ART. XIX.—*On Prairies*; by A. FENDLER.¹

IN my botanical rambles I have seen Prairies, Llanos and Savannahs of different magnitudes and in various stages of progress; and, as I am assured that my suggestions on this subject, although they may not fully coincide with your views, would be received in a kind spirit, I beg to make the following remarks.

The prevalence of moisture, although generally is not always connected directly with a prevalence of forest. For four years I lived on the range of mountains that stretches along the northern coast of Venezuela in lat. 10° N., at an elevation of 6,500 feet above the sea, in the midst of a vast forest. The northern slope of this chain of mountains, from its very crest (7,000–8,000 ft.) down to the margin of the sea, is covered by an immense primeval forest, except in a very few insignificant spots, near some of the seaports, where man has interfered with it. In this mountainous region, from the middle of April to the first of January, hardly a day passes without rain. It is a region enveloped in mist and clouds during most of this time, alternately drizzling, dripping and pouring down, where the temperature rarely ever rises as high as 70° or falls as low as 38°. It is a true "Fern-region," where tree-ferns may be found from 30 to 40 feet high. It is certainly one of the most rainy, moist and humid regions outside of the great equatorial rain-belt. Although the northern or sea-side of this mountain-range is in its whole length covered by forest, savannahs stretch in many places from the very crest down the opposite or southern side, which is constantly exposed to southern or southeastern winds, driving the clouds and mist against it and up along its surface away over the crest. In some localities of the windward side forests alternate with savannahs, but in other localities on the same side, and exposed to the same wet weather, large tracts are entirely bare of forest. The forests, however, do not gain on the savannahs, but from time to time the savannahs gain on the forests by a very simple agent, namely, that of *fire*.

Fire I consider by far the most powerful and the principal agency that gave prairies and savannahs their existence, extending them in the course of time and still busy in extending them. In the prairies of Illinois, Missouri and Texas as well as on the great plains between Missouri and the Rocky mountains, on the llanos of Venezuela and the high savannahs of the mountainous district of the same country, I have seen the same forest-destroyer at work. In the region last named I had the rare opportunity of observing not only the gradual extension of the savannahs,

¹ From a letter to Professor Dana, dated Cambridge, Mass., Dec. 12, 1865.

but also the beginning and the different stages of the conversion of an almost impenetrable primeval forest into a savannah.

I cite the following facts, observed by myself at Colonia Tovar in Venezuela, from an account in the Smithsonian Report for 1857, pages 186-188.

"On the 5th of January I made a botanical excursion to one of the highest mountains of this region, about twelve miles to the east of the colony. The mountain, according to my estimation, may be about 7,800 feet above the level of the sea, and is a kind of central point or knot, from which several rivers, flowing in different directions, take their origin. This mountain is covered by a dense forest, with the exception of a level spot of about half a mile in length and a quarter of a mile in width, which forms a kind of shallow basin, only sparingly covered by a thin coat of short grass and other small plants. * * *

In this excursion I had also an opportunity to form some idea of the vast extent of destruction which was carried into the mountain forest last February by a lucifer match and a thoughtless boy. Over whole tracts of this primeval forest the trees lie dead, one over the other, as if uprooted by a whirlwind, scarcely showing any marks of fire on their trunks. I was struck more than ever with the easy manner in which fire can destroy these dense and humid forests, which, by their shade, preserve a cool and moist atmosphere, and thereby cause the vapors of the adjacent strata of air to condense into clouds, that rest upon them, with little intermission, during nine months in the year. In these high regions the temperature is so low and equable that the vegetable matter which is gathered on the ground between the trees is decomposed very incompletely and very slowly. It forms a stratum of loose half-decomposed matter, in some places two to three feet thick, which, in the rainy season, like an immense layer of sponge filled with water, feeds and supplies the rivulets and rivers *gradually*. In the midst of the dry season this layer becomes sometimes dry enough to burn, when kindled, with but little flame, and more like tinder, spreading in all directions.

In this way the fire extends until met by a river or a road, or some other obstacle. The subsoil which underlies the spongy stratum on these mountains is also very shallow and resting on hard rocks. The roots of the trees, therefore, do not go down very deep, but extend more in a horizontal direction. When the spongy layer, with the smaller roots, are burnt, the trees lose their hold entirely and fall, one over the other, in all directions. They die less from being burnt than from being uprooted. Many different kinds of tall reeds soon take the place of the trees. In a few years these reeds exclude everything else. The fertile mould that may perhaps have escaped destruction by fire is by and by carried down the declivities by the frequent rains. The region, no longer shaded by high trees, becomes dry. Subsequent conflagrations of adjacent savannahs, which are intentionally set on fire to procure a new growth of young grass, take hold of the reeds of the ruined forest, until, by the repeated attacks of these fires, the roots of the reeds can stand it no longer, and the smaller grasses, interspersed with a few other plants, take their places.

On the road from the colony to Caracas we pass through a region in which this process is going on; the reeds giving gradually way to the smaller grasses. Here the great number of half-burnt yet standing trunks of the wax palm tell plainly enough that there existed not long ago a dense and humid forest, in which they luxuriated in all their beauty, for these palms are never found, in their natural state, growing in any other but humid forests. Here they stand isolated in the midst of reeds. Most of them have died already, but many linger yet in a dying condition, until their last green leaf has turned brown, and then they stand like tall and slender pillars, the mournful remnants of a once stately forest."

