A Minor Curriculum in

Watershed Management

by

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# INTRODUCTION

The purpose of this paper is to organize a curriculum for a minor in Watershed Management to be open to students majoring in Technical Forestry at Oregon State College. This curriculum would be composed of eight or nine courses, about 25 credits, covering phases relevent to the management of a watershed area.

Students attend institutions of higher learning to increase their capacity to earn a livelihood, serve society, and enjoy life. A student entering college needs all of the assistance available in planning the courses in the field of his choice, to take to best meet these objectives. In most cases, a student in technical forestry has not decided before his junior year in what field he wants to specialize, or whether he wants to specialize at all.

There are two fields of thought concerning the educational process for foresters. One is that there is not enough time in four years for specialization, and the other is that it should be squeezed into the curriculum along with the basic fundamentals of forestry, a background of the humanities, training in clear thinking, and courses to correlate the whole picture. The purpose of this paper is not to prove that specialization is necessary. However, it will attempt to point out that: (a) Watershed Management is important and if a student wishes to specialize in this field he should follow a well-organized curriculum; and (b) this curriculum should be listed with the six other specialized fields that the school now recognizes.

The Importance of Watershed Management

The problem of how to correlate wild land utilization practice with watershed protection is a problem that has baffled man since the beginning of time. History shows that many mistakes have been made by man because of the failure to understand the soil and the role of the plant and soil mantle in the hydrologic cycle.

Many parts of the world at present are being affected by this problem. In Russia, Argentine pampas, Australian bush, and the Philippines, floods are now issuing from formerly forested mountains which have been converted to grass ranges. An exception to this is the situation in parts of north central Europe where forestry and water problems appear to have been solved. Solutions in these places have evolved under a combination of physiographic and economic conditions which although are not the same in the United States should be considered in the development of a program in Watershed Management for this country.(1)

In Europe, forest utilization started slowly and conditions changed slowly. Certain minor mistakes were made and econimic institutions and management practices were adapted to modify the physical and social requirements.

(1) Craddock, G. W., Forestry and Water, Journal of Forestry, Fol. 38, pp. 141.

In the American scene forest utilization started fairly rapidly and gained momentum. The mistakes that were made were vastly different in character and scope and the physical and social environments were also different. However, underlying these elements are forces similar to those involved in the problem areas in other parts of the world.

The early settlers in the United States felt that the wild land resource was inexhaustible and it was necessary to clear the lands for cities and for agriculture. Later about the time that the concept of inexhaustible resource was recognized to be only an illusion, the railroads opened new lands and power machines made harvesting relatively easy. The profit motif also speeded up the exploitation and the old country practices of conservation were ignored.

Along with this rapid increase in the exploitation of the wild lands large numbers of people have concentrated in cities; rivers and harbors have been highly developed; power plants have been installed in all centers of activity; reservoirs, transmountain diversions, and elaborate canal systems have been constructed to make agriculture possible, by irrigation, in the arid regions.

Nearly all of these developments are situated in or near the flood plains of streams that drain the wild lands. It is now recognized that these rapid strides in civilization in the United States are exacting a toll in the form of serious water problems.

United States. Approximately 465,000,000 acres or three-fourths of our forest land exercise favorable influence on watershed protection and soil-erosion control.[1] However, practically every section of the country is confronted by one or more serious problems of stream flow or erosion. The densely populated areas share with the areas of low rainfall, the immediately vital problem of obtaining adequate and constant quantities of water for human consumption and other domestic uses. The latter areas are confronted with the additional problem of supplying water for irrigation of agriculture land. Populous industrial communities require water, often in huge quantities, for various manufacturing processes. Large sections of the country that receive light in their homes and energy in their factories from water power are concerned over low water in the streams. The threat of low water and clogged channels must also by considered by those portions of the United States where stream-borne commerce is important and navigable harbors give access to the markets of the world. Floods are often an appalling problem not only to the fertile lowlands but also to highland valleys. And erosion, the washing of topsoil from lands exposed to rain and melting snows, is a problem common to nearly all parts of the United States, and is acute in many.

Mississippi's Yazoo River offers, on a small scale, one of many concrete examples of the value of the forest in stream-flow regulation and control of erosion. During the

(1) U.S.F.S., A National Plan for American Forestry, pp. 561.

