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sided channel, evidently not long abandoned by a powerful stream, cuts across the Divide. The withered stream in its western half was named by the surveyors Outlet creek, in the well-grounded belief that this was at least for some time the path by which the lake waters escaped. An indefinite divide, midway in it, is little, if at all, more than 8000 feet above sea-level, perhaps even lower.

The accession of water from the lake enabled this once small stream, originally a tributary of the Lamar river, to dig most of the cañon, not as at Niagara by the backward recession of a waterfall, but more probably by simultaneous erosion all along its length.

The Yellowstone lake itself occupies the largest of the tectonic basins in the park, and is surrounded by lacustrine silts to a height of about 100 feet above its present surface. At least two strand terraces can be traced in these and in the glacial drifts underlying them, and mark separate stages in the drawing off of the lake waters. The underlying drift suggests that the whole basin, but not the higher plateaux to the west, was overridden by ice which gathered here from snowfields to east and south.

Though fishing is permitted with certain restrictions, complete protection is otherwise given to the *fauna*; none are killed unless of species, like the coyote and the puma, destructive to the rest, or individuals which become dangerous to visitors. Besides the bison, four kinds of deer, two or three of bear, and the horned mountain sheep, there are many smaller animals, especially rodents; the beasts are often so tame as to be easily observed in this their natural habitat. Some of the fish have been introduced by man; at least one species is a most significant natural immigrant to the upper Yellowstone from across the continental divide. Because of its altitude, there are at any rate no rattlesnakes in the Yellowstone Park.

III. IMPRESSIONS OF THE VEGETATION IN THE UNITED STATES OF AMERICA.

By ALAN G. OGILVIE.

As this century advances, long and rapid journeys are becoming more and more common. A few years ago it would have been considered ridiculous that a party of people should set out to cover 14,000 miles in two months, with the object of seeing the country through which they passed; and even to-day it might reasonably be asked, What lasting impressions can be formed on such a journey? The American Geographical Society of New York last autumn gave to its European guests an opportunity to find the answer to this by experiment.* Since such opportunities must necessarily come to an increasing number of people, it will be useful to see how the geographer may best profit by what he sees on a journey of this kind.

* *Geog. Journ.*, April, 1913, p. 349.

In the first place, the traveller may scrutinize the landforms, and in a general way he may assign them to their proper position with regard to rock composition and structure, to process and stage of erosion; but into the details of the development of surface relief he cannot go. Secondly, he may observe, superficially at least, the direction which human activity has been forced to follow by the nature of its geographical environment. From this he may form some opinion regarding the climates of the country. It is, however, impossible for most people to make a study of climate in a journey of this character; yet it should be noted that one who already has a sufficiently comprehensive knowledge of the climatic details, may give their true significance to the weather phenomena which he observes on the journey. This has been clearly proved by one of the Transcontinental Excursion party, Prof. R. de C. Ward, in two papers.* In the case of most men, whatever they gain in knowledge of climate from personal observation must come indirectly from examining the kind of agriculture practised, and above all from a systematic watch upon the character of the vegetation.

However attractive and even fascinating are the other aspects of the journey, the following notes are restricted to the main features of the vegetation observed in the course of this admirably planned journey. The relations of the vegetation to climate, relief, and soil will be kept in view throughout.

In reviewing the vegetation of a country it is essential to remember the following principles.† The type of *vegetation* in tropical and temperate zones is determined by the rainfall, by the humidity of the air, and by the movements of the air—the last being important as a desiccating agent.

The type of *flora*, so far as it is determined by existing factors, depends primarily on *heat*. The finer differentiation of vegetation and of flora within a climatic district is chiefly determined by the chemical and physical composition of the soil.

In the first part of this paper the writer will give a brief sketch of the more general features of vegetation and of the changes, sudden and gradual, in its character. In the second part four districts will be dealt with in greater detail. Reference should be made to the two maps, on which the route is printed.

From the Atlantic to the Pacific.

The Western European does not experience any very strange sensations in travelling through the North-Eastern United States. Landscapes do not differ greatly from those in Europe. The journey up the Hudson and Mohawk valleys to Lake Erie can be passed over briefly; for while it was largely through forests of extraordinary beauty, and along streams

* R. de C. Ward, (1) *Journ. of School Geog.*, 1913; (2) *Monthly Weather Review*, December, 1912, p. 1909.

† See Schimper, 'Plant Geography' (Oxford, 1903), p. 159.

bordered with a rich carpet of wild flowers, the general character of its deciduous trees was familiar, and impressions will therefore be omitted. For the same reason, as well as from the hurried nature of the final stage of the homeward journey, the Appalachian region will not be described.

The early morning of the sixth day out found the party at the south end of Lake Michigan, confronted by a range of high sand-dunes of great interest. They are at various stages of development, from the young unfixed dunes with no vegetation, some of them nearly 100 feet high, through all stages of fixation by such plants as bent grass and a dwarf willow, to the old or fossil dunes, covered with well-established oak woods. The form and size of the young dunes tell us of the force and direction of the off-lake winds of Michigan, while the evident rapid undercutting of the oak-covered dunes by the waves remind us of the size of these great bodies of water, and of the storms which can rage upon them.

