automobile caravan stopped at Inspiration Point to take one more look at the spires and pinnacles of Bryce Canyon before returning to the lodge. About 25 visitors in all formed a single line along the rim of the canyon. The sky was hidden beyond the black clouds that clung close to the earth. In the west the clouds parted and a shaft of sunlight shot across the sky, illuminating Bryce Temple, an architectural form beyond the Great Organ. The group's attention was focussed on this form when Thor broke loose - lightning flashed, and a huge bolt struck the top of the Great Organ. Everyone in the group saw the event, as the Organ was in line with Bryce Temple and in the foreground. Rocks and smoke flew into the air just as if a charge of dynamite had been ignited in the Organ. Fragments weighing over fifty pounds were hurled into the air. Several tons of material were blasted from the top of the pinnacle and the horseback trail below was covered with debris. After everyone had recovered from the shock, they all agreed that Inspiration Point was properly named.

F.W.C.

Chickarees (Sciurus f. fremonti) are quite evidently on the increase in Bryce Canyon National Park, as shown by observations during this and the past three seasons. Mention was made of this in Nature Notes for September, 1935, when it was stated that they were then numerous enough to attract the attention of the tourists, but had probably not yet reached their maximum numbers. This year they appear to be nearing the maximum, at least in the southern and higher part of the park. In all of the more heavily forested areas the scolding notes of the squirrels are frequently heard and their "middons" are fairly common. In late October there was plentiful evidence of

their work among the yellow pines, freshly cut cones and branch tips being very common, and the squirrels themselves being often seen. There are indications that the chickaree population will increase still more next year. The crop of cones and seeds has been unusually large this year, permitting the storage of ample food supplies, a condition that is often accompanied by increased reproduction of squirrels and other seed-eaters; and there is plenty of room for increased population to spread into the more scattered stands of yellow pine, some of which are now not completely utilized by other seed-eaters, such as chipmunks. It will be interesting to note how many years this dense population will continue before there occurs a great decrease in numbers such as was reported in 1924 and 1925. C.C.P.

Late in the evening of August 9, 1936, while driving from the north end of Cedar Breaks Monument, accompanied by Mr. F. F. Ralls, Project Superintendent of the CCC camp, a large rabbit ran in front of the car. It was at the top of the hill near Forest view, north of the camp (elev. 10,500 ft.). The rabbit became confused by the headlight of the car and stopped for a few minutes so I had a chance to observe it more closely. It was large in size for a rabbit, top of tail black, upper parts dusky brown, feet whitish. This was the first rabbit I had seen at this elevation, and from what observations I had a chance to make I believe it was a Rocky Mountain Snowshoe (Lepus bardii bardii).

Rabbits similar to this have been seen on the road to Navajo Lake. Barnes (in Utah Mammals) states that they have been taken at Marysville, and I was informed by Mr. John Excell that he had killed them at Panguitch Lake. G.Y.C.

On October 22, 1936, while searching near the eastern boundary of Bryce Park for evidences of the Kangaroo Rats (Dipodomys ordii cupidiinus) recently found there, * I was surprised to find a Grass-hopper Mouse (Onychomys leucogaster melanophrys). It was captured in a sandy wash, that supported a sparse growth of sagebrush, some four miles east of the park at the elevation of 6000 feet. Since habitats that are exactly similar (except a few hundred feet higher) occur inside the park, it is not at all unlikely that these interesting carnivorous mice will be found within the boundaries sooner or later. In fact, we are so sure of it that we are adding this species to the Bryce mammal list. C.C.P.

(* Prestall, C.C., and Hall, E. Raymond. Ranges and Relationships of Certain Mammals in Southwestern Utah. Proc. Utah Acad. Sci. Arts and Let. Vol XII, pp. 211-213. 1936.)

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