SOIL AND WATER RESEARCH NEEDS IN COLORADO

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Fort Collins, Colorado

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This report presents the most important soil and water research needs in Colorado today. It is organized under the following headings:

Part I: RESEARCH PROBLEMS REQUIRING MAJOR NON-RECURRING CAPITAL FACILITIES

Part II: RESEARCH PROBLEMS REQUIRING SUPPLEMENTAL SUPPORT

Part III: GENERAL EVALUATION BY THE COLORADO AGRICULTURAL EXPERIMENT STATION OF SOIL AND WATER RESEARCH NEEDS IN COLORADO.

Foreword

In Part I, the need for two major facilities is presented. The problems that these facilities would study are of such magnitude, even though some research is now underway on the problems, that a large additional expenditure of funds for facilities, staff, and operation will be necessary if immediate and future needs for fundamental knowledge are to be met. The results which these facilities would make possible would undoubtedly be of significance to the entire Western United States, in addition to meeting Colorado's immediate needs.

In Part II, five problems are discussed. All of these problems are currently receiving some study in Colorado but the level of support is inadequate to make it possible to progress at the rate indicated by the need for basic information. Since these study areas are considered extremely important, supplemental support must be obtained. The philosophy of this section is that the goal can be best reached by making use of existing capabilities by bolstering the resources of current studies.

Part III is an evaluation by the Experiment Station of the specific soil and water research problems with which Colorado and the region is faced.

Daily inquiries from private individuals and public agencies for information on their soil and water problems leave no doubt as to the necessity of increasing basic knowledge on the complex soil-water-plant system. Such requests vary from problems of development, delivery and application of water to special problems of soil classification, basic chemistry and physics of soils, fertilization, and soil and crop management. In every case the problem seems to involve efficient production. Proper answers can only be based on an ever increasing fund of basic knowledge which can best be determined through study of the complicated inter-actions of the soil-water-plant complex.

S. S. Wheeler, Director
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PART I

PROBLEMS REQUIRING MAJOR NON-RECURRING CAPITAL FACILITIES

CLASS 4 - SOIL ENVIRONMENT AND PLANT GROWTH

A. Title No. 1: More effective use of natural precipitation in dryland areas.

1. Problem: The underlying problem of agriculture in the dryland areas is a recurring deficiency of moisture for the growth of crops and range forage. This deficiency results in variable production, uncertain farm income and may result in soil erosion.

Despite the fact that most farmers in the Great Plains attempt to make efficient use of the rainfall, a large portion of this rainfall is lost. Estimates indicate that about two-thirds of the rainfall in the Great Plains area is lost by evaporation alone. A reduction of eight percent in the evaporation loss, in a 20-inch rainfall area, would result in a moisture saving equivalent to three inches of precipitation. It is estimated a saving projected over ten Great Plains states would have a value of nearly 400 million dollars annually in terms of crop production.

Some of the more basic problems are as follows:

1) Determining methods to increase the intake of precipitation into the soil.

2) Determining moisture saturation characteristics of the soils.

3) Development of procedures which will keep evaporation losses at a minimum.

4) Increasing the efficiency of soil moisture use of plants by planting according to data correlating critical stages in plant growth with heavy precipitation periods, sequence of crops, spacing of plants, fertilizers, etc.

5) Determing evaporation losses from natural soil and artificial growth media under controlled environmental conditions by use of a wind tunnel.

2. Area Involved: The entire eastern half of Colorado from the Rocky Mountains to the Kansas-Nebraska line is included in the Great Plains area. Some of the research results obtained would apply to the drylands in western Colorado and other areas west of the Rocky Mountains (Great Basin and Intermountain states).

B. Facilities Available: Considerable research is already underway in the Great Plains, but more fundamental data are necessary to aid in the establishment of a more permanent agriculture. Currently, studies are being conducted at the Fort Collins, Akron, and Springfield experiment stations. Some of the work is cooperative between Colorado Agricultural Experiment Station and the Agricultural Research Service. Certain standard equipment as well as laboratory space are available. Limited growth chamber facilities with controlled environment are in use.

