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NATURAL REFORESTATION IN THE MOUNTAINS OF NORTHERN IDAHO

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The factors affecting the natural reforestation of a fire-denuded area may, in general, be said to be the same in Idaho and Oregon as in Maine or Minnesota. There may be and actually are differences in detail as to what species of herbaceous and shrubby plants may prepare the way for the more delicate seedlings of those trees native to the particular locality. But the principle prevails everywhere that certain plants or plant societies are antecedent and probably essential to the appearance and permanent establishment of a forest. The first step in the reforestation of a fire-swept area is the restoration of the conditions necessary to insure the germination and vigorous early development of the tree seedlings. The presence of humus in the soil insures a certain degree of moisture conservation and the retention of certain ingredients of plant food so easily lost by drainage.

Experience and observation teach us that however hardy, however well equipped, may be such trees as those which come to occupy the most trying situations, they were doubtless so sensitive to environmental factors during their first years as to have perished but for the fact that there must have prevailed a proper and essential balance of physiologic factors. To establish this balance may have required but a year, or it may have taken a much longer time.

In this paper it is not our purpose to discourse on the laws which regulate natural reforestation in different sections of the continent; notwithstanding the fact that great practical benefit would very likely result from an extended and careful scientific study of the factors which determine such growth.

Ordinarily the denudation of any considerable area of coniferous forest land means an end of that chapter of forest history. Witness, for example, the thousands of acres of "pine barrens" in Minnesota, Michigan, and Ontario where but a few decades ago stood splendid mixed forests of white and Norway pine, and spruce and fir, holding their own against time and the elements. It is because man in his exploitation of these forests imposed upon their territory an absence of certain growth factors vital to natural reforestation that it has since been impossible for these coniferous species to reëstablish themselves. Time has shown that protection from destructive ground fires will in many instances promote natural reforestation. Zavitz,[1] who has made an extensive and careful study of forest conditions in Ontario, states that the reforestation of the denuded land areas is a problem involving fire control rather than one calling for the hand planting of pines. In Sincoe County, for example, a certain district comprising approximately 50,000 acres, and at one time covered with valuable red pine, still supports enough old seed-bearing red and white pines to insure reforestation were it not for the fact that destructive ground fires are allowed to run.

That the production of a coniferous forest depends greatly upon a real balance of physiological factors can not be denied. No matter how favorable may be the moisture supply, an excessive rate of evaporation will inhibit or make impossible the growth of a crop of seedlings for as long as a single season. Then, again, extreme exposure to sunlight may prove destructive. Or, two or more factors in excess or deficiency may prevent altogether the growth of young plants.

The following example is illustrative. On Kamiak Mountain, an isolated butte near Viola, Idaho, evaporation stations were maintained during the summer of 1913. One Livingston's porous cup atmometer was operated on a south slope a few

[1] Zavitz, E. J., Report on the Reforestation of Waste Lands in Southern Ontario, 10, 1908.

meters from the top of the ridge, and a second atmometer was placed just over the ridge on the north slope. Neither station was occupied by mature trees, although Douglas fir and yellow pine grew on the ridge and north slope on both sides of the prairie in which data were obtained. Coniferous seeds were available at both stations and pine cones were actually lying scattered about on the ground. On the sheltered slope a few pine and fir seedlings had established themsleves, while none occurred near the station on the south slope. The average daily evaporation in the area occupied by these small seedlings, from May 10 to September 5 was 19 cc., while the exposed side of the ridge gave an average daily evaporation of 27.7 cc. The greatest stress on the south side for any seven-day period occurred during the week ending August 29, when the average daily evaporation reached 50.8 cc. On the north side during the same interval it averaged only 34 cc. per day.

Figure 1 shows a sharp ecotone between prairie and forest. This spur of Tekoa Mountain is illustrative of many similar situations of transition from grassland to forest. The sheltered northeast slope supports a dense growth of yellow pine, Douglas fir, and some tamarack, but these invade the prairie of the windward slope with great difficulty. Figure 2 shows a similar situation and illustrates the effect of exposure to wind upon the few trees that have succeeded in growing upon the ridge.

