FOREST INFLUENCES

AND

WATERSHED

by

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INTRODUCTION

Waterflow control must include a complete coordination and adequate protection of entire watersheds. Along with this should go the development and sustained use of all those natural resources found in a given watershed which affects the flow of water. This development and sustained use should be in the permanent interest of the people living on the land as well as of the inhabitants of more remote regions.[3]

The effect of the forest is to retard the runoff by presenting barriers to a rapid flow of the water over the surface of the ground.

Every tree trunk, fallen limb~~s~~, and dead stump~~s~~ presents an obstacle in the paths of the tiny streamlets as they flow down the hillside to the streams, and the shelter of the trees ~~which~~ affords a more uniform deposit of the snowfall and protects the snow against sudden melting in the springtime. Each of these conditions in its own way affords a better opportunity for the water to be absorbed by the ground. The earth acting as does a sponge, absorbs and holds large quantities of water, which obedient to the law of gravitation, gradually flows through the soil and finds an outlet in springs and rills and later flows to the low parts of the valleys. The water absorbed by the earth does not amount on the average, to more than 50 Per Cent of the precipitation, of the other half of the rainfall, about 40 Per Cent finds its way into the streams and flows back towards the sea, while the remaining 10 Per Cent is taken up by evaporation and vegetable growth. These natural actions have some effect in mitigating the severity of freshets and increasing the flow of the streams in the summer periods.

There is no argument that forest protection is not necessary or that reforestation is not desirable.

Conclusive evidence is to be found in the geological formation of the valleys that floods have occurred through all the ages, even though the virgin forests covered the face of the land.

Forest protection is a vital issue and of great public concern and reforestation should be fostered and urged for the sake of the forests themselves, and advantages should be taken of such benefits as may acrue from them in the conservation of water resources. [4]

DISCUSSION

A watershed to foresters and erosion to agricultural and other engineers means all of the land surfaces draining into a single stream.

In the past, there has been a natural and human tendency on the part of those interested in control over the flow of water to think only in terms of their fields. Today, it is recognized that in attacking the problem, not only must entire watersheds be considered, but every phase of land use on watersheds. It is the job of the forester to control water on the forested areas so steep that they cannot be used successfully for agriculture or other purposes than forestry. On the more gentle slopes of land with soil suitable for farming, the agriculturists takes over the work of controlling the flow of water from the fields and terraces. In the streams themselves, the engineers takes charge of the flow of water by means of navagation channels, dams, reservoirs, dykes, and leeves. But, the heart of matter is that real waterflow calls for the united coordinated teamwork of all these specialists.

A second point which is now more fully appreciated than ever before is the fact that not only must adequate control over the flow of water cover entire watersheds, but for completely sussessful control, all forms of land and water use within a given watershed must be recognized as bearing directly upon the problem. This means that, on a given watershed, control necessitates a detailed study of all kinds of land use.

There is a well established popular belief that floods and droughts are directly due, in a very large measure, to the cutting away of the forests on the hillsides, and that reforestation would correct the damage already done, prevent the annual floods, and materially increase the rainfall at the usual seasons of droughts. While it is undoubtedly true that the forest cover does have some beneficial effect, as is later discussed, upon the run-off after rainfall has occurred, it is, however, not true that the forest would take the place of storage reservoirs as an adequate and effectual means of stream flow regulation.

The whole surface of th continent, mountains, meadows, plains, and river courses has been shaped by water in the long centuries during which it has sought the sea; eroding, carrying on and dropping sand, silt, and gravel, and even huge boulders in its path. Cutting of gorges through mountains, filling up depression, making habitable land uninhabitable and turning sandy deserts into gardens. The climate of the earth and our ability to live on the earth depends upon the moisture in the air which stores and regulates the heat of the sun's rays. Every living thing upon which we in turn live, depends upon this water, and in the end our ability to move about the earth, and the power to run our factories and trains, will all come from water.

There is no other resource with which nature has endowed us, which is so important for mankind, or which has been so long neglected and so little studied by man.[3]

ECONOMIC CONCERNS

The economical or commercial value of water conservation will depend upon the extent of the danger of losses resulting from restricted or unrestricted flow of the particular streams under consideration, and the benefits which would result from regulation.[2] It is obvious that the flood waters pouring through the valley of some mountain streams may have enormous power possibilities, and upon reaching the lowlands may inundate large areas of fertile land.