Colorado State University now has two subsonic wind tunnels. The larger of the two is nearing completion as far as the basic circulation system is concerned. Neither tunnel is equipped with humidity control or a radiation source at this time. One wind tunnel has a test section 24-feet long. The cross-section of this test section is 6 x 6 feet or 9 x 9 feet (interchangeable). The second wind tunnel has a test section 72 feet long. The test section is 6 x 6 feet in cross-section. Wind speeds to 150 feet per second will be possible. A wide range of turbulence levels will be available. Turbulent boundary layers 2-feet thick are possible. Present facilities are enumerated in item D.

C. New Facilities Required: Certain new facilities and manpower are needed to investigate adequately the problems enumerated above. With certain additions the existing program at CSU can be made quite effective. These requirements are indicated under item a of part D.

In the development of the principles which will make it possible to understand the soil-water-plant relationships that control dryland agriculture, it is desirable to perform tests in large subsonic wind tunnels. Such wind tunnel research permits control of environmental variables to simulate natural climatic conditions.

Such facilities are essential for conducting experiments in the following areas:

1) Turbulent transport of heat, water vapor and momentum as they affect (or are affected) by the aerodynamic roughness of vegetation, wind breaks, contouring, strip cropping and terrain features.

2) Turbulent transport of mass, such as snow, soil, aerosols, insecticides and fertilizers, as it is affected by vertical temperature gradients, terrain features and terrain surface conditions.

3) Plant growth under known conditions of wind velocity, air temperature, humidity, pollutants, soil moisture, atmospheric pressure and transpiration.

A new large wind tunnel is needed for experiments beyond the physical capabilities of Colorado State University's present facilities. This

equipment should probably have a test section 120 feet long, 16 feet wide and 8 feet high. Wind speeds of 150 feet per second should be attainable. A statement of this need is given under item b of part D.

Many of the experiments mentioned above could be most efficiently performed in the present facilities at Colorado State University. However, additional funding for instrumentation and personnel is required. This need is described in item c of part D.

D. Present and Needed Facilities:

I. Capital Items

a. General	Have	Additional Needs
1. Office	300 sq ft	600 sq ft
Laboratory	750 sq ft	2,000 sq ft
Greenhouse	---	1,500 sq ft
Land	6 sections	---
2. Equipment	$ 2,000	$25,000
3. Personnel		
Professional	4 USDA	
	1½ CSU	2 CSU
Non-professional	1½ CSU	2 CSU
Graduate Assistant	3 USDA	2 CSU
4. Annual Budget		
Salary	$12,000 CSU	$35,000 CSU
	USDA	
Operation	$ 7,500 CSU	$20,000 CSU
	USDA	
b. New Large Wind Tunnel Facility		
1. Office	--	2,000 sq ft
Wind Tunnel Bldg.	--	5,000 sq ft
2. Equipment		
Instrumentation	--	$250,000
Wind Tunnel Structure	--	$600,000
3. Personnel		
Professional	--	5
Non-professional	--	6
Graduate Assistant	--	4
4. Annual Budget		
Salary	--	$150,000
Operation	--	$150,000
c. Present Wind Tunnel Facilities		
1. Capital Items		
Office	500 sq ft	1,000 sq ft
Laboratory	8,400 sq ft	800 sq ft

		Have	Additional Needs
2.	Equipment		
	Humidity Control	---	$ 40,000
	Radiation Control	---	$ 40,000
	Instrumentation	$ 30,000	$ 100,000
	Wind Speed Control	$ 100,000	---
	Wind Tunnel Structure	$ 75,000	$ 20,000
3.	Personnel (man/years)		
	Professional	$1\frac{1}{4}$	3
	Non-professional	$\frac{1}{2}$	4
	Graduate Assistants	2	6
4.	Annual Budget		
	Salary	$ 20,000	$ 75,000
	Operations	$ 20,000	$ 60,000

CLASS 4 - SOIL ENVIRONMENT AND PLANT GROWTH

A. Title 2: Soil-water-plant interrelationships as affected by soil factors, aerial environment, and species and varieties of plants under controlled conditions.

