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COOPERATIVE WATERSHED MANAGEMENT RESEARCH

IN THE

LOWER CONIFER ZONE OF CALIFORNIA

by

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and

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INTRODUCTION

Cooperative watershed management research in California's Lower Conifer Zone started July 1, 1961. The research is conducted by the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service with the formal cooperation of the State of California, Department of Water Resources and the Division of Forestry.

California's Lower Conifer Zone is a 12-1/2 million-acre commercial forest belt below the Snowpack Zone. Snow occurs in the Lower Conifer Zone, but rainfall rather than snow contributes more than half of the zone's streamflow in an average year (Colman,1955). Water is a major product. Thirty-two percent of the state's streamflow comes from this zone. The zone is providing about 80 percent of the State's annual timber harvest. Wildlife, livestock grazing, and increasing outdoor recreation make important local demands throughout the zone. Forest fire hazards are high, and fire protection and control are basic requirements. Mining has played a large role in creating bare soil areas, areas of dredging debris, and sediment loads in streams.

The job of watershed management research is to conduct studies which will suggest better methods of management for water and predict the effects of a wide span of land management practices upon streamflow, water yield, and sedimentation. A program for watershed management research was prepared by Henry Anderson in 1960 (Anderson, 1960). In addition to predicting the consequences of existing and planned practices, research is aimed to find ways of managing Lower Conifer Zone watersheds to:

1. Increase total streamflow in all years, and especially in dry years.

2. Improve the timing of streamflow by reducing flood runoff and by reducing water losses in the late spring and summer.

3. Maintain water quality.

4. Minimize local floods and sedimentation.

To meet these, watershed management research in the Lower Conifer Zone will take a four-pronged attack:

1. Inventories of present conditions of water yield, land conditions, soils, and flood potentials.

2. Basic studies of forest hydrology which will suggest methods of land management for improving water yield, preventing floods and controlling sediment.

3. Plot and small scale tests of management methods.

4. Pilot testing of watershed management alternatives on whole watersheds.

INDIVIDUAL STUDIES

A STUDY OF LOGGING EFFECTS UPON STREAMFLOW, SEDIMENTATION, FISH LIFE AND FISH HABITAT IN THE NORTH COAST REDWOOD-DOUGLAS-FIR FOREST TYPE JACKSON STATE FOREST, FORT BRAGG, CALIFORNIA (STUDY N0. 2-1).

Two experimental watersheds in second growth Redwood-Douglas-fir forest type have been established on the Jackson State Forest which is under the intensive management of the California Division of Forestry.

Objectives

Essentially no quantitative data exist on the comparative performance of logged and unlogged watersheds in the North Coast Region. Fundamental to good management, answers are needed for such questions as:

1. What is the water and sediment production of North Coast watersheds which have been undisturbed for many years?

2. How are water yield, water quality, flood peaks, and stream sedimentation affected when road building and logging practices are designed to minimize excessive runoff and erosion?

3. What changes take place in the channel following logging and what effect do these changes have upon fish life and upon the stream as a habitat for fish?

Methods

The watershed pair consists of the North and the South Forks of Caspar Creek which flows into the Pacific Ocean about 5 miles south of Fort Bragg, California. Each watershed is roughly 1,000 acres in size. Both support excellent stands of dense second growth Douglas-fir and Redwood timber varying in age from 65 to 80 years. The California Department of Fish and Game is and has been studying anadromous fish populations in Caspar Creek and hopes to expand their activities to include habitat research in the two forks of the stream as part of this study. The study will seek to assess the differences in streamflow and sedimentation, fish life and fish habitat between the North Fork and South Fork watersheds after logging. The South Fork is to be carefully logged using the best knowledge of side slope and streambank protection available through research and experience while the North Fork is left unlogged and undisturbed as a control.

Accomplishments

Thanks to the very active interest and participation by the California Division of Forestry (C.D.F.) personnel located at the State Forest, bedrock streamgaging sites have been located and surveyed in each watershed, 5 standard raingages are established in the watersheds, maximum (peak) stage and staff gages are installed, and watershed performance has been regularly measured since the beginning of the water year, October 1, 1961. C.D.F. personnel have been obtaining weekly suspended sediment samples and stage heights. (Additional measurements were made during stormflow periods.) Suspended sediment samples are periodically sent to Berkeley and analyzed.