Investigation made in the matter of damage done by floods must cover the item of property losses, the effect upon the public health and safety, and whether or not disease and death follow as a direct result of the flood. We must ascertain whether these supplies will be depleted or become polluted and thereby made a menance to the public welfare.[2]

Logging is probably the most important economic operation affecting watersheds or communities wishing to maintain a sufficient supply of pure water.[5]

Both the quantity and quality of the water are likely to be adversely affected by clear cutting on a watershed.

The harmful effects of clear cutting are.

1. Fire hazard are greatly increased and burned areas are easily eroded.
2. The storage capacity of a watershed is closely related to its cover.
3. Camps and logging operations are very often sources of pollution.[5]

Selective logging methods, or strip cutting which leaves partial forest cover on the land, and hastens natural reforestation. Wisely regulated logging could be continuous on most watersheds or watershed areas.

FORESTS AND CLIMATE

In watershed management the complete significance of forest effects upon local climates is by no means yet determined. But, research at the various forest experiment stations has shown that the control, by modification of the vegetation, of interception of rain and snow, evaporation and transpiration may have a very important place in watershed management. In discussing the subject, therefore, one has to be very careful in selecting facts and in drawing conclusions from them. 7

The physcial and physiological processes which accompany plants as they carry on their growth, must reduce the temperature of the air, at least during the vegetative period. First, because there is evaporation of water from the leaves. Second, because the heat of the sun is consumed in this evaporation and one knows that a plant cannot become heated to the same extent that a rock or bare soil can. The ground beneath growing plants cannot be greatly heated because of the shading effects. Third, the amount of surface from which heat can radiate at night is much greater when there is vegetation on the ground than when the ground is bare. Experiments have been preformed and the experiments show that crops have a cooling effect on the air. For every pound of dry subatance produced it has been found that corn evaporates 233 pounds of water and turnips 910 pounds.[7]

Under good cultivation an acre may produce about seven tons of dry substance. If the evaporation of water be only five hundred times more than the amount of dry substance produced, then an acre will evaporate during the vegetative period about 3,500 tons of water. This example shows the extent to which ordinary crops can contribute to the moisture content of the air, and the cooling effect which accompanies this evaporation.

Therefore, it can be concluded that as forests are the most highly developed form of vegetative life, they will exert this moisture effect in the greatest degree.[7]

TEMPERATURE OF AIR

In the basin of the Amazon River the largest forest area in the world is found. This basin is 621 miles from the Atlantic Ocean and also separated from the Pacific Ocean by very high mountains.

One would think that being such great distances from the ocean, and so close to the equator that one would find very high temperatures and great dryness. But, yet there the average temperature of the warmest month and the temperature maxima are not greater than the temperature at the sea, and even not as high as temperatures found in the middle latitudes.

Thus one can attribute this moderate temperature to the cooling effects of the forests, due principally to the evaporation of water from plants and soil in the tropics. By looking at Table IV one can see that this evaporation of water likewise takes place in North America, but not to as great a degree.

The evaporation of water from forests differs from evaporation from water surfaces in that, while forests are, during the day, continually using up heat by converting it into latent heat through transpiration, bodies of water are directly heated by the sun's rays, becoming as it were temperature reservoirs, and when the lower air, which is cooler, comes in contact with the water, its temperature is raised.

The reason why leaves cool off so quickly at night is due to the total area of the leaves. When the leaves reach the temperature what dew is formed, vapor of the air condenses on their surface. Therefore, part of the water which has been transpired during the day is brought back to the leaves to be transpired again the next day. The forest, therefore, may be compared to the self feeding boiler, the water is evaporated into the air at the expense of the heat of the sun and surrounding air.

TEMPERATURE OF SOIL

Forests influences the temperature of the soil in almost the same way as they do the air. This can be explained by the fact that the temperatures of bodies of air near each other tend to become equalized by the movement of the air currents. The surface of soil is heated directly by the sun's rays, while the air receives its heat chiefly from the surface of the soil. Thus the difference between the temperature of soil in the forests where the ground is partially protected from the sun's rays is especially pronounced. Also one can say that this difference is not limited to the surface of the soil, but is detectable to considerable depths.

