Primers

of

Forestry

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NO. I.—DRAINAGE.

The rain that falls on the earth either runs directly off the surface or sinks into the ground.

The part that runs directly off the surface collects in small streams that discharge into a river, which finally discharges into some other river, into a lake, or directly into the ocean.

The part which sinks into the ground collects in pockets or places under the surface called reservoirs, from which, as a rule, it comes out at the surface at some lower level, as a spring. The flow of water in a river, during most of the time, is kept up by these springs pouring their waters into the many streams that empty into the river channel.

The water, therefore, that falls from the sky as rain flows directly from the earth's surface into a river, or it first collects in a reservoir, from which it afterwards flows into the river.

The running of the water from the higher level of the place where the rain fell to a lower level, is called drainage.

There are two kinds of drainage:

(1) Surface drainage, or where the rain water runs directly off the surface.

(2) Underground drainage, or where the rain water first sinks into the ground and then discharges into some stream that empties into a river.

Surface drainage takes place rapidly, and occurs mainly during the time rain is falling. It practically stops generally a few hours after the rain ceases.

Underground drainage takes place slowly and may continue for many weeks after the rain ceases.

All the water in a river comes from the rain that falls on the earth's surface. The river continues to flow because before all the water drains from the earth into the river, more rain falls and keeps up the supply.

Some rivers are larger than others. This is because—

(1) More rain falls on those parts of the earth through which they flow, and

(2) The land which slopes towards such rivers covers a greater part of the earth's surface.

The water runs off the earth from a higher to a lower level, because water runs down hill. The direction in which water will drain from the land will depend on the direction of the slope of the land.

If the land slopes so that all the water that drains from it collects in streams that flow into the ocean through a common river mouth, and the rainfall on such an area is large, the river itself will be large.

The smaller streams and rivers which collect in a single and larger river, and discharge their waters through a common mouth, are called collectively a river system.

The area of land that drains into a river is called a river basin.

The size of a river, therefore, depends upon the amount of the rain-fall on its basin, and on the size of its basin.

When the quantity of water discharged into a river is greater than its channel can hold, a flood occurs, or the river is said to inundate its banks.

A heavy rainfall does not necessarily produce

an inundation ; since if the character of the river basin is such that a comparatively small part shall run directly off the surface, and a large part shall sink into the ground, collect in the reservoirs of springs, and slowly pass through such springs into the rivers, sufficient time may be given for the river to discharge the waters of even a very heavy rainfall.

If, however, the character of the surface is such that the larger part of the rainfall runs directly off the slopes into the river channel, then an inundation must necessarily attend every heavy rainfall.

Whenever the greater part of the rainfall runs directly off the surface into the rivers, and a comparatively small part goes to feed the reservoirs of springs, if a comparatively long time elapses before the next rainfall, the springs will dry up, and the water in the river will get very low.

Any disturbance in the natural drainage of a country may cause a damage of two different kinds.

(1) The damage due to the overflowing of the rivers, or that due directly to too much water.

(2) The damage due to the drying up, or the getting low of the rivers, in the intervals between the storms, or that due to too little water.

The portion of the rainfall that sinks quietly into the earth as compared with that which flows directly from its surface depends on the character of the surface. As a rule, a surface devoid of vegetable covering, that is a surface on which no plants or other vegetation are growing, will permit a larger part of the rainfall to drain directly into the river channels than will a surface covered by vegetation. This is especially the case during the colder parts of the year, when the ground is frozen.

When the rain falls on a surface covered by vegetation, the water, by slowly trickling down the stalks or stems of the leaves, branches and trunks of the trees, finds a ready entrance into the ground by following their surfaces and discharging into the porous ground lying outside their roots.

A forest, that is a section of ground covered by trees, permits this action to take place quite readily.

A forest, therefore, tends to decrease the frequency of floods, because it decreases the amount of the rainfall that drains directly from the earth's surface.

A forest also tends to prevent the occurrence of too little water in a river, because it ensures the filling of the reservoirs of springs, which discharge their waters into the rivers in the intervals between the rainfalls.

The forests must therefore be preserved in order that the rivers may properly aid in draining the earth.

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NO. 2.—RAIN.

When rain falls on the earth, it either, for the greater part, runs directly off the surface, or sinks into the ground.

A part, however, passes upward into the air in the form of invisible water or vapor.