The route brought us from Central Wisconsin * to the Mississippi, and up that river to St. Paul. The varied deciduous woodland lent a richness to the wide flood-plain, while the steep bluffs were clothed by shrubs and creepers in great variety, amongst them the sumach and wild grape vine. The change from this rich valley to the muskeg swamps of Minnesota was as complete as it was sudden. Not only were we steadily travelling to regions of more rigorous temperature, but we had passed from a non-glaciated tract by way of a mighty river-valley to a region bearing all the symptoms of glaciation. The vegetation corresponds to these climatic and physiographic conditions. The journey from Duluth with its ice-scoured hills northward to Hibbing was mainly through a dreary waste of innumerable pools amid sphagnum bogs, the result of the ill-defined drainage of this drift-covered plateau. On this surface was an open forest, chiefly coniferous—white pine (*Pinus strobus*), Norway pine (*Pinus resinosa*), white spruce (*Picea alba*), and tamarack (*Larix Americana*), but with birches (*Betula alba*) and aspen (*Populus tremuloides*) interspersed.

A night journey from Duluth brought us again into another type of vegetation. The passage westward from the boulder clay and moraines to the bed of the huge glacial lake "Agassiz"—now marked by the basin of the Red river—corresponds to the transition from forest to prairie. Here are the richest grass lands and the most valued farming country of which Fargo is the centre. The woodland, mainly aspen, is confined to the valleys. A journey of some 200 miles from Fargo brought us to Bismarck, on the Missouri. It lay over country which became steadily more broken. The only variation to the expanse of grass was the numerous ponds—presumably of glacial origin—many of which were nearly dry, and showed the most beautiful zoned arrangement of plant associations round their margins. At Bismarck the fact that the steppe consists not merely of grass, but of grass with a considerable admixture of sage brush (*Artemisia tridentata*) and atriplex, is a sign of decreasing

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* See below, p. 351.

moisture. Moreover, the following day at Medora, on the Little Missouri, 100 miles further west, the sage brush was found to be mingled with a dwarf cactus (*Opuntia*) and the grass was very scanty. This 300-mile journey across North Dakota, in fact, corresponds to a drop in annual rainfall from 24 to 14 inches, or to a change from rich meadows to semi-desert, from wheat farms to horse ranches.

A long day spent in the saddle enabled the riders to form a clear idea of "badland" topography about the Little Missouri. The extreme dissection of the plateau and the fine texture of the ravining is due largely to the absence of vegetation. The slopes, in fact, are mostly of bare clay. The flat tops of the hills have scanty grass, sage, and cactus; in the gullies stunted juniper trees are scattered. Some of the wider and deeper valleys—dry at this season—were covered with fine green turf, forming rich pasture for the herds of horses. The banks of the Little Missouri are well wooded, mainly with aspen and ash.

The climb along the Yellowstone river took place at night, and the morning saw the train well within the confines of the Rocky mountains. A digression was made from this point to the Yellowstone Park.*

The forests of the Western States are confined to the mountains except in the extreme north-west. As the relief increases, so do the contrasts of rainfall, with the result that the chief feature of the vegetation now to be seen was the frequent and sudden changes from forested slopes to treeless plains. The other main point to be noticed is that these western forests practically consist of coniferous trees. The continental divide was crossed by a low pass, and for the next 300 miles the train ran north west through intermont depressions, narrow valleys, and wide basins. On the left were the Bitterroot mountains, densely wooded on the higher slopes, for they probably receive over 40 inches of rain, though the only tree which creeps low enough down to the more arid valley to be recognized is the yellow pine (*Pinus ponderosa*). The western slopes of the Rockies proper, which lay on the right, are here in the rain shadow, and it was very striking to observe their forest caps sending their fingers of trees down every little gully, while the sharp spurs between bore stunted bushes on their northern sides, but were entirely bare on those parts facing the sun. This phenomenon becomes very familiar to the traveller in the Western States.

As we crept round the northern end of the Bitterroot mountains, it became obvious that a tongue of the great Pacific forests was here thrust out to the east. The valleys bore trees to the bottom, mainly yellow pine, with the western white pine and larch higher up. The grandeur and solitude of these forests of northern Idaho is most impressive, and it comes as a surprise to see in their midst an evidence of man in the great stores of lumber floating upon the Pend d'Oreille lake.

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* See below, p. 352.

Again a night journey hid from us the transition to a fresh vegetation. This time a drop of 1500 feet in altitude, and of some 15 inches of rainfall, caused the change. The result is a sage-brush landscape, where it has not been replaced by skilful dry farming. There is an interesting variation, however, to this *Artemisia* formation in the bottom of the gorge left by the Columbia river—the Grand Coulee. Here the soil is charged with alkali salts, and there are even some salt lakes remaining. The *Artemisia* of the plateau gives place to a greasewood formation, with greasewood (*Sarcobatus vermiculatus*) and *Atriplex hastata*.