In the winter the temperature of the soil in the forests and fields differ but little when no snow is present.

The temperature of the soil is higher in the forests than in the fields when snow lies on the ground for several months. Therefore, the fluctuations of temperature of the soil in forest is much smaller than in the field.

In eastern Prussia the following table was formed and showed these results.

Table I [7]

	Outside the Forest			Inside the Forest		
	Maximum °F	Minimum °F	Fluctuation °F	Maximum °F	Minimum °F	Fluctuation °F
First Station	84.02	12.92	71.10	71.24	18.14	50.10
Second Station	86.00	23.00	63.00	63.32	27.68	35.64
Third Station	81.68	6.44	75.24	64.58	16.52	48.06

In the spring and summer especially, the forest soil is cooler than soil in open. And in the fall and winter the soil is warmer in the forest than in the open, but the degree of difference is always less than in summer.

What effect does the forest have upon freezing as compared with open lands? Soils under the forests may remain soft when the ground in the open is frozen hard to some depth. And if the soil does freeze under the forest it is to a depth of from one-half to less than three- fourths of that in the open.

RELATIVE HUMIDITY

It is quite evident that if the temperature of the air is considerably cooler over the forest land than the open land, the relative humidity will be higher. Also the transpiration of water by leaves appreciably increases the moisture content of the air within or near the forests.

PRECIPITATION

EFFECT UPON LOCAL PRECIPITATION

Observation upon the influence of forest on local precipitation began as early as the middle of the last century, but systematic observations did not begin in the second half of the sixties. As a result most of the observation show that forests have greater amounts of precipitation than does non-forests.

When it was first found that forests receive more rain, it was thought that the gauges were inaccurate. Also the gauges in the open are subject to wind which blows the rain from the gauge while in the forests the gauges are protected from the wind. But, can the greater amount of precipitation over a forest area as compared to open fields, however, be ascribed entirely to this. Also today with our improved rain gauges the difference is still the same.

The difficulty of bringing out clearly the fact that forests have an influence upon precipitation, results from the fact that the bulk of the forests are in the mountains. Altitude has a definite effect upon the amount of precipitation, and this argument has been brought forth. But, likewise there are open fields at the high alitiudes so a study was made comparing the precipitation in the forests with the precipitation in the open fields at the higher altitudes. The results found from this experiment show that the forests attract more precipitation at higher altitudes.

Table II [7]

Precipitation Within and Outside of Forests at Different Altitudes

	Altitude in Feet 330-650 Inches	1970-2300 Inches	3000-3250 Inches
In Forests	26.2	42.9	69.9
Outside Forests	22.9	36.0	37.9
Difference	3.3	6.9	32.0
Percent	14.2	19.0	84.2

The figures in the table show that the influence of the forests upon precipitation increases with the increase in altitude. Therefore, while it is true that mountains affect precipitation, wooded mountains affects it to a still greater degree.

Table III [7]

Coniferous and Broadleaf Influence on Rainfall

	Rainfall		
	Above tree Tops Inches	In Open Inches	Difference Inches
Broadleaf	25.8	24.8	1.0
Coniferous	26.3	24.0	2.3

From the above table the results show that coniferous trees have a greater effect upon precipitation than do the broadleave trees. The greater effect of coniferous forests upon the amount of precipitation cannot be due to transpiration since coniferous forest transpire a lesser amount of water than broadleaf forests.

This greater concentration of vapor over coniferous forests must be due to the fact that the crowns of coniferous trees intercept greater amounts of precipitation and therefore return into the atmosphere larger amounts of water by evaporation. [7]

Probably the greater amount of precipitation over forests during the fall and winter, when the clouds are low, is due to the result of condensation, due chiefly to the mechanical obstructions offered to the moisture-ladden strata of air by the trees.

