

and perhaps exhausts it and winter sets in before the tissues have again become hard and stored with food. In such cases trees are liable to injury. No characteristic of hardness is more important in plants than that of early maturity of wood.

One part of the tree may start into growth without regard to the conditions of the other parts. For instance a branch brought into a warm room in winter without severing it from the tree will grow for some time. Sun scald is probably due to the bark on the side most exposed to the sun starting into growth very early after which a sudden freeze destroys the young cellular tissue.

SOIL CONDITIONS.

Water is the most important element in soils for tree growth and the greatest attention must be

WATER SUPPLY. given to its conservation and distribution through the soil. Trees do not grow to best advantage in very wet or in very dry soil although some can live and almost thrive under such unfavorable conditions. There is very little land except in the arid region, but that will support some form of tree growth. The soil best adapted to all kinds of trees is one that is moderately but evenly moist, porous, deep and well drained; yet with a subsoil compact enough to transmit the subsoil water from below upwards without its being so solid that it cannot be easily penetrated by the roots. It does not matter about its being stony if it has these qualities. On land that is very wet in this section as the muskegs of northern Minnesota which are covered with tamarack and spruce the trees never get to be of large size. In the case of one spruce grown on such land, seventy-three years was occupied in growing a tree $1\frac{1}{8}$ inches in diameter and a tamarack under similar conditions formed a diameter of only 1.1-10 inches in forty-eight years. We also find that growth is extremely slow on very dry land. On very open porous land the water sinks quickly out of reach of the roots and where the soil is too compact it cannot be penetrated by the water or by the roots so that on such soils trees generally suffer for moisture a part of the year.

The growth of trees and the kinds growing on land are good though not in-

fallible indexes to the value of the soil for agricultural

RELATION BETWEEN TREES AND SOILS. purposes. For instance, land on which black walnut, hard maple, hackberry or hickory grow to large size is of good quality for grasses, grains and other agricultural crops while black oak is generally abundant on dry, gravelly ridges and sandy soil. Where white pine in this section is the prevailing tree the land is generally of good quality. Norway pine will endure more drouth than the white pine, outgrows it and becomes the prevailing tree on drier land, while the jack pine is the most abund-

ant on the very dry sandy lands of northern Minnesota. In the more humid climate of the eastern states the white pine grows on very sandy soils.

The agriculturist aims to keep the soil porous yet moderately compact that the

MECHANICAL CONDITIONS.

roots may penetrate it easily and the subsoil waters may be readily transmitted upwards to the roots of plants. He aims to prevent the soil from becoming too compact and from the loss of water from evaporation by cultivating the surface soil and to keep out standing water by drainage. The forest grower cannot rely upon such methods because they are too expensive or entirely impracticable. He may indeed plow for his first planting and cultivate the young trees but after a few years cultivation will become impossible and the effects of the first preparation will be lost. He must therefore attain his object in another way, that is, by mulching the soil. The shading is done at first by planting very closely so that the ground may be protected as soon as possible from sun and wind. The shade should be maintained well throughout the life of the tree even if more planting is necessary to accomplish it, and if in later life the trees get thin in the tops or die out, it may become necessary to plant underbrush to protect the land.

Undergrowth in forests may be rather injurious in preventing the proper development of young trees but it is generally very beneficial in retarding evaporation from the surface soil, in retaining the snow in the spring and in killing out grass and weeds.

Forest floor is a term used to indicate the mulch on the ground in forests. This is made up of the fallen twigs and leaves which remain on the ground where they slowly decay and form a cover of rich mould or humus. This protective covering serves a most useful purpose; it permits the rain and snow waters to penetrate the soil without at the same time making it too compact, thus keeping the soil granular so that the air can enter and in the best condition for conducting water while at the same time it prevents washing away of the land and too rapid or excessive evaporation from the surface; the humus is also an active agent in aiding decomposition of the mineral substances in the soil.

Tree growth is less dependent on the condition of the surface soil and more dependent on the SUBSOIL. subsoil than is the growth of agricultural crops. For instance, in the case of drifting sand overlying a moist subsoil, it has been found that where pains are taken to get the young trees started they will often do well although such land is poorly adapted to agricultural crops. There are many acres of land in Minnesota and Wisconsin that have such conditions and

they should seldom be entirely cleared of trees.

The soils most likely to wash badly are those that are fine grained without much adhesive power, such as fine sand and some kinds of clays. When, however, such soils have a forest growth on them they are protected from washing by the forest floor, tree roots and the humus in the soil. Soils which contain large quantities of humus do not wash much, since the particles of organic matter bind it together; thus we find that newly-cleared timber land which contains large amounts of humus may not wash much for a number of years after the clearing and then commence to wash very badly. The washing away then is due to the humus having become used up and there being nothing left to bind the soil particles together. In such cases the application of organic matter will help very materially. For this purpose manure, straw or other material may be applied or crops like clover and the grasses, which leave considerable organic matter, may be grown on the land. Crops that leave very little humus in the ground, such as nursery stock, which is dug out by the roots, are most harmful in exhausting the humus in the soil, and land used for this purpose needs heavy manuring with stable manure and an occasional seeding down to grass or clover.

In the prairie portions and occasionally elsewhere in this section, we have

ALKALI SOILS. a kind of soil in which there is a

superabundance of carbonate and sulphate of soda. This kind of soil seldom extends over large areas and generally occurs in places lower than the surrounding land. In some places the alkali occurs in such abundance as to coat the surface of the soil with a white crust. On such land very few agricultural crops or trees grow well. The leaves of the trees growing there generally take on a yellowish color and the wood does not mature well in autumn. Such land should be drained so that the surface water at least can run off. In this way the alkali can generally be washed out in a few years. It is seldom advisable to plant trees on these places, but if this seems desirable, as is sometimes the case on prairies, the best trees to plant are probably the cottonwood and white willow.

EFFECT OF SLOPE AND ASPECT ON TREE GROWTH.

The slope of the land affords drainage and so affects the growth of trees, but trees will grow on any slope, even on precipices if they can find room for their roots and the soil is somewhat moist. The direction of the slope usually has a very marked effect on the growth of vegetation. This is especially the case