The last section of the westward journey is perhaps the most interesting, for it plunges the traveller suddenly into one of the most luxuriant forests of the Earth. The passage from the Yakima valley over the Cascade mountains to Puget sound must surely be one of the most remarkable journeys of its length which can be made. The sage-brush and the aspen valley woods give place to yellow pines, small at first, then larger. The yellow pine is not a tree which likes moist situations, and on these lower eastern slopes, in fact, the rainfall is small, while *chinook* winds increase the evaporation.

As the low pass (*circ.* 4000 feet) draws near, the Douglas fir (*Pseudotsuga Douglasii*) and lodgepole pine (*Pinus Murrayana*) are also seen. The dense forest covering of the mountains overhangs a group of finger-like glacial lakes, and from time to time a snowclad peak overtops all. Once over the crest, and still greater luxuriance meets the eye. The Douglas firs become huge, and they are mingled with the white cedar (*Libocedrus decurrens*), a gigantic tree, in habit like the deodar, but much darker in colour. Everywhere a dense, moist undergrowth speaks of the humid climate. The material for the accompanying diagram (Fig. 1) is supplied

FIG. 1.—DIAGRAMMATIC PROFILE IN THE NORTHERN CASCADE MOUNTAINS.

by statistics which exist for the belt just to the north of this pass. The diagram may therefore be taken to show approximately the forest conditions in this section of the Cascades.

The forests about Puget sound are magnificent where not destroyed. Many of the trees of the Cascades occur, among which the Douglas fir predominates, the gigantic red cedar (*Thuja gigantea*), while variety is given by the madroña (*Arbutus*) and other deciduous trees.

Southward to California.

The description given below * of the vegetation of the Crater Lake region may be taken as typical of the greater part of western Oregon. The first feature of change in the vegetation observed on this southward route was that due to the decreasing humidity in northern California. Mount Shasta, which guards the northern gateway to the state, stands alone, a veritable queen of the west, an ice-clad cone with a garland of forest draping the glacier tongues. The traveller, spellbound by the sight, may well forget to note the foreground of the picture—a landscape of tumbled cinder cones, bare of all vegetation save some scattered junipers and stunted pines and a thin grey carpet of sage-brush. It is the foreground which gives the keynote of Californian vegetation and climate—the long summer drought. This is firmly impressed on the observer as he makes his way southwards to San Francisco through the wide and treeless Sacramento valley, now all under cultivation. A day amongst the vegetation of the vicinity of San Francisco bay is enough to convince him that the rainfall period coincides with the low temperatures, and that the hot summer is also a dry summer. The view from Mount Tamalpais (2600 feet), overlooking the bay, will never be forgotten. As far as the eye can reach, the hills—except for certain slopes bared by fire—are clad in a mantle of scrub, resembling nothing more than a thick-piled carpet of wonderful colour scheme, comprising all tints from gold to deepest green. The writer was reminded of an autumn view of the forest-clad waves of the Vosges, where the treetops formed the carpet. But the difference was seen when the eye rested on the damp valley bottom to the west, where the stunted nature of the cover was shown up by contrast with full-grown woods—maple, bay-tree, and, towering over all, the giant Californian redwood (*Sequoia sempivirens*).

An excursion into this sea of scrub, or *chaparral* as it is called in America, showed that it contained a great variety of species, from 3 to 5 feet high, of all tints from the dark olive-green of the sticky-leaved yerba santa (*Eriodictyon tomentosum*) through many glaucous shades, such as the greasewood (*Adenostomata fasciculatum*) and the manzanita (*Arctostaphylos glauca*) to the brilliant yellow of the golden fleece (*Bigelovia*) shaped like an inverted cone and covered with flowers. The chaparral is composed almost entirely of sclerophyllous plants, and, but for the redwood trees in the valleys, the landscape might be on the shores of the Mediterranean, a region corresponding in latitude and climate alike.

Eastward to the Great Plains.

The cross-section which was followed in the return journey over the western Cordilleras differed in several important respects from that followed

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* See p. 354.

on the outward route. In the first place, it lay, on the average, 450 miles farther south; next, its length was much greater—roughly 900 miles as the crow flies, as against 600 in the northern part; and thirdly, the ranges are here at their highest and most massive part. The stretch from San Francisco to Denver may be analyzed into the crossing of Sierra Nevada on the west and the Sawatch mountains—as the main divide of the Rockies is called here—on the east; secondly, the traverse of the Great Basin and of the upper parts of the Colorado plateau; and thirdly, the journey along and through the Wahsatch mountains which separate the last two. As there were many features of similarity in the two great mountain ranges crossed, they will be dealt with together.