Opportunities for comparing the climate of similar contiguous areas of large size, differing only in the presence or absence of forests are rare. However, one exists in eastern Tennessee, where in relatively recent years an area of 1000 acres in Copper Basin once heavily forested has been completely denuded by smelter fumes. Surrounding this island of absolutely complete denudation is a zone of 12,000 acres which supports a stand of perennial grass. This in turn surrounded by a hardwood forest of approximately the same composition as that which occupied the basin.[1]

Two years records in these zones show:

Table IV[1]

Table of Denuded and Forested Land

	Wind Velocity		Evaporation	
	Winter	Summer	Winter	Summer
Denuded Land	7 to 10 Times Greater	34 to 40 Times Greater	2 Times Greater	7 Times Greater

	Average Daily Temperature	Precipitation 1936		Precipitation 1937	
		Winter	Summer	Winter	Summer
Forested Land	3 or 4 Degrees Lower	+ 17.5%	+28%	+25%	+28%

This record, although of extreme interest, is so short that until further study and analysis have been made, great caution must be used in classifying " rain production " as an attribute of forest cover.[1]

SUMMARY OF EFFECTS OF FORESTS ON CLIMATE

Accurate observations continued for many years in different parts of the world, established with certainty the following facts in regard to the influence of forest upon climate.

The forest lowers the temperature of the air inside and above it. The vertical influence of forest upon temperatures extends in some cases to a height of 5000 feet.

Forests increases both the abundance and frequency of local precipitation over the areas they occupy, the excess of precipitation, as compared with that over adjoining unforested areas, amounting in some cases to more than twenty-five per cent.

The influence of mountains upon precipitation is increased by the presence of forests. The influence of forests upon precipitation is more marked in the mountains than in the lowlands.

Forests in broad continental valley enrich with moisture the prevailing air currents that pass over them, and thus enable larger quantities of moisture to pentrate into the interior of the continent. The destruction of such forests, especially if followed by weak herbaceous vegetation or complete baring of the ground, affects the climate, not necessarily of the locality where the forest are destroyed but of the drier regions into which air currents flow.

FORESTS AS CONSERVERS OF PRECIPITATION

All of the water which is precipitated over an area covered with vegetation does not go to swell the underground drainage which feeds the springs and the regular flow of streams. Some of it is dissipated before it has a chance to reach the lower stratas.

INTERCEPTION OF TREE CROWNS

On bare grounds, especially plowed fields, it is very evident that the rain which falls has no chance of interception by vegetation. Then on fields which have grass some of the rain is intercepted, but as we come to the trees the interception is the greatest, especially when the trees are in leaf.

The interception by trees varies with different species The broadleaf trees do not intercept nearly as much as coniferous trees during the course of a year. Under average conditions a Spruce forest will intercept about 39 percent of the precipitation, and a broadleaf forest about 13 percent. But, even in the winter, when the leaves are off the broadleaf trees, the branches prevent a portion of the precipitation from reaching the ground directly.

The amount of precipitation intercepted by trees varies with the age of the tree, it is smallest in a young stand and greatest in a middle age one.

When a light rain is experienced, a much greater amount of water is intercepted by the trees in the forest than when a heavy rain is experienced. Also in a region where precipitation is heavy and prolonged, the ground under the forests, no matter whether coniferous or broadleaf, will receive nearly as much as bare ground. To us in the Pacific Northwest this is quite evident, as most of us have been out in the forests during the rainy months and have become as wet as when out in the open.

In regions where rains are light and not of prolonged duration a considerable amount of precipitation will remain in the trees and be soon evaporated without ever having reached the ground.

In many cases where the precipitation is intercepted by the trees, only a part is lost due to evaporation into the air. A considerable amount runs down the branches and then down the trunk into the ground. The amount that reaches the ground in this manner varies with the species, bark, and character of branching.

In coniferous forests the amount of precipitation which reaches the ground along the branches and trunks is very small (0.7 to 3 Per Cent), while in deciduous forest, under average conditions, is about (15 Per Cent).[7]

That portion of precipitation which does not reach the ground directly is not lost to the forests. Its evaporation increases the relative humidity of the air, which with the lower temperature within the forests results in condensation, especially in coniferous forests, of a considerable amount of moisture in the form of fog, dew, or frost.

EVAPORATION FROM THE SOIL

Experiments on the influence that forests have on evaporation from both soil and water surfaces, have been carried on in France, Germany, and Russia.

And, all of the results found in these countries are practically the same and that is, evaporation from a free water surface is two and half times greater outside of the forests than evaporation inside the forests.