The contrast with regard to forests in the above mentioned two mountain slopes (the northern and southern) is easily accounted for. The strong and ever restless southern and south-eastern breezes sweep only the southern side of the mountains in their course up to the crest. Leaving the latter, they go on horizontally through the aerial ocean and never touch the surface of the northern slope, where calms prevail. The fire being fanned by the southern current, ascends the windward side of the mountain, but on reaching the crest is abandoned by the breeze; it can make no further progress and dies out.

I may also remark, that no instance ever came to my knowledge in which a high prairie (savannah) once *firmly established* was encroached on by the extension of a forest, no matter how humid the region may have been. But as long as the loose mould in a partially burnt forest has not been destroyed by fire or swept down by rain, so long is there a chance for the recovery of that forest in a moist region, if no intruding weeds are in the neighborhood, and further attacks of fire excluded.

Although the prevalence of moisture and forest, and that of dryness and prairie generally go together, we are not warranted to conclude that a prairie is the effect of dryness alone, for it can be shown in many instances that dryness of a region is the effect of prairies. The sun, heating the surface of the earth, thereby raising heated columns of air, disperses clouds and fogs, as may often be seen at Colonia Tovar with clouds moving across the cultivated valley, which lies between two nearly parallel mountain-ridges heavily timbered. The clouds as they come moving on from the southern range vanish as soon as they reach the cleared and cultivated area, and form again by condensation on drawing near the opposite or northern range.

New-made land offers a good chance for the establishment of a forest. If we believe in geology we cannot but admit that, at one time or other, far back in the history of our planet, either anterior to, or cotemporaneous with, the great Carboniferous era, a humid, rainy, cloudy climate of a more equable temperature, and resembling in many respects that of the equatorial

low regions of South America, prevailed all over the continent up to high latitudes. Here, then, all the conditions for the existence of a vast continuous forest all over the land are given, and we are entitled to infer that at that period one immense mass of forest spread not only over all the land above water, but also through swamps and other shallow overflowed places. All the grassy plains, prairies and high savannahs must have originated since. Suppose the climate to have changed gradually in later periods, the ground elevated in some places, clouds dispersed and the atmosphere become drier. In this case a majority of the trees will, no doubt, die off gradually; but as long as the ground underneath is shaded, and covered by vegetable mould of a loose texture, resulting from the accumulation of decayed leaves, tree-seeds will germinate, new varieties and new species, better adapted to the new order of things, will in their struggle for existence make their appearance, and still there will be a forest although in a different garment.

Grass cannot well succeed in dense shady forests. In the extensive prairies of western Texas I have seen isolated clumps of timber like little oases in a desert, some not more than 200 feet in diameter, effectually resisting not only the encroaching attacks of the prairie-grass, but even those of the prairie-fires, and this in a pretty dry region subject to long continued droughts. Their margins are so dense with underbrush that in most cases not even a large sized dog could penetrate them.

Let the climate of a mountain region have only drought of two or three months' duration, no matter how moist, damp and wet it may be the remaining nine or ten months, and it will be no difficult task to convert by fire the forest covered slopes into savannahs. In a drier climate, of course, this conversion of forest into prairie by the agency of fire can be accomplished much faster.

On the other, hand in regions perpetually moist and wet the forests are safe enough against all encroachments from prairies, because fire can do no mischief here. But also in comparatively *dry* climates the forest will be safe against the intrusion of prairies, if the trees stand on a deep fertile soil, where their roots may go down deep and support the tree from falling, and where the trees have a tendency to sprout from their roots; for it would take many repeated firings of the undergrowth to lay that ground open to the baking influence of the sun.

Again, at Santa Fe, New Mexico, the atmosphere is so exceedingly dry that, with the exception of the sides of a deep, narrow mountain-valley, through which a creek flows, I have never seen *dew*. The dry, gravelly soil is for the greater part covered with forests of *Coniferæ*, not only on the higher mountains, but also on the low hills. The sterile soil is so dry during summer and

autumn, that the thin grass, although sprouting and growing during spring, has no power of spreading. In winter the ground is generally covered with a considerable layer of snow.

That on sloping land, elevated ridges, mountains, etc., the forest can be changed into prairies or savannahs more readily than in other situations having the same degree of humidity, is easily accounted for. The thin layer of soil in such localities rests mostly on layers of rocks; the tap-roots of trees cannot penetrate to any considerable depth, and the tree is rather loosely fixed to the ground. Fire can easily undermine it, so that it may be prostrated not only by moderate breezes, but by its own weight. When fallen, its shade no longer protects the binding rootlets of thousands of cryptogamic and other plants delighting in shade; they wither and die. The fertile layer of mould is now open to the attacks of sun and rain. By degrees it is washed down the declivities, leaving the more tenacious clay behind, on which reeds and grass spread and with their creeping roots form a dense matting in which no tree-seeds can germinate.

All the moist and forest-covered places and valleys on the lower parts of Tahiti and elsewhere, cited as exceptions, are those by which, on account of their moist surface, the progress of fire that once destroyed the forests on the drier slopes and convex localities, was arrested.