1. Problem: In the past, much research has been done separately on soils, water, and plants, but the interaction of these as well as a host of other soil and aerial factors affecting growth has not been satisfactorily evaluated. A plant is the end product of numerous complex processes. It has not yet been found possible to produce the same yield of a particular plant on different soils even when an attempt has been made to bring all growth factors to an "optimum" level under controlled conditions. The complete role of soil organic matter in this regard has not been evaluated. Because of unknown interactions, it is not now known what "optimum" levels are for different soils, species or varieties of plants. Progress in this area of inquiry depends on discovery of the relationships among all plant growth factors including root environment. Efficiency in production per unit area of land depends on knowledge of these relationships. Proper handling of our water supplies is vital. Fundamental studies are needed to solve these problems; particularly in relation to soil and water conditions typical of the western states.

2. Area Involved: The 11 western states, as well as similar areas of the world, will benefit from such research.

B. Facilities Available: Colorado State University is pursuing certain of these studies at the present time. At Fort Collins, Grand Junction, and Mosca some emphasis is being placed on the effects of hydraulic and osmotic moisture stress on germination, growth, and ion uptake of various species and varieties of plants. In addition, interactions between plant growth and temperature, oxygen, carbon dioxide, soil compaction, and nutrient level are being investigated. Both controlled growth chamber and field studies are involved. Evaluation of this biological complex in respect to the earlier stages of plant growth is emphasized. While studies of later stages of plant growth are being made, they are being conducted under the less exacting conditions of the field. Certain phases of the investigations are being conducted in cooperation with the Agricultural Research Service. Present facilities at Colorado State University are summarized in part D.

C. New Facilities Required: Laboratory, office, and greenhouse space are available at Fort Collins and Grand Junction. Certain equipment is available but additional facilities are required. Particularly critical items needed include controlled growth chambers and greenhouses. Also required are additional personnel trained in soil chemistry, microbiology, and physics; genetics, plant physiology and anatomy; biochemistry. A summary of needed facilities is given in part D.

D. Present and Needed Facilities:

	Have	Additional Needs
Capital Items		
Office	400 sq. ft.	800 sq. ft.
Laboratory	750 sq. ft.	2,000 sq. ft.
Greenhouse	300 sq. ft.	4,000 sq. ft.
Equipment	$ 5,000	$ 25,000
Personnel		
Professional	1 1/2	3
Non-professional	1/6	3
Graduate Student	1	3
Annual Budget		
Salary	$ 1,600	$ 53,000
Operation	$ 8,000	$ 25,000

PART II

RESEARCH PROGRAMS REQUIRING SUPPLEMENTAL SUPPORT

CLASS 2 - IRRIGATION AND DRAINAGE AND CLASS 3 - BASIC SOILS

A. Title No. 1: Pre-irrigation development classification of soils in relation to soluble salts, drainage and type of parent material.

1. Problem: In many irrigation projects, soils have been rendered unproductive after they have been irrigated for a period of years due to poor physical condition, high water table, and accumulation of excess salt. D. W. Thorne (1951) states that 9,000 acres of the soils of Salt Lake County, Utah have deteriorated as a result of such conditions. A similar condition is cited in a report by the Committee of the National Reclamation Association on Soil and Water Research (1951). They conclude that there are from 15,000 - 20,000 acres of land on the Riverton Project in Wyoming which are either completely nonproductive or relatively unproductive and are becoming more so every day. In a report to the Governor of Colorado entitled "An Integrated Policy for the Conservation and Development of the Natural Resources of Colorado" (1957), the following statements are made: "Over 30,000 acres of land in the Grand Junction area, once highly productive, are now submarginal or abandoned." It is later stated in the same report that "it has been estimated that more than 800,000 acres of irrigated land in Colorado are affected to a sufficient degree by soluble salt (including sodium) to restrict yield. Some of this alkali has accumlated through excessive use of poor quality irrigation water high in salt and sodium."

It is evident from the above statements that the reduction in acreage and productivity of our irrigated lands is a serious and costly problem. It is one which might be minimized in the future by better techniques of pre-development classification of lands which are to receive new or supplemental irrigation water.

In general the deterioration of irrigated lands may be traced to one or more of the following factors: (1) the inherent complex characteristics of the soil itself, (2) the accumulation of groundwater, (3) a reduction in aeration (water logging) and, (4) the accumulation of excessive soluble salts, including sodium.