1931 flood, 17 inches of the 21 inch rainstorm ran off from experimental plots of cleared land, taking 34 tons of topsoil per acre. But on adjoining forest land the run-off was only one-tenth of one inch, with no loss of soil.(1)

This is significant in view of: (a) a national average annual flood loss of more than $110,000,000 during the last thirteen years, with 1,265 lives lost; (b) apparent increase in frequency and height of floods as destruction of forest cover by fire and uncontrolled cutting continues; (c) moderate to serious soil deterioration, through erosion, on 50 percent of the areas in regions where forests once occured.

Agriculture that is founded on watershed protection in many western states represents an investment of more than $6,000,000,000. Without water, its crops would be worth but a fraction of their present value, which approximated $900,000,000 in 1929. The greater share of this irrigation water originates on forested slopes. Water that comes from protected mountain slopes in southern Idaho is worth about $7 per acre-foot.(1) In some cases the protection value of forest land, with reference to all water and soil benefits, transcends the value of any equal acerage for all other purposes combined. For example, some mountain watershed cover in southern California is estimated as high as $1,600 per acre.(2)

(1) House Report No. 323, Report of the Joint Congressional Committee on Forestry, pp. 14.
(2) Los Angeles City School District, Conservation in Los Angeles County, School Publication No. 275, pp. 81

Forest cover is also a factor with respect to: (a) the more than one-third of the nation's electric power that is generated by water; (b) the growing problem of urban domestic water used by more than 6,000,000 people in cities like Portland, Oregon; Los Angeles, California; Salt Lake City, Utah; Prescott, Arizona; and Denver, Colorado, which are dependent on forest lands for water supply; (c) the 2,000,000,000 gallons used daily in urban centers from Boston to Baltimore; and (d) the billions of dollars that have been invested, country wide, in municipal waterworks.[(1)]

<u>California</u>. The yield of usable water from the chaparral covered mountains of southern California is of vital importance to the rural and urban population that occupy the valleys below these watershed areas. During the past half-century domestic, industrial, and agricultural demands for water in this semi-arid region have reached a point far greater than the normal supply, as indicated by declining water tables in alluvial filled basins underlying the valley floors. These natural underground basins form an ideal system of storage and distribution of water and are normally replenished by flows from the mountain areas.

The problem of providing an adequate amount of usable water to meet present and future needs is accentuated by the excess of demand over present local supplies.

(1) House Report No. 323, Report of the Joint Congressional Committee on Forestry, pp. 15.

An honorary Watershed Committee appointed by the governor of California, in 1932 stated that "The best possible development and conservation of the waters of the state are of the utmost importance to the continued prosperity of both the rural and urban communities of california." In this committee's opinion, "any great increase in population in this state is impossible without the fullest feasible conservation of its waters. Without a sound program of water conservation - California cannot continue to maintain its present population."

This shortage has led to the importation of water from other regions at great cost. This cost factor necessarily limits its agriculture use. The problem is made more difficult by unequal seasonal distribution of rainfall, characteristic of the region. Rains confined almost entirely to the winter season frequently occur as torrential downpours for which it is difficult to provide sufficient storage by engineering means, and which unless stored, waste to the sea, lost for use as well as creating in transit a very serious hazard to life and property.

The problem of soil erosion control is very acute in this region. The soil as an accompaniment of excessive run-off may render the water supplied by streams unusable for human consumption. Erosion may also result in the silting of storage and flood control reservoirs, in the clogging of gravels in water spreading grounds, and adds much to the danger inherant in floods.

<u>Oregon</u>. The region west of the Cascades in Oregon and Washinton due to the abundance of water and the great fall in streams contain the greatest concentration of water power resource in the United States.(1) There is no strict line of demarcation between drainage basins with power value and those whose greatest value is for irrigation. In general, west of the Cascades, the upper portions of streams have fairly uniform flow and concentrated fall and are therefore attractive for power development; examples are: upper Rogue, Umpqua, McKenzie, and Santiam River basins. Irrigation possibilities exist in the lower parts of these basins, where, in general, rainfall is less, growing season is longer, and arable land exists, in large tracts feasible for irrigation. East of the Cascades, the situation is largely reversed: the irrigated sections lie chiefly in the upper reaches of the rivers while power possibilities are mostly in the lower reaches. Examples are Deschutes, John Day, and Grande Ronde River basins. A few basins, such as Burnt River, Malheur River, and Umatilla River have much irrigation and little or no power value.(2)