Likewise the destruction by fire of the accumulated humus constituting that all-important part of the forest floor may retard for many years the reappearance of young trees of sufficient vigor to endure.

A study of the physiology of reforestation without taking into account the intimate relation of other plants to the reappearance and permanent establishment of the forest growth would be incomplete; for there can be no doubt concerning the vital importance of these plants as agents modifying the factors influencing the restoration of that physiological balance so essential to the incipient growth of coniferous seedlings.

The Thatuna Hills, a western spur of the Bitter Root Moun-

Fig. 1. A sharp ecotone between prairie and forest. The sheltered northeast slope is clothed with a dense forest of yellow pine, Douglas fir and some tamarack. Tekoa Mountain, Washington.

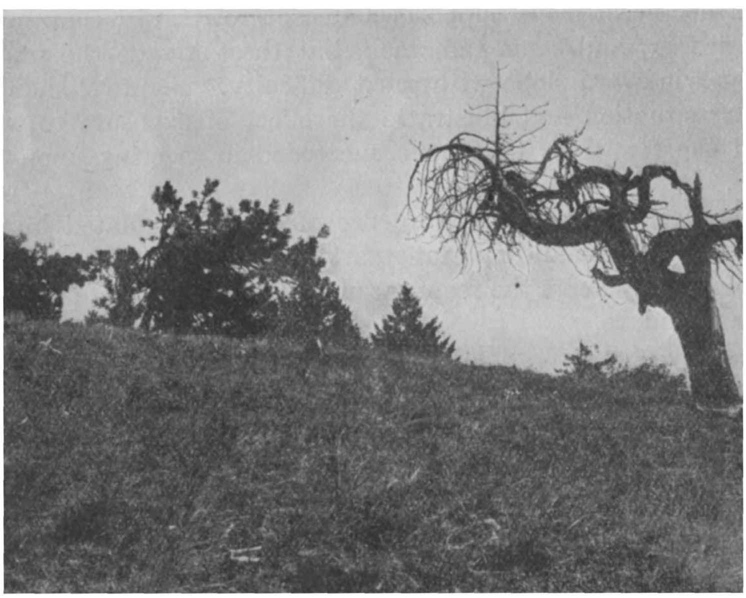

Fig. 2. A situation similar to that in Figure 1 showing the effect of exposure to wind upon the yellow pine.

tains and located in northern Idaho, support a rich coniferous flora consisting of the Western larch, *Larix occidentalis*, the white fir, *Abies grandis*, the Douglas fir, *Pseudotsuga mucronata*, Englemann spruce, *Picea engelmanni*, yellow pine, *Pinus ponderosa*, white pine, *Pinus monticola*, lodge pole pine, *Pinus contorta* var. *murrayana*, white cedar, *Thuya plicata* and the Western yew, *Taxus brevifolia*. These hills, rising to a maximum elevation of 4950 feet above sea level, offer an unusual variety of slope exposure, cañons, and moisture supply. The western and southwestern slopes of these hills receive at all times the full brunt of the prevailing winds which sweep across the many miles of open prairie and desert of south central Washington and northern Oregon and not infrequently attain a velocity of 50 miles an hour. These wind-swept slopes are clothed with a fairly dense growth of Douglas fir, tamarack, and yellow pine except in sheltered ravines where one may find the white cedar, the white fir and an occasional spruce. Pure forests of yellow pine are not unusual, but mixed forests of pine and Douglas fir, or of tamarack, white fir and cedar are more abundant, and it is interesting to note that where reforestation has occurred, slopes formerly occupied by any one of these forest types have in most instances been reclothed with the same species.