Other results from the experiments preformed in Europe the following results were found. Evaporation from bare sandy soil in the open was 33.6 Per Cent. This as compared to these results, evaporation from forest soil without leaf litter is 39 Per Cent, and with a cover of litter 15.4 Per Cent of the amount evaporated by a similar soil in the open. If this same ratio holds for winter then within a forest a soil covered with leaf litter evaporates 7.7 Per Cent, and one without litter 19.5 Per Cent.[7]

In open stand such as Pine in eastern Oregon, the evaporation that takes place from the forest soil will be above the average; while the dense stands of the coast, with heavy foilage, the evaporation that takes place from the soil will be below the average.

Wind exercises a great influence on evaporation at all times of the year, by constantly renewing the air that is in contact with the moisture containing surfaces.

Thus the forests act as a breaking force of the wind and acts as a check of the circulation of the air, and reduces the evaporation of water or snow from the forest soil.

The character of the soil cover has its effects upon the amount of water evaporated from the soil. If there is a heavy mulch or leaf litter it acts as a cover for the soil and prohibits the evaporation. Leaf litter will decrease evaporation by about 15 Per Cent.[7]

Evaporation from the soil in open points decreases greatly with an increase in altitude, but with the forest and litter cover, there is a considerable amount of difference, although the difference between evaporation in the open and the forests at high altitudes is not as great as at the lower levels.

TRANSPIRATION

This may be called physiological evaporation in distinction from physcial, since it is essential to the physiological function of the tree.

This is a very complicated physiological process, and although this problem has been studied by a large number of investigators, the exact quantities of water transpired by different trees and plants is still unknown.

Hoknel carried on experiments on forest trees and his results are shown in the next table. The figures are only for the vegetative season and show the number of pounds of water transpired for every pound of dry leaf substance.

In the drier climates the plants need a greater amount of water because the transpiration rate increases. Therefore, if transpiration greatly exceeds absorption, the plant may wilt or even die. Thus one is able to see that transpiration is not only a physcial necessity, but may be injurious to the plant. In some cases it hinders nutrition, which is checked by wilting, in others it leads to death. This is why in years of drought plants are poorly developed or even perish.

Table V [7]

AMOUNT OF WATER TRANSPIRED BY DIFFERENT FOREST TREES PER POUND OF DRY LEAF SUBSTANCE

Species	1878 Pounds	1879 Pounds	1880 Pounds
Birch	679.87	845.13	918.00
Ash	566.89	983.05	1018.50
Beech	472.46	859.50	913.80
Maple	462.87	517.22	611.80
Elm	407.31	755.00	822.80
Oak	283.45	622.21	691.50
Spruce	58.47	206.36	140.20
Scotch Pine	58.02	103.72	121.80
Fir	44.02	77.54	93.80
Austrian Pine	32.07	99.92	70.05

In all probability this table is far from right, but it does show that trees do transpire a considerable amount of water. It also shows that during the vegetative period, Birch and Ash trees transpire for every pound of dried out leaves, more than any other forest trees. Coniferous trees transpire the least. The difference in the amount of transpiration in the different years is explained by the fact that during 1879 and 1880 more rain was experienced, therefore, more water pentrated the soil.

SURFACE RUNOFF CONVERTED TO SEEPAGE

In the mountains and in the open fields the greatest sources of loss of precipitation is through surface runoff, and the most important influences which a forest cover has, is a reduction of this loss.

A german investigator, Ney, estimates the amount of water which the forest cover saves for the soil by reducing the surface runoff and changing it to underground seepage to be as follows. For forests at low altitudes where rains are not heavy and the soil is less subject to freezing, 20 Per Cent; for forests of moderate elevations, 35 Per Cent; and for mountain forests, 50 Per Cent of the precipitation.[7]

The saving which forest affects the amount of runoff is more than sufficient to affect whatever loss may be sustained through transpiration or interception of tree crowns.

When the ground beneath a forest has a unbroken leaf litter, the ability of the forests to check surface runoff is greatest. A forest that does not have a leaf litter has little effect on the checking of surface runoff.

It is quite evident that a normal forest in the mountains saves more water for stream flow than any other vegetal cover or any bare surface is shown by the abundance of springs in the mountain forests.