If a plate filled with water be exposed to the air on a warm day the water will at last entirely disappear. In a similar manner wet clothes, when hung out in the air, become dry, because all the water they contain passes off into the atmosphere as invisible water or vapor.

When water disappears in this way, that is, when visible water turns into invisible vapor, the process is called evaporation.

The amount of invisible water or vapor which a given quantity of air can hold depends on the warmth or coldness of the air. The hotter the air, the greater is the amount of invisible water or vapor it can contain.

When moist air is heated it acquires the power of holding a greater amount of water in an invisible state than it formerly did, and therefore becomes drier.

When moist air is cooled the quantity of invisible water it can hold becomes smaller, and, if the cooling is carried sufficiently far, some of this invisible water becomes visible as rain, dew, fog or cloud.

When, therefore, air containing moisture is sufficiently cooled, the moisture it can no longer hold

falls as rain. The amount of the rain which falls depends not only on the quantity of air that is chilled, but also on the extent of this chilling and the quantity of moisture the air contained before it was chilled.

The lowering of temperature necessary to produce rain may be caused in the following ways:

(1) The moist air may blow along the earth's surface towards colder regions.

(2) The moist air may rise directly from the earth's surface into the higher and colder regions of the air.

As a rule, the moist air which blows along the earth's surface towards the poles becomes chilled and deposits its moisture as rain or snow. On the contrary, for the greater part, the moist air, which blows along the earth's surface towards the equator, becomes warmer, and, thus becoming drier, takes rather than gives moisture, and produces drought.

Therefore, as a rule, only the surface winds which blow towards the colder regions of the earth can be expected to bring rain.

Mountains form excellent means for cooling the air, and causing its invisible water or vapor to fall as rain. They act, no matter in what direction the wind may be blowing.

When a wind blows against the side or slopes of a mountain, it is forced by the pressure of the wind back of it to slowly creep up the slopes of the mountain, where it becomes chilled in the colder regions which lie near the summit of the mountain. If this lowering of temperature be sufficiently great, the moisture will be precipitated from the air, no matter from what direction the wind may come.

Mountains may therefore cause rain to fall from any wind that is forced to blow over them, provided they are sufficiently high to cause the necessary amount of cooling. When a mountain reaches sufficiently upward into the air, or is high enough to make the temperature fall below the freezing point of water, the moisture falls as snow.

The reason so many rivers rise in mountains is to be found in the fact that they act to chill the winds, and so rob the air of its moisture, no matter in from what direction the wind, which is forced to ascend their slopes, may happen to blow.

The sources of nearly all the rivers of the world are found in mountainous districts. As a rule, the largest rivers of the world rise in the highest mountains. This is because the higher the mountain the colder its slopes ; the cold mountain slopes acting, as explained, to deprive the air of its moisture.

The rain that falls on a mountain's slopes, like that which falls on any other part of the earth's surface, either runs directly off the surface, or sinks into the ground.

The part which runs directly off the surface will be greater than the part which sinks into the ground when the surface is bare and devoid of vegetation. On the contrary, the part which sinks into the ground will be greater than the part which runs directly off the surface, when the surface is covered with forests. But where the sides of a mountain are covered with forests, the part of the rainfall which sinks into the ground, as compared with that which runs directly off the surface, is greater than in any other case.

Since the rivers which rise in the mountains

are more regularly fed by the springs when the greater part of the rainfall sinks quietly into the ground, and since this occurs on mountains that are covered with trees, the importance of keeping the sides of the mountains wooded is evident.

When the sides of mountains are covered with forests the rivers that rise on their slopes are both less apt to overflow their banks during heavy rainfalls and also less apt to dry up and become shallow during droughts, than if such forests are removed.

The forests should, therefore, be preserved on the mountain sides, in order to protect the low lands either from inundations or floods, or from the effects of too small a quantity of water in the rivers which flow through them.

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NO. 3.—CONDITIONS NECESSARY FOR THE GROWTH OF PLANTS.

The following conditions are necessary for the growth of plants:

(1) The germ or seed from which the plant grows.

The germ or seed in all cases comes directly from a plant exactly similar to that which will be produced when the seed sprouts or germinates.

(2) The cradle where the plant is born.

The plant's cradle is the soil. In this soil the plant spreads its roots, and from it, obtains, in greater part, the materials necessary for its nourishment and growth.