The above temporary arrangements were to obtain calibration information during the 1961-62 water year. In the meantime, plans and action are under way to more thoroughly measure watershed performance. A recording raingage has been purchased by the Station and will be installed in the summer of 1962. The Department of Water Resources, working with personnel from the Station, Division of Forestry, and Department of Fish and Game, has designed a weir type streamgaging station for each watershed, and the C.D.F. has prepared the detailed engineering specifications and materials needed. These designs include supplemental splash dams and ladders below the weirs to permit the passage of fish. Cement, reinforcing steel, and aggregate have been purchased by the Station and the gaging stations will be built by the Division of Forestry during the summer and fall of 1962. The Station has purchased two Stevens water-stage recorders for installation at the gaging stations. It is everyone's aim to have these stations in operation by October 1, 1962, the start of the 1962-63 water year.

Plans for 1962-63

Construct concrete streamgaging stations and establish intensive measurements of watershed performance in the North and South Fork watersheds of Caspar Creek. Continue rainfall, streamflow, and sedimentation measurements for calibration of the watershed pair. Make intensive inventories of soils and vegetative cover of both experimental watersheds.

EVALUATION OF FACTORS CONTRIBUTING TO FLOOD PEAKS IN NORTHERN CALIFORNIA WILDLANDS (STUDY NO. 2-2)

This regional flood analysis is one of three companion studies spanning watersheds in both the Snowpack and Lower Conifer Zones. The other northern California regional studies are part of the California Cooperative Snow Management Research Project and are:

Evaluation of Variation of Water Yield with Terrain and Meteorologic Conditions in the Sierra Nevada, (Study No. 1-10.)

Erodibility of California's.Wildland Soils in Relation to Sedimentation, (Study No. 1-18.)

The water yield and erodibility studies are reported in the 1961-62_ Progress Report of Cooperative Snow Management Research.

In California, about 95 percent of the state's water supply has its source in wildland regions (Colman, l955). These lands receive the most precipitation and present the first opportunities to manage this critical commodity. Floods pose one of the most serious water management problems facing the people of California.

To illustrate the magnitude of California's flood problem, floods from streams and rives flowing to the Pacific cause an average annual damage of more than $520.00 per square mile. More than half of this damage occurs in small watersheds--those with areas of less than 390 square miles (Senate, l960).

Since a majority of the flood damage occurs on small watersheds and almost all of the flood waters originate in wildland areas, this problem may be susceptible to moderation by vegetational control if contributing factors and flood peak source areas can be quantitatively determined.

Objectives

One of the goals of watershed management is to even out the disparate distribution of water over time. Our present knowledge is too inadequate to allow us to rationally manage northern California watersheds

to achieve this goal, particularly when we are called upon to retard flood flows. We do not know much about flood potentials under existing conditions and less about how the magnitudes of peak flows are affected by forest management. Before the land manager can design and apply land use practices for flood reduction purposes, he will need the answers to the following questions:

1. What combinations of inherent watershed characteristics cause the greatest flood potentials? Which cause the least?

2. How does vegetative cover and condition interact with other watershed characteristics in influencing flood peaks?

3: How are the magnitudes and timing of peak discharges affected solely by land management practices under given conditions?

4. In evaluating flood frequencies and magnitudes over a span of years, how have changes in land use and the resultant changes in vegetation cover influenced these frequencies and magnitudes?

With answers to the above questions, the wildland manager can locate areas of high flood potential and manage them considering their contributions to flood hazards. Knowing the trouble spots, he can better balance his land management plans for flood reduction. For example, replanting and fire control efforts may be concentrated in high flood yielding watersheds when assigning priorities; logging and related timber management decisions might be modified because of potential flood hazards. The design of minor structures (i.e., culverts) could take into account the effects of land use changes upon stream regimen. All in all, the answers to these questions would provide sound criteria by which flood reduction possibilities of alternative wildland management, proposals can be evaluated. These answers are possible using techniques that have been successfully applied in other regions.