In general, it can be stated that erosion in irrigated districts, or drainage basins, is not a serious problem in Oregon. There are places where sediment enters the canals in quantities sufficient to require the use of sand traps, with little additional expense for operation. Reservoirs

(1) U.S.D.A., The Western Range, Senate Doc. No. 199, pp. 312.
(2) Oregon planning council, Report of Committee on Watersheds and Erosion, pp. 6.

tend to accumulate some sediment, but that factor has been serious only in the case of Furnish Reservoir near Pendleton. From 1909 to 1931, this reservoir lost 82 percent of its original capacity through sedimentation.(1)

The Willamette River is one of many that has been examined by the National Resources Committee for the purpose of development and improvement. In a broad way this plan includes the construction of a number of large reservoirs on the principal tributaries of the Willamette River for regulation. At several of these reservoir sites, hydroelectric power can ultimately be developed. The river regulation afforded by such a series of reservoirs, together with proper watershed management practices will greatly reduce the damaging effect of large floods; also provide an irrigation supply sufficient for 355,000 acres of valley lands, and double the low waterflow of the lower river, thus aiding navigation and reducing river contamination.(2)

The necessity for the protection of watersheds furnishing water for municipal use has been recognized almost universally where the source of supply is relatively near to the point of consumption. As a rule, the watersheds yielding water for cities of any size, such as Portland, are either under municiap regulation or are included in the national forests. The role of vegetation is recognized and strict supervision of all activities on the watersheds is enforced.

(1)Oregon planning council, Report of Committee on Watersheds and Erosion, pp. 6.

(2)Drainage Basin Committee Report for the Pacific Northwest Basins, pp. 50.

There are approximately fifty cities and towns in Oregon that obtain their water supplies from surface sources. These watersheds vary greatly in character, and are under radically different types of control and supervision. In many cases they will prove invaluable assets in the growth of the communities which they serve.(1)

Methods of Procedure and Sources of Data

The field of Watershed Management was analyzed in respect to the western states. A definition was constructed and the problems and objectives were studied to determine the basic fundamental principles of the field. This was done by means of library reference and personal experience gained at the San Dimas branch of the California Forest and Range Experiment Station. The research carried on in the San Dimas Experimental Forest is dedicated to the pursuit of studies in the management of chaparral watersheds for the maximum yield of useful water.

The next step was to examine the Oregon State College catalog and pick out the courses available to forestry students that were related to the field of watershed management. These courses were then analyzed and correlated with the basic fundamental principles of the field. In cases where one course overlapped another the course with the least coverage was discarded. Necessarily a course was dis-

(1) Oregon planning council, Report of Committee on Watersheds and Erosion, pp. 4.

carded if its contribution to the field was small. The proposed curriculum was once more set up and compared with the field to determine what points or principles were not covered. These principles were then analyzed and a course was organized to cover them.

# DISCUSSION

## Analysis of the Field of Watershed Management

### Definition of Watershed Management

Watershed Management is the practice of handling the resource of a drainage basin to produce maximum yields of usable water.(1) This definition can be interpreted in a broad sense to include, for instance, the Mississippi River and tributaries as a drainage basin and the use of the water for power, navigation, irrigation, or domestic use. On the other hand, it would also define the management practice on a small municipal watershed. In either case the fundamentals would be similar.

The popular belief that Watershed Management was merely protecting the area from fire is probably due to two factors. One: the term commonly used to describe the practice of keeping fire out of an area is protection, and two: the term 'Protection Forest' is used synonomously with with watershed.

In many countries 'Protection Forests' are defined by law. They are forests the main object of which is to help prevent avalanches and snowslides; check or reduce soil erosion; retard snow melt; preserve favorable conditions of run-off; stabilize shifting sands; protect other forests or property from wind, or contribute to the national defense.(2)

(1) Connaughton, C. A., Watershed Management - More than Mere Protection, Journal of For., Vol. 37, pp. 341.
(2) Forsling, C.L., The Water Conservation Problem in Forestry, Journal of For., Vol 31, pp. 58.

In short the definition embraces all the many indirect benefits which the forest exerts upon water, soil, and climate.

It can be seen that the best management practice necessary to produce the maximum yield of water from an area would be to denude the area and build huge storage reservoirs. However the size of the reservoirs would in almost every case make this impossible. The costs of removing the sediments and debris and purifying the water would be inhibative. And this practice would limit the use of this land solely to the production of water.