Figure 3 shows a north slope which was cut over more than 25 years ago, while in figure 4 the steep southern exposure just opposite is shown. A belt transect 2 meters wide from near the top of the north slope to its foot showed this forest to be composed of 30% tamarack, 26% white fir, 39.5% cedar, 4% red fir, and 0.5% yellow pine. The exposed opposite slope was studied in a similar manner and revealed a decidedly different composition with 10% tamarack, 40% white fir, 14% red fir, and 36% yellow pine. Superficially the north slope appears to be clothed with a nearly pure tamarack forest, due to the more rapid vertical growth of this species. The cedars are mostly small; in fact many are mere seedlings. An actual count of the annual rings showed that they came in after the other trees had by their shade made conditions less xerophytic. Such mixed forests of tamarack, white fir and cedar are very characteristic of the sheltered slopes and ravines (fig. 5). The large percentage of white fir shown to occur on the south slope occupies dense thickets near the protected base. That the south slope supports a very open forest (mostly yellow pine and Douglas fir above the ravine) is shown by the fact that the average number of trees per square meter is only one, as compared with 3.5 per unit area on the north slope.

No less characteristic of the two exposures are the shrubs of the undergrowth. *Opulaster pauciflorus, Ceanothus velutinus* and

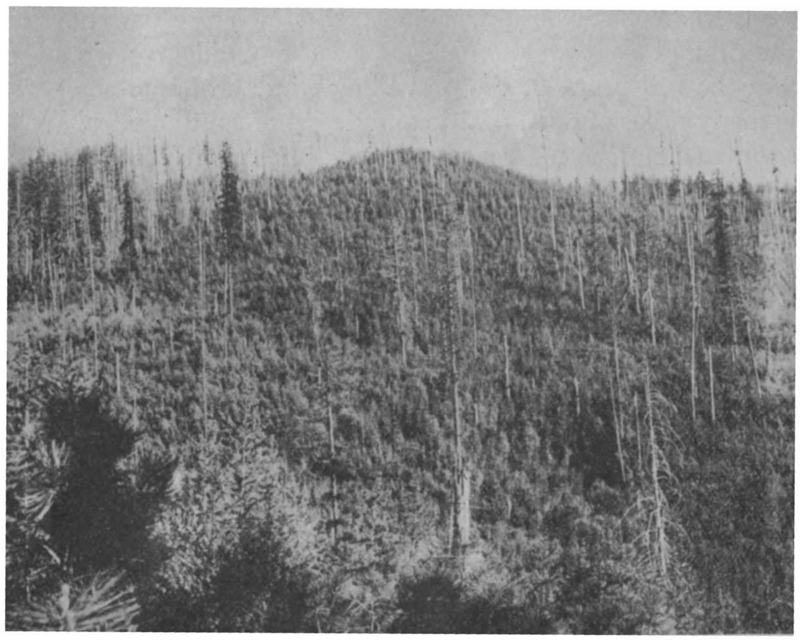

Fig. 3. A young forest of white fir, tamarack, and cedar occupying a cut-over north slope in Thatuna Hills.

Salix scouleriana make up the chief shrubby growth on the south slope, often covering many square meters exclusively. On the north slope both *Opulaster pauciflorus* and *Ceanothus velutinus* occur but rarely, while *Vaccinium membranaceum* is more abundant than *Salix scouleriana*. *Coptis occidentalis, Clintonia uniflora, Thalictrum occidentale, Mitella stauropetala, Galium* sp., *Asarum caudatum, Anemone piperi, Pyrola bracteata, Cytherea* *bulbosa* and species of *Smilicina*, all found here, are typical plants of the more moist slopes and contrast markedly with *Calamagrostis suksdorfii*, *Bromus marginatus*, *Pteridium aquilinum* var. *pubescens*, *Penstemon pinetorum*, *Phaca mortoni*, *Aster*