(3) The sunshine, as well as the heatshine, which awaken the sleeping germ and call it into activity; or, in other words, the light and heat, which are so essential to a plant's life and growth.

(4) The nourishment, or the food which the plant takes into its structure and so causes it to become a part of itself.

The process by which a plant takes different materials from the soil in which it grows or from the air around it, and causes them to become a part of its structure, is called assimilation. At the commencement of its life the plant gets its nourishment from materials in the seed surrounding that part of the seed which is called the germ. Soon, however, the plant gets its nourishment from the soil and the atmosphere; or, in other words, from outside the seed.

This latter nourishment of the plant comes from various materials, the most important of which are:

(1) Moisture.

This moisture is taken up mainly by the roots

of the plant, but is sometimes absorbed directly by the leaves.

(2) Carbonic acid.

Carbonic acid is a gaseous substance formed of carbon or charcoal combined with an invisible gas called oxygen. The carbonic acid is absorbed by the leaves of the plant, and, in the presence of sunshine, is broken up into carbon and oxygen. The oxygen is given off from the surface, and the carbon is kept by the plant to form its woody fibre. In the case of large vegetable forms like forest trees, the amount of carbonic acid that is taken from the air and converted into woody fibre must be very great.

(3) Mineral matters taken from the soil.

A plant contains various kinds of mineral substances which are taken directly from the soil. For the proper growth of the plant the soil in which it grows must contain the particular mineral substances which naturally exist in its structure. In addition to this, the soil must contain such mineral substances in a condition or state in which they can be readily taken up by the plant.

The conditions necessary for plant growth: viz., the germ, the cradle, the sun's light and heat, and some form of solid and liquid food, are not equally necessary for the growth of a plant.

The presence of the germ or seed is, of course, of the greatest importance, since without it no plant can grow.

The sunshine and the heat may possibly be considered as next in importance to the growth of the plant. Heat and light are to be found in practically all parts of the earth. They differ, however, in amount, and such differences cause the differences that are noticed in the plants that grow in different regions of the earth.

The nourishment of the plant comes next in order of importance. The quantity of carbonic acid found in the air is practically the same in all parts of the earth. The quantity of moisture found in the air differs very greatly in different parts of the earth, and on this difference, together with the difference in temperature, depends the difference observed in the plants of various regions.

The soil is, perhaps, the least important of the conditions required for plant growth.

Where a particular kind of plant is to be raised, the character of the soil probably stands next in importance to the presence of the germ or seed; for, each plant thrives best in a particular kind of soil. The variety of plants that exist are, however, so great that, given almost any kind of soil, together with the other conditions of heat, light and moisture, that soil will be found to be the soil best suited to the growth of some particular kind of plant. In other words, if the proper conditions of moisture, heat and light are present, and the germ is present, vegetation will appear in almost any region of the earth.

Nature has generously scattered the germs of various forms of plant-life all over nearly the earth's surface; and, if unmolested by man, will maintain on such surfaces the kind of plant-forms or plant growths best suited to grow naturally.

There will, therefore, be found in every section of country a plant-growth, or plant-life, that is peculiar to, or that naturally belongs to such a section of country. Each section of country possesses, so to speak, a nationality in its plant-growth; or, in other words, there lives in each section of country a particular nation of plants. Such a nation of plants, or such plants as are peculiar to each section of the country, is called its flora.

Since heat, light and moisture are, next to the presence of the plant-germ, the most important things for plant growth, there will necessarily exist a difference in the flora of different parts of the earth according to the differences that exist in the distribution of heat, light and moisture over the earth's surface.

The heat, light and moisture that exist at the Equator are greater in amount than at any other portion of the earth's surface. Therefore, the vegetation at the tropics is more luxuriant and possesses a greater diversity of forms than at any other part of the surface. As we pass from the Equator towards the poles the decrease in the heat, light and moisture causes a similar decrease in the variety and luxuriance of vegetation.

In passing from the base to the summit of a high tropical mountain, the same differences in the variety and luxuriance of plant life will be noticed that are seen in going from the Equator to the poles. This is due mainly to the differences in the distribution of the heat and moisture.

The planting of a germ or seed, therefore, in any soil, will not result in its continual growth, unless the conditions of heat, light and moisture are practically the same as those in which the plant from which such germ or seed was derived required for its existence.