<u>Objectives of Watershed Management</u>

The objectives of watershed management are to regulate, and stabilize stream flow, to control erosion and floods, and to maintain pure water for domestic use.

Stabilizing stream flow means providing for a more even flow in streams throughout the year and at all times of day. It involves the holding back of floods to afford an ample flow of water during dry periods, to provide for more water for irrigation during the dry season when it is needed.

The problem of stabilizing stream flow varies in different parts of the country. In the more humid regions it is more permanently one of evening the flow to prevent excessive flood stages rather than providing against drought. In the semi-arid regions it involves making more water available for the irrigation season and controlling the flash floods of relatively short duration. In all regions it involves a restoration of, or a substitution for, the natural checks to stream flow found under primitive conditions and where possible, improving and extending them.(1)

Water has a thousand contacts with other substances in its course from water vapor in the atmosphere to streams in the bowels of the earth.(2) Research is needed on the interactions between water, soil, and vegitation before all of the fundamental principles are determined. However, the interactions between these three elements form the basis of Watershed Management. Although the study of these interactions has not been exhausted, a great many of the fundamental principles are known. The fields of Climatology, Pedology, Physiography, Botany, and Ecology cover most of the basic fundamentals.

Flood control and erosion control are in many ways overlapping with stream flow stabilization. If stream flow could be perfectly stabilized by maintaining proper vegetative cover there would be little need for any other flood or erosion control. However, this is impossible in most areas because man can do little to change the climate, geological structure and the topography of a watershed, and these are of major importance to the volume and velocity of surface run-off. There is a great deal that can be done, however, in both up-stream and down-stream flood control to regulate this excessive run-off. The water that runs

(1) Lory, Chas. A., The Economic and Social Value of Watershed Management, Journal of For., Vol 35, p. 177.
(2) Burrage, Clarence H., Watershed Management is More than Production of Water, Journal of For., Vol 37, P. 822.

off of the steep mountain slopes finds its way first into the minor canyons and then into the major drainages growing in volume and velocity as other side canyons empty their flow into the main stream. Small check dams or contour terraces or other minor engineering works are very important in cutting down the erosion. This is also a flood control measure.[1]

In some areas merely stabilizing the stream flow is not enough. Under the greater precipitation of the eastern United States the problem is one of what to do with the surplus run-off. Under the limited rainfall of the West, water is the limiting factor of plant growth and of civilization and watershed management is concerned entirely with the conservation of water supplies for domestic use and plant growth. Here there is little surplus of water, usually a shortage and so the possibilities of increasing the water yield by management are very important. The problem is to lessen the consumptive use of the water by plants. Run-off or stream flow is the residual water after the losses by transpiration, interception, evaporation, and deep seepage have been deducted from the precipitation. The rainfall and the deep seepage are little if any influenced by the vegetation. There remain, therefore, the losses by transpiration and interception of the vegetation and evaporation from the soil, which vary with the kind, size, and density

(1)Cecil, Geo. H., Fifteen Years of Flood Control in Los Angeles County, p. 7.

of the vegetation and are, therefore, water losses which influence run-off and are subject to modification by forest management.

The other objective, maintaining a pure supply of water for domestic use, is very important on municiap watersheds and to a lesser degree on other watersheds. The problem of pollution is in some cases the limiting factor of multiple use.(1)

## Analysis of Courses Offered at O.S.C. that are Related to the Field of Watershed Management

Practically every course that is required for technical forestry students is related in some way to the field of Watershed Management. This was necessarily kept in mind when organizing the curriculum for the Watershed Management minor. However, only those subjects that are not covered in the general curriculum and are related to the field were considered. The following courses were selected as the best coverage of the field available to technical foresters:

### Principles of Plant Ecology

This is a 4-credit course covering the principles governing the interrelations of plants and environment; the influence of living agencies and of light, heat, and other atmospheric and soil factors on the native vegitation and cultivated crops. It is only open to upperclassmen and Botany 201, 202 are prerequisites for the course.

(1) Oregon State Planning Board, Water Sources and Watershed Protection Problems of Oregon Municipalities, p. 14.

Climatology

This is a 2-credit course that approaches meterology from the practical standpoint. It also covers observation and recording of local weather and forecasting and includes a study of the climate of Oregon and the effect of climate upon agriculture.

Engineering Geology

This 3-credit course covers the general field of geology from the engineering standpoint.