The route over the Sierra Nevada was by the Yuba river (south fork) to Donner pass (7100 feet) and down the Truckee river, which drains to the Great Basin. The Sawatch were crossed at Hagerman pass (11,500 feet), reached by the valley of the Gunnison river, which drains to the Colorado river, while the descent was made to the basin of the Arkansas rivers. In both cases the mountains had been glaciated, and in both a long ascent in a trough-like valley led to a wider and nearly flat stretch of high meadow on the west side of the pass. In each this was in strong contrast to deep and steep corries of bare rock, and to moraine-dammed lakes on the eastern face. In the case of the Sawatch, lateral moraines stood very high on the sides of the western valley, and by damming back streams had produced lakes, now marked by damp pastures.

The Sawatch are considerably higher than the northern Sierra Nevada, but it must be remembered that the latter are high enough to extract much of the moisture from the west winds, so that the rainfall at Donner pass is probably much greater than that at Hagerman.* The greater altitude must ensure lower temperatures, however, and on the east side of the Hagerman pass the glaciers have left a relic, in the form of a patch of stratified *névé*.

The zones of vegetation were interesting in the two cases. First, in the Sierras. The dry foothills are covered with oak and mixed scrub, and the first conifer to appear is the small digger pine (*Pinus sabiniana*); in the scrub the manzanita (*Arctostaphylos glauca*) predominates. About 4000 feet the oaks were left behind, and the yellow pines which had succeeded the digger pines were joined by the Douglas fir. About 5000 feet this was replaced by the white pine (*Pinus monticola*) which, with the yellow pines, continued as a scattered growth right over the pass and down the eastern slope.

In the Sawatch the yellow pine and its companion, the Douglas fir, are left behind in the valley at 7000 to 8000 feet. From 8000 feet to 10,000 feet the Engelmann spruce predominates, and above that a subalpine

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* From Sacramento with 19.9 inches to Summit with 46.9 inches is an increase of 27 inches. In the case of the Sawatch, no statistics have been found for the Hagerman pass.

fir (*Picea lasiocarpa*) which reaches the summit in a stunted and scattered growth.

The abrupt eastern slopes of both ranges have at their foot similar treeless depressions, which provide much good pasture. In the Rockies these are called "parks," and the party, on descending into South park, had a foretaste of the Mexican flora in the piñon pines (*Pinus edulis*) and yuccas (*Yucca angustifolia*) of the foothills round its margin.

There are two features of the Great Basin which make a great impression when seen for the first time, and the vegetation plays an important part in producing the impression. One is the salt desert, and the other the mighty scarp of the Wahsatch mountains overlooking it on the east. The two great depressions, once filled respectively by Lakes "Lahontan" and "Bonneville," are now areas of semi-desert and desert. Slight changes only may be discerned in the vegetation over wide tracts, according as the area is (a) intensely alkaline, (b) arid without being alkaline, or (c) slightly less arid. The less arid type is found on the mountains, which rise in isolated groups throughout the basin. Their slopes are nearly bare, and are scored with dry gullies, but a scattered growth of juniper (*Juniperus Californica*) can sometimes be seen. The more arid tracts are grey-green in colour, with an open sage-brush formation (*Artemisia tridentata* and *Atriplex canescens*). Lastly, the most striking of all are the lowest parts with their glistening white salt-fields sprinkled over with clumps of xerophilous salt-loving plants, sometimes pale green, sometimes tinged with red (*Salicornia herbacea*, *Sarcobatus vermiculatus*, *Spirotachys occidentalis*).

The Wahsatch escarpment presents a bold front, broken only by narrow gorges. To leave the flat colours of the desert and plunge into the verdant cases of irrigation about Salt Lake City is indeed refreshing to the eye. Of forest trees few remain on the western slopes of the Wahsatch. On the crests pine forests were visible, and, before the settlers came, they must have extended lower. The sight of the clouds collecting on the slopes and remaining there all through a hot day, made one feel sure that the conditions are suitable for forest growth. The Wahsatch canyons were indescribably beautiful. The plashing streams were bordered by box-elders and aspens, while the September frosts had given the most brilliant hues of scarlet and orange to the maple and scrub-oak on the slopes.

The journey southward and westward to southern Arizona was full of interest from the point of view of vegetation. The European traveller is made to feel that he is surely entering the strangest part of the continent. The increasing number of Indians, the ancient architecture, native and early Spanish, and most of all the changing flora, combine to produce this effect. Part of the transition area will be described below.* The deserts

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* See p. 355.

and semi-deserts have recently been described in the *Geographical Journal* by two leading authorities,* and a few words must suffice here to describe the landscape of the intensely interesting region crossed in travelling (by motor car) from Phœnix to the Roosevelt dam.