A unfounded contention is that if forests are to control stream flow it is necessary to keep them not only on the head waters of the streams, but also on their lower levels, since the latter forms by far the largest part of the drainage basin.

The greatest influence of a forest upon stream flow, is at high altitudes, where precipitation is heaviest, slopes steepest, and erosion easiest.

A reduction in the amount of surface runoff has two main advantages, these are first, it means an increase of underground seepage and second, prevention of erosion. These two factors are the result of:

SEVERITY OF RAINFALL CHECKED

The amount of water that filters into the ground depends for on thing, upon the length of time water remains in contact with the soil. A forest acts in modifying the severity and the duration of the rainfall. The branches and leaves break the force of the rain, so that the water reaches the soil without great violence, and at the same time prolongs the duration. Of course, as it was stated before that the amount of rain which hits the ground direct will depend upon the severity of the rainfall and the length of time that it has been raining. One can go into a forest after a good rainstorm and for several hours water will drip from the leaves and twigs. Therefore, water in the forests falls more quietly and for a longer time which enables the soil to absorb the water.

MELTING OF SNOW RETARDED

In the open spaces where there is a rapid melting of the snow when the ground is frozen, a considerable amount of surface runoff is the result and the surface soil is unable to absorb the water.

The rapidity at which snow melts in a forest will vary with the different species, and with the age, density, and the location of the stand. This variation has been proven from year to year by experiments, irrespective to the weather at the time of melting. The snow first disappears from the openings or clearings in the forests, simultaneously with the snows disappearance in the open fields. The next location that the snow disappears is from young forest plantations, where the stand has not been able to close, followed by the disappearance of snow in the dense stands of older timber.

Table VI [7]

Table of Snow Disappearance

In fields, clearings and open places	April 22
In young open stands	April 24
In old openstands on south slopes	April 26
In Birch stands	April 29
In Pine stands	May 6
In Spruce stands	May 15

Thus, while compared with deciduous stand, coniferous forests, especially pure dense spruce, prevents large accumulations of snow from rapid melting, and for this reason they are more efficient in reducing the height of the spring freshets. The reason why deciduous forests do not hold the snow longer is due to the absence of foilage while the coniferous trees have foliage which protects the snow from the sun.

In cultivated fields and clearings in the north, the ground is still frozen when it is time for the snow to melt. This, together with the rapid melting of the snow in these open spaces causes the water to runoff in large quantities. This freezing of the ground in the fields and clearings is due to the unimpeded radiation in the fall, and the blowing away of the snow, which would otherwise offer a protective cover. So with the freezing of the ground in the winter, and when the snow melts and a large amount of water runs over the frozen land surface, the water is unable to pentrate into the ground.

In the forest the soil is warmer than the soil in the open, due to the protection from the trees and other vegetation which prevents radiation to take place. Also the soil under the forest is protected by the leaf litter, which is a poor conductor of heat, which both prevents it to cool off and freeze in the winter, and in the process of decom, position heat is added to the soil. One has to be careful now of making too bold a statement, as in the north country there is very little decomposition, but there is a very deep layer of litter which offers good protection. Added to this is the protective cover which is offered by the snow.

Thus with this protection the forest soil either does not freeze at all or it freezes later in the winter and to not as great a depth as soil in the open spaces, and it thaws out in the spring under the snow. One can rapidly see that with the slow melting of the snow with the unfrozen or slightly frozen condition of the ground beneath, permits a much greater amount of percolation than in the open. Coniferous stands have a larger tendency to hold water than broadleaf stands.

There is one other important fact that is sometimes overlooked, besides the relative high temperature of forest soil, and this is if the soil of watersheds remain soft and unfrozen, the ground water which feeds the streams continue too flow all winter, keeping the normal winter water stages up. If this underground water ceases to flow in the winter the streams freeze to the bottom and when the snow melts in the spring large quantities of water are put forth.

SURFACE RUNOFF OBSTRUCTED

In the forest floor which is pentrated by many roots and covered by branches, stumps, and other obstructions, the surface runoff is obstructed and the water is permitted to sink into the ground. Pentration of the water into the soil is made easier by the deep channels in the soil which have been left by the decay of the roots.