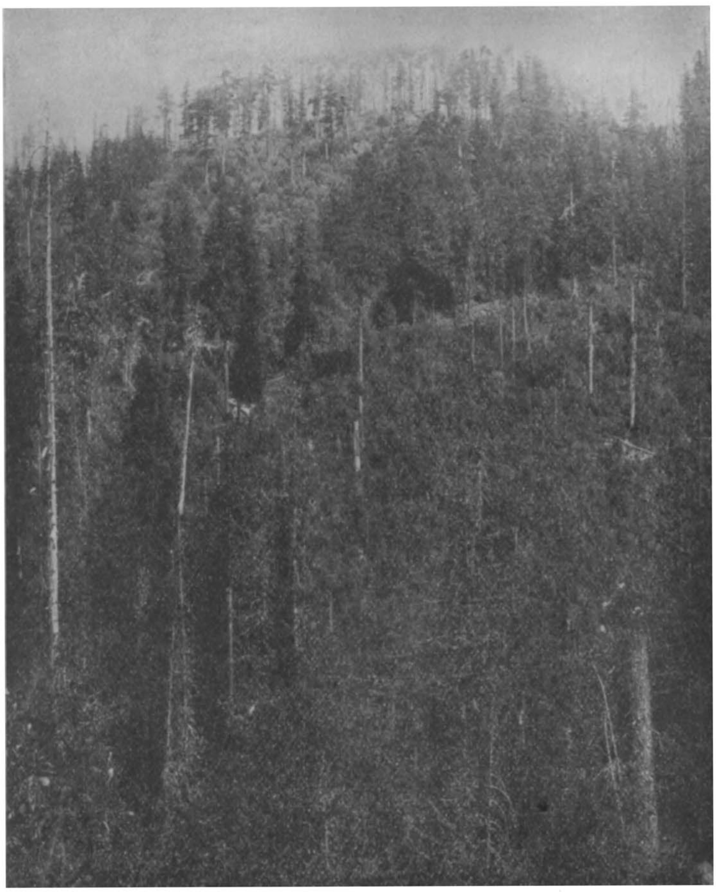

Fig. 4. The steep south exposure just opposite that shown in Figure 3, clothed with an open forest of yellow pine, red fir, and tamarack.

conspicuus, *Anaphalis margaritacea* var. *occidentalis*, *Antennaria racemosa*, *Pedicularis racemosa*, and *Berberis repens*, found on the more open south mountain side.

About 26 years ago many square miles of these hills were overrun by a fire which destroyed more or less completely much of the virgin timber, leaving here and there a few living trees representing the different species to serve as seed trees in subse-

Fig. 5. A virgin forest of white fir, tamarack and cedar. Characteristic plants are *Acer glabrum* var. *douglasii*, *Lonicera utahensis*, *Vaccinium membranaceum*, *Ribes lacustre*, *Thalictrum occidentale*, and *Disporum* spp., under which is a carpet of *Smilicina sessilifolia*, *Coptis occidentalis*, *Asarum caudatum*, and *Clintonia uniflora*. Thatuna Hills, Idaho.

quent years. These burns covered chiefly the north and northeast slopes of the mountains. In these mixed forests of white fir, tamarack, Douglas fir and cedar, the thick-barked tamarack suffered least and often only the trees of this species less than 6 to 8 inches in diameter were killed. This gave rise to what are apparently nearly pure forests of tamarack; but in most all cases sufficient seed trees of the other species were left to insure re-seeding; and at present a new generation of white fir and tamarack are especially prominent (fig. 6). In some of the more accessible cañons, lumbering has been carried on and in some places the operations of the lumberman have been followed by ground fires, some of which must have occurred not more than 5 years prior to the time when the authors made their observations.

On these most recent burns the predominating plants were *Epilobium angustifolium*, and *Carduus breweri* and occasional specimens of *Erigeron acris*. These three species along with other annuals and biennials and some young willows afforded conditions suitable to the early growth of the scattered seedlings of *Larix*, *Pseudotsuga* and *Pinus ponderosa*, which had already established themselves. On those slopes formerly occupied by a mixed forest of larch, Douglas fir, white fir, spruce, and white cedar, it was interesting to note that in the older burns these same species had succeeded in reëstablishing themselves. Cutting off a large number of the trees of each species at the surface of the ground and counting the annual rings, it was found that the most xerophytic species, *i.e.*, Douglas fir, yellow pine, and larch, were the oldest, and therefore, the first to establish themselves. It is also a matter of interest to note that a period of 2 or more years must elapse before any but a limited number of even the hardiest of these trees can launch into permanency. Naturally, those slopes and situations affording the greatest degree of protection from evaporation and excessive heat and light produce a more abundant stand of those annuals and biennials which prepare the way for the coniferous forest of later years. And observation has shown that the preparation of exposed slopes for coniferous seedlings is considerably delayed because of the limited number of individual herbaceous plants produced in any season and the consequent slow accumulation of humus.