The first impression on detraining in the "desert" is one of disillusionment, for, quite apart from the irrigated fruit gardens, the natural vegetation of these outwash plains appears to be incomparably more luxuriant than that of the Great Basin (Fig. 2). It is true that the general tint is a glaucous green, but the variety of species, of form, and—within limit—of colour is very great. A hasty examination, however, shows that the covering is by no means closed, the soil being quite bare often for several square yards. Moreover, the plants are all extremely xerophilous, and the great variety above mentioned is due partly to the differences in the nature of the means for withstanding drought, with which the plants are provided. The greater number are either sclerophyllous or succulent. Of the first class the creosote bush (*Covillea tridentata*) is the commonest. It provides the darkest green to the landscape; its leaves are small, pointed, leathery, and sticky. The richest green as well as the most graceful form is that of the palo verde (*Parkinsonia microphylla*), a small feathery tree with minute leaves and a bright green bark. This and the mesquit (*Prosopis*), with an acacia (*Acacia greggii*), are the only trees, having anything like northern tree form, which were seen in the region, except certain broad-leaved species along the river-banks.

Only a few of the succulent plants can be described here. On the plain cacti of many species were intermingled with the other shrubs; the giant cactus (*Cereus giganteus*) dominates everything, but for beauty of form and tint there is none equal to the *Opuntia fulgida* and the *Opuntia Bigelovii*, with their dense armament of silvery spines, while the prickly pear (*Opuntia ficus indica*) is the most quaint in shape. The 100-mile motor journey into the mountains and zones of greater rainfall was marked by ever-changing vegetation, either species altering or the density and general habit changing. The giant *Cereus* seemed to get more and more contorted and unearthly as we went on, the graceful occatilla (*Fouquieria splendens*) appeared, its long whip-like stalks radiating from a point and bearing scarlet flowers. The thick-leaved agaves and yuccas, many of them bearing the high flower stalks, completed the picture.

Eastward to the Mississippi.

A rapid, unbroken journey of $2\frac{1}{2}$ days brought the party to the Mississippi at Memphis. In approaching the river the line runs through magnificent and varied forest, both conifers and hardwoods being present. White oak (*Quercus alba*), a hickory (? *Carya amara*), and a cypress

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* D. T. MacDougall, *Geog. Journ.*, **39**, pp. 105–200, "North American Deserts;" C. Lumholtz, *Geog. Journ.*, **40**, pp. 503–510, "The Sonora Desert."

FIG. 2.—SEMI-DESERT NEAR PHOENIX, ARIZONA.
CEREUS GIGANTEUS, *OPUNTIA FULGIDA*, *PARKLY-*
SONIA MICROPHYLLA, *COVILLEA TRIDENTATA*.

FIG. 7.—FOREST OF SUGAR PINES (*PINUS LAMBER-*
TIANA), NEAR CRATER LAKE, OREGON.

FIG. 6.—UPPER GEYSER BASIN, YELLOWSTONE PARK. LODGEPOLE PINE (*PINUS MURRAYANA*).

FIG. 4.—FALLEN TREES (*PINUS MURRAYANA*), YELLOWSTONE PARK.

FIG. 9.—TONTO PLATEAU, GRAND CANYON, ARIZONA. *COLEOGYNE RAMOSISSIMA*, *PROSOPIS*, *OPUNTIA FICUS INDICA*.

FIG. 8.—SOUTHERN RIM OF GRAND CANYON, ARIZONA. VIEW OF WOODLAND FROM A FOREST WATCH-TOWER.

(*Taxodium distychium*) appeared to be dominant. A steamer voyage of 70 miles downstream was most impressive, but chiefly from its extreme monotony, one bend of the river appeared exactly like another; the richly varied forests could not be seen, as they were hidden by a dense growth of poplar (*Populus monilifera*). The growth of vegetation is undoubtedly rapid here, but so is its destruction. The river, in fact, is constantly undercutting its soft tree-clad banks. Many times throughout the 70-mile journey large sections of bank, generally bearing one or more trees, were seen to slip into the river.

From the Mississippi a hurried journey through the Appalachians, and the return to New York after a four days' halt at Washington, brought the excursion to a close.

Central Wisconsin.

At Camp Douglass, a point 90 miles north-west of Madison, the railway emerges from valleys cut in sandstones to a wide flat plain, from which those strata (the Potsdam series) have been removed by denudation. The transition from one area to the other is marked by a number of isolated and rocky buttes, the outliers of the sandstone. The summit of one of these afforded a wide view (Fig. 3), and the forest features which were

FIG. 3.—VIEW NORTH-WEST FROM A BUTTE AT CAMP DOUGLASS, WISCONSIN.

prominent in it tempted reflection upon the probable history of the different vegetation types, and the probability that each is inherited from a different climatic period.

Camp Douglass stands in that triangle of country—the “driftless area”—which, alone in Eastern Canada and the North-Eastern United States, was never covered by the ice-sheet. The ice, however, was near enough to give it a boreal climate. Then, as the ice retreated, swamps took its place. Farther north these swamps can be seen to-day, and the tamarack (*Larix Americana*) still found in this area is a relic of this stage. As the climate improved, drier forests, mainly coniferous, extended over the whole region, and these in turn were ousted from all but the more inhospitable situations by the deciduous forests spreading from the south-east as warmer conditions supervened. In the vicinity of Camp Douglass

the less hospitable situations are represented by the sandstone crags, whose stunted white and Norway pines (*P. strobus* and *P. resinosa*) are relics of a once continuous coniferous forest, such as is found to-day farther to the north.*