Pre-irrigation development classification techniques which could be used to predict the extent of difficulties that might occur on new projects would permit more intelligent selection of new lands for irrigation, thus making better economic use of our lands. This would eliminate the use of potentially unproductive lands. Efficient utilization of the limited water supplies would be a consequence of such a procedure.

2. Area Involved: The problem of pre-development classification is especially important in the Upper Colorado River project and is encountered in the Upper Rio Grande water shed, the South Platte from Denver east and the lower Arkansas Valley and in all areas of the west where new water is to be developed. Studies in the Upper Colorado River Basin have established some basic facts which could be used with modifications in solving similar problems in the other areas of the western region.

B. Facilities Available: Both basic and applied work is underway in Colorado. Part of the work is being conducted on the campus at Fort Collins and part in the field. Both the Colorado Experiment Station staff and members of the ARS staff in the state are cooperating. Much of the equipment is available for making these studies.

In an effort to classify such soils, studies are underway on the effect of parent materials, including clay minerals, on soil characteristics. This work is being done with the objective of reclaiming some of the problem soils of the Grand Junction area in the Upper Colorado River Basin.

Drainage investigation techniques and equipment are being developed which will make thorough studies in advance of irrigation development economically feasible. Studies to develop methods of analysing drainage problems and predicting the occurrence of future drainage problems are in progress at Fort Collins and at Grand Junction.

C. New Facilities Required: Additional studies are necessary to develop techniques for pre-irrigation development classification including drainage possibilities. Studies are also needed to determine the influence of kinds and amounts of salt on soil microbiological processes, colloidal particle phenomena and their influence on soil characterization. Additional facilities and support needed to fully implement the studies are given in item D.

D. Present and Needed Facilities:

	Have	Additional Needs
1. Capital Items		
Office	1,000 sq ft	1,000 sq ft
Laboratory	3,000 sq ft	3,000 sq ft
2. Equipment	$30,000	$20,000
3. Personnel		
Professional	$2\frac{1}{2}$	2
Non-professional	2	2
Graduate Students	1	2
4. Annual Budget		
Salary	$28,000	$28,000
Operating Costs	$10,000	$15,000

CLASS 1 - WATER SUPPLY, HYDROLOGY AND WATERSHED ENGINEERING

A. Title No. 2: Increasing the water supply available to crops by improvement of water storage, conveyance, and distribution systems.

1. Problem: In order to increase the consumable supply of water for agricultural use, it is necessary to develop a hydrologic system which minimizes water losses from deep percolation due to excess irrigation, evaporation, excess canal seepage and pollution. At the same time the role of seepage in recharge and tributary ground water flows must be recognized. The problem may be reduced to sub-problems, several of which are: a) development of better flow measuring devices and methods of using them, b) discovery of ways of better reducing the evaporation from water surfaces, perhaps by additives to the water surface, underground storage or high-altitude storage, c) research on the feasibility of combining many of the old distribution systems now in operation to cut seepage and evaporation losses, d) the effects of detergents, other pollutants, excess irrigation and drainage on irrigation water quality, 3) research on the mechanics of seepage, particularly in the unsaturated case, and locating and sealing high seepage areas, f) research on the hydraulics of alluvial channels, ephemeral streams and steep mountain streams, and g) development of economical erosion control structures.

2. Area Involved: The area served would be Colorado's east and west slopes. However, the principles established would also be of value to other areas.

B. Facilities Available: Colorado State University now has a 24,000 sq ft fully equipped hydraulics laboratory in use, primarily on research for the federal and foreign governments. This laboratory has a competent staff of 35 full time men working on some 40 projects. Five of these men are working on Colorado projects. Discharges to 50 cfs are possible. The Bureau of Reclamation has a laboratory in Denver, Colorado where field problems are resolved.

C, New Facilities Required: An additional 10,000 sq ft of hydraulics laboratory would be needed to carry on an adequate program on Colorado's problems. The necessary additional staff, equipment, and laboratory instrumentation would also be required. Details are presented in part D.