During the month of August, 1910, the greater part of northern Idaho and much of eastern Montana were swept by one of the most extensive and destructive forest fires ever experienced in that part of the country. In many heavily wooded

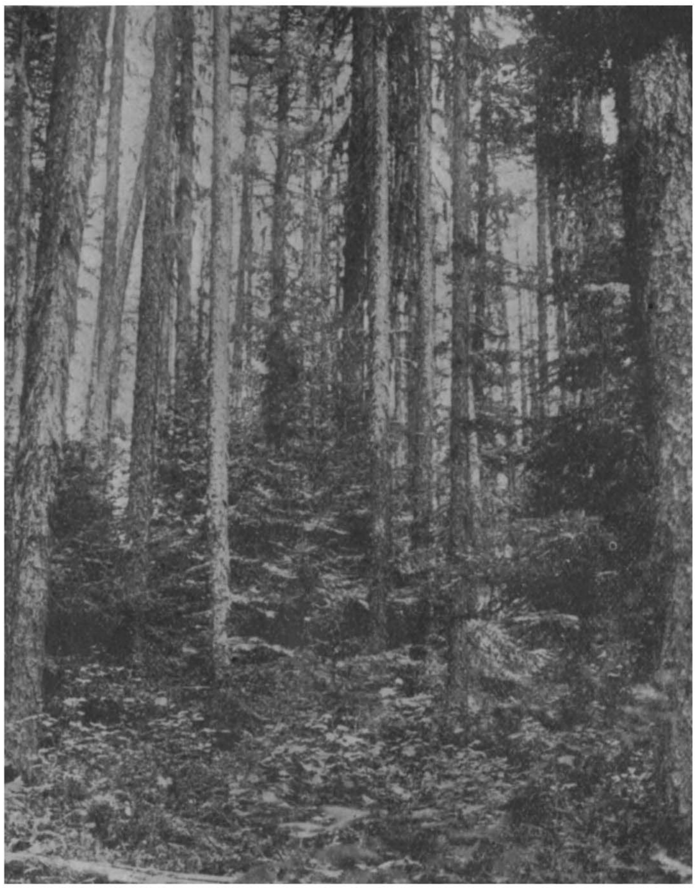

Fig. 6. Interior view of a forest burned over about 26 years ago. The older trees are mostly tamarack under which the white fir is especially abundant.

cañons the draft was so violent during the fire and the heat so intense as to destroy every vestige of life above ground (fig. 7).

The town of St. Maries, Idaho, lies against the slopes of foot-hills which, prior to 1910, were covered with a more or less mixed forest of coniferous trees comprising the following species: *Pseudotsuga mucronata,* in practically all situations; *Pinus ponderosa,* abundant on south slopes and in exposed and rocky situations; *Larix occidentalis* associated with *Abies grandis* and *Pseudotsuga; Pinus monticola* and *Thuya plicata* accompanied

Fig. 7. An old "burn" in Ferry County, Washington. Typical representation of the destruction by fire of the coniferous forests of the Northwest.

by individuals of *Pseudotsuga* and *Abies,* confined generally to the cañons and rich levels at the bases of north slopes.

These mountain slopes were overrun by fire on August 21 and 22, 1910. Seeming to represent fairly the average forest conditions for northern Idaho, it was decided that here if anywhere would be the most satisfactory place to carry on a study of the problem of natural reforestation. The region was not visited during the summer of 1911, hence a complete account of the plant successions and list of species can not be furnished. But observations made on east, north and northwest slopes on May 25, 1912, established the fact that in all probability *Funaria hygrometrica* and *Marchantia polymorpha* were among the very first of the pioneers to help reclaim the unshaded and charred soil. It was also possible to identify the following angiosperms of the preceding year's growth: *Carduus breweri*, *Erigeron* sp., *Epilobium angustifolium*, *Arnica cordifolia*, *Salix* sp., *Physocarpus pauciflorus*, and *Erythronium grandiflorum*. It is not unlikely that other more perishable species were present, but identifiable remains were quite wanting.