Trees planted in a particular locality may, therefore, fail to grow in such locality from want of the proper conditions of heat, light and moisture. Consequently, trees, that are so important to the proper flow of rivers, should be carefully preserved in all those localities where they can grow naturally; for, in such places, they will grow the best. When it is necessary to cut down forests, they should, wherever practicable, be replanted.

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NO. 4.—CONDITIONS NECESSARY FOR THE GROWTH OF TREES.

If a soil exist in any locality, and certain conditions of light, heat and moisture are present, the character of the vegetation that naturally grows in such a region will depend more on the peculiarities of the distribution of the heat, light and moisture, than on the character of the soil itself.

If the moisture be entirely absent, or if it exists in such a form, as for example as ice or snow, in which it can not be readily appropriated by the plants, then that region becomes a desert.

Deserts occur either in dry, arid regions, or in the cold regions that exist on the higher mountain slopes amid the regions of perpetual snow.

If the moisture is absent during certain months of the year, and a rainfall occurs during the other months, that is, if one part of the year is dry and the rest is wet, the vegetable forms, which die or disappear during the dry season, reappear during the wet season. Portions of the earth that have this character of vegetation are called steppe regions.

When the moisture does not fall as rain in very great amounts, but is fairly well distributed throughout the year, regions occur which are called prairies or meadows.

If there is an abundance of moisture at nearly all times throughout the year, and, for no very long time is such moisture absent, then the coun-

try may be covered by trees, and form what are called forest regions.

Forests cannot exist in the temperate zones of the earth in localities where, during the time of the trees' growth, a very long interval exists during which no rain falls. While the growth of the tree is suspended, as during the winter, this necessity for liquid nourishment of course no longer exists.

The reason forests cannot grow except where moisture is present nearly all the time the plants are growing will be easily understood from the following considerations :

Suppose a soil exists in any section of country, and suppose such soil contains plant germs of practically all varieties : then, when such a soil is submitted to the action of light, heat and moisture, these germs will be called into active life, and various forms of plant life will begin their existence.

Suppose this particular section to be a region where for several months of the year no rain falls. On the appearance of such a dry season all forms of plant life will disappear or die from want of proper nourishment.

On the reappearance of the wet season only those forms of plant life that have been able, during the brief time of the wet season, to reach their full growth and to produce their fruit or seeds, will be able to supply the germs necessary for a new growth. Such forms as trees, which, as is well known, require many years to mature their fruit or seed, will necessarily be unable to grow naturally in such a region of country.

Of course, it might easily happen that during the first wet season all the germs might not have

been called into active life by the combined influence of the light and heat, so that on the next wet season such forms might spring up naturally. But their continued existence, under such circumstances, would be impossible from the absence of the new germs necessary to produce such plants.

Only those plants, therefore, can grow in a section of country where the rainfall is limited to certain periods of the year, that, during the time the rain continues and water is supplied to them, can reach their maturity and develop their seeds, so that they may be capable of reproducing the germ, and therefore be ready for the appearance of the next rainy season.

For the growth of forests, a certain depth of soil and, in general, a certain character of soil is necessary. This soil may have been, in greater part, the result of prior generations of plants, and, in the beginning, forests could not grow in localities even where the proper conditions of light, heat and moisture are present, until such soil has been prepared for them.

Extensive forests, therefore, can exist naturally only in such regions where the rainfall during their time of growth is maintained with a certain approach towards regularity ; that is where trees are properly and continually supplied with their liquid nourishment.

It is mainly in the temperate regions of the earth that the great forest districts are to be found, since it is mainly in these regions that the rain may fall at almost any time of day and on almost any day of the year.

There are, however, extensive forest districts in parts of the tropical regions where the rainfall may occur at certain times during the day

throughout nearly all the days of the year, even though the rest of the year is dry.

It is especially on the sides of mountains, where rain may fall in no matter from what direction the wind comes, that forests are to be found in nearly all portions of the earth's surface, provided the heat is sufficiently great, and a suitable soil is present. These conditions exist on nearly all mountain slopes outside of the polar regions.

The mountains may, therefore, be regarded as the natural home of the forests. The mountains are also the natural places where the rivers begin. The preservation of the forests on the sides of mountains is necessary for such a drainage of the rainfall as will best preserve the uniform flow of the rivers and will best prevent the rivers from overflowing their banks in times of rain, or becoming too shallow in times of drought.