D. Present and Needed Facilities

		Have	Additional Needs
1.	Capital Items		
	Office	4,000 sq ft	2,000 sq ft
	Laboratory	24,000 sq ft	10,000 sq ft
2.	Equipment	$120,000	$ 50,000
3.	Personnel (man years/year on Colorado problems)		
	Professional	2	4
	Non-professional	1	4
	Graduate Students	2	4
4.	Annual Budget for Colorado Problems		
	Salary	$ 25,000	$ 75,000
	Operating Costs	$ 9,000	$100,000

CLASS 3 - BASIC SOILS

A. Title 3: Determination of the nature and behavior of clay minerals and amorphous colloids in western soils.

1. Problem: Knowledge of the type and quantity of clay minerals and amorphous colloidal material in soils and soil materials is based on an understanding of their physical and chemical behavior and their interaction with plants and soils. An extensive program to characterize clay minerals is needed to supply the basic information needed for projects involving soil structure, soil moisture, and soil chemistry.

Clay mineral investigations in the West have been limited to relatively few soils and only a few locations. Many of these investigations were conducted with older equipment. Recent progress in physics and electronics research has resulted in better instrumentation which is capable of giving greater accuracy in mineralogical studies. Better procedures have been developed; but further methodology studies are needed to adapt them to the soil studies in the western states. Uniform procedures and criteria must be established for identification and estimation of the amount of soil minerals. Many of the older mineralogical analyses will need to be repeated in light of the newer procedures.

The problem can be resolved into (1) a basic study dealing with specific methods of identification and quantitative analysis of minerals in soils, and (2) characterization of the properties of clay minerals and amorphous materials in soils.

2. Area Involved: The study of soil minerals and amorphous materials is needed to supply knowledge required for carrying out projects involving (1) pre-irrigation development classification of soils, (2) characterizing mountain meadow and forest soils, (3) soil structure-soil drainage interrelationships, (4) fixation of plant nutrients in soils, and (5) microbiological relationships in soils. The results have application to the 11 western states and Great Plains area.

B. Facilities Available: Identification of minerals in soil clays has been carried out for a few soils of Colorado by utilizing facilities loaned by other institutions. The lack of complete facilities at Colorado State University limits progress along this line. These studies have to be used to support numerous research projects at this institution.

C. New Facilities Required: The Department of Agronomy has adequate space facilities for conducting clay mineral research. Most of the equipment needed for chemical analyses is available. Special equipment for differential thermal analysis is available. Additional items needed include an X-ray diffractometer and X-ray diffraction cameras, and a centrifuge. One new staff member trained in soil chemistry and physical chemistry will be required.

D. Present and Needed Facilities:

	Have	Additional Needs
Capital Items		
Office	200 sq. ft.	_____
Laboratory	750 sq. ft.	_____
Greenhouse	_____	_____
Equipment		
DTA, et al.	$ 5,000	_____
X-ray	_____	$ 30,000
Personnel		
Professional	1/6	1
Non-professional		1
Graduate Student	1	2
Annual Budget		
Salary	$ 4,000	$ 20,000
Operations	$ 1,000	$ 10,000

CLASS 3 - BASIC SOILS

A. Title 4: Properties and Characteristics of Mountain Range, Forest and Meadow Soils.

1. The Problem. Geographically the problems are closely associated, but for delineation of the efforts involved, they can best be considered under the two headings: (1) mountain range and forest soils, and (2) mountain meadow soils.

(1) Basic studies of mountain range and forest soils to determine their measurable characteristics for purposes of classification are essential to the development of better management practices for maximum yield and quality of water, forage, and forest products. Forest and range soils in the mountains of Colorado and much of the West dominate all of our major water-yield areas. High quality water is the principal resource derived from these areas. Management of range and forest cover is necessary for the protection of the watershed and water quality. Mountain soils are commonly shallow, rocky, immature, steeply sloping, and are subject to climatic extremes. As a consequence, the technics used in measuring and classifying agricultural soils can be adopted only in part. Attendant to a study of the soil characteristics is the determination of the productive capacity of the soil in terms of forage and forest products.

(2) In mountain meadows, which are essentially irrigated areas, peat-like sod mats of varying thickness often develop on the soil surface. The type of plant growth and management practices, especially in regard to irrigation, affect the type and thickness of the mat formed. The complexities associated with organic matter on relatively undeveloped raw profiles having textural and structural discontinuities present difficult nutritional and water management problems. Efficiency in hay production depends upon a knowledge of the fundamental properties of the meadow soils. The problems are associated with irrigation method, air and soil temperature, drainage, available nutrient supply, and the varied characteristics of the soil profiles.