Forest Soils

This is a 3-credit course covering the origin, development, characteristics, and classification of forest soils. The relation of soil to vegitation, moisture reaction and fertility is also considered.

Cover Crop and Soil Erosion Prevention Plants

This course is for 2 credits. It covers the production, development, and maintenance of plants suited to soil, dike, and bank protection and to cover-cropping purposes. It also includes the control of sand dunes and cover crops used for soil protection and building up of the organic content in tillable areas.

Soil Conservation

This is a 3-credit course covering climate, topography, and soil in relation to erosion, its causes, types, and importance. It also considers soil mapping and methods of soil erosion control.

Soil Conservation Engineering

This is a 3-credit course that covers the agricultural engineering phases of soil-erosion control, including methods of construction dams and terraces, terracing machinery, mapping, measurement or run-off, and similar problems.

Forest Sanitation

This is a 3-credit course covering the sanitary provisions necessary for forest camps, camp grounds, and summer homes and the location and construction of camp facilities.

Correlation of the Courses with the Field

Most of the courses outlined approach a phase of Watershed Management very well, from the standpoint of the objectives of this curriculum, however, some do not. Forest Sanitation, as an example, approaches the subject from the recreation standpoint but the principles can be applied directly to watersheds where multiple-use occurs. These ideas can apply to logging camps and permanent residences as well as camp grounds and summer homes. Pollution is also caused by industrial wastes and drainage from densely settled areas, but it is believed that these problems should be handled by sanitary engineers.

Soil Conservation Engineering, Soil Conservation, and Cover Crops and Soil Erosion Prevention Plants give a good coverage of the methods of controlling erosion and floods. The other group of courses, Climatology, Forest Soils, Geology, and Plant Ecology give a fairly good picture of the basic fundamentals that govern the stabilization of stream flow and, indirectly, flood and erosion control. Methods of retarding run-off, can be divided into two groups; natural and artifical. They overlap to a certain extent, in that artifical methods are only used when natural methods will not do the job satisfactorily. If the run-off can be retarded by natural methods, artificial methods would not be necessary. This emphasizes the importance of using and improving, when possible, natural methods. Therefore to organize a curriculum in Watershed Management it is necessary to cover every phase of retarding run-off by natural methods. The role of the vegetative cover in retarding run-off and increasing infiltration is not thoroughly covered. The course in Plant Ecology covers the influence of atmospheric and soil factors on vegetation, but what is needed more is a course that covers the influence of vegetation on the soil and atmospheric factors.

A Watershed Management curriculum would not be complete without a course in forest influences. It should be a 3-credit course including a study of the consumptive use of water by the vegetation as well as the influence of the forests and brush lands on soil moisture or infiltration. Forest Influences would cover, forexample, the influence of the forests in retarding snow melt and the influence that different types of cover have on stream flow or flood and erosion control. This course should be so organized as to correlate: Climatology, Forest Soils, Plant Ecology, and Geology and to study the interactions of water, soil, and vegetation. It would be necessary, therefore, to take those four courses first.

## SUMMARY

### Findings

1. It was found that the field of Watershed Management is of utmost importance in the administration of wild lands in all parts of the United States.
2. If a student wishes to minor in Watershed Management, he should follow a well-organized curriculum.
3. Although a curriculum for this field has not been listed, there are courses available to technical foresters at Oregon State College that with the exception of Forest Influences, cover satisfactorily the field of Watershed Management.

### Recommendations

1. It is recommended that a three-credit course in Forest Influences be added in the School of Forestry.
2. It is suggested that the following curriculum be listed in the Oregon State College catalog:

| | Term Hours | | |
|---|---|---|---|
| Watershed Management: | F | W | S |
| Forest Soils (Sls 214) . . . . . . . | - | - | 3 |
| Climatology (Sls 319) . . . . . . . . | - | - | 2 |
| Engineering Geology . . . . . . . . . | - | 3 | - |
| Principles of Plant Ecology . . . . . | - | 4 | - |
| Soil Conservation Engineering . . . | 3 | - | - |
| Forest Sanitation . . . . . . . . . . | 3 | - | - |
| Soil Conservation . . . . . . . . . . | - | 3 | - |
| Cover Crops and Soil Erosion Prevention Plants . . . . . . . . . | - | 2 | - |
| Forest Influences . . . . . . . . | - | - | 3 |

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