The forests should be preserved and maintained on the sides of mountains. When it is necessary to cut down the forests for the sake of the timber they furnish, the trees should, in all cases, be replanted, so that forests shall not disappear from the face of the earth.

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NO. 5.—THE DESTRUCTION OF THE FORESTS.

When the forests are removed from any considerable section of country, disturbances are produced not only in the climate of that section, but also to a marked extent in the character of the distribution of its rainfall, and, to a more limited extent, in the amount of its rainfall.

The removal of the forests from any considerable section of country is, in the end, invariably attended by the following results:

(1) An increase in the frequency with which the rivers of that section of country inundate or overflow their banks.

(2) An increase in the frequency and severity of droughts as witnessed by a marked decrease in the amount of water in the river channel, and in the frequency with which the springs, in such section of country, either show a marked decrease in their flow, or dry up altogether.

(3) A marked disturbance in the lower course of the river, produced by the filling up of its channel by sand bars or mud flats.

(4) A decrease in the healthfulness of the districts that border the lower course of the river; that is, in those portions of the river which lie in the lowlands near the river's mouth, or where the river empties into the sea.

When the forests are removed from any section of country the rain that formerly drained that section, mainly by gradually sinking into

the porous ground, by running along the branches and trunks of the trees and so entering and penetrating the ground to comparatively great depths, now drains rapidly off the surface. The rainfall, instead of reaching the river channel quietly and slowly through a discharge from the reservoirs of springs, now rapidly drains directly off the surface into the river channel.

Instead of reaching the river channel in, say a period of three weeks, the rain water drains into the channel in often a period of as many hours. The river channel is therefore overcharged with water; the river overflows its banks, and the floods, so caused, carry loss to the low lands along the river banks, and often death to the inhabitants.

Not only are the riches of the rainfall thus squandered to the loss of the people living in the river valleys from the excess of water immediately after a rainfall, but a still greater and far more reaching loss occurs from the failure of the rainfall to fill the reservoirs of springs, the continuous discharge of which is necessary to maintain the proper flow of water in the river.

The damage, however, does not stop here. The rapid drainage of the surface carries off and discharges into the river channel the soil in which the forest grew; for, this soil, being now no longer held together by the roots of the trees and the underbrush of the forest is rapidly carried away by the water. The soil thus carried away resulted from the continued growth of former generations of plants and probably required centuries for its production. Its loss in a few years is, therefore, a very serious matter.

The soil, the wealth of the highlands, is now thrown into the river channel, and

though it may for the time fertilize the lowlands, through inundations by the river, yet it often, for the greater part, collects in sand bars and mud flats on the lower courses of the once navigable rivers which formed the natural waterways of intercommunication.

These mud flats work injury,

(1) By hindering navigation and thus interfering with the commerce between different parts of the country.

(2) By becoming sources of contamination to the air of the lowlands by breeding weakening and other fatal miasmatic diseases.

The axe of the pioneer, so often regarded as the emblem of civilization, is, perhaps, more correctly to be regarded as the emblem of an entirely different character.

The solution of the problem of the preservation and protection of the forest is one of extreme difficulty for the following reasons:

The parts of the earth where the highest civilization exists, or which form the natural home of civilized man, were originally covered by trees. Civilized man cannot continue, as a dweller in the forest. The dense populations which now exist in most of the temperate regions of the earth could not continue to exist in the forest regions which once covered them.

There are, however, regions where forests can and should be maintained by the strictest provisions of law, and these are to be found on the slopes of mountain ranges, which form the natural places where rivers rise.

Forests should be preserved on the slopes of those mountain ranges in which the important rivers of a country take their origin for the following purposes:

(1) For the proper distribution of the rain which falls on such mountains.

(2) For the purpose of keeping constant the rate of drainage of the rainfall.

(3) For the purpose of protecting the navigable rivers which have their origin on such mountain slopes.

(4) For the purpose of decreasing the area of the malarial districts at the mouths of such rivers.

(5) For the purpose of preventing the loss of that soil which required so many generations of plants to produce.

Let laws therefore be enacted providing for the replanting of trees on such mountain slopes, either when they have been removed by the axe of the woodman, or by fire.