2. Area Involved: The Upper Colorado River, upper Rio Grande, Arkansas and Platte rivers all rise in Colorado's mountain country. Water developed in these areas contributes to a high percentage of the irrigated areas of the West. Mountain meadows in Colorado comprise about 500,000 acres, which are a part of approximately two million acres of mountain meadow in the West. There are about 250 million acres of range and forest in the West. Therefore, the management of forest soils including mountain meadows is important to the economy of the western states where water is a limiting factor in production.

B. Facilities Available: Studies on mountain meadows are being conducted at Gunnison, Hayden, and Fairplay which represent at least three different types of meadows, soils and elevations. Main efforts

have been directed toward: water management, forage management, fertility management, species of plants, and livestock management. Investigations involving lysimeters have been undertaken to develop information as to losses and availability of nitrogen, method of irrigation, and position of water table at Gunnison. Laboratory and office facilities are available at Grand Junction and Fort Collins. Results are evaluated agronomically and in terms of beef production; the investigations start with the soil and end on the consumers' table. The work is cooperatively conducted by the Colorado Agricultural Experiment Station and the Agricultural Research Service. A summary of facilities is given in part D.

C. New Facilities Required: Additional laboratory space, professional and non-professional personnel are needed in order to adequately characterize the soils of mountain meadows and the forest areas. Additional equipment will also be required.

D. Present and Needed Facilities:

	Have[1]	Additional Needs[2]
Capital Items		
Laboratory & Office	2,000 sq. ft.	5,000 sq. ft.
Land	Leased 40 acres	
Equipment	$ 25,000	$ 55,000
Personnel		
Professional	1 1/2 Colorado 2 1/2 USDA	5
Non-professional	1 1/2	3
Graduate Assistants		2
Annual Budget		
Salary	$ 30,000	$ 70,000
Operation	$ 17,000	$ 60,000

1/ These relate to mountain meadow studies.

2/ These relate to mountain meadow studies and additional studies on mountain range and forest soils.

CLASS 3 - BASIC SOILS

A. Title 5: Chemical nature of plant nutrient sources in soils and factors affecting their solubility.

1. Problem: The chemistry of the soil is very complex and in spite of the advances during the last 30 years, a great deal of the fundamental chemistry of the sources of plant nutrients is still obscure. The development of soil chemistry closely parallels the state of our general chemical knowledge. This greater understanding of soil chemistry will clarify many practical problems, e.g., it will help to establish the criteria needed for predicting the needs for the primary nutrient elements in soils, and it will help to establish a sound program for the use of other elements, especially the trace elements, which are becoming or more importance in the West each year.

The problem consists of a study of solid phase-liquid equilibria of plant nutrients in soil systems. It requires (1) characterization of the solid phase forms in which nutrient elements occur in soils and (2) an investigation of factors affecting their solubility and availability to plants.

2. Area of Study: The fundamental principles derived from this study will be basic to all projects dealing with soil-water-plant relationships. The results will apply to the Great Plains area as well as throughout the 11 western states.

B. Facilities Available: Some of these studies are now in progress at Colorado State University. Emphasis has been placed on the nature and behavior of artificial and applied phosphates in soils. Limited work is being conducted with nitrogen transformations and with cation exchange equilibria in saline and high sodium soils. These studies need expanding and basic work with trace elements needs attention.

C. New Facilities Required: Laboratory and office space is available at Fort Collins. Additional equipment needed to expand the work includes a centrifuge, temperature controlled room, Beckman spectrophotometer, flame photometer and a stainless steel hood. An additional staff member trained in soil chemistry will be required.

D. Present and Needed Facilities:

	Have	Additional Needs
Office	600 sq. ft.	
Laboratory	1500 sq. ft.	
Greenhouse	700 sq. ft.	
Equipment	$30,000 (ARS) $ 5,000 (CSU)	$13,000
Personnel		
Professional	3 (ARS) 1 3/4 (CSU)	1
Non-professional	1/3	1
Graduate Student	1	2
Annual Budget		
Salary	$18,000 (USDA) $16,000	$20,000
Operations	$ 5,000	$10,000

PART III

GENERAL EVALUATION BY THE COLORADO AGRICULTURAL EXPERIMENT STATION OF SOIL AND WATER RESEARCH NEEDS IN COLORADO

A. Priority listing of problems in terms of research needed in Colorado.

The problems covered in Part I, those requiring major non-recurring capital facilities, are listed below in the order of priority.