But in the district we are considering the plains, as far as the eye can reach, are covered with deciduous forests, in which the oak is dominant, broken by tracts of grassland. It would seem, in fact, that this is one of those regions in which deciduous forest and prairie struggle for mastery. There is, undoubtedly, sufficient rainfall for an open forest, and we may presume that it existed formerly, but, being partly destroyed by fire or other cause, it gave place to the thick prairie sod which established itself in the district. Without the aid of erosion to break this soil cover, the forest was unable to recover the lost ground. Thus it is that a map of the vegetation of the United States (see map) shows the meeting of three main types in central Wisconsin—the mixed temperate forest, in which conifers predominate, and of which the hilltop pine woods just referred to are outliers on its south side; the deciduous forest adjusted to warm temperate conditions; and, finally, the prairie, which in its eastern parts may well be called “park steppe,” from the fact that the grassland has isolated tracts of woodland throughout.

Yellowstone Park.

The Yellowstone Park occupies a high lava plateau in the eastern part of the Cordilleras. Its altitude varies from 7000 to 9500 feet, but the greater part is between 7000 and 8500 feet. It is bordered on all sides by higher mountains, which are snow-clad for most of the year.

This plateau is reached from the north by a long and steady ascent, while the Yellowstone river leaves it on this side by two great waterfalls and a deep canyon. From the isolation of the plateau, it is to be expected that the vegetation will be rather special in character; but the traveller, as a rule, is unprepared for the monotony which is the most striking feature.

The dry conditions of the great plains are continued up the valley of the Yellowstone river to the Park. Except for the woods of aspen and willow fringing the river, the valley is everywhere a steppe. The spurs in many places, even at the height of 5000 to 6000 feet, bear vegetation only on their north-facing sides. Mammoth Springs (alt. 6300 feet), near the north edge of the park, is considerably below the level of the tableland; but the annual rainfall is 19·6 inches,† and the plateau vegetation may be said to begin here. Variety of scene throughout the circuit of the plateau

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* The writer's attention was called to this fact by Prof. H. C. Cowles, of the University of Chicago.

† Henry, ‘Climatology of the United States.’ *Bulletin Q*, U.S. Weather Bureau.

is derived entirely from the physiography—the geysers and geyser-basins, the lake, and the canyon : the vegetation, as stated above, is interesting chiefly because of its monotony. It is a dense pine forest, in which practically one species alone is represented, the lodgepole pine (*Pinus Murrayana*). The areas which are not forested are, first, the valleys and depressions filled with glacial drift, river alluvium, or lake-deposits ; and, secondly, the vicinity of the geysers and hot lakes.

The lodgepole pine is the tree characteristic of the drier plateaus of the Rocky mountains, and it never grows to a great size. In the Yellowstone the stands of trees are generally very dense and without undergrowth ; but even where they are open the woods are difficult to penetrate, on account of the number of fallen trees. The Yellowstone Park is purposely left in a state of nature, and to one who has never seen a great forest untouched by man, these pine woods are of the greatest interest. Trees, dying a natural death, fall and slowly decay ; others fall across them before their decay is complete, and a tangled mass of fallen trees, in many places quite impenetrable, is everywhere to be seen (Fig. 4). The timber is in all stages of decomposition, and often a long moss-covered ridge, or even a mere strip of richer soil, marks the spot where a tree has been resolved

FIG. 5.—THE PLATEAU OF YELLOWSTONE PARK FROM OBSERVATION PEAK ; ABSAROKA MOUNTAINS IN THE BACKGROUND.

into its elements. This condition of the forest is a source of grave danger to the living timber, and the wisdom of allowing it to continue, in view of the risk of fire, is now being discussed. A peculiar quality of the lodgepole pine is that it is the only pine whose seeds remain alive after a mixed pine forest has been burned. For this reason the lodgepole tends to grow over all burnt areas in the interior mountains of the States. On some of the higher slopes in the Yellowstone (at 8500 feet on the continental divide) Douglas firs were seen, and it seems possible that they were relics of a varied coniferous forest. If such be the case, the monotonous lodgepole forest may owe its existence to fire.

The view south from Observation peak (9300 feet) (Fig. 5) showed up the contrast of the forested lava-sheets and the grass-covered drift of the valleys. These meadows have a rich carpet of flowering plants and grasses, and there is much bog. In many cases, although the streams meander over their surface to-day, the old lake-bed and its meadow or bog cover must

sooner or later be eroded when the old lip of the lake has been sufficiently cut down. The area may then be expected to become forested.

The Upper Geyser basin (Fig. 6), as seen from the top of the precipitous rim 800 feet above it, presents, perhaps, the most varied picture to be seen on the plateau. The surface is dotted with snow-white cones and circles of sinter, bare of all vegetation. In the centre of each circle is either a steaming vent or else a hot lake of the most wonderful blue or green tints. The higher parts between the geysers and streams are tree-clad with lodgepole pine, but the trees thin out as they approach the sinter. Everywhere trees are killed as they stand, and other signs bear witness to the encroachment of the sinter or the hot and alkaline waters. The rest of the basin is filled with the alluvium of the Firehole river. But here again is a contrast, for the older and higher terraces are composed of coarse black pitchstone sand which has a glaucous veil of *Artemisia* and *Atriplex canescens*. The newer silt along the present river, on the other hand, is covered with rich green meadows and in some places with bog plants.