Plants observed on May 25, 1912, and belonging to the 1912 growth were the following: predominant everywhere, *Epilobium angustifolium*, individuals of which varied in size from that of mere seedlings to plants 12 to 18 inches in height. These (fire weeds) often occur as abundantly as 34 individuals per square meter, and certainly do much toward reducing light intensities and evaporation. Thousands of the smallest of these were succumbing to an epidemic of *Aecidium*. Other herbaceous plants observed were *Carduus breweri*, everywhere abundant; and here, as observed elsewhere, one of the first seed plants to secure a footing in forest burns. Associated with *Epilobium* and *Carduus* were *Erigeron acris*, *Arnica cordifolia*, *Antennaria luzuloides*, and *Salix scouleriana*. These species all depend upon wind for seed distribution; and doubtless this accounts in some measure for the fact that they are among the very first seed plants to take possession of fire devastated areas.

Every inch of ground seemed to be occupied by *Funaria*, a plant of very considerable importance to the complete development of other forms, because of the double rôle it plays in the conservation of soil moisture and the formation of humus.

Other plants were *Physocarpus pauciflorus*, *Rosa gymnocarpa*, *Potentilla* sp., *Mitella stauropetala* (abundant), *Leptotaenia mul-*

tifida, *Rubus nutkanus*, *Disporum trachycarpum*, *Arenaria macrophylla*, *Antennaria luzuloides*, *Coptis occidentalis*, *Viola canina*, two species of *Lathyrus*, *Vicia* sp., *Zygadenus venenosus*, *Fritillaria lanceolata*, and *Erythronium grandiflorum*. The three last named plants occurred in considerable abundance and upon investigation it was found that their bulbs were, in every case examined, at depths of 5 to 7 inches below the soil surface. These bulbous plants could have been hardly so abundant had they depended upon winds or other natural carrying agents for the distribution of their seed. It is also quite probable that many if not all the shrubs in which an underground root-stock development obtains were able to withstand the effects of the fire. In fact, one can with difficulty account for the abundance and general distribution of such plants in any other way, for their growth habits, are such as to preclude the possibility of so much development in a single season from seed. It is of interest here to note that in spite of the terrific heat which must have prevailed over those mountain slopes, except where the undergrowth was dense, a considerable depth of humus remained intact. Where this was wholly consumed and the soil had been washed bare by rains there was a fairly complete turf of *Funaria* and *Marchantia* along with certain herbaceous plants already given. The effects of this forest fire were more profound in certain parts of the forest than in others, depending somewhat upon the topography of the devastated region. In the "draws" or small lateral cañons where growth conditions were such as to produce the most excellent stand of white pine (*Pinus monticola*), Douglas fir, white fir and cedar, the fire was most destructive, leaving no trees alive. Whereas, on lateral or secondary ridges it was frequently observed that from 25% to 75% of these species, including yellow pine, survived the heat. These constituted the seed trees so valuable in the reforestation now going forward.

A diligent search was made for any seedlings of the cone-bearing trees characteristic of the region under observation, and a few were found. A limited number of these (all were *Larix occidentalis*) were from seed germinated in 1911, but the majority were but a few weeks old at the time of observation. They were indeed scarce; not more than sixty to eighty per acre on east and north slopes and none at all on south and southeast or southwest exposures. In two instances it was observed that as many as fifteen to twenty seedlings were growing in one spot as though a cone had become planted and all its viable seeds had germinated. The area investigated seemed to show no signs of any other conifer, which fact corroborates observations of a similar nature made 2 years earlier in a certain denuded section in the Thatuna Hills.

In September, 1912, another trip was taken to the hills about St. Maries, and it was found that between May 25 and the September date many seedlings of *Thuya, Larix, Pseudotsuga* and a few of *Abies* had sprung into existence, apparently from seed of scattered surviving parent trees in the immediate neighborhood. Their distribution was very irregular. In some areas of a square meter or more none could be found, while in other more favored spots the seedlings would average as many as eight per square meter. The ground occupied by these seedlings was well covered with a mulch of the dead leaves and stems of such herbaceous plants as have already been described for the region.