Title 1. More Effective Use of Natural Precipitation in Dryland Areas.

Title 2. Soil-Water-Plant Inter-relationships as Affected by Soil Factors, Aerial Environment, and Species and Varieties of Plants Under Controlled Conditions.

Research under both titles is currently being conducted in Colorado, but it is restricted in scope due to limited facilities, personnel, and financing.

The efficient accomplishment of this research would require the establishment of major facilities and the supplementing of present budgets of the State Agricultural Experiment Stations and the Agricultural Research Service.

Part II of the report lists those research programs which do not require major capital expenditures. The research programs referred to can be made more effective by expansion of present programs and existing facilities. They are by title:

1. Pre-irrigation development classification of soils in relation to soluble salts, drainage, and type of plant material.

2. Increasing the water supply available to crops by improvement of water storage, conveyance, and distribution systems.

3. Determination of the nature and behavior of clay minerals and amorphous colloids in western soils.

4. Properties and characteristics of mountain range, forest, and meadow soils.

5. Chemical nature of plant nutrient sources in soils and factors affecting their solubility.

While these projects are necessarily listed in an order of priority, the Experiment Station believes that all are vital to the agriculture of Colorado and the West. It appears appropriate to continue and to expand the state and/or cooperative state and federal work in these fields in the interest of most efficient use of funds.

B. Recommendations for Implementation of Research Work.

The success of Federal research centers such as the Salinity Laboratory at Riverside, California, is widely recognized. Similarly, outstanding research contributions have been made by State Agricultural Experiment Stations and through cooperative state-federal programs.

We recognize that for types of research referred to in Part I of this report, it may be desirable to establish central facilities located at and operated in cooperation with State Agricultural Experiment Stations. The Experiment Station believes that the research needs listed in Part II can be most effectively and economically met through the expansion of present state or cooperative state-federal facilities and programs.

The Experiment Station has several recommendations concerning an operational policy for research programs handled through new centralized research facilities. It is suggested that the broad direction of any regional program that may be tied to a new central facility be placed under a Board of Collaborators. This Board should have responsibility for approving research programs and for the distribution of research funds.

The Board of Collaborators should be made up of one representative from each actively cooperating State Agricultural Experiment Stations, and one representative from each of the several Federal Government agencies in the region which rely upon soil and water research. The Director of each station, or his appointed representative, should be the representative for each State Agricultural Experiment Station.

The Board of Collaborators should be responsible for determining which proposed research projects and facilities are to be financed from the total funds made available. Determination would be on the basis of the technical merit and potential contribution of the project or facility, the probability of establishing basic scientific principles, and the capability of the scientists proposing

the program. The Federal staff and the Agricultural Experiment Station staff of interested states would each submit research proposals for consideration by the Board.

The Board would review annually research projects underway and decide which should be continued. This would assure that no "doubtful" projects, once approved, could long survive.

It is intended that the Board of Collaborators would have the responsibility of recommending the allocation of available funds among State Agricultural Experiment Stations, Federal Agencies and the central facility. The distribution of funds should be entirely on the basis of merit of the individual research proposals -- thus assuring that only the very best research would be undertaken. The percentage of the total budget that would go to the federal staff and the station staffs would, of course, vary from year to year -- a constant percentage distribution seems unwise since it could make it possible for weak projects to be continued when they should be terminated.

In considering the establishment of Federal laboratories, an important point comes out, i.e., the source of suitably trained personnel to do the research for which the laboratory has been established. In order to meet this demand, an additional strain will be placed on the training centers where such personnel are developed. To aid in the training of the technical staff needed, funds should be made available to the Land-Grant Colleges for training research personnel.

Coordination between all state and federal work is necessary if maximum progress is to be made. Full and effective cooperation can by all odds be accomplished best where state and federal research personnel are housed under one roof.