The Ascent to Crater Lake, Oregon.

Although Medford, Oregon, is the centre of one of the richest fruit-growing districts in the United States, its annual rainfall is but 20 inches, for it is situated in the great longitudinal valley of Oregon, in the lee of the coast ranges. The conditions then, where no irrigation is practised, are those of a steppe. The journey from Medford at 1400 feet to the rim of Crater lake at 8000 feet represents perhaps the most striking change in vegetation which was seen on the Transcontinental Excursion. This stretch of 50 miles (over 80 by road) with its 6600-foot climb corresponds to an increase in annual rainfall probably of 50 inches.

For nearly 20 miles north from Medford there was little rise in altitude on the aggraded plain, and but slight change in the steppe-like vegetation. Then as the valley of the Rogue river narrowed, we entered a xerophilous woodland of dark-leaved Pacific oak (*Quercus Garryana*), arbutus, and small yellow pines, with an open undergrowth of manzanita (*Arctostaphylos*), the dark and spiny *Dahlia spinosa*, and other shrubs. The first change which appeared as we climbed was that the broad-leaved trees became restricted to the valley bottom, the yellow pines grew bigger, and the stately Douglas fir was seen at about 2000 feet, and with it the incense cedar (*Thuya occidentalis*). At about 3000 feet the sugar pine (*P. Lambertiana*) appeared. This noble tree is in many ways the most beautiful of the Cascade species, its great height and its smooth light red bark making it stand out boldly among the other trees.

The fine development of the sugar pine at this point is remarkable, for it is here about its northern limit. It appeared first with Douglas and cedar, and higher up we rode for miles through woods in which there was little else than this pine (Fig. 7), with an undergrowth of mountain laurel and beech. From this grand forest we emerged into an area recently

burned—a scene of utter desolation, the charred trunks, or sometimes merely the stumps remaining, to remind us that a great forest had stood there. As the slopes became steeper, at about 3500 feet, we passed through dense woods of lodgepole pine (*P. Murrayana*), which may have spread, after a fire, to take the place of a larger species. Above this, at about 6000 feet, at the foot of the steep ascent to the crater, came a zone of varied woodland, in which the trees were no longer giants, but were well grown: hemlock (*Tsuga Pattoniana*) and noble fir (*Abies nobilis*) predominated. Finally the five-leaved *Abies albicaulis* appeared. This tree extended above all other species, first as an open wood, and then in clumps of trees ever more and more stunted, upon the slopes of rich alpine pasture which reach almost to the summit.

The view from the edge of the crater can never be forgotten. Inwards lay the placid waters of the crater lake of the deepest blue tint, contrasting with the brilliant hues of the circling ring of precipice. Outwards there stretched on all sides a sea of peaks, almost smothered in those dense forests, which are the surest witness to the humid character of the winds of the Northern Pacific coast of the United States.

*Northern Arizona, from the New Mexico Border to the Bottom
of Grand Canyon.*

Northern Arizona forms the southern part of the Colorado plateau, with its deep and narrow canyons and table-topped hills, or mesas. The plateau is, however, varied by volcanic masses which form outstanding features, such as the San Francisco mountains.

A night journey brought us from the Rio Grande basin in New Mexico to the Little Colorado in Arizona. We had left the outwash slopes of the southern Rockies with their isolated clumps of piñon pine and juniper, where the rainfall is some 20 inches, and we found ourselves in a much more arid region where the rainfall is under 10 inches (Holbrook, 7.9 inches).^{*} Not a tree was to be seen; everywhere an unclosed growth of sage-brush, and a waggon ride to the south from Adamanna to visit the petrified forest showed only a change for the worse, to bare clay hills, except at the crossing of a dry wadi where aspens and golden *Bigelovia* bushes refreshed the eye.

Another excursion to Meteor crater showed similar vegetation, and there was but little to be seen even in the bottom of Cañon Diablo. The day's route afforded several evidences of the erosive action of sand-laden wind, and we were also lucky enough to see the manner in which the region receives much of its scanty rain—from small cyclonic storms sweeping across the land and causing precipitation over a narrow strip. On the following night the train made its way round the San Francisco mountains, and by daylight had reached the Grand Canyon. We were thus unable

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^{*} Bulletin Q, U.S. Weather Bureau, 'Climatology of the United States'

at this stage to see the gradual improvement in the vegetation. The Colorado plateau, in fact, rises steadily northward from the east of the mountains up to and beyond the Grand Canyon; at Cañon Diablo the altitude is 5000 feet, and on the south side of the Grand Canyon 7000 feet; there is a corresponding increase in the rainfall. Upon this tilted plateau the San Francisco mountains rise nearly to 13,000 feet. We had, however, to pass under the heavy forests of their slopes without seeing them, for the journey was by night.