An examination of denuded south slopes where the original forest growth consisted of an abundant stand of *Pinus ponderosa* with scattered individuals of *Pseudotsuga mucronata* resulted in the enumeration of the following plants: *Funaria hygrometrica, Achillea* sp., *Symphoricarpos racemosus, Pteridium aquilinum* var. *pubescens* (most abundant), *Epilobium paniculatum, Carduus breweri,* all, excepting *Pteridium,* about equally abundant and intermingled so as to form a semi-shaded area. Stray specimens of *Aster douglasii, Rosa nutkana,* and *Gnaphalium* sp. were observed; and in spots *Berberis repens* was predominant.

The most careful search failed to reveal any coniferous seedlings even in the most favorably shaded ravines of these south slopes, an absence due, no doubt, to insufficient soil moisture and excessive evaporation, although the writers had no recording instruments in this field. That these same south mountain sides and their ravines and cañons will in the course of time be reclaimed by a new growth of yellow pine and Douglas fir can not be prevented so long as ground fires do not occur and natural growth conditions are not obliterated.

An example of the yellow pine, our hardiest tree pioneer, taking possession of an extremely xerophytic situation was carefully observed on Kamiak Mountain during the summer of 1913. Near the top of the mountain where the soil is rocky,

Fig. 8. A prairie on the exposed south slope of a quartzite butte near Viola, Idaho. It is being invaded by yellow pines which occupy the crest and the northwest side of the butte and the ravine in the foreground.

Pinus ponderosa has succeeded in establishing itself on the exposed south slope. A weekly record was kept of the evaporating power of the air and of the moisture content of the soil near the edge of a group of pine trees under cover of which a few three- and four-year-old seedlings were growing. On May 10 a 25 cm. core of this quartzitic soil contained 21% of its dry weight (at 105°C.) of water. The soil moisture gradually decreased until on July 24 only 7.4% remained, and this was reduced to 4%

by September 5. The wilting coefficient of this soil free from rocks is 10%, and records show that after July 20 of 1913 no moisture was available in the first 25 cm. of soil. During the whole period from May 10 to September 5 the average daily evaporation was 24 cc. and during the week ending August 29 it ran as high as 44.8 cc. daily; and still the seedlings were not

Fig. 9. The northeast side of the same butte shown in Figure 8. Douglas fir and tamarack are the chief components of this forest.

killed! In fact the soil mulch of needles and the shade afforded by the parent trees kept down the evaporation considerably both from soil and air, as compared with a prairie station a few meters lower down the mountain slope.

[2] Weaver, John Ernst, Evaporation and Plant Succession in Southeastern Washington and Adjacent Idaho. The Plant World, **17**: 273–294, 1914.

This, we believe, is an extreme case, but it illustrates possibility of tree growth. The junior writer has shown[2] that although the yellow pine stage in succession is usually preceded by shrubs, especially *Opulaster pauciflorus*, *Prunus emarginata*, *Spiraea corymbosus*, or species of *Ceanothus*, it is still able to invade the prairie even without the protection of an intervening shrubby stage (figs. 8 and 9).

In a region such as the Pacific Northwest where summer rains are rare or altogether wanting, a new growth of coniferous trees depends upon soil moisture conservation. Soil moisture in sufficient amount to tide seedlings over a four months' period of drought and sunshine depends upon the presence of sufficient humus to retain the moisture and at the same time support a forest cover-growth of early maturing plants which will afford some protection to the tree seedlings of all but the most xerophytic species such as the yellow pine and Douglas fir. That the growth of herbaceous plants and shrubs may be so dense as to preclude the development of the young conifers not infrequently happens. That the preclusion of tree seedlings is usually due to light is a question to be determined by experiment and in the field. Repeated observations and measurements of the soil moisture content and the evaporating power of the air together with light values show conclusively that, although the soil moisture may be far more than sufficient for tree growth and the humidity of the air relatively high, yet when the light values drop to $\frac{1}{25}$ of normal sunshine our hardiest pioneer, the yellow pine, is excluded. These observed facts invite the inference that light is here the factor of prime importance. Of soil moisture and humus there may be plenty, but if light beyond a certain degree is shut out these seedlings will not be found.