Methods

Multiple regression analysis and high speed data processing methods will be used to quantify the following physical model:

$$Qp = f(M + P + G + V + L)$$

Expressed verbally, flood peak discharge (Qp) is a function of meteorology (M), watershed geometry and topography (P), geology (G), vegetative cover (V), and land use (L).

Data for the dependent and independent variables in this model are being collected and compiled from maps, aerial photographs, and existing published and unpublished records. Existing flood records will be secured from the U. S. Geological Survey, the California Department of

Water Resources, and other agencies; precipitation data from the U. S. Weather Bureau, Army Corps of Engineers, and Department of Water Resources; topographic maps primarily from the U. S. Geological Survey; geologic maps from the California Division of Mines, and other sources; aerial photographs from the U. S. Department of Agriculture; and fire records from the U. S. Forest Service and California Division of Forestry.

The final watersheds and storms will be selected to represent the wide range of conditions encountered in northern California. A detailed discussion of the problem, objectives, and proposed methods is available in a formal study plan.1/

The results will be expressed as a mathematical-physical model of flood peaks. Because it is only a model, it will not be able to predict the exact magnitude of flood flows but it can be used to estimate this magnitude within a known range of error.

Accomplishments

Initially, past work in related flood investigations was reviewed, and the adequacy of various data sources checked before setting up this study. Then, a preliminary selection of about 350 northern California watersheds varying in size from less than 1 square mile to more than 9,000 was made. These watersheds have flood flow records unaffected by reservoir storage or diversions. Geographically, they cover the wildland portions of the state, north of the Santa Barbara-Ventura county line and the Tehachapi Mountains -- and west of the Sierra Nevada crest.

The watersheds used in this and the two related companion studies (water yield and erodibility) have been delineated on maps suitable for data collection purposes, most commonly at a scale of one-half inch equals one mile. In many instances the three regional studies require the same data -particularly land use information -- so a common data pool has been formed.

Thanks to the cooperation of the California Division of Forestry in loaning original fire reports to the Experiment Station, all fires over 100 acres in size (1939-1959) and reported to them or to the U. S. Forest Service have had their acreages partitioned among the study watersheds (approximately 400 units) and/or Department of Water Resources hydrographic regions (110 units). The filing system is designed to permit considerable

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l/ Bowden, Kenneth L. 1961. An Evaluation of Factors Contributing to Flood Peaks in Northern California Wildlands, Study No. 2-2. Division of Watershed Management Research, Pacific Southwest Forest and Range Experiment Station, Berkeley. 19 pp.

flexibility in rapidly determining the fire history of additional watersheds.

Our other land use data are based upon rapid aerial photo interpretation sampling techniques. Information is being collected on the percent of the watershed area in the following categories: urban, cropland, roads, stream channel, water surface, grass, barren, brush, forest, and logged area. In addition, slope and aspect estimates are made for each vegetative cover type and for barren areas. Cover densities are estimated for brushlands and forest. Several measures of logging effects are collected in this inventory including road location, and exposure of bare ground within the logged area.

The Region Five office of the U. S. Forest Service has cooperated by loaning aerial photographs. Aerial photo interpretations have been completed for study watersheds within Sonoma County, Six Rivers National Forest, and portions of the Trinity-Shasta and Klamath National Forests. All land use data are being recorded on forms suitable for direct punching on IBM cards for machine processing.

Establishment reports giving detailed discussions of the methods of collection, organization, and scope of the fire and aerial photo land use data are in the process of preparation.

Plans for 1962-63

Assign a fire intensity index (based upon fire danger rating regions and climatic data) to each 100-acre fire occurring during the last decade. These indices have been computed for this period by the Division of Forest Fire Research, Pacific Southwest Forest and Range Experiment Station. Then the fire data for study watersheds will be key punched on IBM cards and tabulated by watersheds. Complete the collection of land use data from aerial photographs and tabulate these data by study watersheds.

Concurrently, work will proceed on the collection of geologic, physiographic, and meteorological data. The data will then be analyzed utilizing the computer facilities of the University of California.