The rainfall of the plateau south of Grand Canyon is sufficient to maintain an open woodland with a xerophilous undergrowth. A wide view (Fig. 8) over this tableland was afforded by a wooden watch-tower, erected by the Forest Service for use in locating fires.* Trees cover the southern plateau as far as the eye can reach, while a field-glass showed forests at the northern rim, 10 miles away.†

It is to be expected that this woodland of the south side will be at its best on the canyon edge, for not only does the plateau slope away from this, so that, as the highest part of the area, the rim receives the greatest precipitation, but there is also a special addition to the moisture here, for the air rising from the canyon below and cooling as it rises, seems to have moisture to spare at the top.

The woodland along this strip is formed of a variety of species, yellow pine (*Pinus ponderosa*) up to 50 feet in height, the small piñon pine (*Pinus edulis*), and the juniper (*Juniperus californica*). Mingled with the pines were a robinia (*Robinia neo-mexicana*), and the *Cowania Mexicana*, with small, dark, and sticky leaves and a white flower. Thus, while the existence of this open woodland point to relatively humid conditions, yet the species represented show that the precipitation really cannot be very great. That this is so is clear when the undergrowth is examined. It consists of a scrub-oak (*Quercus submollis*), sage brush, yucca (*Y. baccata*), and prickly pear (*Opuntia ficus indica*).

The Grand Canyon at this part is some 4500 feet deep (roughly 7000 to 2500 feet). The descent is broken at 3600–3800 feet, by a wide ledge—the Tonto plateau. Above this the Canyon is wide and cut in limestones and sandstones; below, it is a narrow gorge in granite.

For several hundred feet below the rim the steep slopes bear woods of Douglas fir (*Pseudotsuga Douglasii*)—a sure proof that the air must be relatively humid. Lower the Douglas gave place to juniper and piñon, and then to mixed scrub, growing on every ledge and crevice; oak and an

* As a result of the admirable organization of the U.S. Forest Service, the damage to forests from fires decreases steadily. In all forests where fires may be expected observation stations are maintained, equipped with instruments to enable the watchers to locate fires as soon as they break out, and to communicate—generally by telephone—with the nearest forest station. In this manner many fires are isolated at their start.

† The plateau here attains its greatest height, and the greater rainfall gives a rich forest of yellow pine.

Ephedra were perhaps the most noticeable. Then the feathery mesquit (*Prosopis*) came in and continued right to the bottom. Towards the Tonto platform the scrub became more dwarfed, but a pleasing and surprising variant occurred at the so-called "Indian Garden," where a spring comes out, and a verdant and tangled thicket of willow, poplar, and reeds meets the eye. Among the trees and pools, grape vines, *Baccharis*, and a *Datura* with large violet flowers were recognized. From this oasis the change is sudden to the semi-desert of the platform. The general tint of the vegetation was more grey than green, chiefly owing to the predominance of a low rosaceous shrub (*Coleogyne ramosissima*), which was grey at this season (September), though it is dark green after rains. Mingled with this shrub were the low *Atriplex canescens*, the globular *Echinocactus*, an agave, and the prickly pear.

The last 1000 feet of the descent were marked by more scattered shrubs of the same character, the mesquit giving a refreshing tint to the slopes; but very arid conditions appear to prevail at the bottom of the narrow canyon, and the dry winds which form the great heaps of blown sand bordering the Colorado river must greatly hinder the growth of plants.

Thus the journey through northern Arizona, from the eastern border to the bottom of the Grand Canyon, was marked first, by a gradual transition from semi-desert to fairly luxuriant woodland, and then by a sudden change back to a xerophilous vegetation.

It will be seen from the foregoing notes that the participants in this excursion of 1912 had opportunity to study in a general way a variety of aspects of the vegetation. The following are a few of the points which perhaps impressed themselves with greatest emphasis upon the observer. First, the dependence of the vegetation upon the climate, and especially upon conditions of temperature and moisture. Secondly, the great contrast of floristic types in extreme regions, *e.g.* the deciduous forest of the north-east and the cactus semi-desert of the south-west. Thirdly, the effects of the Ice Age on the vegetation. Fourthly, the effect of various forces destructive of vegetation. Under this last heading would come fire in the forests, river-erosion in the lower Mississippi, alkali on the flats of the Great Basin, hot waters and the salts contained in them in the geyser basins of the Yellowstone.

Moreover, to some members of the party this excursion provided the first opportunity of observing personally that essential similarity of vegetation types in corresponding parts of another continent. It is such observations which make us realize the full importance of the major natural regions of the globe and their classification.

The PRESIDENT (before the papers): Last autumn the American Geographical Society of New York celebrated the jubilee of its foundation. Many of its members are liberal minded and, I am happy to add, wealthy men, and the Society was able to carry out this celebration on a scale with which we in this country can hardly

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