The porosity or premeability of the soil has a great influence on the amount of surface runoff. The crowns of the trees offers protection to the soil by breaking the force of the rain which falls to the ground and this prevents the soil from becoming compact.

The depth of the soil has a bearing upon the amount of water which it can retain. No matter what kind of soil it is, a thin soil cannot retain any large amounts of water. The forests will offer additions to the soil by two ways. First, the leaves, litter when decomposed becomes a part of the soil and second, by inducing the rock under the soil to disintegrate.

During the vegetative season the demand of the forest upon the water stored in the ground is very great. In the summer the forest, like crops, consume more water than it receives in the form of precipitation. At the end of the vegetative season, therefore, the level of the underground water is low as a result, thus the forest soil can absorb large quantities of water during the period of vegetative rest, where there is an excess of water on the ground, either from heavy rains or melting snow. The forest soil, therefore, forms a reservoir whose capacity is greatest when the excess of water on the ground and danger of floods is the greatest. The water stored in the time of rest is used by the vegetation and for the flow of streams later or when there is usually a deficiency of precipitation.

A brief summary would show that forest really affect not only the water to be conserved but the entire climate. In the coming years more attention will be given to these ideas and scientific investigation will be carried on to comfirm all the ideas which have been offered.

MULTIPLE USE

A well stocked forest is unexcelled in furnishing natural protection for watershed and reservoirs.

If an excellent protection forest can be established and maintained in a manner to pay its way and return a profit, this should be accomplished.

The popular idea sometimes encountered that all cutting of trees in the forest must be prevented if good protection and pleasing landscape effects are to be secured is erroneous. Cutting of trees is the most effective tool which the forest manager has at his command, not only for securing a steady supply of timber, but also developing and maintaining satisfactory forest landscapes and the best protection forest.[2]

From all three viewpoints it is essential for satisfactory results that the maximum cut of wood and timber to be held within certain limits. Very rarely can more material be removed than is equivalent to the growth of the forest during that period. If a larger cut is made the effectiveness of the forest in accomplishing its functions is dimished.

Growth is allowed to accumulate and build up the growing stock of trees. This is a necessary step before the forest can reach its highest usefulness as a protective cover.

TIMBER PRODUCTION ON WATERSHEDS

Many American town have discovered that watersheds can be used for other purposes than water production.[6]

The development of these forests means that money can be brought into the city coffers, and idle men put to work.

THE CEDAR RIVER WATERSHED

When the city of Seattle set out in 1900 to acquire control of the Cedar River Watershed in order to protect its city water supply, there were those who said that the watershed contained enough good timber to pay for the forest.

People wondered at this and were skeptical, but the city took a chance and as a result the forest has paid back to the city nearly a million dollars or enough to pay the debts and surplus enough to pay expenses.

This area was originally bought only for protection of water supply, but the city discovered that forests if properly managed has many uses and can serve many purposes.

But, in order to have good management, forest protection is the primary need. Also as the forest products are cut, means are needed to put trees back on the area, and this usually is accomplished by planting, which although expensive, puts the area back to a producing capacity and also a water conserver in a shorter length of time.

THE ELI WHITNEY FOREST

The Eli Whitney Forest, which was set up by the New Haven Watershed Company of New Haven Massachusetts, in conjunction with the Yale School of Forestry, has done much in the proving that watershed and timber production can be carried on together.

Other multiple use are game production, recreation and grazing, which if properly managed will aid the people and the surrounding territory.

CONCLUSIONS

The report shows that forests have effects upon the climate, temperature, rainfall, and others, but this is not sufficient proof to conclude that this influence really exists or is of importance. One would like to believe that forests do have beneficial effects and in the coming years, research will give evidence of the real influence that forests do have on the conditions which humans live. Also research should be done to see if there is other vegetation that will preserve more water than do the forests. Because large quantities of water is lost due to transpiration and evaporation from the trees.

In years before, people could only think of preserving the timber for watershed protection and set large areas aside soley for this purpose. As a result considerable expenditures were spent in protecting these watersheds and no returns were gathered. Now there has been a reverting change of this policy to the multiple use policy of the watersheds. Paying not only for the expense of the watershed, but also providing a means of employment for many individuals. Why should large areas of timber be set aside and allowed to decay without any other benefits other than water production? There are many arguments both pro and con.

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