SEARCH FOR EXPERIMENTAL WATERSHEDS

The Lower Conifer Zone is complex in its make-up, extending from the southern Sierra Nevada to the Cascades, Siskiyous, and the North Coast. Rainfall, topography, geology, streamflow, and forest cover vary considerably. At present, we feel that at least three more sets of experimental watersheds are needed--one set in the Douglas-fir region, another in the pine type of the northern Sierra, and another in the pine type of the southern Sierra.

Finding suitable experimental watersheds in the largely undisturbed and mostly unlogged Snowpack Zone for our Cooperative Snow Management Research project was relatively easy. In contrast, we are finding that many of the Lower Conifer sites which at one time might have been considered, have been recently logged or burned, or logged and burned. Many of these and others also are burdened with mines and mine debris, most often in and along stream channels.

Briefly, the ideal, which is seldom attained but always strived for is:

1. The experimental watersheds are representative in forest type, density, topography, geology, and climate for a large portion of the research area.

2. Each experimental watershed be of sufficient size (at least 100 acres) so that land management measures can be applied and evaluated on a practical basis, but sufficiently small (not over 2,000 acres) so that such measures can be applied at a reasonable expense.

3. The watersheds contain representative forest conditions (i.e., timber, riparian growth, brush) of sufficient maturity that management measures can be applied in the next 5 to_ 10 years.

4. The watershed group at the site includes at least a matched pair and preferably, 3 or more, all nearly the same in size, shape, elevation, forest type and density, and oriented in the same direction.

5. A bedrock control site be located for each streamgaging station.

6. The streamgaging station site in each watershed be accessible by road or jeep trail so that the stations can be conveniently constructed and maintained.

7. The watershed contain no active, abandoned, or contemplated mines; or that mines and mine dumps are measured and evaluated so their sediment contribution can be determined.

8. The ownership of the watersheds be such that control can be exercised for sufficient years (minimum 15) so that studies and treatments can be adequately evaluated.

Lucille Richards of the Station's Watershed Management Research staff has pored over a great many maps, quadrangle sheets, and aerial photos as time saving preliminaries in our search for experimental watersheds. From these

preliminaries, the choice of the Caspar Creek watersheds evolved. Other areas in the Feather, Yuba, Klamath, Eel, Mad, and Van Duzen River drainages have been field checked. One set of Douglas-fir watersheds in the West Fork of the North Fork of the Eel River headwaters has been tentatively selected, but as it misses several of the ideals listed above, we are continuing our search in the Douglas-fir region, as well as in the Lower Conifer pine type of the Sierra Nevada.

Plans for 1962-63

Locate and establish suitable experimental watershed pairs or groups in important representative areas of the Lower Conifer Zone. Priority emphasis first in the pine type of the northern Sierra Nevada, second in the Douglas-fir forest type of the Siskiyous or North Coast, then the southern Sierra Nevada.

FURTHER PLANS FOR 1962-63

SOIL MOISTURE STORAGE AND LOSSES

Initiate a study of soil moisture losses under different forest conditions throughout the Lower Conifer Zone. Study to include pine, Douglas-fir and Douglas-fir-Redwood types, in the major soils. Substudies to include different logging practices, stocking, and maturity.

Evaluating soil moisture characteristics and their losses under a span of conditions common to the Lower Conifer Zone and relating them to other watershed characteristics should provide a knowledge of the range in water losses, the prospects of reducing water losses, and a measure of the extent of the areas that may be subjected to management for the improvement of water yield.

LANDSLIDES

Initiate a basic study of the physical and chemical characteristics of landslide-prone geology and soils in the Lower Conifer Zone.

Slide soils are a critical problem to land use and sedimentation. To date, no quantitative analyses have been made relating characteristics to slide probability, and insufficient work has been done in the way of understanding chemical. and physical characteristics, and modifying these to obtain better control and management of slide areas.

HEAT BALANCE

Initiate a study of heat balance in the northern portion of the Sierra Nevada Lower Conifer Zone.

Shallow, low elevation snowpacks have been serious contributors to major floods. A study of the heat exchange on shallow packs during rain events can increase understanding and help in the prediction of floods.

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